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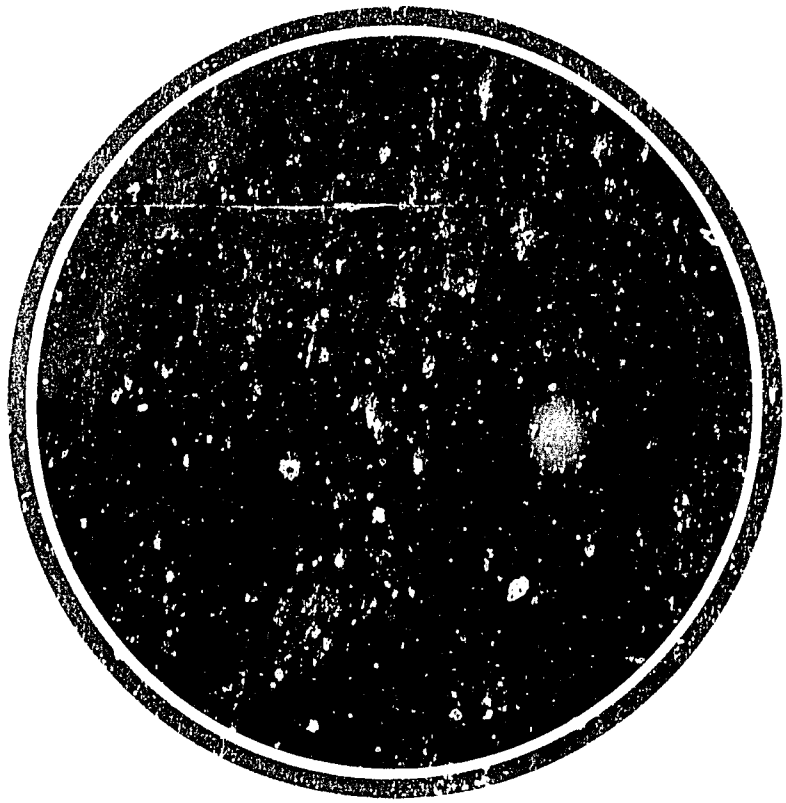

Linking Main and Farm Irrigation Systems in Order to Control Water

Volume 5:
Two Tank Systems in Polonnaruwa District, Sri Lanka

Water Management Synthesis Project
WMS Report 69

LINKING MAIN AND FARM IRRIGATION SYSTEMS IN ORDER TO CONTROL WATER

VOLUME 5:

TWO TANK SYSTEMS IN POLONNARUWA DISTRICT, SRI LANKA

by

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WMS Report 69

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WATER MANAGEMENT SYNTHESIS PROJECT
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PREFACE

In recognition of the importance of water management for improving irrigated agricultural production, Water Management Synthesis II Project developed several activities related to irrigation system management. One such activity was the special studies research program initiated by Colorado State University. The program examined formal and informal organizational relationships between main system managers and farmers in their efforts to control water in four irrigation systems in Pakistan, India, Thailand, and Sri Lanka. The information that was obtained is presented in the following five volumes:

Linking Main and Farm Irrigation Systems in Order to Control Water. WMS Report 69. Water Management Synthesis Project, Colorado State University, Fort Collins.

Volume 1: Designing local organizations for reconciling water supply and demand (D.M. Freeman).
Volume 2: A case study of the Niazbeg distributary in Punjab, Pakistan (E. Shinn and D.M. Freeman).
Volume 3: A tank system in Madhya Pradesh, India (V. Bhandarkar and D.M. Freeman).
Volume 4: The case of Lam Chamuak, Thailand (K. Paranakian, W.R. Laitos, D.M. Freeman).
Volume 5: Two tank systems in Polonnaruwa District, Sri Lanka (J. Wilkens-Wells, P. Wilkens-Wells, D.M. Freeman).

The reader is advised that reading Volume 1 will enhance his or her understanding of the significance of the information reported in volumes 2-5.

EXECUTIVE SUMMARY

This, the fifth volume in the Water Management Synthesis II special studies series, reports findings of a study of farmers and main irrigation system management officials on two tank irrigation projects in the northeast Dry Zone near Polonnaruwa, Sri Lanka. A purposive sample of 82 farmers representing 6 distributaries from Parakrama Samudra Scheme and 9 distributaries from the Giritale system were studied intensively during 1985 and 1986. Data reported here were gathered during yala (dry season, March-August) 1986. All study variables were measured on the sample of 82 farms, but a larger sample was drawn (n=304) from the 15 sample distributaries on the two systems to examine farmer support for the concept of local, distributary-level, water user associations.

Special attention was paid to the manner in which the state irrigation bureaucracy was linked to irrigators, as farmers and central irrigation managers struggled to control irrigation water. The logic of inquiry was as follows: adequacy of organizational mechanisms between main system civil service managers and irrigators was viewed as affecting farmer control over irrigation water. Farmer water control was seen to affect farmer choices, which affect rice yields and willingness to support local distributary-level, farmer water user associations. Therefore, the quality of middle-level organization (physical tools appropriately combined with enforceable social rules) between individual farmers and main system management was seen to be critical to irrigation water productivity and farmer willingness to support local organizational development.

What was found? Informal, local organizational arrangements between farmers and main system management varied considerably among the 15 sample distributaries. Where such informal organizational arrangements have provided increased local distributary management capacity (i.e., where farmers have developed procedures at the distributary level to provide greater support to the vel vidane (elected official within Agrarian Services) to allocate water, maintain the distributary, and manage local disputes), fewer distributary problems were reported by farmers, water control was enhanced, weed problems declined, and rice yields increased.

These findings hold when the effects of potential rival hypotheses are introduced into the analysis -- e.g., the effects of variation in tenancy along the distributaries, number of irrigators on the distributary, location in the system, farm size, and relative water supply available to the distributaries. Distributary irrigation communities that have developed better management capacity clearly revealed stronger support for the idea of farmer-managed water user associations in the near future. Overall, the data revealed that a majority of sample farmers support the concept of more formal, local, water user associations.

The important implications of this analysis follow. First, policymakers are asked to recognize the degree to which at least a portion of the distributary farmer communities have constructively adjusted to

lack of adequate linkages to main system management. Some irrigation communities have accomplished much by using and generating support for the traditional role of the vel vidane in allocating water, performing system maintenance, and managing water-related conflict. Second, the strong and sustained relationship between distributary organization, water control, and yields implies a priority for securing greater main system support for local organizational development between farmers and main system management. Third, willingness of farmers to support local water user associations should not be underestimated. The desire was substantial across all sample distributaries, but it increased where farmers had experienced previous success in improving water control through locally instituted farmer practices. All of the above reinforces the crucial nature of designing and implementing appropriate water user associations at the middle management level with main system support and with main system respect for local organizational autonomy.

Proper design and implementation of such organizations can do much to reduce problems for both farmers and main system management. Concepts and procedures for such organizational design are addressed in Volume 1 of this series of reports: **Linking Main and Farm Irrigation Systems in Order to Control Water — Designing Local Organizations for Reconciling Water Supply and Demand.**

I. INTRODUCTION

A. PROBLEM

This study examined the availability and timing of water deliveries to farms served by two centrally managed tank irrigation systems -- Parakrama Samudra and Giritale schemes in Polonnaruwa District -- in the Dry Zone of Sri Lanka. The organizational arrangements linking main system management and farmer demand were investigated.

Centrally administered irrigation systems have been constructed at great public expense to increase agricultural productivity and improve the quality of rural life in many nations, but these systems have frequently failed to meet desired production objectives. Many are unable to guarantee the delivery of reliable water supplies to farmers (Wade, 1982; Moore, 1980). Volume 1 of this series has a detailed analysis of the problem.

Much research has suggested that an autonomous or semi-autonomous water users association can be a successful organizational arrangement between main system managers and farmers (Maass and Anderson, 1978; Harriss, 1984; Moore, 1980; Murray-Rust, 1984). Freeman and Lowdermilk (1985) referred to such associations as constituting an "organizational interface" between the resource management goals and reward structures of main system managers and farmers.

This study was centrally concerned with investigating the effect of linkage between central administration and farmers on water availability and control at the farm level. Water control was viewed as an important determinant of crop yields and of farmers' willingness to collectively act to more equitably allocate water and maintain the irrigation system.

B. RESEARCH OBJECTIVES

Study objectives were to:

1. Present qualitative and quantitative data which reveal important facets of existing farmer organizational linkages between main system management and farmers on two tank irrigation systems in the Dry Zone of Sri Lanka.

2. Examine the nature of informal arrangements for water management in the middle reaches of the irrigation system. The quality of these arrangements varied considerably from one distributary to another. The consequences of such variation on agricultural production and farmers' support for local, collective organization could be investigated.

3. Test a set of interrelated hypotheses about relationships between water management practices on sample distributaries, water control, crop yields, and the willingness of farmers to support water users associations. The degree of supervision of water allocation by local irrigation headmen and the degree of agreement about water allocation procedures defined the degree of water management capacity at the middle level. Water management capacity was viewed as being related to water control in the distributary. Water control was examined as it affected yields and farmer willingness to support the development of local water user associations.

4. Examine factors relating to management capacities on distributaries. Attention was paid to the potential for developing local water user associations in the near future.

The next chapter summarizes the physical and organizational features of irrigation systems in Sri Lanka within an historical perspective, and presents a brief account of methods used to allocate and distribute water and of the water management practices in the study area.

II. BACKGROUND

A. THE PHYSICAL AND SOCIAL CONTEXT OF WATER MANAGEMENT IN THE SETTLEMENT SCHEMES

1. Water Allocation

The Irrigation Department is responsible for allocating water from reservoirs (tanks) to main canals and through branch canals and distributaries to field channels. Farm turnouts typically obtain water directly from field channels, but some farm allotments obtain water directly from distributaries. The Irrigation Department is the custodian of all irrigation structures -- reservoirs, canals, irrigation structures, farm turnouts, and lands reserved for canals and channels (see Figure 1 for a schematic diagram of the Parakrama Samudra and Giritale systems).

Main canals in the study area have capacities ranging from 100 to 300 cusecs and each runs about 12 miles. Branch canals have smaller capacities. Distributaries carry from 4 to 10 cusecs depending on the size of the distributary, and serve 75 to 350 acres. Distributaries are clearly defined hydrological units, and farmers along each distributary have traditionally viewed themselves as a "community of irrigators." Field channels are served by pipes of 6 to 9 inches in diameter and deliver water to 4 to 20 farmers.

An irrigation plan is formulated by the Irrigation Department before each cultivation season. This plan analyzes the water balance at the beginning of the season, anticipated catchment flow, acres to be cultivated, first and last dates of water issue, and the proposed rotation schedule. Kanna (cultivation) meetings are held to inform farmers about the amount of water available in the reservoir and the distribution schedule. Rotation schedules indicate pre-set times for proposed water issues to distributaries from the main or branch canals. The Irrigation Department determines the amount of water to release to meet crop requirements and whether or not sufficient water has been delivered to distributaries. These procedures are viewed as being guidelines and are altered from time to time.

Officially, junior officials in the Irrigation Department are responsible for distributing water along main canals, through distributary headgates to field channel headgates. Actually, farmers allocate water amongst themselves below the distributary headgate and irrigation officers are called upon only in instances of disputes or emergencies.

The lack of equitable and reliable distribution and allocation of water below tank sluices remains a persistent problem in Sri Lanka. In recognition of this, the Government of Sri Lanka initiated an institutional development program to address issues related to water allocation, maintenance, and dispute resolution at the organizational level between tank sluices and individual farm turnouts. This program allows farmers

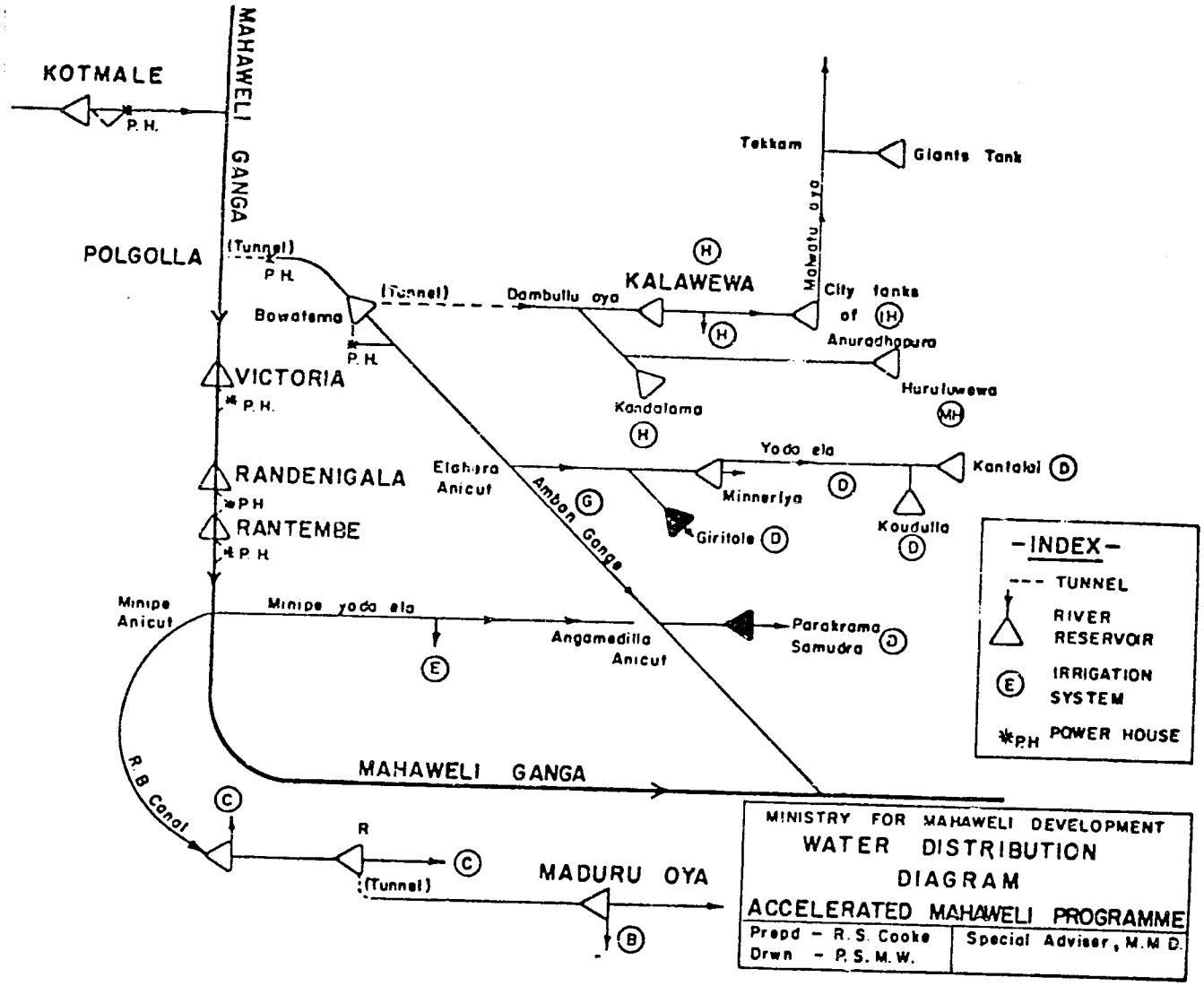


Figure 1. Schematic of water distribution for Parakrama Samudra and Giritale schemes.

to form field channel turnout groups and to appoint field channel representatives to a committee at the distributary level. Farmers elect representatives from distributary committees to represent farmers' interests on a project committee at the settlement scheme level. This program is supervised by the Irrigation Management Division (IMD) of the Irrigation Department.

In the last three years, the major focus of the middle-level organizational development program has been to organize farmers and junior management personnel from the Irrigation Department into field channel groups and distributary committees. The Irrigation Department believes that turnout groups will eventually be federated into strong subproject committees with the support of farmers.

The Irrigation Department controls water distribution along the main canals. No provision exists for farmer organizations to participate directly in managing storage tanks. These tanks have traditionally been supervised by the Irrigation Department.

The Irrigation Department does not supervise the vel vidanes, who distribute water at the distributary level and who work under the Commissioner of Agrarian Services. As a result of this divided authority and responsibility for water allocation, disputes between these two government agencies over water allocation occasionally erupted.

No concept of a water use right or share exists. It was originally intended that a rotation would be enforced between field channels along each distributary and among farm turnouts. However, this has rarely been the case.

There are many different kinds of local farmer cooperatives in the settlement schemes with governing boards and shareholding memberships. However, there has never been such an organization responsible for managing irrigation water. Over the years, various committees have been mandated by legislative acts to manage water below the settlement tanks. Such committees were usually chaired by local government officers assigned to the settlement schemes. These committees were generally popular with farmers until it became clear that government officers were making all decisions and ignoring suggestions of farmers.

At the local level, a long tradition of irrigation involvement by the vel vidanes exists. The government has attempted to adapt this traditional water management role by holding distributary elections for vel vidanes.

2. Local History

The Parakrama Samudra and Giritale irrigation schemes represented an effort by the Government of Sri Lanka to develop irrigated agriculture in the North Central Province prior to independence. This province was a major center of agricultural production and cultural life in the 12th and 13th centuries, but the district was uninhabited from the fall of the medieval capital at Polonnaruwa to the beginning of the 20th century,

except for a few small hamlets located immediately below the ancient tank bunds of Minneriya, Giritale, and Parakrama Samudra. Early British explorers reported only small paddy fields along local streams, fed by breaches in the old bunds. There were probably no more than 500 ac cultivated under all three tanks.

In tracts below the Parakrama Samudra Tank, remnants of at least 200 small, village tank bunds are spread across an area of 20,000 ac. These bunds are still visible and are identifiable on the engineering sheets used to lay out the Parakrama Samudra Scheme. Many bunds are aligned in a complex cascade system, suggesting an ancient extensive use of drainage water.

Evidence at Giritale Tank strongly suggests that in ancient times water was dumped from the main canal into a complex network of smaller tanks. Today, modern distributaries accept water from the ancient main canal and convey it along crown ridges scattered throughout the paddy tracts. Field channels run perpendicular from the distributaries down these ridges. This is the same basic hydrological design found in the Parakrama Samudra Scheme.

In the early 1890s, plans were initiated by the Central Irrigation Board for restoring the tanks in the studied area. Major restoration work on the Giritale Tank was completed in 1905. However, little land was brought into paddy production for another 15 years.

Restoration work was not begun on the larger Parakrama Samudra Tank until 1939. Private shareholding companies, usually European-managed, financed most of these early settlement schemes. The Parakrama Samudra Scheme was initiated during World War II, although most of the settlers arrived after the war. As with other schemes, the Irrigation Department and the Survey Department designed and constructed the Parakrama Samudra works using settler labor and hired laborers. Each settler and his family were given 8 ac -- 5 ac for paddy cultivation and 3 ac of unirrigated highland. In Giritale, each allottee was given 5 ac -- 3 ac for paddy cultivation and 2 ac for unirrigated tree crops.

Land fragmentation is more prevalent in the Parakrama Samudra Scheme than in Giritale. The average farm size in the study area was unknown, but probably ranged from 2 to 4 ac. For the sample of 82 farms, the average size of the paddy landholding was 2.8 ac (1.13 ha).

Land tenure in the settlement schemes is semi-private. Original settlers were selected from different parts of the island and received deeds to land. About one-quarter of the settlers were veterans of World War II who received an allotment of land in compensation for military service. The transfer of these deeds through open market sales is not authorized. However, an unofficial land market exists.

The Polonnaruwa District exhibits a generally homogeneous population; there are no major ethnic cleavages. The population is 91 percent Sinhalese and 7 percent Moor (Table 1). Six percent of the population in the district speaks Tamil as their first language, and nearly 90 percent of the Tamil-speaking population are Muslim.

Table 1. Polonnaruwa District population.

Total Population	Sinhalese	Tamil	Moor	Other
	----------% of total----------			
262,800	90.9	2.3	6.5	.3

Average Population Density -- 83 persons/km2

The rate of population growth in the district is 2.2 percent, whereas the national average is 1.2 percent. The average household size appears to be slightly higher than the national average of 5.2 persons/household. Off-farm employment is fairly low in the district; approximately one-fifth of the households reported regular off-farm income. The combined effect of population growth and low off-farm employment has been considerable land fragmentation.

The Polonnaruwa area is noted for its relatively high agricultural yields. Sunlight and rainfall in yala (dry season; April to September) are determined by the southwest monsoons. Usually some rain falls early and late in yala, and throughout most of the season the skies are partly cloudy and the days are 12 hours long. Sunlight is ample for vigorous plant growth. Wind velocity is light early in yala (about 2 to 5 km/hour), but it increases gradually up to 10 to 12 kph toward the end of the season. Hot, strong winds can considerably reduce yields if they occur during flowering. About 95 percent of the irrigated land is cultivated with rice (paddy), while the remaining area is under chili, green gram, and tobacco.

Generally, yala is viewed by local farmers as an excellent season for plant growth, whereas during maha (wet season; October to March), flooding, poor drainage, and less sunlight are common, and all contribute to plant disease. However, maha yields are generally higher because water supplies are more reliable.

The schedule of water delivery during maha traditionally has not been a problem because water supply from storage tanks is supplemented by the northeast monsoons. During yala, however, farmers rely almost entirely on the tank storage and the surface irrigation systems.

Until the early 1980s, the Amban Ganga (river) was the major source of water supply during yala. Now storage and conveyance structures on the upper reaches of the Mahaweli River drainage basin provide additional water. For instance, the two settlement schemes are hydrologically connected to the Mahaweli River by a large feeder canal that conveys water to the Amban Ganga above the storage tank diversions (Figure 1).

3. Property Rights

From the beginning the central government's control over settlement schemes extended to property rights, procurement of agricultural inputs, and financing. Of these, a major issue in the 1930s was land entitlement.

The Crown Lands Ordinance (1840) designated all unoccupied land throughout Sri Lanka as Crown land. This ordinance was eventually followed by a declaration of the Land Commission (1927) specifying that all Crown land would be held in public trust "according to the interest of the community" as defined by the national government. The Land Development Ordinance (1935) provided for leasing lands to settlers, who were given the right to designate a family successor. This lease arrangement was eventually revoked in favor of a 99-year lease after recommendations of the World Bank in 1952 (Gunawardena, 1981).

Ultimate ownership of the land is retained by the government. This reflects a general concern for administrative justice prevalent among settlement planners and administrators, which has frequently led to policies that doggedly attempt to control land transfers and traditional moneylending practices. The government has always subscribed to the policy that public control of lands prevents their takeover by urban absentee landlords, shop owners, and moneylenders. This assumption has carried over in the current paternalistic attitudes of settlement administrators toward settlers.

In settlement schemes, landholders are referred to as allottees and must carry on identity card when applying for government agricultural services. The concept of land ownership is vague, and irrigation schemes are administered much like public housing projects. Researchers repeatedly observed government field officers, representing various agricultural agencies, enter homes unannounced to demand information from farmer allottees.

Allotment holders legally cannot sell or mortgage their land, but transfers of land do occur regularly. Land fragmentation, population increase, and the mortgaging of land to local credit sources have created a complex pattern of extra-legal land ownership. Farmers who wish to sell or lease land for credit frequently record these transfers in official registers by paying unofficial service fees.

Tenancy is widespread. Although legislation has been enacted over the years to strengthen and secure tenancy rights and to prevent moneylenders from taking land as collateral, most attempts to do so have failed. Furthermore, the threat of eviction and use of other forms of leverage by landowners on tenants have consistently dampened tenant interest in filing grievances (Herring, 1981). Thirty percent of the food producers along sample distributaries were tenants (Figure 2). Key informants reported that land is illegally secured, even coerced, from allottees by individuals residing outside the settlement schemes. In the absence of an official land market, such transactions occur without legal sanction.

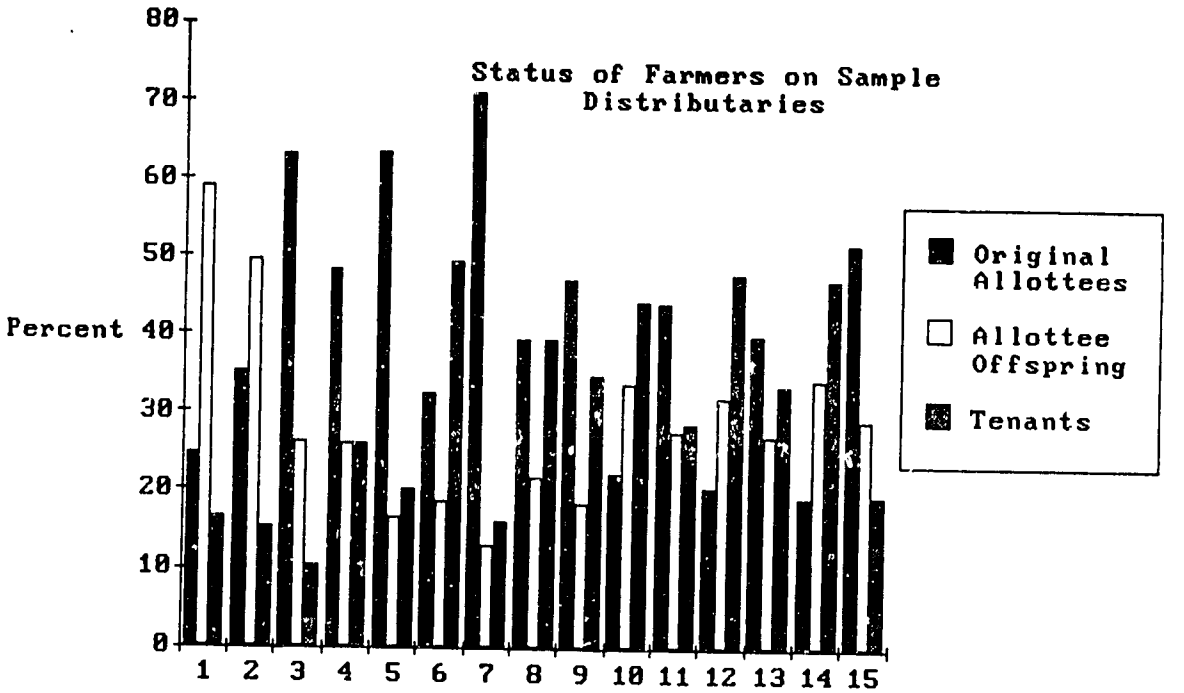


Figure 2. Status of farmers on sample distributaries.

Attempts of government planners to restrict land exchanges in order to contain the power of local credit sources have been thwarted by the development of extra-legal land and credit markets. In such markets neither indebted farmers nor lenders have legal protection. Farmers reported violent incidents over land, especially when attempts were made to reclaim land mortgaged to moneylenders. Neither an allottee nor a moneylender can legitimately call on government agents for support, since both have engaged in an illegal transaction.

The ideology of distributive justice, and the strong paternalistic attitude toward settlement schemes, has clouded the government's ability to evaluate the role of traditional credit sources for farmers. Farmers face difficulties in obtaining credit to purchase agricultural inputs at the beginning of each season. In the absence of an effective credit system through the government, or sufficient availability of commercial credit in the private sector, traditional sources of rural credit play an important role, even though interest rates are frequently usurious.

Farmers were also insecure regarding local property rights pertaining to irrigation structures, canals, and water. The Irrigation Department, as a public agency, claims ownership of, and responsibility for, all

irrigation canals and structures to the lowest level of the system. Farmers are not authorized to alter, rebuild, or remove any structure, or to change canal or channel features. Farmers sometimes work as laborers for the Irrigation Department in maintenance activities, and allottees are required to contribute labor for maintenance organized by the local vel vidane. Such labor mobilization is difficult to enforce and has been highly variable in effectiveness.

Water is distributed to farmers according to a standardized plan specifying the amount of water required per acre to cultivate a crop. A field officer in the Irrigation Department determines whether or not a sufficient amount of water has been delivered in aggregate to an area of a distributary. If a farmer or group of farmers request additional water, or complains that someone else receives more water than they should rightfully obtain, junior irrigation officers personally assess the situation and intervene according to their best judgment. No organized, legitimate set of joint agreements exists between farmers and officials to address such matters.

The implications of this management situation are many. Farmers do not have a legally recognized definition of "fair share" of water that they may use as a basis for complaint; neither does the Irrigation Department have a definition to use in settling disputes. Farmers may agree on the amount of water each should receive, but they must rely on the final judgment of an outside official who is not bound by any organized set of expectations. This provides a few farmers, who have disproportionate access to resources, with an opportunity to influence the judgment of the officers.

Farmers must make formal complaints or requests for change to the Irrigation Department. Since all repairs and alterations to irrigation structures must be authorized and directed by the Irrigation Department, farmers interpret these restrictions to mean that the Irrigation Department bears full responsibility for system performance and maintenance.

B. CONSTITUTIONAL FRAMEWORK FOR FARMER ASSOCIATIONS

The legal formation of farmer associations affects local water management. Thus, important questions follow. What is the relationship between the government and the irrigation community regarding the local distribution of agricultural resources? Does this relationship create incentives for community participation in irrigation system management?

1. Cultivation Committees

The Paddy Lands Act (1958) was initially a response to tenant insecurity. This act authorized the formation of cultivation committees. Each cultivation committee consisted of an elected body of farmers in a yaya tract (150 to 350 ac) irrigated by a single distributary. The committee was given responsibility for adjudicating land disputes, coordinating land preparation for paddy cultivation, and distributing water. Herring (1981, p. 152) observed that the formation of these committees was "in part a [government] response to the absence of village-level

democratic institutions or associations of cultivators" to manage such affairs.

Each committee was supervised by a local colonization officer from the Land Development Office. When problems occurred, the colonization officer was to be the final arbitrator.

In Polonnaruwa District, the cultivation committee was responsible for collecting an acreage tax. Collection of this tax was conducted under the supervision of the colonization officer, whose close ties to the revenue officers at the Government Agent's office was distrusted by farmers. Between 1942 and 1958, these government civil servants were able to punish offenders of the Irrigation Ordinance by confiscating seed paddy or by withholding water.

In 1952, vel vidanes were elected in the study area, and were officially under the supervision of colonization officers. Although the Paddy Lands Act (1958) later gave the traditional vel vidane water management role to the cultivation committees, the vel vidane role persisted. Today, irrigators are represented by a paddy tract manager called yaya palaka. These tract managers are usually former vel vidanes, and they continue to carry out all of the supplementary activities of the traditional vel vidane. In addition, farmers refer to them as vel vidanes.

Pieris (1976) and Inayatullah (1972) have contended that the cultivation committee was not effective in implementing land reform policies, but it was successful in coordinating paddy production and helped settle water disputes. The most probable reason for the failure of the cultivation committee was the multiplicity of tasks imposed upon it. In addition, to adjudicate disputes and collect the acreage tax, cultivation committees were also responsible for issuing identity cards to farmers. These cards were required to obtain agricultural inputs provided by the government, to rent agricultural equipment, and to maintain land ownership and cultivation records in the Land Development Office (Moore, 1979).

In 1972, the Agricultural Productivity Law placed cultivation committees under the supervision of the Agricultural Productivity Committee (APC). Agricultural Productivity Committee officers were selected by political appointment, but these appointments were terminated by the UNP (United National Party) national government in 1977. These events, together with the abolishment of the traditional village headman position in 1963 and its replacement by a government officer (grama sevaka), clearly demonstrated the increasing role of the central government in the economic and social life of the settlement schemes.

2. Production and Marketing Organization

K.M. De Silva (1981) indicated that about 50 percent of the gross national product of Sri Lanka was allocated to welfare programs in 1947, and settlement schemes were a large part of this expenditure. The government attempted to initiate settlement cooperatives to provide credit and marketing facilities to settlers. Brohier (1941) reported that the government goal, by way of the Registrar of Cooperative Societies, was to see all future agricultural activities conducted through cooperatives:

"The object of the cooperative effort at Minneriya [in the Polonnaruwa District] is to work towards the day when it will be possible to conduct all activities in the colony on cooperative lines. The colonist will then buy his goods from his cooperative store, sell his produce through his marketing society, and bank his money through his credit society."

Farmer (1957, pp. 266-271) noted that the government was energetic in its efforts to form cooperatives as organizations of production and distribution in settlement schemes, although their early function was limited to administering the guaranteed price program for commodities (excluding vegetables, plantains, and coconuts).

Government officers were appointed as ex-officio presidents of cooperative associations, while settlers performed routine secretarial duties. In addition, the cooperatives worked under the guidance and patronage of the local Government Agent. This policy has remained basically unchanged to the present day, with the exception that local politicians now recommend appointment of association board members. In recent years, multipurpose cooperatives have been organized for supplying a variety of consumer goods. Cooperative managers are politically appointed.

In reviewing the history of the cooperative movement in Sri Lanka, Inayatullah (1972, pp. 74-77) notes that since its inception in 1912, cooperative administration has gradually moved away from the goal of relying on widespread local participation to achieve local autonomy and to build democratic institutions in the rural sector. Instead, the central government has increasingly moved toward greater control of cooperatives.

3. Rural Development Societies

One of the major goals of the central government since independence in 1948 has been to develop rural integrative institutions to coordinate government departments, and to coordinate planning and implementation of community development projects (roads, schools, public health, and irrigation works). The Rural Development Department was formed to coordinate the activities of village-based rural development societies in 1948. District agricultural committees established after independence were responsible for coordinating agricultural production at the district level and for acting as advisory councils for government agents on development matters. The Rural Development Department appoints a Rural Development Officer at the divisional (village headman) level to coordinate the activities of the village-based societies.

Societies have always depended on funds from the government for their continued existence. Uphoff and Wanigaratne (1982, p. 517) have noted that locally elected leaders frequently have been displaced after national elections. Many settlers believe that rural development societies are of little use. One reason might be the early attempt to incorporate into them responsibility for dispute resolution (Tiruchelvam,

1984a). Uphoff and Wanigaratne (1982, pp. 518-519) reported that of all associations, rural development societies have shown the highest level of participation and the greatest amount of project activity. However, these societies have been plagued by political manipulation, and they rely heavily on the direction and control of the central government.

C. THE ADMINISTRATION OF AGRICULTURAL SERVICES

The role of the central government in administering agricultural resources greatly affects local water management and local resource mobilization. The history of the policies and practices of rural administration in recent years is characterized by a high degree of centralized authority and control and a reluctance on the part of the government to grant decision-making powers to local organizations.

1. Production and Distribution of Agricultural Inputs

The national government plays a dominant role in agriculture by stabilizing commodity prices and heavily subsidizing the production of fertilizer and agro-chemicals. Pieris (1976) refers to these policies as "welfare-statism," which is characterized by the production and distribution of agricultural resources to farmers through a state-financed and state-managed agro-chemical industry. The production and distribution systems employ a large cadre of government officials who are responsible for distributing agricultural inputs to farmers at numerous local agricultural service centers.

Agricultural inputs are allocated primarily by the Department of Agrarian Services and under the supervision of a local divisional officer. Divisional officers in and near the study area were frequently nominated or appointed by the local Minister of Parliament.

Given the high demand for agricultural inputs, but insufficient supply, tenants must make special arrangements with their landlords or seek alternative, but typically expensive, methods of resource acquisition. Farmers reported that officials and field officers engage in favoritism in input distribution. They are aware, however, that in the absence of other viable options for procuring resources they must maintain satisfactory relations with local field officers. Observations of farmers and officers indicated an overwhelming propensity for farmers to exhibit compliance and withdrawal in relationships with officers.

During the final months of field work in yala 1986, there were indications that this situation was changing somewhat because farmers were increasingly obtaining agro-chemicals and seed paddy from the commercial private sector. There were two operative explanations. First, government agents had difficulty delivering inputs on time and storing adequate stocks of inputs. Secondly, the UNP government began to encourage the private sector to become more involved in selected economic activities.

2. District Agricultural Committees

District agricultural committees have played an important role in coordinating agricultural activities. District agricultural committees were designed to coordinate the agenda of the various agricultural agencies (the Department of Agriculture, Agrarian Services, and the Irrigation Department). The district agricultural committee is concerned with broad agricultural policy at the district level. The Government Agent, as the chairman of the district agricultural committee, is responsible for coordinating the local activities of these agencies, but does not have the power or staff to perform this function. The district agricultural committee comprises the chief district officers (or their appointees) of the agricultural agencies. The Government Agent receives recommendations from the district officers with regard to formulating the seasonal agricultural calendar. He then presents the calendar to farmers or their representative irrigation headmen at a cultivation meeting at the beginning of each cultivation season.

Farmers are expected to make suggestions at district agricultural committee meetings, but this rarely occurs. Agrarian Service committees which operate at a sub-district level, are more closely linked to farmers. The Agrarian Service committee consists of field officers from the same agencies of agricultural development represented on the district agricultural committees. Each local Agrarian Service committee is responsible for carrying out the policies made by the district agricultural committee, including collecting crop statistics, distributing agricultural inputs, supervising water deliveries, and delivering extension services.

The capacity of the committees to coordinate the line agencies has been limited. Wanasinghe (1985, p. 244) stated:

> "The technical departmental cadres [agencies] continued to maintain their allegiance to their departments rather than to the "district organization" [District Agricultural Committee]. They viewed the district as a "temporary place of work" -- not as a locale of development commitment. Their commitment was to the development program of their own department as a whole -- whether it was the agricultural extension programme, or the irrigation program. This was but natural in a context wherein career advancement depended entirely on the parent department, and not on the Government Agent at the district level, and wherein the majority of the technical cadres belonged to transferable services and not to the district."

Wanasinghe (1985) further stated that the most prominent feature of the organizational structure was the absence of farmer involvement in and commitment to the planning and implementation of agricultural policy. Murray-Rust and Moore (1983) stated that the Government Agent frequently suspends the legal requirements of the meeting simply because he cannot realistically communicate to farmers under present conditions. Furthermore, the seasonal agricultural plan is so general in nature that the majority of farmers have little interest in it.

3. The District Development Council and Ministers of Parliament

Several changes in district administration affected the roles of the District Minister, district ministers of Parliament and, to a lesser extent, the Government Agent. These public officials are linked to one another by the District Development Council (Tiruchelvam, 1984a; Tiruchelvam, 1984b), which is responsible for allocating an annual block grant (decentralized district budget) from the central government. The District Development Council has assumed many of the responsibilities previously held by the district agricultural committee, leaving the latter concerned primarily with coordinating agricultural line agencies.

The position of District Minister was established in 1978. The District Minister is accountable directly to the President of Sri Lanka. The District Minister, with the assistance of district Members of Parliament, is responsible for coordinating district development projects and allocating the block grant. The role of Parliament ministers locally has become increasingly significant. Leaders of political party units and other voluntary organizations provide information to ministers of Parliament on requirements for developing paddy tracts.

The Government Agent is designated the permanent secretary to the District Minister (Oberst, 1986, p. 17). This has reduced the status of the Government Agent significantly. The decentralized budget is allocated on an electoral basis. In this way, all ministers of Parliament, along with the District Minister, receive a grant that fuels the patronage structure in the rural sector, which is an important link between state and local communities.

Agricultural development agencies receive a portion of the decentralized budget for development projects identified by the Government Agent's planning unit. These projects are forwarded to the District Minister and ministers of Parliament for their evaluation.

The District Development Council, which now oversees all district rural development projects, is structured along the lines of a miniature parliament. The council consists of a specified number of people elected proportionally for four years, who are responsible for debating and voting on development plans or projects formulated by the district executive committee.

"Grass roots" involvement is promoted by the appointment of gramodaya mandalaya (village development councils). A gramodaya madalaya exists for each grama seveka division in the district. The council consists of representatives from cooperatives, rural development societies, temple committees, and death benefit societies. The gramodaya manadalaya is responsible for formulating and submitting local projects to the pradeshiya mandalaya (regional development council), which then passes them on to the District Development Council.

Political party penetration into the rural sector typically takes the form of overlapping leadership in the several community-level organi-

zations (Oberst, 1986, p. 108). Elected officials in these organizations are frequently the local party representatives who dominate direct linkages to the District Development Council. Members of the local community make their demands through the local elites to the Member of Parliament.

D. ORGANIZATIONS THAT RESOLVE DISPUTES

Institutions for dispute resolution at the village level have also been controlled by the central government. Tiruchelvam (1984a) has summarized the historical accounts of the traditional gamsabhava, or village tribunal, in the central provinces. The gamsabhava was an ad hoc tribunal consisting of village elders responsible for handling administrative and adjudication matters in the village, such as arbitrating breaches in caste rules, mediating land disputes, sanctioning property theft, and regulating village irrigation water and structures according to traditional procedures and standards. Village tribunals were overseen by a rata sabhava, a council summoned by important citizens and officials in the Kandy-kingdom district when a local gamsabhava could not come to a resolution.

In 1924, the Village Community Ordinance formalized village councils, which then possessed powers to issue licenses and make bylaws. Village tribunals were established as rural courts under the Rural Courts Ordinance of 1945, and were presided over by the Judicial Service Commission (Pieris, 1976). Village tribunals held jurisdiction over all breaches of bylaws and criminal offenses under the Village Communities Ordinance of 1871 and the Rural Courts Ordinance of 1945. However, these rural courts were abolished in 1977, and the District Court became the only remaining adjudicating body for farmers and other community residents.

Uphoff and Wanigaratne (1982, p. 511) stated that village councils lacked sufficient economic resources, authority, and local autonomy.

> "The calibre of persons who were elected to such quasi-autonomous bodies, or who were recruited for staff positions in the netherworld between patronage and merit appointments, left much to be desired. Add to this the effects of party competition and resource constraints already mentioned, and one can see why such institutions' performance was frequently stalemated."

Farmers are concerned about the absence of local, rural adjudication bodies. Property damage and minor civil disturbances frequently go unpunished, and irrigation offenses have increased. Farmers express a feeling of helplessness about property damage and theft. Many farmers reported that the increase of irrigation violations in recent years is due to the delays in hearing offenses by the district court system.

Irrigation offenses are reported to the local divisional engineer, who reports to the Additional Government Agent at the kachcheri. The Additional Government Agent then forwards the complaint to a court coordinator (a paralegal) who then writes a legal brief and consults with a lawyer if necessary. The divisional engineer is then requested to produce witnesses, along with the plaintiff. Irrigation violations are brought

before the court only on Fridays. Since a judge can hear on the average only two cases per day, it typically takes months for a case to come before the court. Frequently, by the time the case comes to court, the problem has been negotiated locally and witnesses express reluctance to come forward. Influential people often become involved in a case, either directly or indirectly, in support of one of the litigants, and farmers see the process as being so capricious, slow, and risky that they tend to withdraw.

E. WATER MANAGEMENT ROLES

The Resident Deputy Director of Irrigation is responsible for overall supervision and management of district irrigation work. There are three to five field divisions under him, each managed by a resident divisional irrigation engineer, whose staff consists of a deputy irrigation engineer, technical assistants, work supervisors, patrol laborers, and a few administrative support personnel (Figure 3).

The divisional irrigation engineer is in charge of the administration, financial, and technical aspects of managing one or more storage tanks, river diversion structures, sluices, spillways, service bridges, and roads. This officer supervises the technical assistants, who allocate water from the tanks through main canals, branch canals, and distributaries.

The irrigation engineer furnishes information about water management requirements in his division to the Deputy Director of Irrigation for preparing the annual implementation plan and budget. He also specifies requirements for structural improvements in yaya tracts based on information relayed by technical assistants.

Farmers and farmer representatives are informed about methods of water allocation and distribution at cultivation meetings and district agricultural committee meetings. In operation, technical assistants, work supervisors, and patrol laborers distribute water from one area to another by opening and closing headgates. In addition, these junior officers supervise maintenance work, control water flows, and attempt to resolve disputes.

No organized procedures for water allocation have been agreed to by all parties. Procedures are often altered by the irrigation engineer and technical assistants according to site-specific problems encountered in managing water throughout the season, and as local opportunity permits. The technical assistant is generally responsible for supervising water distribution and maintenance work within an area of 4 to 8 miles^2 along several distributaries. He has no authority over vel vidanes. Therefore, technical assistants tend to avoid distributing water below the distributary headgates, and consider this the responsibility of the vel vidane.

There are instances when technical assistants become involved in problems of local water distribution -- especially when alterations occur at the level of turnouts or positions of drop structures. The rotation schedule also can be changed by the technical assistant when

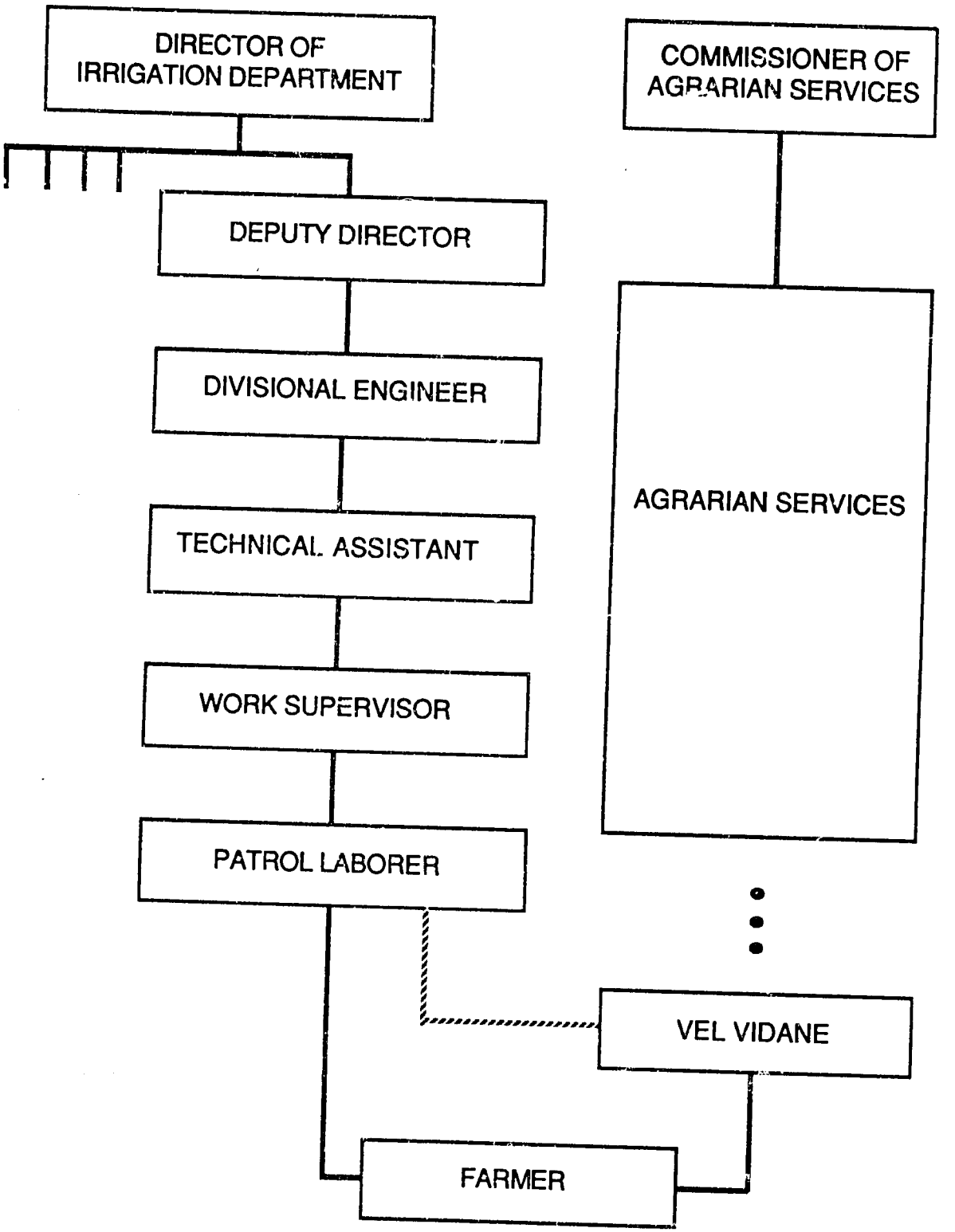


Figure 3. Organizational chart.

water shortages are reported or when there is a request for an extension of water deliveries to irrigators.

Work supervisors are assigned to several distributaries. They report water shortages, forward written complaints from farmers to technical assistants, read water flows at tank sluices, record changes of water volumes from distributary headgates, and adjust distributary headgates. The work supervisor is not authorized to increase the number of days in a rotation schedule, but he can block a head field channel in order to divert more water to the tail. Work supervisors also assess costs of broken structures and cleaning up trash in a distributary.

Patrol laborers are primarily responsible for adjusting distributary headgates according to rotation schedules and monitoring water flows in the main canals running through their areas of responsibility. They usually supervise the headgates of 3 to 5 distributaries and report violations of rotation schedules. Patrol laborers keep headgate keys during working hours and then return them to their work supervisor. They are authorized to open and close field channel gates and to check for obstructions along the main canal.

The major responsibility of the vel vidane is to ensure equitable distribution of water among farmers along the distributary after the water has been issued from the distributary headgate. In addition, the vel vidane is also expected to settle water disputes and report any damage done to turnout structures. As a farmer representative, the vel vidane attends cultivation meetings and passes information to farmers about dates of water issues and dates for initial land preparation. Vel vidanes also mobilize farmers for cleaning distributary canals and field channels. The total distance of a distributary or a field channel is divided among the number of farmers, and a portion of each channel is assigned to each farmer. A fine of Rs. 25 is assessed for each 6 ft of a field channel that is not cleaned. The vel vidane is also given the responsibility to monitor water flows along 6 to 10 field channels. The vel vidane may close field channel headgates in the upper reaches of a distributary if tail farmers are short of water.

III. RESEARCH DESIGN

Data were collected in Parakrama Samudra and Giritale schemes during maha 1985-86 and yala 1986. However, only data gathered during yala 1986 are presented here.

A. CONCEPTUALIZATION OF THE RESEARCH

A research design was developed to permit systematic investigation of the water management technologies, procedures, and roles existing between the storage tanks and irrigators (Appendix A). Research proceeded at three levels:

1. The technologies, procedures, and management roles involved in managing water flow from main canals to the headgates of local distributaries (summarized in Chapter II).

2. The management of the distributaries, which deliver water to individual farms by way of farm field channels.

3. Individual farmer response to the irrigation system.

The distributary headgate was considered to be the major organizational dividing point between the first and second levels.

Qualitative information was gathered to document the effects of water management procedures and roles at the first level on water flows to distributaries. Quantitative data were employed to document the effects of water management procedures and roles at the second level on water control and yield at the third level.

1. Qualitative Information

Information was collected by interviewing Irrigation Department officers and laborers individually, by interviewing those same officers in groups, and by participant observation. Researchers were careful to distinguish official responsibilities and procedures from actual responsibilities for junior officers and their assistants in the Irrigation Department.

2. Quantitative Data

Data were gathered to measure water management capacity in sample distributaries and to evaluate the willingness of sample farmers to support water user associations. Water control was measured at 82 sample farm headgates. Crop yields were also measured.

3. Variables and Hypotheses

Management capacity at the distributary level was considered to be a local organizational attribute affecting water control at the individual

farm headgate. Water control at the farm headgate was in turn hypothesized to explain a portion of variance in farm yields. Similarly, the degree of management capacity along the distributary was expected to explain a significant portion of farmer willingness to support water user associations. Variables were defined as follows:

1. Management Capacity. Management capacity above the distributary headgate was defined primarily in terms of the water management procedures and roles of Irrigation Department personnel. The predominance of government control and ownership of the irrigation system means that management at this level is characterized by standardized central planning, modified at the discretion of individual officers operating in the field.

   Below the distributary headgate, management capacity (Appendices A and B) was defined primarily in terms of the supervision and authority of the vel vidane and the cooperation he receives from local farmers. This cooperation was seen to be a function of consensus among farmers about water allocation procedures and the degree of farmer support for the vel vidane.

2. Distributary Problems. The severity of water distribution problems were reported by sample farmers and appropriate measurements were devised (Appendices A and C).

3. Water control is defined as the degree to which the timing and quantity of water deliveries to sample farms met minimal water requirements of paddy cultivation at different growth stages (Appendices A and D).

4. Yield. Sample farm paddy yields were computed in bushels per acre (Appendix A).

5. Willingness to support water users sssociations was viewed as being the degree to which sample farmers along each sample distributary supported the idea of local water users associations at the distributary level (Appendices A and E).

The major hypotheses of the study are diagrammed in Figure 4. Model 1 represents relationships between distributary characteristics (management capacity and distributary problems), water control, and yield. Model 2 posits a simple bivariate relationship between management capacity and willingness to support water users associations at the distributary level. Model 1 raises the questions: How does management capacity of a distributary affect water control at the farm turnout, and what is the effect of distributary water control on crop yield. Model 2 addresses the question: How does management capacity of a distributary affect farmer willingness to support local water users associations?

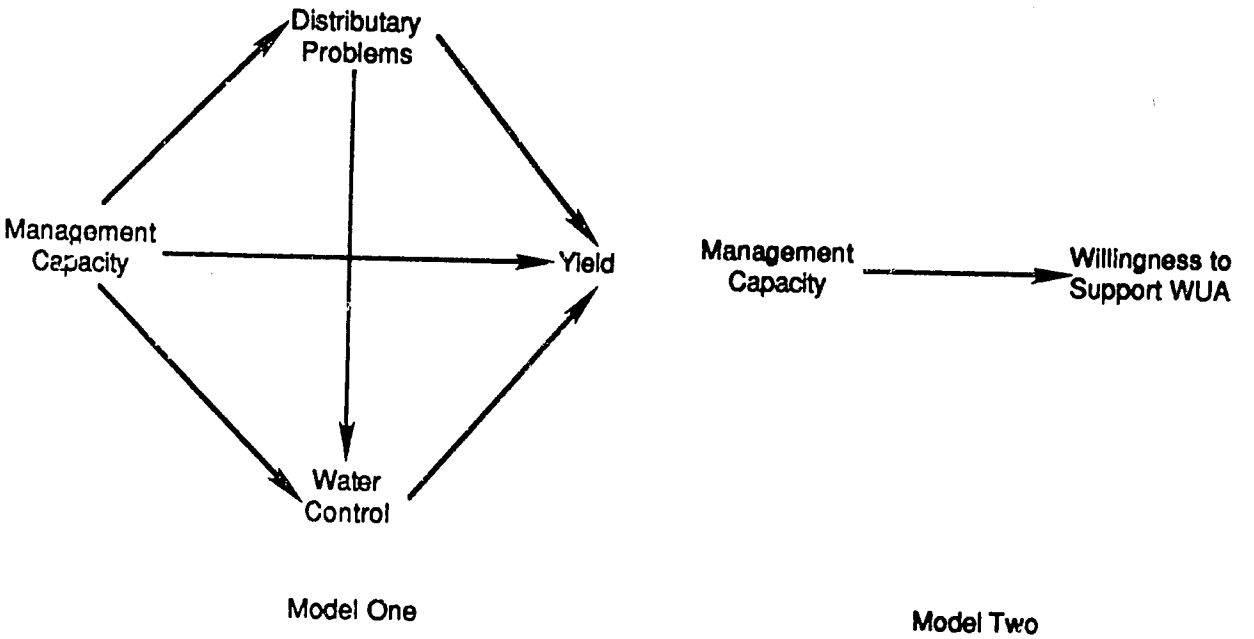


Figure 4. Models of relationships between and among study variables.

B. SAMPLING PROCEDURES

Data were collected in 30 sample areas representing 15 distributaries in the two settlement schemes. These distributaries varied in length from 1 to 2 miles and served from 40 to 150 farmers. On each distributary, a vel vidane supervised water allocation. Procedures studied included distribution and allocation of water through main canals and farm turnouts. In addition, information was collected on water availability and yield at the farm level in order to evaluate the effect of existing middle-level organizational arrangements for water management on farm production.

Six distributaries were selected from Parakrama Samudra system, nine from the Giritale Scheme. Distributaries were purposively selected to obtain substantial variance in the conditions of water distribution by securing variance in the source of water and farm location (head, middle, or tail) (Figure 5). Characteristics of sample distributaries are listed in Tables 2 and 3. Table 2 reports the number of original allotments in distributaries, acreages of distributary command areas, and the seasonal relative water supply. Table 3 shows the tenancy status and total numbers of farmers on distributaries. Appendix F provides the distribution of the 304 farmers among the 15 sample distributaries.

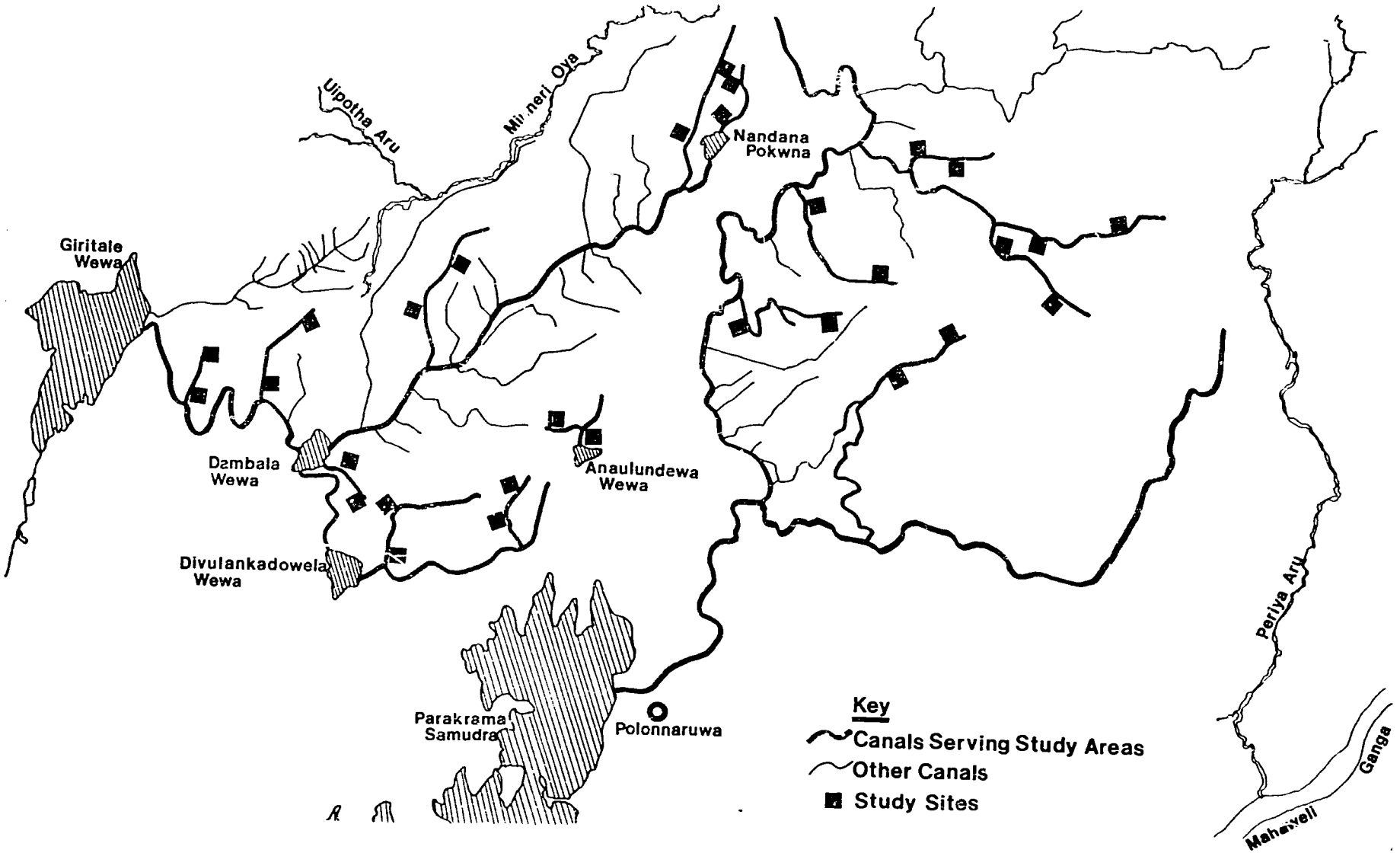


Figure 5. Research blocks (study sites) and sample distributaries.

Table 2. Physical characteristics of sample distributaries.

Distributary	No. of Original Allotments	Irrigated Acreage	Relative Water Supply
1	27	76.75	4.26
2	59	183.75	1.07
3	67	200.75	2.83
4	110	360.50	1.43
5	26	84.00	1.72
6	38	124.00	1.37
7	126	254.50	2.67
8	45	93.25	1.96
9	40	129.75	1.06
10	51	252.50	1.55
11	67	319.75	1.38
12	20	98.00	3.13
13	46	258.00	1.82
14	40	189.25	1.45
15	35	123.00	1.53

Table 3. Tenancy status of farmers on sample distributaries.

Distributary	Percent Original Allottees	Percent Offspring of Original Allottees	Percent Tenants	Total No. of Farmers
1	25	58	17	73
2	35	50	15	125
3	63	26	11	76
4	48	26	26	135
5	63	17	20	30
6	32	19	49	65
7	71	13	16	131
8	39	22	39	51
9	46	18	36	49
10	22	34	44	77
11	44	27	29	91
12	20	32	48	44
13	40	27	33	78
14	19	34	47	79
15	52	29	19	31

1. Measurement of Management Capacity and Distributary Problems

Sample farmers evaluated the management capacity of each distributary. They were asked to respond to a questionnaire administered in a group session, which protected respondent anonymity. The questionnaire obtained information about procedures and practices for water allocation

to field channels, canal maintenance, resolution of water disputes, and willingness to support water user associations in the future.

2. Procedures for Measuring Water Control and Yield

A sample was drawn of 82 farm households within predesignated research blocks (study sites) at the head and tail of each distributary. These 30 blocks ranged from 15 to 20 ac in size, and researchers conducted surveys of soils, cropping pattern, and yields in each block.

Designating research blocks was essential. The land irrigated by field channels ranged from 30 to 50 ac, an area too large for careful surveys of soil conditions and cropping patterns, and comprehensive monitoring of water flows. Consequently, a portion of each sample distributary was demarcated for the study and labeled a "block". Water flows were measured in each block throughout yala. Soil conditions, cropping patterns, and water supplies in each block were monitored regularly.

Research blocks were chosen to represent types of soils, cropping patterns, and slope in the larger irrigated area. Socio-economic information was also collected from sample farmers irrigating within each block. Depending upon the acreage of individual blocks, two or three sample farm households were chosen to represent each block's water control situation at the farm headgate and crop yields. Appendix G includes maps showing soil conditions for three of the blocks. Appendix F (Tables 10 and 11) reports cropping patterns for each block, and acreage in rice by soil types.

The farm household comprised those family members who shared the benefits (income) from one or more fields in the designated research block. If family members separately cultivated a portion of a land allotment and did not share the generated income, they were considered separate households. Land fragmentation resulted in a rich array of cultivation groups among parents, siblings, and children.

C. TESTING THE RESEARCH HYPOTHESES

The first step was to conduct a simple bivariate analysis for the relationships specified in the two models. This analysis was used to verify the direction and strength of each of the hypothesized relationships. Pearson's product moment correlation coefficients were used. Tests of significance for relationships were not used since the sample was purposive. It was not possible to infer from the sample to the larger population of farms in the Dry Zone since key parameters of such populations were not known. Therefore, the study is mainly concerned with the strength and logical consistency of relationships found in the sample.

The analysis of zero-order correlation coefficients was followed by partial correlation analysis in order to investigate the strength of bivariate relationships, controlling for effects of potentially confounding variables outside the models. Control variables included the seasonal relative water supply for each sample distributary command area (DRWS), the number of irrigators per acre along the distributary (DENSITY), the

percent of tenant irrigators below the distributary headgate (TENANCY), location of the 82 sample farms in terms of head/tail position, slope, and soil criteria (LOCATION), the size of farm (FARM SIZE), the rupee investment in fertilizer and chemicals per acre for each sample farm (INVEST), and weed problems found on each sample farm (WEEDS). Figure 6 displays the specified relationships.

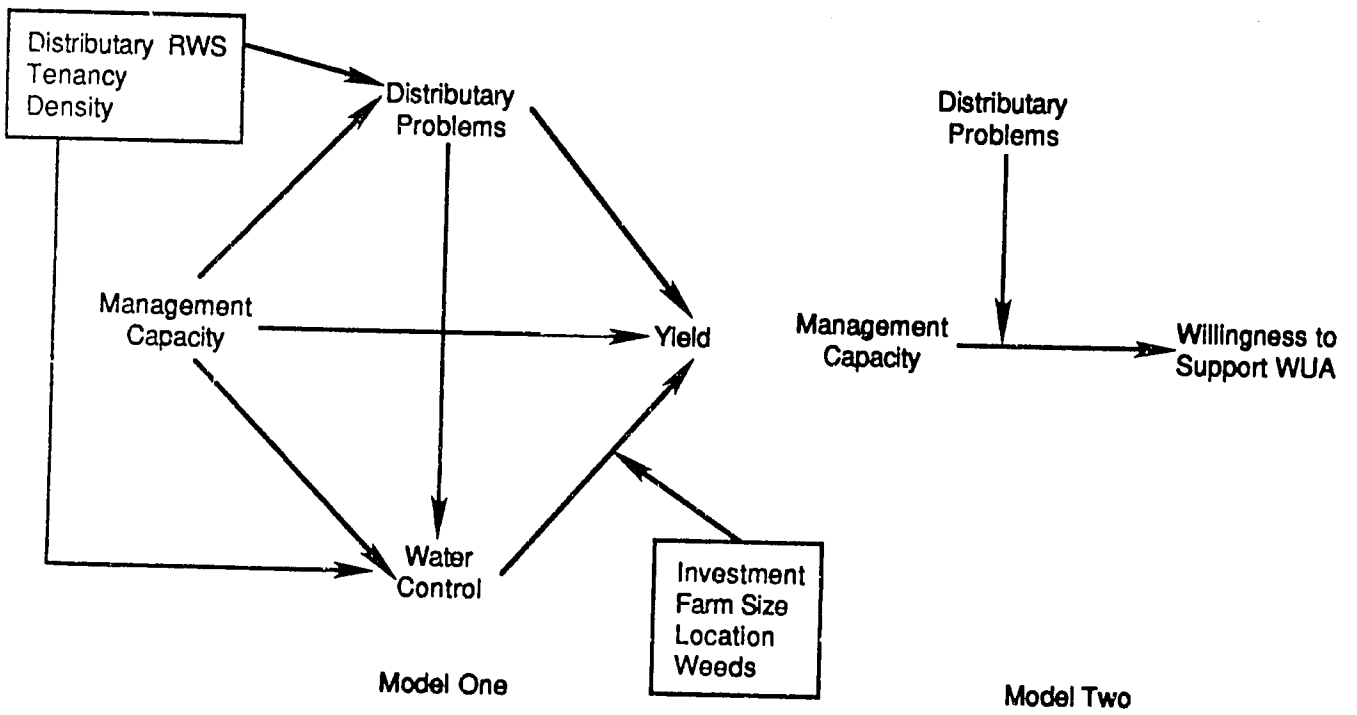


Figure 6. Relationship of control variables to models.

IV. DATA ANALYSIS AND RESULTS

A. INTRODUCTION

This chapter analyzes the degree of management capacity found below the distributary headgate along the sample distributaries, and the degree to which management capacity affects water control at the farm turnout, farmer yields, and willingness of farmers to support water user associations in the future.

Data are reported in Figures 7 and 8. Management capacity served as the independent variable in both models, while distributary problems and water control were employed as intervening variables. Yield and willingness to support water user associations were dependent variables.

In addition, for Model 1, weed problems were included as an intervening variable. The presence or absence of weeds correlated highly with yield, and both were hypothesized to be primarily a function of water control. In many ways, weeds and yield show comparable responses to water control, except for the potential influence of investment, farm size, and location.

Management capacity, distributary problems, and willingness to support water users associations are features of the distributary social web. They may be referred to as conditional variables. Conditional variables represent the socio-technical conditions of the social web within which sample farmers must irrigate. The 82 sample farmers were assigned conditional variable values according to how their particular distributary scored during the evaluation exercise. The values for the conditional variables on each distributary are provided in Table 4. The number of farmers who participated in the evaluation exercise for each distributary is provided in Appendix F. It is argued that it is logical to ascribe socio-technical conditions (i.e., management capacity and distributary problems) to sample irrigators since these conditions can be assumed to constantly affect water control at farm turnouts throughout the length of the distributary.

Regression analysis was chosen to evaluate the relationships in Model 1. The yield variable was well suited to regression analysis, and independent and intervening variables did not violate the assumptions needed to conduct a successful regression analysis (Lewis-Beck, 1980; Asher, 1983; Davis, 1986). Furthermore, multicollinearity among variables was low, and the analysis of residuals (error terms) showed no violations of normality in the distribution of index scores, or in the values of the water control, weed, or yield variables. There was no indication of clustering or any other abnormality in the distributary index scores for the variables of management capacity, distributary problems, and willingness to support water users associations. The control variables were chosen to strengthen the specification of the models as much as possible by building in tests of potential rival hypotheses.

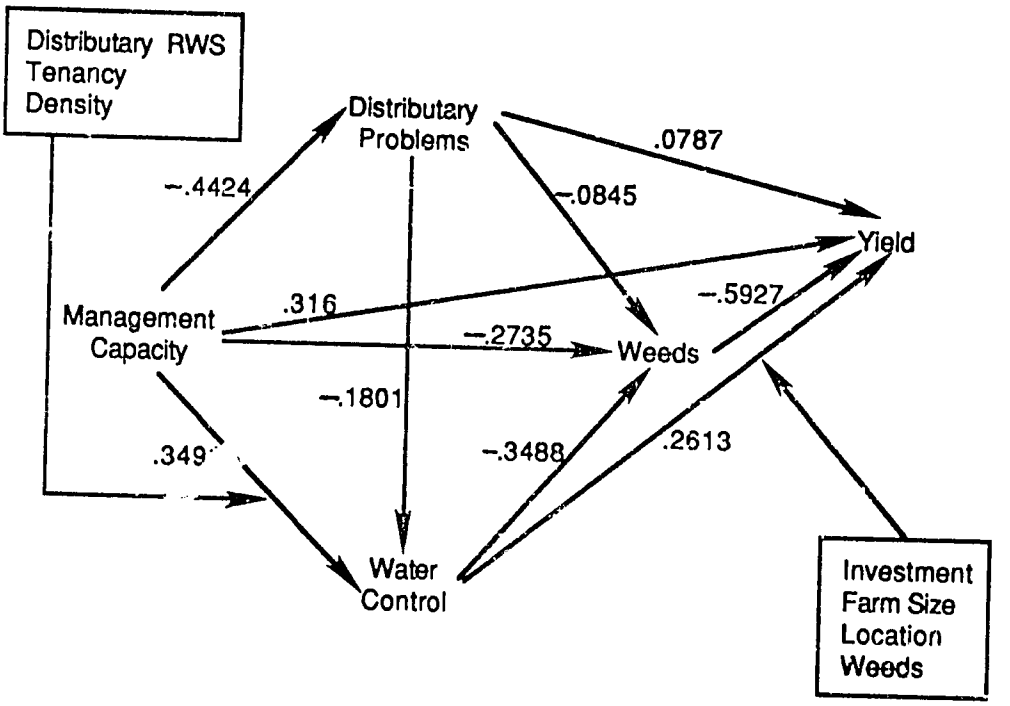


Figure 7. Assessment of research hypotheses (Model 1): Relationship of management capacity to yield.

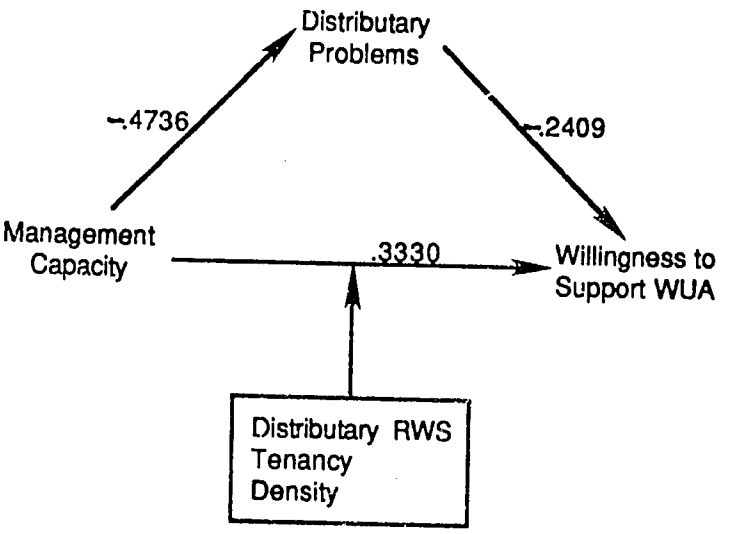


Figure 8. Assessment of research hypotheses (Model 2): The relationship of management capacity to farmer willingness to support water users associations.

Table 4. Summed index values of indicators for management capacity, distributary problems, and willingness to support water user associations.

Distributary	Management Capacity	Distributary Problems	Willingness to Support WUA
1	538	624	723
2	615	651	754
3	610	628	712
4	431	701	783
5	526	719	708
6	712	581	845
7	382	722	752
8	505	672	693
9	389	636	750
10	622	649	810
11	540	669	827
12	537	610	692
13	456	582	813
14	588	604	740
15	452	660	654

Since a non-random sample was used, it was difficult to make statistical statements about the error terms, and therefore, about the degree of homoskedasticity and autocorrelation of error terms in Model 1. However, there was no evidence of abnormality in the distribution of any of the variables in the model.

B. ANALYSIS OF MODEL 1

To analyze Model 1, each bivariate relationship was evaluated separately by examining the Pearson "r" correlation coefficient and the partial correlation coefficient for each relationship to examine any change when the effects of the control variables were removed. This analysis provided an evaluation of the overall strength of each relationship in the model.

Two relationships were of minimal interest, either because of the small size of the bivariate correlation coefficient or because of the extremely powerful effect on the relationship by other variables in the model. These two relationships were those between distributary problems and yield (.0787), and distributary problems and weeds (-.0845). (Table 5 provides zero-order correlation coefficients for all variables employed in the models.) Although it appears the relationship between distributary problems and weeds might be significant, the relationship is negligible and virtually disappears when controlling for management capacity.

Table 5. Zero-order correlations between variables.

	Management Capacity	Water Control	Distributary Problems	Weeds	Yield	Distri-butary	Tenancy	Density	Invest-ment	Size
Model Variables										
Water control	.3491	-	-	-	-	-	-	-	-	-
Distributary problems	-.4424	-.1801	-	-	-	-	-	-	-	-
Weeds	-.2735	-.3488	-.0845	-	-	-	-	-	-	-
Yield	.3160	.2613	.0787	-.5927	-	-	-	-	-	-
Control Variables										
Distributary RWS	-.0771	.1570	-.0526	-.1992	.1711	-	-	-	-	-
Tenancy	.2878	.1366	-.5383	.0499	-.2052	-.2778	-	-	-	-
Density	.1525	-.0282	-.0783	.0022	.1035	.5606	-.2524	-	-	-
Investment	.2139	-.0061	.0163	-.1143	.0771	-.0187	.0943	-.0579	-	-
Size	-.0154	.1790	-.0307	-.1827	.1173	-.2043	.1277	-.4609	-.2725	-
Location	.1799	-.0468	.0001	-.0540	.0158	-.0601	-.1150	-.0421	.2656	-.1165

1. The Relationship Between Management Capacity and Distributary Problems

Table 6 displays the zero-order relationship between management capacity and distributary problems (-.4424), and the change in this relationship when controlling for sample distributary relative water supply, the number of irrigators in the distributary command area, and the proportion of tenants on the distributary.

Table 6. Partial correlation analysis of the effects of selected control variables on the bivariate correlation between management capacity and distributary problems.

Dependent Variable	Control Variable	Independent Variable Management Capacity: Zero-Order Correlation	Independent Variable Management Capacity: Partial Correlation
Distributary problems		-.4424	-
Distributary problems	Distributary RWS	-	-.4484
Distributary problems	Density	-	-.4369
Distributary problems	Tenancy	-	-.3562

The relationship between management capacity and distributary problems is quite strong and negative. Increased management capacity at the distributary level does reduce distributary problems, although the number of tenants irrigating within the distributary command area seems to have a mild positive effect on this relationship. Distributary problems decrease as tenancy increases.

Table 5 shows that the relationship between tenancy and distributary problems is rather strong (-.5383). The negative relationship between tenancy and distributary problems is believed to be because distributaries with high management capacity attract tenant cultivators. During the field work, it was noticed that tenant farmers frequently cultivated high value cash crops, such as tobacco and chilies, which require high levels of investment. It is argued that tenant farmers tend to favor irrigating along distributaries where management capacity and water control at the farm level are high. The bivariate relationship between management capacity and tenancy is .2878 (Table 5).

It is somewhat surprising that the number of irrigators in the distributary command area (density) and the seasonal water supply for the distributary command area (distributary RWS) do not appreciably

affect the relationship between management capacity and distributary problems (Figure 7). Variation in the management capacity of sample distributaries simply overwhelms the impact of farmer numbers and relative water supply. Development of management capacity is a way of coping with local water supplies and with farmer numbers.

2. The Relationship Between Management Capacity and Water Control

Table 7 reports the zero-order coefficient between management capacity and water control (.3491), and the change in this relationship under the impact of all control variables except investment. Farmers' investment in agricultural inputs was not considered sequentially relevant to the relationship between management capacity and water control. Investment in fertilizer and chemicals was thought to be the "effect" of management capacity and water control, rather than a "cause" of those variables.

Table 7. Partial correlation analysis of the effects of selected control and intervening variables on the bivariate correlation between management capacity and water control.

Dependent Variable	Intervening Variable	Control Variable	Independent Variable Management Capacity: Zero Order Correlation	Independent Variable Management Capacity: Partial Correlation
Water control			.3491	-
Water control	Distributary problems			.3054
Water control		Distributary RWS	-	.3668
Water control		Density	-	.3577
Water control		Tenancy	-	.3265
Water control		Location	-	.3638
Water control		Farm Size	-	.3576

The relationship between management capacity and water control is quite strong, and is affected only a little by the other temporally relevant variable in the model (distributary problems). An effect of distributary problems on water control would be predicted by the model.

It is again surprising that none of the control variables had any substantial effect on the relationship between management capacity and water control. One might have predicted that either relative water supply in the distributary (distributary RWS) or percent of tenant farmers (tenancy) would have affected this relationship. For instance, one

(tenancy) would have affected this relationship. For instance, one could argue that poor relative water supply would affect the ability of the vel vidane to perform his duties. Likewise, one could predict that the greater the number of tenants, the greater would be disagreement over water allocation, since tenants might be more unwilling to follow "the rules of the game" established by the local community of irrigators. However, a strong argument can be made that tenant farmers want good water supplies and are reluctant to cause problems along distributaries.

Again, management capacity along a distributary tends to limit the effects of other physical and social conditions. If a distributary has a good vel vidane, if the services of locally influential people can be called on from time to time to assist the vel vidane in resolving water disputes, and if irrigators along the distributary have developed workable agreements about placing check dams in the distributary and field channels when water is flowing, then there is a greater likelihood of individual farmers having relatively better water control at the farm turnout. When the vel vidane secures informal organized support from farmers at this middle level of management, there is a positive effect on water control.

3. The Relationship Between Distributary Problems and Water Control

Table 8 presents data regarding the relationship between distributary problems and water control (-.1801) and the change in this relationship for all control variables except farmer investment in agricultural inputs. The effect of distributary problems on water control becomes negligible when controlling for management capacity. Management capacity sustains its relationship with water control when the effects of the control are held constant.

4. The Relationship Between Management Capacity and Weeds

Table 9 shows the zero-order correlation between management capacity and the extent to which farm fields are affected by the presence of weeds (-.2735). Two important partial correlations stand out. The first is the effect of water control on this relationship. The weed problem at the farm level is substantially reduced as water control at the farm turnout increases. Water control, in turn, is a function of management capacity at the distributary level. The second is the logical (although small) effect of investment on weeds.

5. The Relationship Between Management Capacity and Yield

Table 10 reports the relationship between management capacity and yield (.3160), and the change in this relationship when effects of the control variables are statistically removed.

Table 8. Partial correlation analysis of the effects of selected control and intervening variables on the bivariate correlation between distributary problems and water control.

Dependent Variable	Intervening Variable	Control Variable	Independent Variable Distributary Problems Zero Order Correlation	Partial Correlation
Water control			-.1801	-
Water control	Management capacity			-.0305
Water control		Distributary RWS	-	-.1742
Water control		Density	-	-.1829
Water control		Tenancy	-	-.1276
Water control		Location	-	-.1803
Water control		Farm Size		-.1775

Table 9. Partial correlation analysis of the effects of selected control and intervening variables on the bivariate correlation between management capacity and weed problems.

Dependent Variable	Intervening Variable	Control Variable	Independent Variable Management Capacity Zero-Order Correlation	Partial Correlation
Weeds			-.2735	-
Weeds	Distributary problems		-	-.3479
Weeds	Water Control			-.1728
Weeds		Distributary RWS	-	-.2957
Weeds		Density	-	-.2771
Weeds		Tenancy	-	-.3010
Weeds		Location	-	-.2686
Weeds		Farm size	-	-.2810
Weeds		Investment	-	-.2567

None of the control variables, particularly location, farm size, and investment, have any appreciable effect on this relationship. However, it would be predicted that water control and weeds would have some influence on yield. Th model temporally specifies that this would be the case, and it is a logical interpretation to make. Water control, weed problems, and yield are closely interrelated, and their sequential relationship is strong. The effect of weeds is the most notable in the relationship between management capacity and yield, and reveals a rather significant "causal" relationship; namely, that as management capacity increases, weed problems decrease.

Table 10. Partial correlation analysis of the effects of selected control and intervening variables on the bivariate correlation between management capacity and yield.

Dependent Variable	Intervening Variable	Control Variable	Independent Variable Management Capacity Zero-Order Correlation	Partial Correlation
Yield			.3160	-
Yield	Distributary Problems			.3924
Yield	Water Control			.2485
Yield	Weeds			.1986
Yield		Distributary RWS	-	.3351
Yield		Density	-	.3054
Yield		Tenancy	-	.4001
Yield		Location	-	.3183
Yield		Farm size	-	.3200
Yield		Investment		.3075

Farm size and location have a negligible effect on the relationship between management capacity and yield. One could predict that larger farms would have greater problems managing the water they receive, and that unfavorable hydrological location of sample farms would further add to problems with water control and yield. Yet it seems that management capacity tends to compensate for such problems. For the present, it appears that management capacity not only affects yield directly, but also affects yield by reducing distributary problems and improving water control.

6. The Relationship Between Water Control and Weeds

Table 11 displays the bivariate relationship between water control and weeds (-.3488). This is a significant relationship, one which is expected under the environmental conditions of the Dry Zone. Of greater importance, however, is that none of the control variables, particularly investment, seems to markedly change this relationship. Without adequate water control, investment in herbicides, pesticides, and fertilizer seems to have little influence on yield (Table 5). However, it is known from examining Table 5 that sample farmer willingness to undertake investment does increase with better distribution management capacity (r = .2139), and that investment is affected more by the quality of management capacity at the distributary level than at the farm turnout. The greater the management capacity at the distributary level, the greater the willingness of farmers to invest in agricultural inputs.

Table 11. Partial correlation analysis of the effects of selected control variables on the bivariate correlation between water control and weed problems.

Dependent Variable	Control Variable	Independent Variable Water Control	
		Zero-Order Correlation	Partial Correlation
Weeds		-.3488	-
Weeds	Location	-	-.3522
Weeds	Farm size	-	-.3268
Weeds	Investment	-	-.3518

7. The Relationship Between Water Control and Yield

The bivariate relationship between water control and yield (.2613) is positive (Table 12), as are the partial coefficients when the effects of control variables (location, farm size, and investment) are partialled out. There is no significant change in this relationship when effects of the control variables are removed. However, as noted earlier, the effect of weeds is dramatic.

8. The Relationship Between Weeds and Yield

Table 13 reports the bivariate relationship between weeds and yield (-.5927) and the partial coefficients remain about the same after having controlled for the effects of location, farm size, and investment. Yield appears to be heavily a function of weed control at the farm level, while presence of weeds is clearly a function of water control at the farm turnout (Tables 5 and 11).

Table 12. Partial correlation analysis of the effects of selected control and intervening variables on the bivariate correlation between water control and yield.

Dependent Variable	Intervening Variable	Control Variable	Independent Variable Water Control	
			Zero-Order Correlation	Partial Correlation
Yield			.2613	-
Yield	Weeds			.0723
Yield		Location	-	.2624
Yield		Farm size	-	.2460
Yield		Investment	-	.2626

Table 13. Partial correlation analysis of the effects of selected control variables on the bivariate correlation between weed problems and yield.

Dependent Variable	Control Variable	Independent Variable Weed Problem	
		Zero-Order Correlation	Partial Correlation
Yield		-.5927	-
Yield	Location	-	-.5928
Yield	Farm size		-.5851
Yield	Investment		-.5895

C. DIRECT, INDIRECT, AND SPURIOUS INFLUENCES IN MODEL 1

The partial correlation analyses contributed much. They have also tended to strongly support the hypotheses defined by the model.

One way to evaluate the potential direct influence of management capacity on the yield is to subtract from this direct influence the indirect influence of the intervening variables in the model and the spurious influence of selected control variables. Direct influence gives a slightly more realistic picture of the potential power of management capacity in explaining variance in yield. Davis (1985) has discussed the importance of such an evaluation in better understanding the nature of relationships in a multiple variable model, and suggests some simple

and useful techniques for conducting such an evaluation. One technique proposed by Davis was applied to the model and is reported in Table 14.

Tenancy and investment were chosen as control variables in this analysis. Both variables show modest correlation with management capacity and, therefore, may be expected to affect the relationships between management capacity and other variables in the model more than other control variables.

Direct influence is that portion of the bivariate relationship that does not include any indirect influence from intervening variables inside the model or any spurious influence from control variables outside the model. Indirect influence is that portion of the bivariate relationship explained by other variables in the model that intervene between management capacity and yield.

Table 14. Effects of management capacity and yield, controlling for significant potentially confounding variables.

(A)	**Bivariate** relationship between management capacity and yield	= .3160
(B)	**Direct** influence of management capacity on yield, controlling for tenancy, investment, distributary problems, water control, and weeds	= .2557
(C)	**Indirect** influence of management capacity on yield caused by (the intervening variables) distributary problems, water control, and weeds (D - B)	= .1345
(D)	**Causal** influence of management capacity on yield, controlling for both tenancy and investment	= .3902
(E)	**Spurious** influence between management capacity and yield caused specifically by tenancy and investment (A - D)	= .0000

Causal influence is the combination of the direct influence of the independent variable on the dependent variable, as well as its indirect influence through all of the intervening variables in the model. Causal influence is usually a little less than the bivariate correlation because it is a product of the interaction of all of the variables in the model, and the coefficient suffers slightly from this interaction. Notice, however, that this is not the case in Table 14. The causal coefficient is higher than the bivariate coefficient.

Spurious influence is that portion of the bivariate correlation contributed by variables not specified by the model (control variables). It is always assumed that there are unspecified variables, and that one or more of these explain a portion of a given bivariate correlation and, therefore, a portion of the variance in the dependent variable.

Computations (Table 14) show the direct influence of management capacity on yield (.2557). This is a high coefficient considering the potential effects of the control and intervening variables. There is virtually no spurious influence from the control variables chosen for this analysis. However, this means that there are other unknown, unspecified, and unmeasured variables "out there" which contribute to the relationship between management capacity and yield.

The causal influence of management capacity on yield (Table 14) is slightly higher than the bivariate relationship between these two variables, presumably because management capacity has some effect on the control variables of tenancy and investment as well. That is, one could speculate that tenancy rates increase with greater management capacity (Table 5) because tenants perceive a distributary command area with good management capacity as a good investment locality. Likewise, investments in fertilizer, herbicides, and pesticides tend to increase (Table 5) in distributary command areas with relatively better management capacity. The control variables chosen to challenge the model do not seem to greatly affect the model relationships.

In any event, the causal influence of management capacity on yield reveals the importance of informal organizational arrangements at the distributary level on water control and yield for sample farmers. Middle-level distributary organization does make a considerable difference in local rice production despite the problems with management capacity above the distributary headgate, described in Chapter II.

D. PATH ANALYSIS OF MODEL 1

A path analysis of Model 1 provides similar results, although the focus is on which particular path from management capacity through the intervening variables explains most of the variance in yield (Figure 9).

When employing path analysis in a multiple variable model, there are three effects on the dependent variable that can be evaluated.

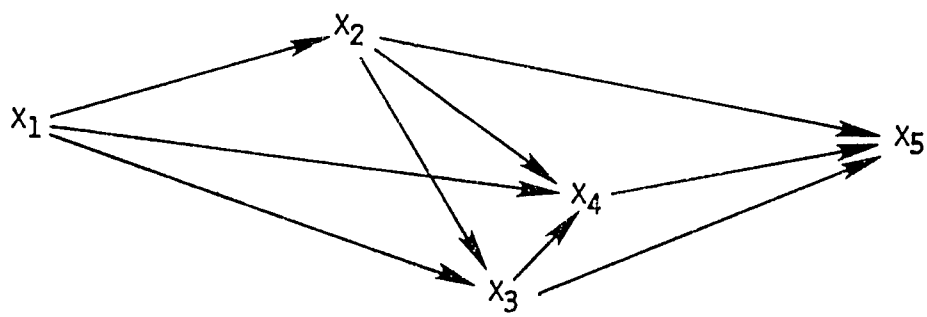
1. The direct path effect of the independent variable on the dependent variable. This is the bivariate relationship between these two variables.

2. The indirect path effect of the independent variable along all of the intervening variable paths leading to the dependent variable.

3. The total path effect of the independent variable, which is the sum of the direct and indirect path effects.

Table 15 shows the standardized regression coefficients (beta coefficients) between model variables. These coefficients are derived from multiple regression analysis, using yield as the dependent variable. A comparison of the analyses in Tables 14 and 15 shows the results to be very similar, if not identical, as Davis (1986) predicted should be the case. What is different is the additional information provided in Table 15 about the individual path effects.

Table 15 shows that the path with the most explanatory power is that directly from management capacity to yield, while the second most useful path for explaining the relationship is through the weeds variable. Even though the paths running through water control seem to be of tertiary importance, water control at the farm turnout has a direct and important effect on weed problems. For this reason, water control was viewed as the most critical intervening variable between management capacity and yield in the path analysis.



X_1 = Management capacity
X_2 = Distributary problems
X_3 = Water control
X_4 = Weeds
X_5 = Yield

PATH		
X_1 X_2 X_5	-.3402 * .0221	= -.0007
X_1 X_2 X_3 X_4 X_5	-.3402 * .0002 * -.3027 * -.4985	= -.0000
X_1 X_2 X_4 X_5	-.3402 * -.2311 * -.4985	= -.0392
X_1 X_3 X_5	-.3560 * .0379	= .0135
X_1 X_3 X_4 X_5	-.3560 * -.3027 * -.4985	= .0537
X_1 X_4 X_5	-.2721 * -.4985	= .1356
X_1 X_2 X_3	-.3402 * .0002 * .0379	= -.0000
Subtotal of indirect effect		= .1629
Subtotal of direct effect		= .2487
Total effect of management capacity on yield		= .4116

Figure 9. Path analysis of the relationships in Model 1, including beta values, summed path effects, and total causal influence of management capacity on yield, controlling for tenants and investment in all paths.

Ar analysis of Pearson's R^2 further shows the importance of Model 1 in explaining variance in rice yields. The combined influence of management capacity, distributary problems, water control, and weeds explain nearly 40 percent of the variance in yield (R^2 = .3924). Management capacity and weeds alone explain 96 percent of the 40 percent variance. The combined influence of management capacity, weeds, tenancy, and relative water supply explain 43 percent of the variance in yield (R^2 = .4339).

In addition to measurement error, there are undoubtedly many variables which could be suggested or investigated to explain the unexplained variance in yield. Probably one of the more important variables to investigate in the future would be the degree of manual labor employed for weeding. Values for this variable were collected only on a subset of the 82 sample farms and, therefore, were not incorporated into this analysis.

E. THE RELATIONSHIP BETWEEN MANAGEMENT CAPACITY AND FARMER WILLINGNESS TO SUPPORT WATER USER ASSOCIATIONS IN THE FUTURE (MODEL 2)

In evaluation exercises, farmers were twice presented with questions which were intended to measure their willingness to support the development of local distribution, water users associations in the near future. Taking a larger sample of 304 farmers for the 15 distributaries as a whole, 57 percent either strongly agreed or agreed that they were willing to support water user associations in the future when they answered the question the first time. The second time they were asked, 65 percent indicated willingness to support a water users association.

The two questions were worded somewhat differently, each postulating somewhat different powers for the proposed water user association (see Appendix E). This contributed to the difference in scores. In the first question, an association was described as having the power to collect maintenance fees and conduct maintenance work on the distributary. The second question posited a water users association which would make final decisions regarding water rotation schedules between field channels on the distributary, as well as making decisions concerning the use of maintenance fees. Also, the role of government officers was specified as nonvoting advisors in the second question, while in the first question their role was unspecified. More farmers "strongly agreed" or "agreed" that they would support a water users association having the second set of specifications.

Of further interest is the relationship between various aspects of the distributary environment and farmer willingness to support water user associations. As stated previously, this type of evaluation is best conducted using conditional variables that define socio-technical conditions experienced by farmers within each distributary command area. The relationship of primary interest to the researchers was that between management capacity and willingness to support water users associations, controlling for several variables that might bear on this relationship.

The intercorrelations for this set of variables are given in Table 15. Some of these coefficients are slightly different from those reported

in Table 5 because they are based on composite index scores for 15 distributary cases, rather than on the 82 cases derived from ascribing composite index scores to sample farmers irrigating along each distributary. What is important is that the signs and relative strength of relationships remained unchanged.

Table 15. Zero-order correlations between variables related to willingness to support water users associations.

	WUA*	Management Capacity	Distributary Problems	Distributary RWS	Tenants
Management capacity	.3330	-	-	-	-
Distributary problems	-.2409	-.4736	-	-	-
Distributary RWS	-.3733	-.0445	-.0864	-	-
Tenants	.3247	.2583	-.5032	-.2673	-
Density	-.1296	.1825	-.1078	.5701	-.2145

*WUA - Willingness to support water users associations.

Table 15 reports that management capacity and willingness to support water users associations are positively related to each other (r = .3330). Table 16 reveals that the relationship between management capacity and sample farmer support for water user associations decreased with rising distributary problems. These relationships are not inconsistent with earlier discussions of the model. It has already been shown that distributary problems are a function of management capacity and tend to minimally affect other variables as management capacity increases. It was also shown earlier that tenancy tends to occur in command areas where management capacity is good, rather than in command areas with better relative water supply. In fact, Table 15 reports that the relationship between tenancy and relative water supply is negative (-.2673). The issue for tenants, as for farmers in general, is not how much water comes through the distributary headgate (although this is undoubtedly important to farmers), but what management capacity is available at the distributary level to allocate the given water supply.

Since management capacity and distributary RWS do not appear to be much related to each other (-.0445), they must operate independently on farmers support for water users associations. This is also suggested by the partial correlation analysis presented in Table 16.

There is virtually no difference between the zero-order bivariate correlation between management capacity and willingness to support water users associations and the partial coefficient obtained when, controlling for distributary RWS. It is likely that management capacity and distri-

butary relative water supply are two distinct options available to local farmers for improving water availability and control at the distributary level. (At the farm level, management is considerably more important for water control and yield.) Nevertheless, distributary RWS and organized management capacity have dramatically different effects on the willingness to support water user associations in the future, as seen in Table 15.

Table 16. Partial correlation analysis of the effects of selected control variables on the bivariate correlation between management capacity and willingness to support water user associations.

Dependent Variable	Intervening Variable	Control Variable	Independent Variable Management Capacity: Zero-Order Correlation	Independent Variable Management Capacity: Partial Correlation
WUA*			.3330	-
WUA	Distributary problems		-	.2561
WUA		Distributary RWS		.3413
WUA		Tenants		.2726
WUA		Density		.3658

*WUA - Willingness to support water users associations.

Increases in distributary relative water supplies do not greatly affect the demand for water users associations. Tables 15 and 16 show that there is little or no relationship between management capacity and distributary relative water supply. Yet, sample farmer support for water user associations increases on distributaries with more management capacity -- i.e., with active vel vidanes, with higher degrees of consensus on the placement of check dams during the day and night, and with more normative control over serious destructive actions such as bathing cattle and weashing farm equipment in the distributary. High support or appreciation for water users associations under conditions of strong management capacity may come out of the everyday struggle for better water availability and control (i.e., moderate improvements in water control due to existing collective efforts).

Management capacity has a dramatic effect on both yield and the willingness of farmers to support water users associations in the future. Management capacity overcomes the effects of a number of significant socio-technical variables to insure better water control at the farm turnout, which in turn reduces weed problems and insures higher yield. Despite the low level of management capacity above the distributary headgate, informal organizational arrangements below the headgate demon-

strate the importance of middle-level organization in improving overall production.

F. CONCLUSIONS

This chapter focused on organizational arrangements for water allocation, system maintenance, and dispute settlement in centrally administered irrigation settlement schemes in the Dry Zone of Sri Lanka. It has attempted to quantitatively document key features of the organizational arrangements for water management at this community level.

The policy issue here is whether or not the middle management level should be strengthened through water user associations and if so, is there support for such associations within the irrigation community? Management capacity within the community of irrigators made a positive difference in water control and yield. A policy of strengthening and building upon current informal organizational arrangements is given support.

It was found that management capacity reduced reported problems along the distributary considerably, which in turn provided better water control for sample farmers. This finding held when conditions imposed by significant control variables were introduced into the analysis. Management capacity positively affected water control, reduced weed problems, and resulted in better yields. Weed problems were found to be much less severe where management capacity at the distributary level and water control at the farm level was higher. Finally, management capacity was found to strongly correlate with the willingness of farmers to support water user associations in the future.

Unlike management capacity above the distributary headgate, management capacity below the headgate varied considerably. A number of irrigation communities had successfully improved water management through various informal arrangements. This management capacity did not seem to be affected as much as one might expect by land fragmentation, tenancy, or relative water supply to the distributary. When management capacity is high, it tends to adapt to and compensate for such socio-technical influences. Willingness to support water user associations in the future does seem to be related to distributary relative water supply. Distributary communities which have developed good management capacity clearly revealed stronger support for the idea of having water user associations in the near future.

There are three important implications of the findings for policy. First, policymakers must recognize the degree to which a portion of the local distributary irrigation communities have adjusted to adverse organizational conditions above them. They have accomplished much through making use of the traditional role of <u>vel vidane</u>, even in the absence of formal farmer organizations to support this role. The <u>vel vidane</u> is an active member in distributary communities having higher management capacity, and the role of the <u>vel vidane</u> should be recognized in any attempt to strengthen organizational arrangements among water users in the settlement schemes.

Second, policymakers should recognize the strong relationship between distributary water control and yield. The middle management below the distributary headgate has proven crucial to providing water control, and is, therefore, of considerable importance to further organizational development.

Third, the willingness of farmers to support local water user associations should not be underestimated. Not only is this desire strong, but it is most frequently associated with previous successes in improving water control through locally instituted practices. This reinforces the importance of designing locally appropriate water user associations at the middle management level.

V. SUMMARY AND DISCUSSION

This report has described the social organization of water management in two centrally managed irrigation settlement schemes in the Dry Zone of Sri Lanka. Procedures and roles at the middle level of management (operations between storage tank sluices and individual farm turnouts) were examined. The central thesis has been that variation in middle-level management capacity affects water control. In turn, water control affects crop yields and the willingness of farmers to support local water user associations at the distributary level. This chapter reflects on the findings presented in Chapter IV and incorporates qualitative information from extended key informant interviews and participant observation.

Middle management was considered to be divided into two organizational levels. The first level was defined by the hydrological and organizational area between the storage tank sluices and the many distributary headgates served by the two systems. This level is supervised by junior Irrigation Department personnel and their assistants. The second level was defined as that area between the distributary headgates and individual farm turnouts. This level includes the hydrological and organizational area within the paddy tracts themselves, and is supervised by locally elected irrigation headmen (vel vidanes), who represent the community of irrigators along each distributary. The distributary headgate defines the point at which the public agency managing the schemes turns water management, in a de facto sense, over to the local community of irrigators.

Hypotheses were formulated to evaluate the central thesis, using data collected at both middle management levels. These hypotheses were presented and tested to evaluate the effect of middle-level management capacity on water control, yield, and the willingness of farmers to support water user associations.

Qualitative data on procedures and roles at the first middle management level revealed little variance in management capacity. The organizational and institutional arrangements for water allocation, system maintenance, and dispute resolution were found to be uniformly weak in both irrigation schemes, even though the systems were not the same size. All distributary communities appeared to be negatively affected by problematic management capacity at this level. Quantitative data gathered at the second level revealed considerable variation in local farmer and vel vidane management capacity observed from one distributary to another.

The two settlement schemes exhibited weak organizational arrangements at the middle management level for basically the same reasons. First, no adequate accountability procedures exist for specifying the rights and obligations of junior Irrigation Department personnel and farmers. Second, junior personnel are recruited mainly from non-local "cosmopolitan" backgrounds. This kind of recruitment results in considerable distance in status and interests between the personnel and the farmers. Third, no adequate means of mobilizing resources for maintenance exist

that permit local irrigators to define a relationship between individual water use and maintenance obligations. Finally, no adequately recognized concept exists which defines an individual irrigator's right to use water (water share).

However, in the absence of viable formal water user associations to clarify such matters, local distributary irrigation communities have developed informal arrangements (of variable capacity) for water management. Management capacity was determined by the supervision and authority of the local vel vidane, the degree of consensus among farmers over the rules of water allocation along the distributary, and the positive role of one or more locally influential people in assisting the vel vidane in resolving water disputes successfully. Distributary communities that revealed a higher degree of management capacity exhibited better water availability and control at the farm level, higher yields, and a greater willingness of farmers to support water user associations in the future.

This finding suggests three points regarding agricultural production potential. First, yield was demonstrated to be a direct and indirect function of the degree of management capacity exhibited at the middle management level. Thus, the problem of water productivity and crop production is really an organizational issue. This is not to say that part of the variance in yield cannot be explained by the on-farm water management practices of individual farmers. However, data presented in this study show that production levels vary with the degree of water control at the farm turnout, and that water control is greatly influenced by how the distributary is managed. Distribution management, in turn, is constrained by factors operating upstream.

Second, the traditional role of the vel vidane was officially introduced in the early years of settlement to facilitate water distribution. This role was eliminated with the passing of the Paddy Lands Act (1958). Yet, the role of the vel vidane continues to be acknowledged by farmers. Although considerably weakened by legislation and larger socio-economic forces, the traditional role of the vel vidane is viable and active, at least in some communities.

Third, most of the problems faced by vel vidanes have to do with their ability to enforce agreements between farmers along the distributary. Vel vidanes everywhere lack formal organization that gives legitimacy to their authority and that can provide resources for regularly maintaining the distributary. Vel vidanes face the community alone and must rely on persuasion and good humor to convince unwilling farmers to play by the traditional informal "rules of the game." They are, as local farmers say, a management "cup" without support of an organizational "saucer."

If water user associations are to be developed, they should be built to support the traditional vel vidane water management role. This role does not need to be replaced so much as it need strengthening. This can be done by incorporating the role of the vel vidane into appropriate local organization.

A. CONTEXT OF FINDINGS

The ownership of canals, structures, and water by the government, the government's policy of centrally administering the system, have generally prevented farmers from assuming the initiative in maintenance activities along distributaries. This legal and administrative framework creates little incentive for local farmer participation. In addition, the lack of local and effective enforcement mechanisms to control "free riders" further contributes to the problem by undermining the community's sense of identity and its ability to enforce its standards of behavior on its members. Attempts to initiate farmer-sponsored organizational and physical improvements along distributaries often meet with reluctance on the part of government officers and some community residents for fear that influential farmers will object to any changes in flow rates.

In Volume 1 of this series, the following questions were posed: Are middle managers accountable to the local irrigation community? Were middle managers recruited from local labor markets? Does a workable water share system unite maintenance obligation with water service? Except for the vel vidane, middle management roles were found to be accountable to the Irrigation Department almost exclusively, and most personnel recruited have a "cosmopolitan" background. In this study area, local farmer resources were not effectively mobilized for maintenance. No concept of a water share existed that defined an irrigator's right to use water in return for an obligation to contribute to local maintenance and other costs of controlling water.

It is argued that a clear concept of property rights to water and to physical structures provide an important basis for collective action in water management. Water exchange -- whether between individuals, between individuals within an organization, or between organizations -- provides irrigators with a means of moving water to areas within the irrigation community where it can be used more beneficially. Water measurements are crucial to effective local organization, and the concept of organized water shares helps determine eligibility requirements for irrigation community membership. Organized water shares can also stitch together water allocation and maintenance. These organizational features were found to be absent in the two settlement schemes studied.

B. THE MEANING OF MANAGEMENT CAPACITY AT THE DISTRIBUTARY LEVEL

Briefly, management capacity at the distributary level was defined as the ability of the local community of irrigators to elect an effective vel vidane and to arrive at a consensus over how water should be allocated to field channels along the distributary. It was observed during the study that water allocation generally went smoothly under normal demand conditions, but on no distributary was there sufficient management capacity to cope with peak demand conditions. Vel vidanes singly withdrew in such conditions.

Data presented in Chapter IV showed that the management capacity explained more variance in yield than the percentage of tenant farmers in an area or the density of the local farming population. Management capacity explained more variance in yield than the relative water supply

at the distributary headgate, than investment levels in agro-chemicals, or than the hydrological location of the farmer. The negative effects of such control variables were reduced by the positive effects of informal collective arrangements for distributary water allocation. Management problems arise in communities of irrigators which give evidence of less capacity to organize to manage water. Problems are also evident in inadequate linkages between public agencies and irrigation communities and in defective organization of the lower echelons of the main system management.

C. WILLINGNESS TO SUPPORT WATER USER ASSOCIATIONS

If water user associations are viewed as able to make important contributions to managing water and improving yields, it must next be determined whether or not farmers are receptive to water user associations. It was interesting to learn that distributaries with higher management capacity tended to favor water users associations more than distributaries with lower management capacity. Farmers on distributaries with higher management capacity have a greater capacity to address water allocation problems and look for ways to resolve maintenance and adjudication problems. As determined by extended participant observation and discussion with key informants, they see water users associations as a way to accomplish this goal. Such distributaries experience positive results from high levels of informal cooperation.

Distributaries with low management capacity have broken into more atomized dyadic relations of power and coercion where might is right. In such social webs, great skepticism exists about organizations in general, especially given past failures at creating organized agreements capable of controlling the more powerful.

Chapter II painted a troubling picture of social life in the settlement schemes. An unstable situation obtains with regard to land and water property rights. This has created feelings of investment insecurity within the irrigation community. In addition, the lack of control over the operation and maintenance of irrigation structures has reduced incentives for farmers to participate in maintenance. The weakness of current farmer organizations has led to feelings of vulnerability and ineffectiveness. The loss of local institutions of adjudication and the general absence of redress for property damage have led to fear of reprisals by government officers, and helplessness. Village elites are viewed by farmers as the primary source of power available to the local community to get things done in the wider environment. These social conditions were found to profoundly affect the attitudes and behavior of farmers. It is in this context that the majority of farmers indicated a preference for water users associations, particularly at the distributary level. Many sample farmers interviewed had been thinking about water users associations for many years.

Sample farmers were asked why there had been a lack of farmer effort to develop such organizations. Many of them reasoned as follows: if a farmer has no ownership rights to the land he or she cultivates, if the public agency responsible for the irrigation system discourages maintenance and repairs not authorized by the agency, and if repairs made

cannot be protected as a property investment by the local irrigation community, then there is little incentive to develop an organization for collective action. Previous organizational attempts, such as the cultivation committees, were really only efforts to increase participation. As farmers frequently stated, this participation was an attempt to make farmers think they had power and influence in the system, when they did not have such power or influence.

Coward (1984) stated that in irrigation systems in Asia which have been built by farmers,

> "One could see that the group making the original irrigation investment also had the responsibility for the upkeep of the facilities they had constructed. Their efforts to maintain these works could then be seen as rational economic behavior aimed at protecting prior investment."

This rational economic behavior does not appear to be any less prevalent among farmers in the settlement schemes studied in Sri Lanka. Although farmers readily acknowledged and appreciated the original investment in public funds for constructing such systems, they did not understand why it was necessary for that same public agency to operate and maintain the systems indefinitely.

Furthermore, it had become clear to farmers that the public agency could not allocate water, maintain the system, or resolve conflicts successfully with available resources. Farmers reported that they did not expect this situation to improve in the foreseeable future. Yet, the announced rehabilitation policy on institutional development in the irrigation schemes is expected to promote greater self-sufficiency on the part of local irrigation communities to relieve the resource burden on the public agency responsible for water management.

Farmers expressed willingness to assume responsibility for water management at an appropriate hydrological level, while acknowledging that the public agency had special skills that were obviously needed to manage the large storage tanks and feeder canals. Farmers, for the most part, did not want to be involved in the financial matters of the main system, although they wanted to have some influence over how it was managed. In interviews, farmers seemed to voice the need for a mixture of public, centrally managed and public, locally managed (i.e., water users association) property in such systems.

Farmers stated that for water users associations to succeed, they must be free from central public agency control, agency politics, and the domination of local elites. In many respects, however, the influence of government officers is preferred over local political party representatives since government officers are outside the community and do not remain in the area for a long time, thereby reducing their ability to build a strong power base with local elites. They are appreciated for their advisory status. They are not appreciated when they attempt to control activities within the community.

Long experience has provided farmers with a wealth of ideas about how not to organize. Experience with poor record-keeping, the absconding of organization funds, and other problems have alerted farmers to the care with which such organizations must be designed. Farmers expressed a strong interest in organizational design and an eagerness to participate in constructing their own organizations. They did not feel they needed someone in a public agency designing organizations for them, although they were not opposed to taking suggestions.

World War II veterans, in particular, seemed to have a keen understanding of what makes a good organization. They appeared to be particularly aware of how authority to enforce organizational rules is ultimately based on some power source to make participants regularly comply, irrespective of the social rank they hold in the community. Organizations need leverage to secure compliance, and they can get such leverage through the local collective control of water and irrigation structures. They understand that the power of a local organization fundamentally rests on its capacity to deliver water to members who fulfill their obligations, and on its ability to deny water to transgressors.

Farmers favor water users associations for a third reason having to do with current arrangements for dispute adjudication. Farmers elect vel vidanes to resolve things locally, rather than calling in outsiders. Farmers do not like to be witnesses against neighbors in police court, and they are afraid to face lawyers. They fear that such actions damage the reputation of their community, and there are real financial costs involved. Yet, vel vidanes are reluctant to face more powerful farmers about repeated offenses because they have no organizational leverage to exert.

Fear is experienced by public agency people as well. Irrigation Department personnel do not involve themselves at the community level in disputes; rather they prefer to wait until the paperwork on a complaint enters the "safety zone" of their office. Police do not like to respond to water disputes. They feel they have no practical authority to deal with such offenses. Certainly, no official wants to go out at night to respond to a complaint.

The feeling of helplessness on the part of farmers and officials is a product of the incapacity of current organizational arrangements to punish offenders swiftly, predictably, and fairly. Given the existing lack of organized and enforceable joint agreements, nobody wants to press charges on individuals for irrigation violations -- not the vel vidane, not the technical assistant, not the police, and not other government officers in the area. Nobody has confidence in the institutional arrangements currently available.

Given this organizational context, the majority of farmers favor creating local water users associations which would allocate water and maintain the system. At the same time, they desire to form local water tribunals to resolve water disputes. Since water is a major cause of conflict in the community, they feel that if water disputes can be resolved predictably, fairly, quickly, and inexpensively, the overall social climate of the settlement schemes will improve. Ability to resolve

disputes over water will help restore confidence in the ability of local communities to solve many other kinds of economic and social problems.

Water control and crop yields are organizational issues and are functions of organizational capacity. The organization of water management requires accountability, local knowledge, maintenance obligations tied to water rights, and use rights linked to the concept of a water share. The concept of property, the ability to exchange water, effective measurement techniques, and local autonomy are basic requirements. Appropriately designed, local water user associations can do much to reduce problems of both farmers and main system managers.

VI. REFERENCES

Asher, H.B. 1983. Causal modeling. Second edition. Series: Quantitative Applications in the Social Sciences. Beverly Hills: Sage Publications.

Brohier, R.L. 1941. The Tamankaduwa District and the Elahera-Minneriya Canal. Colombo: Ceylon Government Press. p. 36

Coward, E.W. 1984. State and locality in Asian irrigation development: the property factor. Paper presented at International School for Agricultural and Resource Development, Colorado State University, Fort Collins. p. 2.

Davis, J.A. 1986. The logic of causal order. Beverly Hills: Sage Publications.

DeSilva, K.M. 1981. A history of Sri Lanka. Berkeley: University of California Press.

Farmer, B.H. 1957. Pioneer peasant colonization in Ceylon. London: Oxford University Press.

Freeman, D.M. and M.K. Lowdermilk. 1985. Middle-level organizational linkages in irrigation projects. In: Cernea, M. (ed.). Putting People First: Sociological Variables in Rural Development. World Bank, Oxford University Press. pp. 91-118.

Gunawardena, P.J. 1981. Land policy and agrarian change in independent Sri Lanka. Sri Lanka Journal of Agrarian Studies. 2(2):27-43.

Harriss, J.C. 1984. Social organization and irrigation: ideology, planning, and practice in Sri Lanka's settlement schemes. In: Bayliss-Smity, T.P. and S. Wanmali (eds.). Understanding Green Revolutions: Agrarian Change and Planning in South Asia. Cambridge: Cambridge University Press. pp. 315-338.

Herring, R.J. 1981. Embedded production relations and the rationality of tenant quiescence in tenure reform. The Journal of Peasant Studies. 8(2):131-172.

Inayatullah. 1972. Cooperatives and development in Asia: A study of cooperatives fourteen rural communities of Iran, Pakistan, and Ceylon. Volum 8. Geneva: United Nations Research Institute for Social Development.

Lewis-Beck, M.S. 1980. Applied regression: an introduction. Series: Quantitative Applications in the Social Sciences. Beverly Hills: Sage Publications.

Maass, A. and R.L. Anderson. 1978. And the desert shall rejoice: conflict, growth, and justice in arid environments. Cambridge, MA: MIT Press.

Moore, M.P. 1979. Social structure and institutional performance: local farmers' organizations in Sri Lanka. Journal of Administration Overseas. 18(1):240-249.

Moore, M.P. 1980. Approaches to improving water management on large-scale irrigation schemes in Sri Lanka. Occasional Papers. Colombo, ARTI.

Murray-Rust, H. 1984. Impact of physical and operational rehabilitation on equity of water distribution and performance of farmer organization. Water Management Synthesis II Project TDY Report. Ithaca, NY: Cornell University.

Murray-Rust, H. and M.P. Moore. 1983. Formal and informal water management systems: cultivation meetings and water deliveries in two Sri Lankan irrigation schemes. Cornell University studies in irrigation. Ithaca, New York: Cornell University.

Oberst, R.C. 1986. Legislators and representation in Sri Lanka: the decentralization of development planning. Boulder, Colorado: Westview Press.

Pieris, R. 1976. Social development and planning in Asia. New Delhi: Abhinav Publication.

Tiruchelvam, N. 1984a. The ideology of popular justice: a socio-legal inquiry. Sahibabad: Vikas Publishing House PVT, LTD.

Tiruchelvam, N. 1984b. The politics of decentralization and devolution: computing concepts of district development councils in Sri Lanka. In: Goodman, R.B. and J.A. Wilson (eds.). Independence to Statehood: Managing Ethnic Conflicts in Five African and Asian States. New York: St. Martins Press.

Uphoff, N. and R.D. Wanigaratne. 1982. Local organization and rural development in Sri Lanka. In: Uphoff, N. (ed.). Rural Development and Local Organization in Asia. India: MacMillan.

Wade, R. 1982. The system and administrative and political corruption: canal irrigation in South India. The Journal of Development Studies.

Wanasinghe, S. 1985. Decentralization for rural development: the Sri Lankan experience. In: Cheema, G.S. (ed.). Rural Development in Asia: Case Studies on Programme Implementation. New Delhi: Sterling Publishers LTD.

VII. APPENDICES

APPENDIX A

RESEARCH METHODOLOGY

In September 1985, several months before data collection, the research team discussed the research effort with district government officers. The Irrigation Department was informed of the scope and purpose of the study, and their approval was secured. The Government Agent (GA), the Additional Government Agent for Development, and assistant government agents were also consulted. A special meeting was held at the Kachcheri (district revenue offices) to discuss objectives of the research project with government officials to secure their approval and support. The Minister of Parliament (MP) was also informed of the nature and purpose of the study.

Meetings were arranged with officials of development agencies in the area in order to keep them informed of the planned research activities. There were several officers from the Department of Agriculture, Land Commissioners Office, and Agrarian Services who worked at the research sites. It was necessary to explain the data collection activities to them, such as farmer interviews, installation of flumes and staff gauges in distributaries and field channels, soil surveys, and water flow measurements.

RESEARCH STAFF AND MATERIALS

The principal investigators adopted an interdisciplinary approach. Agronomic and economic data were necessary to estimate paddy production and to evaluate water control, water management procedures, maintenance, and dispute resolution. Six full-time investigators collected this data. In addition, the following people were hired: a field crop specialist from the divisional office of the Department of Agriculture as an agronomy consultant, a technical assistant from the Irrigation Department as an engineering consultant, and a graduate student in agricultural economics at the University of Peradeniya as an economics consultant.

These consultants supervised two part-time data collectors and four full-time Agricultural Diploma holders, who were responsible for measuring water flows and evaporation and assisting in the crop-cutting surveys. Several laborers were hired to install staff gauges, flumes, and evaporation pans.

Two engineering graduate students from Colorado State University supervised flume installations and water measurements for the yala 1986 season. A faculty member from the Department of Agricultural and Chemical Engineering, Colorado State University, recommended the selection of the research blocks. The research design and the final selections of research blocks were the responsibility of the principal researcher.

Equipment for the research effort was procured locally. Local machine shops fabricated the flumes and evapotranspiration pans. The Irrigation Department provided wooden staff gauges, a transit, a planimeter, maps of the irrigation systems, a jeep, a small pickup truck for two or three days at a time, and a centrally located field bungalow for the Agricultural Diploma holders.

Salaries, five motorcycles for the diploma holders, furniture for the field bungalow and a central project house in Kaduruwela, gas and vehicle repairs, and the cost of fabricating flumes and other field equipment was funded by special studies, Water Management Synthesis II Project, Colorado State University. The principal researcher purchased an old Toyota stationwagon which served transportation and hauling needs, and a motorcycle for the agronomy consultant. The technical assistant used the Irrigation Department jeep. Finally, a part-time data collector (local farmer) used his motorcycle.

EARLY ORIENTATION AND OBSERVATION

The principal researcher was employed as staff sociologist for a seven-week data collection workshop conducted by the Water Management Synthesis II Project, Colorado State University, in June and July, 1984. During the workshop, eight settlement officers were trained as data collectors for anticipated baseline surveys. Some of these officers were later employed only as part-time consultants and data processors to prevent their authority in the community from biasing information.

The special studies research project in Sri Lanka was implemented in September 1985. Experiences in conducting the baseline survey during the workshop provided insights into the irrigation and agricultural problems in Sri Lanka. Nevertheless, the methodology of the baseline survey was less than adequate. This called for greater caution in using proper methodologies and data collection techniques for the special studies research. There was little overlap between research sites and the research blocks in the baseline survey.

A series of community meetings was held to develop trust between farmers and data collectors. A first round of meetings was held during maha 1985-86, the second round was at the beginning of yala 1986, and the final round was in the middle of yala 1986.

A meeting was also scheduled with the vel vidane for each of the distributaries. These interviews were primarily concerned with identifying water problems. At the end of the interview, vel vidanes were requested to meet with irrigators as a group to discuss water problems. This request was always granted.

The group meetings or community meetings were usually held at the local Buddhist temple near each distributary. Settlement officers were not invited, unless they themselves were irrigators. At each of the meetings, an invocation was administered by the head priest of the temple, and the local vel vidane then opened the meeting with a speech. The principal researcher was introduced to the distributary community, and

the vel vidane urged the farmers in attendance to "answer any questions asked by the foreign gentleman." Farmers were informed about the research effort and data collection procedures. Furthermore, it was explained that information would be treated as the private property of the researcher, and farmers were assured that information would not be given to government officers.

The overall strategy of building trust between the research team and local farmers was actually suggested by farmers themselves. They recommended that researchers must respond promptly to farmer's requests and observe water stress situations, and promise to "report the farmer's side of the story." We took these recommendations seriously.

EVALUATING KEY WATER MANAGEMENT ROLES AND PROCEDURES

By the end of the second round of community meetings, and toward the middle of the growing season, a substantial body of information had been collected on water management practices for each of the sample distributaries by means of routine field observations, daily water measurements, and complaints of water stress conditions by farmers. Key informant interviews were conducted throughout the season. Several visits to a research block were made in response to farmer requests to adjust flumes or to clear away debris. These events provided opportunities to meet and interview farmers on a very informal and impromptu basis. Quite often, some of the best information was gathered in such encounters.

Occasionally, government officers were encountered in the field and [illegible] scheduled a series of day-long, roundtable discussions at one of the local hotels. Since there were officers of different ranks from several governmental departments, a day was assigned for officers of each category. There were ten such discussions.

A[illegible] weeks before the discussions with settlement officers, an experienced social scientist* informed us that group interview formats had been successfully employed in field research. He observed that people feel more at ease when interviewed in group settings rather than as individuals. We used a similar method.

The research team decided that the discussions should be structured to maximize the opportunity for officers to respond to a list of issues on community values and water management problems. Officers were divided into small work groups of four to six individuals, and each officer was given an opportunity to react to a series of questions about general community norms. This initial discussion on community norms tended to put the participants more at ease. After a mid-morning tea break, the major focus of discussion turned to water management practices and problems. In addition, officers were asked to review job descriptions in water management. After lunch, the work groups were brought together for a lengthy and informal discussion of water management issues and

*Tennakoon, M.U.A. Data collection in the social sciences with special reference to the open interview method. Colombo, Sri Lanka: Central Bank Training Institute.

problems. Each officer was asked to speak about water management issues in his or her area, and to give observations about ways in which the irrigation management system could be improved.

Following an afternoon tea break, a session was devoted to discussing experiences with local institutional development efforts, such as the cultivation committees, and their analysis of the reasons for past successes and failures in these efforts. Occasionally, we described possible options for creating water user associations, using analogies and examples from water management practices in other countries, such as Spain, Mexico, the U.S., and Nepal.

MEASURING DISTRIBUTARY MANAGEMENT CAPACITY: THE INDEPENDENT VARIABLE

The group interview method of data collection was successfully employed. A questionnaire was administered to farmers living along the sample distributaries. This provided for a farmer self-evaluation of current water management conditions along distributaries. The contents of the questionnaire were based in part on the information collected in the previous group sessions with government officers. The questionnaire was administered at a series of meetings held at the local grade school along each distributary. The questionnaire comprised a number of current management issues and possible future organizational arrangements for their respective distributaries (Appendix B).

The schools were not in session during the first two weeks of August, approximately two weeks before the beginning of harvest. This was an appropriate time to invite farmers to participate as evaluators, since there was a temporary lull in the farm work as the paddy ripened. A set of questions was developed, subjected to several pre-tests and re-translations, and then printed on three-by-five cards. On the cards, farmers marked an "x" in a box next to one of several statements or options following a question on water management practices and issues. Upon completing the questionnaire, participating farmers placed a rubber-band around their packet. The card packet was then sealed with glue and their packet was placed in a cardboard box. This was done in order to maintain anonymity.

Fifteen evaluation meetings were held during the first two weeks of August; they were arranged by the principal researcher with the assistance of translators and four monitors to assist farmers if they needed clarification during the exercise.

There were many reasons for holding these meetings at the local schools. The schools are frequently used for community meetings and provided protection from the heat of the day. Also, there were ample chairs and tables for the participants.

An original colony block map was used to select approximately one-quarter of the farmers along each distributary as evaluators. Households were selected starting from the head and counting down to the tail on one side of the distributary, and then back on the other side. Only original allottees were asked to attend the evaluation exercise because

tenants are temporary residents and their attendance might have offended original allottees.

On a few occasions, the vel vidane recommended the list of farmers to invite to the meeting. Such recommendations were not accepted. However, on one occasion, the vel vidane expressed his unwillingness to participate if his selection of farmers was not invited to the meeting. The vel vidane was contacted the evening before the meeting; he was asked to check with the invited farmers and confirm whether they intended to attend. The letters of invitation had been mailed two weeks earlier. On the morning of the meeting, a research team member with a motorcycle was assigned to assist farmers to the school if they had difficulty walking or were without a bicycle.

Farmers who were not invited as evaluators, but who came to the meeting anyway, were allowed to remain and asked to sit at the back of the room. It was explained that the invited farmers were selected according to the location of their allotments, rather than social or political characteristics. Nevertheless, some of the uninvited farmers clearly felt they were being left out, although they appreciated the conditions of participant selection.

As the meeting opened, the investigators acknowledged appreciation of the farmers' attendance and introduced the research team. A series of explanatory statements were made at each meeting in order to standardize the translations. The procedures at one meeting were repeated at another in order to reduce any bias in procedural variations.

The questionnaire provided the data for the development of index measurements of management capacity and water allocation problems along the distributary.

Four questions (Appendix C) measured various dimensions of management capacity. They were:

1. The overall supervision of water deliveries to field channels along the distributary (SUPERVISN).

2. The ability of the vel vidane to solve water disputes (AUTHORTVV).

3. The positive role of one or more local influentials in assisting the vel vidane in solving water disputes (INFLUENCE).

4. The consensus among farmers along the distributary for placing temporary checks or brush dams in the distributary to manipulate water flows when needed (CONSENSUS).

An index score for each sample distributary was constructed in three steps. Step one was to rank the responses to each question according to the degree of management capacity awarded by sample farmers.

In step two, farmer response scores were summed for each question for all participants from each distributary. The response scores for each question were then divided by the highest possible summed score that could be achieved for each individual question, an operation which provided a ratio of the possible score over the actual score. This operation created a percentage index value for each question -- a percent of potential value.

The third step was to develop a composite score of management capacity for each distributary based on four questions. This was done by summing the percentage index values from four questions and then dividing this sum by the highest possible composite index value (4,000). The composite management capacity score for each distributary and the composite scores of other variables are given in Appendix F, Table 3.

EVALUATING WATER CONTROL: THE INTERVENING VARIABLE

The research blocks at the head and tail of each distributary were selected based on soils, cropping patterns, and slope. The technical information about water availability and control at the farm level were collected from research blocks. There were usually four to six farmers irrigating in each research block. Sample farmers were selected on three criteria: 1) willingness to cooperate with the data collectors throughout the season, 2) selection of at least two or three farmers from each block, and 3) selection of at least one farmer from the head and tail of each block. Water measurements were taken daily, data on demographic characteristics and budget were gathered in households, and crop-cuttings were gathered for estimating yield.

The supply of water to research blocks was measured twice a day by the Agricultural Diploma holders -- once in the early morning and once in the evening before dark. Some research blocks required only one flume, while others needed three or more flumes to measure water. Water was measured for the entire duration of the season. In addition, staff gauges were set at the head of each distributary to evaluate water supply to the entire irrigated acreage reported and supervised by the vel vidane.

These water measurements were then used to calculate an index of relative water supply for each sample from the block. Relative water supply is a ratio of the amount of water supplied to the research block, through flumes or in the form of rainfall, and the demand for water based on a calculation of total crop consumptive use for the block area.

An intensive soil survey of each research block was conducted by the Land Use Division of the Irrigation Department, and was funded by the project. The purpose of the soil survey was to determine the percentage of each major soil type in a given block. This information was then used to estimate seepage and percolation rates for the block. Seepage and percolation rates were then combined with data on evapotranspiration and cropping pattern to estimate total crop consumptive use. Each sample farm was assigned a relative water supply score.

A second measure of water control employed daily reports by sample farmers of water delivery to their individual farm units. Additional

agronomic information on the variety of paddy sown and the sowing date provided the base for constructing a water stress index (WSI) for each sample farmer. A water report form, with daily entries filled out by sample farmers, was collected weekly throughout the season. A translated copy of this form is presented in Appendix D.

Sample farmers in research blocks were asked to keep a daily record of water deliveries to their farm, and to evaluate deliveries according to their need for the water at the time. The questions consisted of three statements of yes or no responses: "Did you receive water?", "If so, was it needed?", and "If so, was it sufficient?"

Sample farmer responses were scaled and then weighted for the different growth stages of the paddy variety of each sample farmer. The varieties cultivated and their estimated average days for each growth stage are presented in Appendix H.

THE MEASUREMENT OF DISTRIBUTARY PROBLEMS

Three indicator questions were asked of sample farmers at different points during the evaluation exercise. One of the questions measures the more serious problems along the distributary, while the other two questions refer to placing temporary check dams in the distributary during the day or night to divert more water to field channel headgates or farm turnouts without the consent of the vel vidane or affected farmers.

The index scores for PROBLEM1, PROBLEM2, and PROBLEM3 are presented in Appendix F, Tables 6 and 7. The index scores for these three questions were computed in the same way as the indicator index scores for management capacity. The composite index was also derived in the same manner. This was accomplished by summing the percentage index values from all three questions and then dividing this sum by the highest possible composite index value (i.e., 3,000). The composite score for DISTPROB for each distributary is reported in Appendix F, Table 4. The intercorrelations between the three distributary problem indicator questions demonstrate internal consistency (Appendix F, Table 7).

MEASUREMENT OF WILLINGNESS TO SUPPORT WATER USER ASSOCIATIONS IN THE FUTURE

Two questions were included in the evaluation exercise as indicators of farmers willingness to support water user associations (see Appendix E). The index derived from these questions measured the overall support for such an associations within the distributary in the future.

The two questions for this variable were scaled and scored in the same manner as the questions for management capacity and distributary problems. The index values in the form of percentages for each question are given in Appendix F, Table 8, and the combined composite index value for willingness to support water users associations based on both questions is reported in Table 4. The correlation for the two indicator questions is given in Appendix F, Table 9. The Pearson's "r" of .52

indicates that opinions were changing as evaluators proceeded through the exercise.

The questions from which the WILLING1 and WILLLING2 index scores were built had to do with: 1) Farmer provision of salaries and transport facilities for work supervisors and patrol laborers; 2) the "feeling of helplessness" about current procedures for taking action against violators of the Irrigation Ordinance; 3) willingness to support establishment of a local water tribunal, rather than relying on the police or district courts; and 4) timeliness in the punishment of violators of the irrigation ordinance.

THE RELIABILITY AND VALIDITY OF MEASUREMENTS

Since multiple indicators were used to measure variables in the two models -- a replicated study would be the best method for evaluating reliability and validity. However, this was not possible given the constraints on the researchers' time and budget. Therefore, more conventional methods were used to evaluate measurement error.

Reliability is a statement of the accuracy of a measurement in terms of its freedom from random chance error. The reliability of the measurement of management capacity, distribution problems, and support for water users associations was evaluated using Cronbach's Alpha (Zeller and Carmines, 1980). This coefficient evaluates the assumption that the indicators measuring a concept are equivalent. The higher the value of "alpha", the greater the equivalence of the indicators. Zeller and Carmines (1980, p. 56) define equivalence as the degree to which "each indicator is considered a separate but equivalent measure of the underlying concept."

Cronbach's Alpha varies between .00 and 1.00. A value of .35 or lower was chosen to reject the assumption of equivalence for questions. The procedure for computing Cronbach's Alpha is reported in Appendix I. Cronbach's alpha values for the variables are as follows: 1) management capacity (.58), distributary problems (.71), and support for water users associations (.69). These values tend to support the assumption that the indicator questions for each variable provided similar rating for each of the 15 distributaries.

MEASUREMENT OF DISTRIBUTARY RELATIVE WATER SUPPLY

Distributary relative water supply refers to the total water supply from a distributary headgate to the distributary command area over the season. It is considered an important intervening or control variable. It was thought that increased availability of water to the distributary might affect the need or desire to develop management capacity at the local level. Water abundance, in other words, might create a different environment within a distributary.

Distributary relative water supply was measured with a staff gauge located near the headgate of the distributary, which was calibrated to the distributary bed profile by a series of current meter readings.

The staff gauge was read twice a day -- once in the early morning, and once in the late afternoon. Relative water supply for the distributary command area was calculated to equal the total seasonal water supply divided by the estimated demand for the total irrigated acreage under the distributary headgate.

Vel vidanes conducted a survey on original allotments and newly encroached reservation land along their respective distributary to provide us with accurate information for the calculation.

MEASUREMENT OF TENANCY

This variable represents the percent of tenant irrigators along the distributary as reported by the vel vidane in his personal ledger. Tenancy was viewed as an important intervening or control variable, since it relates to the degree to which a particular water user is sanctioned by the local community.

According to vel vidanes in the study area, there are basically three types of farmers in a distributary: 1) original allottees, 2) offspring of original allottees; 3) other farmers. The latter category includes those who cultivate under a variety of tenancy arrangements. Furthermore, the majority of such irrigators do not regularly cultivate the same land. The minority who have been cultivating as tenants for several years have become part of the local irrigation community.

Thus, a tenant farmer is defined as one who is not an original allottee along the distributary, nor an offspring of an original allottee, nor one who has been irrigating under the distributary headgate for more than two years. Such tenant farmers are not considered by the vel vidanes as a part of the community of irrigators. Vel vidanes stated that the original allottee or the offspring who rented out land is responsible to ensure that these tenants cooperate with other farmers. Tenants sometimes ignore the authority of the vel vidanes.

MEASUREMENT OF DENSITY

This variable represents the number of farmers per acre irrigating within the distributary command area. It was viewed as an indirect or partial measure of land fragmentation and as a control variable.

MEASUREMENT OF INVESTMENT IN FERTILIZER AND CHEMICALS

This variable represents the total rupee value of investment in fertilizer and other chemical applications per acre by each of the sample farmers. Computations included costs for weed and pest chemicals, and fertilizer costs for the common fertilizer applications. Labor costs for chemical applications and other land preparation activities were not computed.

MEASUREMENT OF FARM SIZE

This variable represents the total acreage under paddy for each of the sample farmers.

MEASUREMENT OF HYDROLOGICAL LOCATION

This variable represents the location of each of the sample farmers in respect to position at head or tail in the distributary, the research block, and the soil groups of the farm. A scaling procedure was used to compute scores for each sample farm according to above criteria. The information on soil groups was collected by a soil survey in each research block during the crop cutting phase of work.

DATA COLLECTION CONSTRAINTS

Socio-Economic Factors

Farmers were very cooperative with the research effort, but such cooperation could have been the result of fear as well as trust. In the early stages of the research, there were several instances where settlement officers were used as facilitators. These officers frequently instructed farmers to answer questions of "the foreigner." Farmers interpreted these instructions to mean, "paint a rosy picture of settlement life."

At first, farmers hesitated in answering questions about water management. Farmers occasionally requested that flumes must be located elsewhere. When such requests were made, another research site was selected.

However, the installation of flumes provided an excellent opportunity for the research team to meet with farmers and discuss their individual water problems. We found that the majority of farmers were willing to cooperate, particularly when they were told that the flumes would be checked twice a day for debris. They were also concerned that water measurements be taken correctly. The research team repeatedly assured them that measurement tasks could be carefully supervised.

Farmers occasionally expressed fear that the flumes might be damaged by cattle or children. The research team explained that farmers would not be held accountable for any damage. Yet, it was clear that the socio-economic status of farmers created problems in data collection because the absence of a farmer organization provided opportunities for discretionary action on the part of Irrigation Department personnel and local influentials.

Initially, farmers reported no water problems in their area and <u>vel vidanes</u> stated that all the farmers cooperate with them. Nonetheless, as trust developed between farmers and the research team, and between farmers and the translators, more accurate opinions were expressed. During the project, both translators were irrigating in more favorable hydrological locations than many of the farmers interviewed. The researcher and translators learned many things together.

Irrigation System Management Factors

The season in which the data were collected was generally characterized by normal weather conditions, although strong winds occurred rather later than usual (during the late flowering and throughout the ripening stage for most of the yaya (paddy) tracts in the area). Farmers did express some concern about the winds. In post-harvest interviews, farmers characterized the yields as slightly below average. Some farmers suffered much wind damage.

However, many farmers reported that more water was available during yala 1986 than ever before. At least part of this improved water supply was the result of changes in the rotation procedures. There appeared to be no direct relationship between the selection of distributaries for research and areas of improved water supply. The proposed rehabilitation project had, however, generated some interest within the Irrigation Department to experiment with continuous water deliveries in the main canals.

In one irrigation scheme, a local politician had requested additional water issues to farmers during land preparation. This was in response to a local community development effort (the Gamudawa). These early water issues drew down the tank supply, which was not supplemented by Mahaweli water until late in the season, a situation which forced the Irrigation Department to conserve water during an important growth stage until the tank was replenished.

The water situation provided an opportunity to evaluate current management procedures under somewhat higher than normal water issues in one settlement scheme, and somewhat less than normal water issues in the other. Discussions with farmers and local officers suggested that they were accustomed to changing water schedules and that such alterations were typically announced to farmers only at the last moment.

The storage tanks for the two irrigation schemes did not have sufficient capacity to deliver water continuously for the whole season. In order to supply water continuously to the main canals, the tanks must be replenished with Mahaweli water at some point during the season. During the 1986 yala, the divisional engineer made arrangements to bring water from the Mahaweli diversion.

The national community development and beautification program, or Gamudawa, was a further major factor which made the 1986 yala unique as compared with other seasons. In addition to changes in the water issue schedule, this program initiated considerable building activity in the main market town of the area. These activities included repaving most of the major roads in the district, plus initiating a number of housing projects for the poor or landless. There was a flurry of community development meetings and shramadanas (community work groups) to repair schools and other public buildings. As a result, very little additional or new maintenance work was performed on the two irrigation schemes.

APPENDIX B

INDICATOR QUESTIONS FOR DISTRIBUTARY PROBLEMS

PROBLEM 1 What are the actions which farmers generally consider wrong or unfair to do when water is flowing in the distributary? We would appreciate if you would take a few minutes to list two of these actions according to the seriousness or unfairness of the offense.

Responses	Frequency		
	Always	Occasionally	Rarely
1. First most serious	___	___	___
2. Second most serious	___	___	___

Ranking of Offenses

1. Miscellaneous.
2. Putting farm equipment or tieing cattle in distributary.
3. Using pumps, irrigating highlands, or stealing water from distributary.
4. Putting checks, blocking outlets, or throwing debris into distributary.
5. Breaking structures or breaking outlets along the distributary.
6. Breaking or drilling the bund, or lowering the bed of the distributary.
7. Creating disputes or thuggery.

PROBLEM 2 When turning water from the distributary to the field during the daytime, which of the following statements affect you most?

Responses

1. No checks are along the distributary channel during the day.
2. There is always an appointed representative present to supervise water distribution along the distributary.
3. Check dams are occasionally placed across the distributary, but always with consent of neighboring farmers.
4. Placing unauthorized check dams across the distributary is only a problem during the blooming period for paddy, or when there is a severe water shortage.
5. To prevent putting unauthorized check dams across their distributary, farmers must always personally inspect the distributary.

PROBLEM 3 Irrigating your paddy at night can be difficult at times. How often do you have to watch during the night to make sure that no unauthorized check structures have been placed along the distributary above the outlet/turnout of your field channel?

Responses

1. My field does not receive water from a field channel. It receives water from a turnout directly fixed to the distributary.
2. I go and check occasionally, when there is a water shortage to my field.
3. Must go and check/observe every night when water is flowing along the distributary.
4. There is no supervision of water at night. It is very risky for anyone to do such work.

APPENDIX C

INDICATOR QUESTIONS AND ANSWERS FOR MANAGEMENT CAPACITY

Indicator	Question
SUPERVISN	Inadequate control/supervision of water deliveries to field channels along the distributary. Please circle one of the following according to your opinion.

Responses:

1. Has always been a major problem.
2. Has become a problem only recently.
3. A minor problem.
4. Has never been a problem.

AUTHORTVV	Please grade your vel vidane according to his ability to solve various water disputes successfully that occur along your distributary. Mark one of the following conditions.

Conditions:

1. He is not consulted when there is a water problem.
2. He is not effective in settling water disputes.
3. He can settle some disputes only, but not all.
4. Farmers listen to him and the water dispute is always settled to the satisfaction of all the parties involved in the water dispute.

INFLUENCE	Please grade a local influential according to his ability to solve various water disputes successfully that occur along your distributary. Mark one of the following four conditions.

Conditions:

1. He/she is not consulted when there is a water problem.
2. He/she is not effective in settling water disputes.
3. He/she can settle some disputes only, but not all.
4. Farmers listen to him/her and the water dispute is always settled to the satisfaction of all the parties involved in the water dispute.

CONSENSUS

When a farmer needs water, is it permissible for him to put a check structure dam across the field channel below his turnout to enable water to reach his field?

Responses:

YES	Yes, particularly if his field is beginning to dry up and crack.
YES	Yes, by informing the neighboring farmers.
NO	Only the vel vidane is authorized to put a check dam across the field channels.
YES	It is permissible for a farmer to put a check dam across the field channel when he needs, but not permissible to put a check dam across the distributary unless the vel vidane approves.
NO	It is illegal to put check dams across the field channel.

APPENDIX D

WEEKLY WATER REPORT FORM

Code Number _____

Day 1: Date _____

	Yes	No
1. Needed		
2. Received		
3. Sufficient		

Day 2: Date _____

	Yes	No
1. Needed		
2. Received		
3. Sufficient		

Day 3: Date _____

	Yes	No
1. Needed		
2. Received		
3. Sufficient		

Day 4: Date _____

	Yes	No
1. Needed		
2. Received		
3. Sufficient		

Day 5: Date _____

	Yes	No
1. Needed		
2. Received		
3. Sufficient		

Day 6: Date _____

	Yes	No
1. Needed		
2. Received		
3. Sufficient		

Day 7: Date _____

	Yes	No
1. Needed		
2. Received		
3. Sufficient		

APPENDIX E

WILLINGNESS TO SUPPORT LOCAL WATER USERS ASSOCIATIONS

WILLING 1 The main canal should be managed by the Irrigation Department, while distributary canals and field channels should be managed by a water cooperative with a board of farmers under legislation. This society must have legal rights to collect O&M fees to do maintenance work of distributaries.

Responses

1. Disagree very strongly
2. Disagree
3. I am not sure in my opinion
4. Agree
5. Agree very strongly

WILLING 2 Farmers need a water cooperative to manage the distributary. Government officers could act as advisors, but farmers on the cooperative must have the authority to make final decisions on water delivery schedules to the field channels along the distributary, as well as the use of O&M fees.

Responses

1. Disagree very strongly
2. Disagree
3. I am not sure in my opinion
4. Agree
5. Agree very strongly

APPENDIX F

DATA SUMMARIES

Table 1. Physical characteristics of sample distributary.

Distributary	No. of Orig. Allotments	Irrigated Acreage	Relative Water Supply
1	27	76.75	4.26
2	59	183.75	1.07
3	67	200.75	2.83
4	110	360.50	1.43
5	26	84.00	1.72
6	38	124.00	1.37
7	126	254.50	2.67
8	45	93.25	1.96
9	40	129.75	1.06
10	51	252.50	1.55
11	67	319.75	1.38
12	20	98.00	3.13
13	46	258.00	1.82
14	40	189.25	1.45
15	35	123.00	1.53

Table 2. Tenancy status of farmers on sample distributaries.

Sample Distributary	Percent Original Allottees	Percent Offspring	Percent Tenants	Total No. of Farmers
1	25	58	17	73
2	35	50	15	125
3	63	26	11	76
4	48	26	26	135
5	63	17	20	30
6	32	19	49	65
7	71	13	16	131
8	39	22	39	51
9	46	18	36	49
10	22	34	44	77
11	44	27	29	91
12	20	32	48	44
13	40	27	33	78
14	19	34	47	79
15	52	29	19	31

Table 3. Index of management capacity -- summated scores of indicator questions by distributary.

DISTRIBUTARY	SUPERVISN	AUTHORTVV	INFLUENCE	CONSENSUS
1	362	803	653	333
2	490	772	533	666
3	360	690	490	900
4	333	833	475	84
5	442	923	404	333
6	463	934	688	764
7	300	740	438	48
8	350	917	367	384
9	321	712	321	200
10	369	714	405	999
11	341	807	568	444
12	313	771	313	750
13	409	818	398	200
14	417	817	617	500
15	469	760	420	158

Table 4. Summated index values of indicators for management capacity, distributary problems, and willingness to support water user associations.

Distributary	Management Capacity	Distributary Problems	Willingness to Support WUA
1	538	624	723
2	615	651	754
3	610	628	712
4	431	701	783
5	526	719	708
6	712	581	845
7	382	722	752
8	505	672	693
9	389	636	750
10	622	649	810
11	540	669	827
12	537	610	692
13	456	582	813
14	588	604	740
15	452	660	654

Table 5. Intercorrelations of indicator questions for the variable management capacity.

	ATHORTVV	INFLUENCE	CONSENSUS
SUPERVISN	.3474	.3750	.1711
ATHORTVV	-	.2771	-.1533
INFLUENCE	-	-	.1799

Table 6. Index of distributary problems -- summated scores of indicator questions by distributary.

DISTRIBUTARY	PROBLEM1	PROBLEM2	PROBLEM3
1	430	780	662
2	444	758	750
3	446	736	702
4	483	813	806
5	462	877	818
6	341	760	641
7	515	848	802
8	452	813	750
9	486	814	607
10	454	809	684
11	479	873	655
12	392	750	688
13	416	655	675
14	418	760	635
15	411	850	721

Table 7. Intercorrelations of indicator questions for the variable distributary problems.

	PROBLEM2	PROBLEM3
PROBLEM1	.5251	.4355
PROBLEM2	-	.3783

Table 8. Index of willingness to support WUAs -- summated scores of indicator questions by distributary.

DISTRIBUTARY	WILLING1	WILLING2
1	666	780
2	758	750
3	632	792
4	773	793
5	708	708
6	840	850
7	760	744
8	653	733
9	772	779
10	762	857
11	773	882
12	700	683
13	800	827
14	720	760
15	567	742

Table 9. Intercorrelation of indicator questions for the variable willingness to support water users associations.

	WILLING1
WILLING2	.5219

Table 10. Research block cropping patterns.

Distributary and Block number	Acres in Vegetables	Acres in Rice	Total Acreage
1 Head	2.05	10.13	12.18
1 Tail	2.89	17.10	19.99
2 Head	.11	11.07	11.18
2 Tail	6.62	16.37	22.99
3 Head	3.34	16.76	20.10
3 Tail	1.55	20.51	22.06
4 Head	.97	17.54	18.51
4 Tail	1.34	19.27	20.61
5 Head	1.45	18.25	19.70
5 Tail	.85	13.73	14.58
6 Head	2.68	15.46	18.14
6 Tail	3.01	17.29	20.30
7 Head	2.97	12.79	15.76
7 Tail	.74	8.33	9.07
8 Head	1.11	5.40	6.51
8 Tail	.25	20.28	20.53
9 Head	.46	11.51	11.97
9 Tail	.00	12.99	12.99
10 Head	2.59	15.48	18.07
10 Tail	.40	25.33	25.73
11 Head	.80	9.01	9.81
11 Tail	.00	16.15	16.15
12 Head	.81	10.50	11.31
12 Tail	.35	15.46	15.81
13 Head	.80	12.66	13.46
13 Tail	.33	29.09	29.42
14 Head	.73	14.99	15.72
14 Tail	.00	13.39	13.39
15 Head	.77	9.45	10.22
15 Tail	2.70	15.96	18.66

Table 11. Research block acreage in rice by soil type.

Distributary and Block Number	Well Drained	Imperfectly Drained	Poorly Drained	Total in Rice
1 Head	.59	2.17	7.37	10.13
1 Tail	.86	.34	15.90	17.10
2 Head	.46	7.45	3.16	11.07
2 Tail	.00	1.48	14.89	16.37
3 Head	.00	3.26	13.50	16.76
3 Tail	.00	1.73	18.78	20.51
4 Head	3.40	4.59	9.55	17.54
4 Tail	3.81	12.27	3.19	19.27
5 Head	1.90	3.26	13.09	18.25
5 Tail	.35	.00	13.38	13.73
6 Head	.67	9.57	5.22	15.46
6 Tail	.67	.98	15.64	17.29
7 Head	.00	2.96	9.83	12.79
7 Tail	1.53	3.60	3.20	8.33
8 Head	1.20	2.47	1.73	5.40
8 Tail	2.56	14.29	3.43	20.28
9 Head	.00	7.70	3.81	11.51
9 Tail	.00	.00	12.99	12.99
10 Head	.00	4.31	11.17	15.48
10 Tail	.28	7.80	17.25	25.33
11 Head	.00	5.06	3.95	9.01
11 Tail	.00	8.71	7.44	16.15
12 Head	.93	6.48	3.09	10.50
12 Tail	1.52	9.39	4.55	15.46
13 Head	.11	6.43	6.12	12.66
13 Tail	.00	18.22	10.87	29.09
14 Head	1.72	9.94	3.33	14.99
14 Tail	.00	5.89	7.50	13.39
15 Head	.00	4.96	4.49	9.45
15 Tail	.18	5.37	10.41	15.96

Table 12. Number of farmers on distributary participating in the evaluation exercise (n=304).

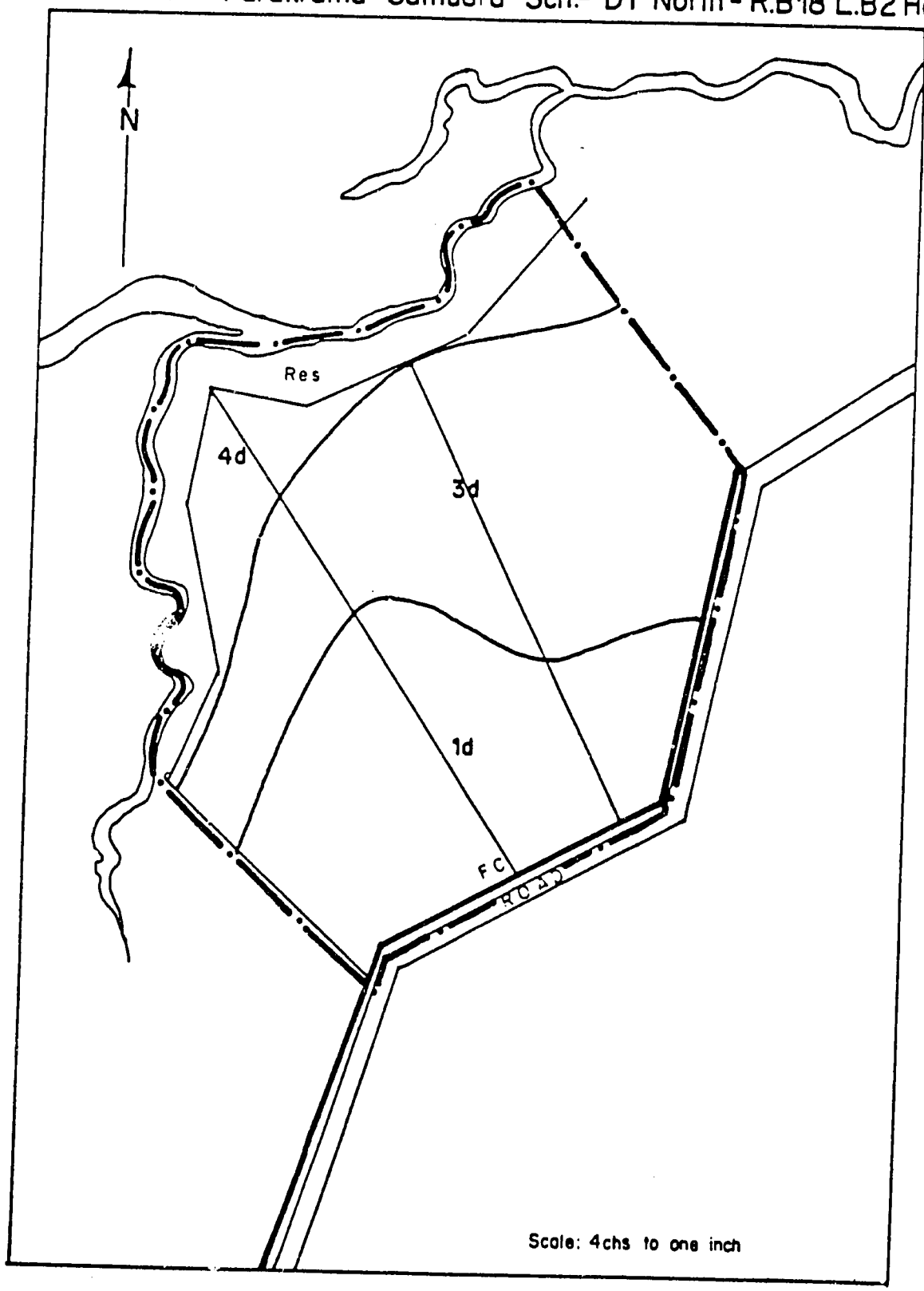
Distributary	Farmers Participating in Evaluation Exercise		Total Number of Farmers on the Distributary
	Number	Percent	
1	20	27*	73
2	24	19	125
3	25	33	76
4	30	22	135
5	13	43	30
6	20	31	65
7	25	19	131
8	15	29	51
9	14	29	49
10	21	27	77
11	22	24	91
12	12	27	44
13	24	31	78
14	15	19	79
15	24	32	74

*In the computation of index scores for management capacity, distributary problems, and willingness to support water users associations in the future, there was no significant correlation observable between the percentage of farmers participating in the evaluation exercise on a given distributary and the composite index values for these three variables.

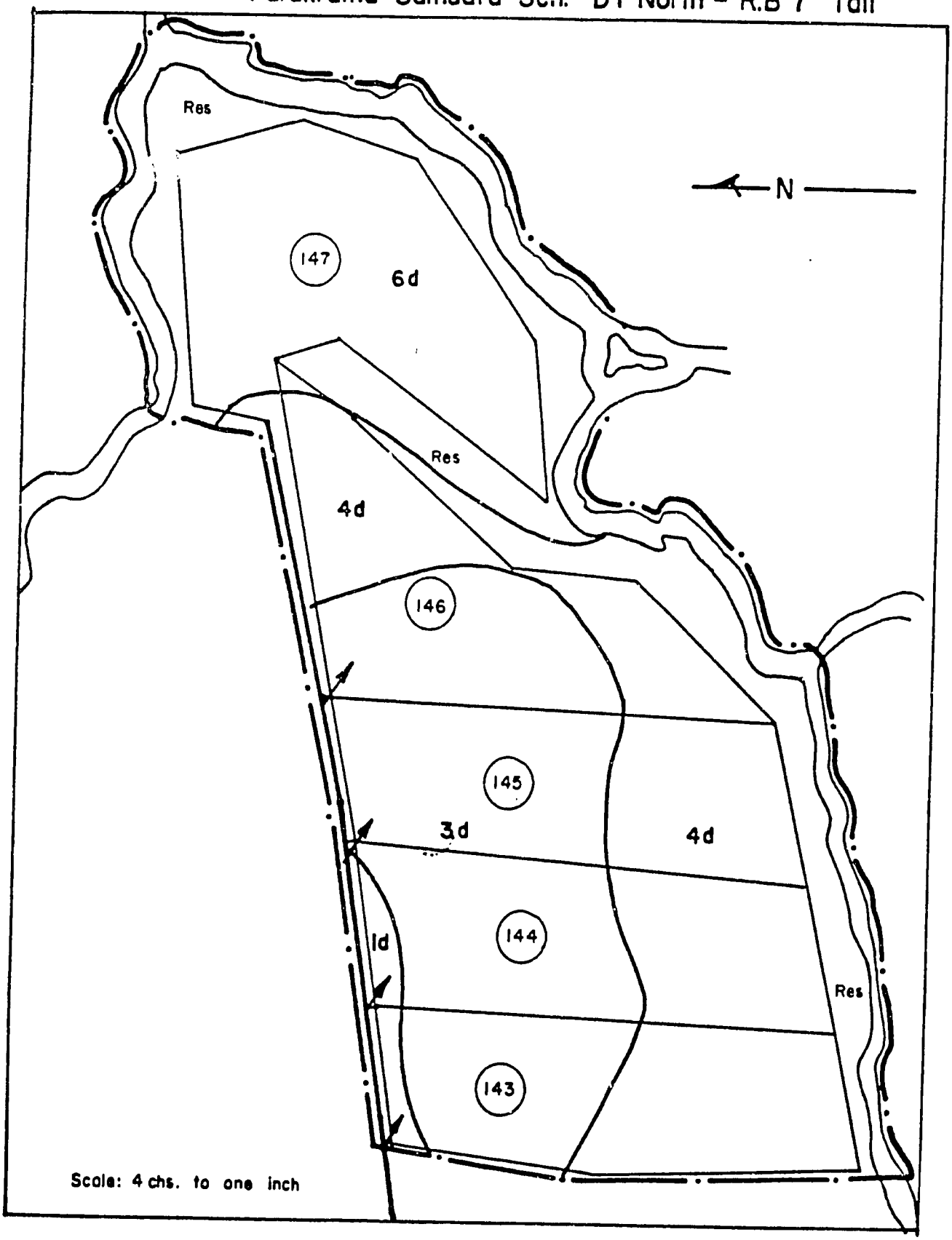
APPENDIX G

SOIL SURVEY MAPS FOR SAMPLE RESEARCH BLOCKS

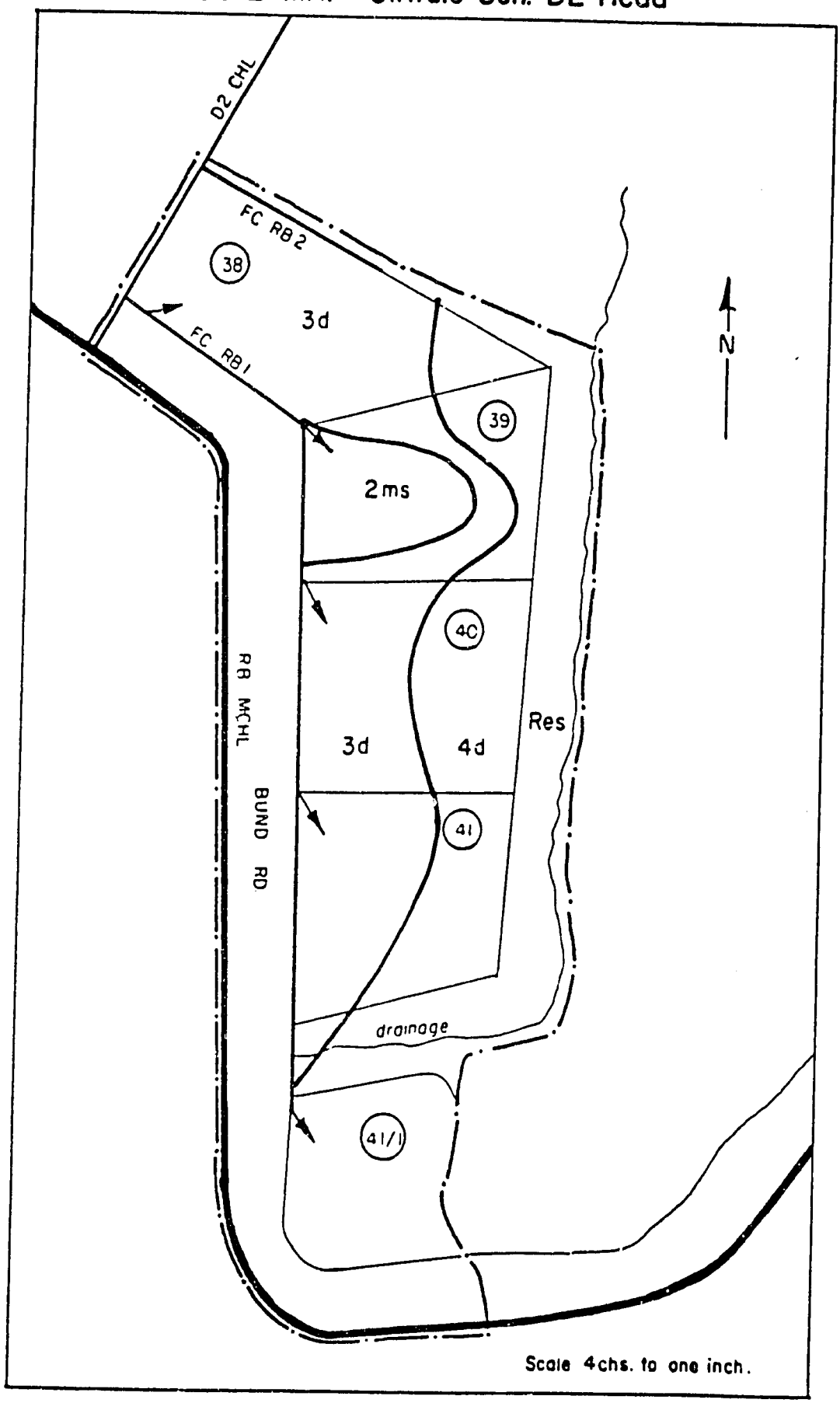
SOIL MAP - Parakrama Samudra Sch.- D1 North - R.B18 L.B2 Head



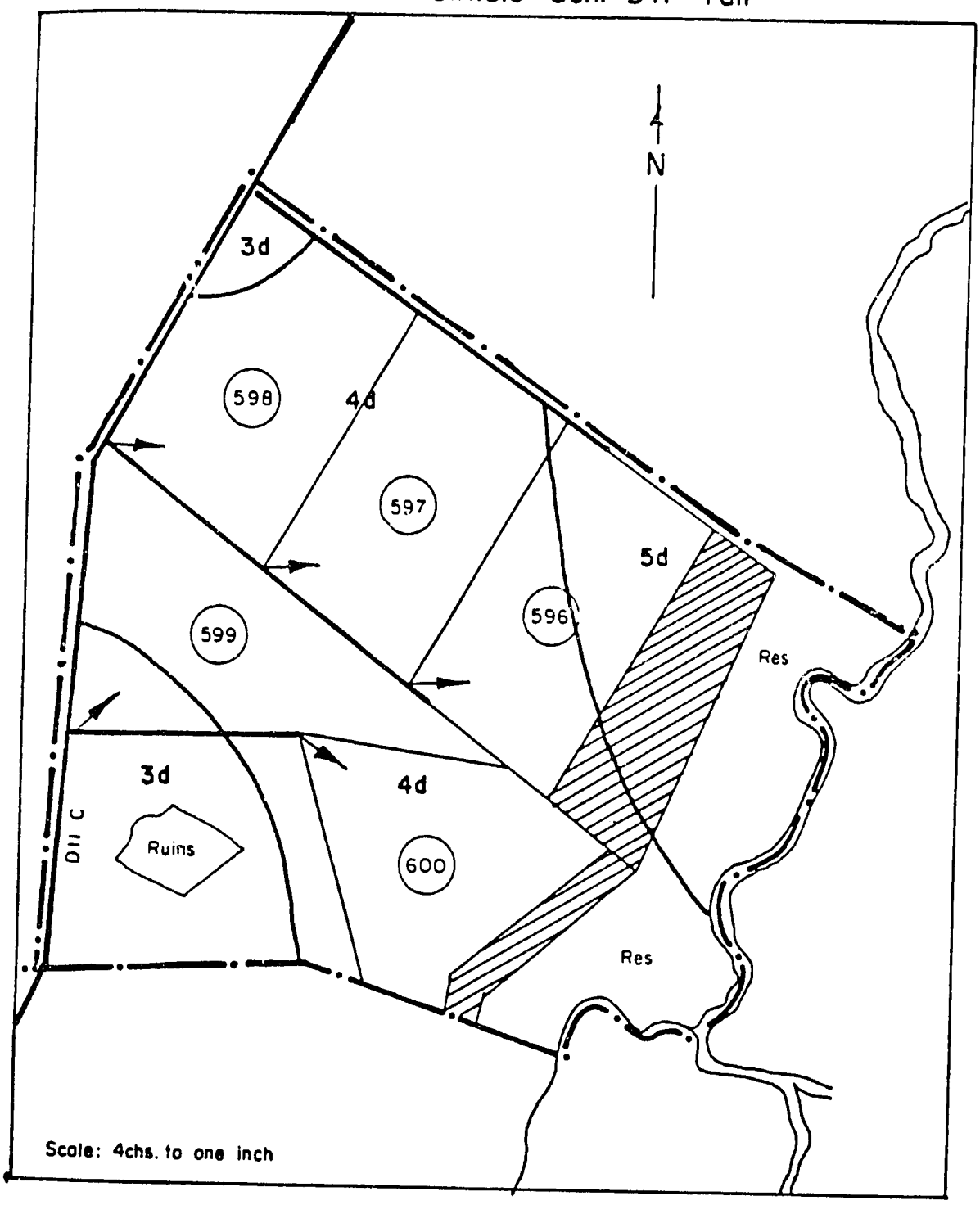
SOIL MAP - Parakrama Samudra Sch. - D1 North - R.B 7 Tail



SOIL MAP-Giritale Sch. D2 Head

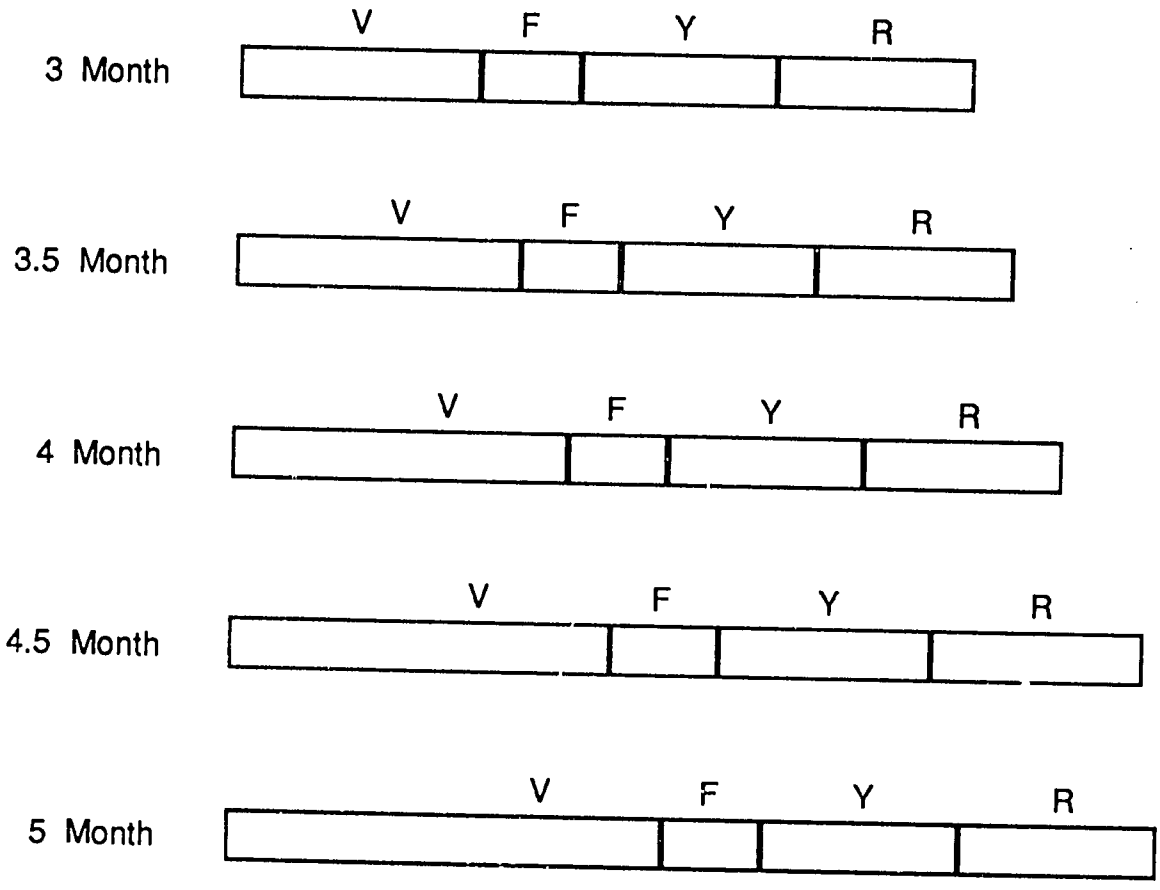


SOIL MAP - Giritale Sch. D11 Tail



APPENDIX H

VARIETIES OF PADDY CULTIVATED IN THE DRY ZONE



V = Vegetative Phase
F = Flowering Phase
Y = Yield Formation Phase
R = Ripening Phase

APPENDIX I

FORMULA FOR CALCULATING CRONBACH'S ALPHA FROM "MEASUREMENTS IN SOCIAL SCIENCES" BY ZELLER AND CARMINES

$$x = \frac{a}{a-1}\left[1 - \frac{a}{a+2b}\right]$$

a = number of indicants in the composite.
b = sum of the correlations among the indicants

Cronbach's alpha/measurement capacity

$$x = \frac{5}{5-1}\left[1 - \frac{5}{5+2(2.1528)}\right]$$

$$= \frac{5}{4}\left[1 - \frac{5}{9.3056}\right]$$

$$= 1.25\,[1 - .5373]$$

$$= .5784$$

Source: Zeller and Carmines. 1980. Measurements in social sciences. Cambridge University Press. p. 56.

APPENDIX J

WATER MANAGEMENT ISSUES AND ANALYSES IN SRI LANKA

Several researchers have studied Sri Lankan irrigation systems with a concern for making improvements in water delivery efficiencies and inequitable treatment of farmers. They have suggested possible approaches for improving irrigation systems, ranging from administrative initiatives to "grass roots" development of farmer associations. However, their approaches to rectification have varied widely. The purpose of this appendix is to provide a brief review of the analyses offered by a few such individuals.

We begin by acknowledging a debt to Robert Chambers (1977; 1978) who investigated water management issues and problems in Sri Lanka and identified numerous social and environmental costs and consequences of further irrigation development in the Dry Zone. Chambers was optimistic about the potential for reviving old indigenous institutions of water management as a development strategy. The research effort in Sri Lanka reported in this study was greatly inspired by questions he so forthrightly advanced.

John Harriss

Many observers have focused on the impact of the political ideology and government policies toward the initiation of settlement schemes (Farmer, 1957; Chambers, 1978). Harriss (1977, 1984) raised the importance of ideology as an independent variable in settlement development policy in Sri Lanka, which was viewed as leading to a set of social conditions of production (the intervening variable) affecting the capacity of farmers to engage in collective action to improve agricultural production (the dependent variable). In particular, these social conditions have become obstacles for collective action to resolve maintenance problems and equitable water distribution. Thus, according to Harriss, the ideology of settlement policy has contributed to adverse social conditions of production and has served to obscure those conditions.

Harriss argued that there are a number of factors which have contributed to the inability of settlers to engage in collective action: 1) the heterogeneity of the colonists in terms of caste memberships and other traditional social divisions such as settlement patterns, 2) settler dependence on government administration, and 3) the nature of land tenure policy. He further observed the impact of organizational culture of government bureaucracies on the rural sector, with their top-heavy paternalism and departmentalism. These are treated primarily as "sufficient" causes for the lack of collective action.

For Harriss, culture is the primary factor contributing to capacity for water management collective action in traditional, socially cohesive village tanks (wewa) of the Wet Zone. It is noted that collective action

is not a product of distinct and localized interest formation in the agricultural sector, but rather a natural by-product of the inner strength of traditional Sinhalese culture. Therefore, relevant ministries attempt to transmit the solidarity of traditional village life in the Wet Zone to the Dry Zone.

The indigenous system of sharing water during periods of drought (bethma), has received greater attention by Sri Lankan policy-makers and water management specialists. This practice of water sharing can take at least three different forms: 1) only a portion of irrigated land under a village tank is cultivated during periods of water shortage, 2) tail-end farmers operate as tenants on the land of head-end farmers during drought periods, or 3) the total of agricultural production is shared by the villagers at the end of the season. This provides an example of the successful social organization of village irrigation work (not taken from the observations of Harriss).

Government administrators have, therefore, considered bethma as an appropriate collective practice for sharing water in the settlement schemes. The Irrigation Department has introduced similar practices during periods of water shortage and frequently cite local examples of its successful implementation.

Leach (1961) suggested that bethma may be an invention of government agents during the early years of British colonial rule. It is noteworthy that Pieris (1956) uses Brodie's description in 1856 as verification of bethma's historical authenticity and states in a footnote that Ievers "found that this [form of] common cultivation was very unusual in 1892, and it is never practiced today." Perera (1985) implies that bethma may have been mainly a custom for insuring a guaranteed supply of seed paddy for villagers during periods of drought. It seems, therefore, that the origins of bethma are obscure, and bethma may not be successful as a water management practice.

According to Harriss, the social conditions of production includes: 1) small-scale production in fragmented landholdings, 2) disruptive settlement patterns, 3) insecure land tenure patterns, 4) heavy dependency on government-sponsored agricultural programs, and 5) the failure of the government to promote democratic institutions in the rural sector.

Harriss states that water is wasted due to poor system design and the lack of volumetric measuring. Poor soils and staggered cultivation patterns further contribute to inefficient use of water. In addition, weak institutional structures and adverse political intervention lead to a kind of anarchy in water management below the tank sluice. These social conditions of production lead to the self-fulfilling prophesy of the "uncooperative farmer" who has become unfaithful to the traditional customs and values of Wet Zone village life.

Harriss (1984, p. 336) did not suggest a particular social change to address these disruptive social conditions, but indicated the need to improve water management in Sri Lanka. Greater flexibility in the allocation of water, and water management practices in general, must be

developed. Finally, he argued that the Irrigation Department needs to be reformed.

Harriss further contended that consultants frequently overemphasize the capacity of water user associations to solve some of these problems in the absence of a simultaneous reform of broader institutional structures in the rural sector. Water user associations alone will not solve the "settlement problem".

Harriss does not provide details of how a broader institutional reform might be implemented, but he has defined and articulated the problem. Harriss analyzes the role of water user associations only in passing. There may be two reasons. First, there is the disillusion over the government's attempts to initiate collective, self-management of irrigation schemes. Organizations in the rural sector have been controlled by rural elites and political party leaders. Secondly, Harriss may be taking it as a forgone conclusion that such organizations will tend to fail unless the social conditions of production are first addressed.

In summary, Harriss has observed that ideology obstructs serious efforts of the government to address present social conditions of production, which prevent farmers from developing water user associations.

Mick Moore

For Moore (1980, 1981, 1983, 1984), the organizational culture of the Irrigation Department is the major independent variable affecting water management in Sri Lanka. The major policy recommendation is that bureaucratic reform should be conducted on behalf of Irrigation Department personnel directly involved in water management. Robert Wade (1979, 1980, 1982), examining Indian conditions, also emphasized the importance of bureaucratic reform in the domain of water management. There are many similar characteristics in respect to the role of the central irrigation bureaucracy in Sri Lanka and India (Malhotra, 1982).

Moore (1981) identified two interrelated problems for Sri Lankan water management: 1) attempts to organize farmers to improve water management have usually been top-down and have multiple objectives (i.e., community cultivation committees), and 2) the irrigation bureaucracy should be reformed in order to improve water deliveries, smooth relations between local Irrigation Department officials and farmers, and reduce the conflict between farmers.

Moore (1980, p. 22; 1981, p. 119) stated, however, that demand-type organizational arrangements for water distribution, such as those found in the United States and Spain, have little relevance in Sri Lanka due to the size of landholdings and poor communication. Furthermore, he suggested that there are unique cultural and social factors which negatively affect farmer organizations in Sri Lanka.

The major problem, according to Moore, is the organizational culture of the Irrigation Department. There are four aspects of this organizational culture that, in his opinion, should be reformed. The first is

the "social distance" between Irrigation Department personnel and farmers due to educational background, ideology, and values (urban versus rural). Moore argues that the distance may be reduced by improving the work conditions and increasing the length of assignments for Irrigation Department personnel. Currently, personnel are frequently rotated out of a service area before they have an opportunity to understand local water management problems and gain acceptance in the local community.

The second aspect of the organizational culture which requires some reform is the lack of internal communication within the Irrigation Department. Communication procedures are excessively formal and contribute to poor working relationships between senior and junior level staff officers. The third aspect of reform is the evaluation of personnel skills. Moore emphasized the need for specific training in water management, particularly for junior personnel.

Finally, the fourth aspect of reform is providing incentives for good work. According to Moore, the Irrigation Department has greater skills in design and construction of irrigation works than in water management. There is a great need to de-emphasize promotions based on "highly visible tasks" such as improving concrete structures. Moore believes that officials could be rewarded for innovation in local water management procedures, with farmer support and participation.

Moore states (1981, p. 122) that several management practices of the Irrigation Department should be improved: 1) proper scheduling of land preparation activities and water supply, 2) making reliable water measurements and controlling and managing headgates, and 3) implementing water allocation rules and enforcing sanctions against rule-breakers. Moore draws special attention to the need for water user associations to insure more reliable water supplies from the Irrigation Department. Rights and responsibilities between farmers and the Irrigation Department need to be defined.

Moore has stated the current water management problem candidly:

> "If staff fail to deliver water, farmers have recourse only to the blunt and destructive weapons of destroying control structures or calling on politicians, whose interest is unpredictable, and whose interference saps further the morale of the irrigation staff.
>
> Correspondingly, if farmers destroy or do not perform maintenance work on canals, irrigation staff only have recourse to the very ineffective and unpredictable weapons of denying water or prosecution. And these may incur the wrath of politicians. If the problem is recognized as one of lack of bargaining potential, then it seems much more important to pursue the strategy mentioned above: to promote farmers' groups able to barter local level channel maintenance and water distribution against guaranteed supplies of water." (1981, p. 132)

"Lack of formally recognized institutions does not imply lack of collective action [by farmers]. The policy implication is that the legal and procedural provisions for farmer's groups ought to be formulated and implemented in as flexible a way as possible in order to "capture" within the formal institutions as much informal collective activity as possible." (1980, p. 23)

Norman Uphoff

Uphoff (1985a) has addressed the issue of improved water management below the settlement tank sluice -- the middle management level -- at the Gal Oya project in Sri Lanka. In this irrigation rehabilitation project, the social change strategy was and is to form water users associations by mobilizing farmers at the field channel level, which is a variation on the development strategy implemented in the Philippines (Bagadion and Korten, 1985). Experiences of the two efforts have been informally shared. The explanatory independent variable seems to be the effect of local elite power structures on farmer collective action for water management. One of the key objectives of the participatory approach is to break down, or otherwise neutralize, rural elite power structures that potentially obstruct collective action for better water management.

Uphoff observed the negative impact of the independent variable on collective action for water management. He believes that rural power elite structures, cultural norms and values related to village cooperation, traditional attitudes toward authority, and the problem of the "free rider" at the head of the watercourse (Uphoff and Wijayratne, N.D.), can be overcome through a "mobilization of consciousness" among farmers. This mobilization of consciousness, in turn, is achieved by implementing a "learning process" developmental approach.

Uphoff indicated six guidelines:

1. Use community organizers (government employees) to meet with farmers and develop "grass roots" interest and initiatives in collective action for water management.

2. Proceed from informal to formal associational initiatives gradually, in order to gain self-confidence.

3. Initiate collective action at the lowest hydrological level (the field channel), and then organize collective action at the next level.

4. Formal associations should be related to hydrological boundaries.

5. Water user associations should serve multiple objectives.

6. Water user associations need to be formed during rehabilitation efforts, not subsequent to them.

The Irrigation Department was given the major responsibility for initiating such organizations at Gal Oya Project, but it was not clear how farmers participated in the process. Although formal organizational arrangements for water management below the tank sluice was clearly recognized, Uphoff suggests a flexible learning process for farmers. He stated that farmers must settle water difficulties at the field channel level. (Uphoff and Wijayratne, N.D., p. 26-27).

In the first phase of this process, informal committees of farmers along each field channel were formed. These committees then selected a field channel representative to supervise water distribution along the distributary. A representative from the distributary would then participate on a committee at the system level. This process leads to a multi-tiered, federated organizational structure with strong vertical and horizontal linkages of influence and power. (A similar strategy was used in Pakistan in the late 1950s; see Hasan, 1960.) The multi-tiered organizational design was implemented during the Gal Oya rehabilitation effort in order to circumvent negative attributes of rural elite power structures.

In addition, Esman and Uphoff (1984) and Uphoff (1986), amassed case studies from several countries to investigate whether this developmental strategy was theoretically, as well as pragmatically, sound. The results suggested that several aspects of this developmental strategy were clearly successful elsewhere, but further investigations were seen to be required.

The experience at Gal Oya and Minipe has been a learning experience for the Irrigation Department, farmers, and implementors. The Irrigation Department borrowed the concept of a multi-tiered, federated organizational structure, with the intention of building such organizations in other settlement schemes. This can be considered an important step in making the transition from centrally administered to decentralized organizational arrangements for water management in Sri Lanka. Farmers have shown a willingness to participate in water management and maintenance activities when assistance of community organizers have been provided to link to the Irrigation Department (Ganewatte, 1985).

However, there are major difficulties in implementation. The Irrigation Department views the effort with some ambiguity, since the process does not necessarily include specification of rights and obligations for both farmers and the Irrigation Department. There also have been difficulties in maintaining an experienced set of community organizers (who were originally under the supervision of the Agrarian Research and Training Institute, but were later placed under the supervision of the Irrigation Department). Furthermore, budget allocations have not been adequate.

There has been no policy toward establishing some form of organizational property rights or use rights to water or to irrigation structures, nor toward determining a water allocation share system by a water user association. Finally, there is no legal backing to form such associations.

Uphoff (1985a, p. 137) stated that the Gal Oya project has generated important lessons for a "inductive, processual, learning" social change strategy. There is, he contends, a strong need to involve farmers in organizational activities "who would otherwise be pushed out of the picture by more influential farmers, if an attempt to create formal organizations began right away." Uphoff further observed that collective action at the field channel level tended to reduce influence of influential farmers, thereby contributing to higher levels of participation and the emergence of egalitarian ideals.

Uphoff (1985a, p. 49) also reported that farmers favor legal recognition of their organizational efforts. Apparently some farmers have been concerned about the delay in formalization of their committees, and "there have been requests from farmers for some model bylaws or constitutions." Farmers seek organizational buffers to protect them from pressures of more influential people.

Major Assumptions of the Gal Oya Project Approach. Gal Oya experiences have important implications for the development of water user associations in the future at the middle management level. Rural culture in Sri Lanka is characterized by a normative opposition to decision-making through voting. Uphoff (1985b, p. 150) argues that there is a normative preference for working "towards consensus rather than majority voting." This implies the kind of organizational process envisioned for leadership selection and decision-making in water user associations. Uphoff argues that there has been a long history of failure of more formal farm organizations. Therefore, informal organizational structures, at least in the initial stages of association development, are preferred (1985b, p. 151). This has important implications for the potential organizational designs of water user associations.

Uphoff and Wanigaratne (1982) reviewed the successes and failures of rural development societies and agricultural cooperatives. They concluded that such organizations are weak primarily because of extensive control by the central government. Individuals in important positions in rural development societies and cooperatives were appointed on the basis of upstream political loyalties, resulting in the lack of community participation in these organizations.

Robert Oberst (1986) has reported that there is a direct relationship between political appointments to rural organizations and the degree to which such organizations experience low levels of participation. He noted that leaders of cooperatives were usually the same as the leaders of rural development societies, and that they were "elected" to office because of their strong ties to influential villagers and the local Minister of Parliament (Oberst, 1986, p. 108).

The political appointments of presidents or managers in organizations leads to political factionalism within the organizations, as well as within the community. Abeyrama and Saeed (1934, p. 26) stated that "political factionalism is quite commonly observed in government-regulated organizations in Sri Lanka, such as cooperative societies and rural development societies." Low attendance at meetings, irregularly held meetings, and poor access to information about cooperative budgets and

purchasing decisions appear to be the result of the control of these formal organizations by politically appointed managers.

OTHER ORGANIZATIONAL EFFORTS

Several studies in Sri Lanka address current water management problems and the potential for institutional improvements. The strategy of organizing farmers in System H of the Mahaweli Development Program has been to use a centrally administered training program in water management and agricultural extension. The major objective of the program is farmer involvement in water distribution at the secondary and tertiary levels through water user associations (Ganewatte, 1986; Karunatilake, 1986).

Turnouts usually serve a dozen farmers irrigating 30 or more acres. The development strategy is to teach farmers to coordinate group farming practices under "collective" turnouts and to cooperate with each other in the allocation of water below the tertiary turnout (Jayawardene, 1986).

There have been recent attempts to federate these groups into distributary channel organizations, but with variable success. Furthermore, much criticism has been leveled at the current conceptualization, which requires turnout groups to perform both water management functions and those of community development or agricultural extension (Scudder and Wimaladharma, 1981-85). Planners and policy makers seem to express a preference for multi-purposed organizations in the context of achieving higher goals in newly constructed irrigation settlement schemes. Yet, there is little evidence to support the view that multi-purpose water management organizations are superior (Coward, 1980).

A small tank Irrigation Rehabilitation Program has been initiated by the central government recently (Shyamala, 1986). It is reported that tank rehabilitation committees consist primarily of government officials "looking upward" to their administrative superiors rather than the needs of farmers.

The tank committee format is a standardized "blueprint" approach, in which the rehabilitated tank becomes essentially an extension of state agricultural production management in the village. Community participation in such rehabilitated efforts is lacking, and property rights or water use rights are virtually non-existent.

> "It appears that the problem for VIRP arises because it expects the kind of farmer involvement or participation...that can emerge only if certain prior conditions conducive to farmer/community participation are met. But in a situation where local organizational capacity is hardly involved in the different phases of system rehabilitation and development, and therefore called upon only for undertaking irrigation-related tasks with little concomitant decision-making responsibility, it is difficult to expect effective farmer participation that is at the

same time self-reliant and self-sustaining and willing to take on future responsibility for system operation and maintenance." (Shyamala, 1986, p. 144).

Various governmental and non-governmental agencies and foreign foundations are involved in community development efforts with village tank restoration (Wimaladharma, 1986). Emphasis is placed on involving farmers in the planning of water distribution, adjusting cropping patterns, and providing financial assistance and technical training for farmers in the interest of promoting self-reliance.

Lundqvist, Karunanayake, Alwis, and Gunasekera

The political economy of development is regarded as the independent variable explaining the lack of collective action in water management (Lundqvist, 1986; Karunanayake, 1982; Alwis, 1986; and Gunasekera, 1982). These analysts recognize the profound impact of settlement ideology, the organizational culture of bureaucracies, and the power of rural elites on collective action of farmers.

Lundqvist (1986) advocates a policy to promote intermediary organizations between the farming community and the bureaucracy. He notes the important contribution made by central government institutions in promoting rural development and agricultural production in Sri Lanka since World War II. However, central government controls productions inputs through agricultural officers and political appointments to rural cooperatives. The important role of politics is a direct outcome of the linkage between the allocation of agricultural inputs (particularly seed, fertilizer, chemicals, and credit) and the party affiliation of the organizational leadership. Lundqvist's solution is to promote the development of intermediary institutional structures that restore the balance of power between farmers and the administrators of agricultural inputs, including water:

> "The importance of having some intermediary institution or system between farmers on the one hand and officials and the urban system on the other hand is obvious. In the case of Sri Lanka and in other places, there have been various arrangements to cater for this need. Today, a lot of efforts are made to find solutions to this problem and the creation of farmer leaders [in the settlement schemes] is one attempt to do so. But it appears that a starting point in the discussion must be the power relations between the two poles, to which the intermediary institution is supposed to be connected. In the present context where the officials and the whole political establishment have a very strong position, it is fairly unrealistic to expect the farmer leaders to work successfully from the perspective of the farmers as a community demanding various concessions from the officials. It would seem important to focus on the very control aspects of a [irrigation] scheme and not only the formal arrangements for its operation." (Lundqvist, 1986, p. 68)

Karunanayake (1982), Alwis (1986), and Gunasekera (1982) advocated a development strategy of strengthening water institutions in the rural sector. Water management is defined as the institutionalization of local water tribunals, the development of effective water users associations at the local level, and adoption of an equitable water pricing policy to cover a fair portion of the costs incurred by the central government in developing water resources. They perceive these three institutional developments as being critical to the improvement of water management procedures in the future (Karunanayake, 1982; Alwis, 1986; Gunasekera, 1982). Implementation strategies for improving water management, such as the federated project subcommittees sponsored by the Irrigation Department, represent top-down approaches "utilized as channels of government policy and programmes" (Alwis, 1986, p. 98). The equitable distribution of water is strongly related with the strengthening of property rights to water through water users associations.

Gunasekera (1982, p. 104) states that historically there was "an apparent richness of rules" of allocation, maintenance, and dispute settlement; a great country-wide diversity which has been "lost sight of by current water management policies" and Irrigation Ordinance enactments promulgated in a standardized manner to serve many different and uniquely complex irrigation situations throughout the country.

REFERENCES

Abeyrama, T. and K. Saeed. 1984. The gramadaya mandalaya scheme in Sri Lanka: participatory development or power play. Community Development Journal. 19(1).

Alwis, J. 1986. Irrigation legislation and participatory management. In: Kanday (ed.). Participatory Management in Sri Lanka's Irrigation Schemes. Sri Lanka: International Irrigation Management Institute. pp. 29-39.

Bagadion, B.U. and F.K. Korten. 1985. Developing irrigators' organizations: a learning process approach. In: Cernea, M. (ed.). Putting People First: Sociological Variables in Rural Development. World Bank, Oxford University Press. pp. 52-90.

Chambers, R. 1977. Man and water: the organization and operation of irrigation. In: Farmer, B.H. (ed.). Green Revolution: Technology and Change in Rice Growing Areas of Tamil Nadu and Sri Lanka. Boulder, Colorado: Westview Press. pp. 340-363.

Chambers, R. 1978. Water management and paddy production in the Dry Zone of Sri Lanka. Occasional Publication #8. Colombo: Agrarian Research and Training Institute.

Coward, E.W. 1980. Irrigation and agricultural development in Asia. Ithaca, NY: Cornell University Press.

Esman, M.J. and N. Uphoff. 1984. Local organizations: intermediaries in rural development. Ithaca, NY: Cornell University Press.

Farmer, B.H. 1957. Pioneer peasant colonization in Ceylon. London: Oxford University Press.

Ganewatte, P. 1985. Farmer participation in planning, construction and management of irrigation systems. Paper prepared for IIMI-EDI course on the planning and management of irrigation systems. Digana: Sri Lanka.

Ganewatte, P. 1986. Farmer training programs. In: Kanday (ed.). Participatory Management in Sri Lanka's Irrigation Schemes. Digana, Sri Lanka: International Irrigation Management Institute.

Gunasekera, W. 1982. The role of traditional water management in modern paddy cultivation in Sri Lanka. Marga. 6:69-123.

Harriss, J. 1977. Problems of water management in Hambantota District. In: Farmer, B.H. (ed.). Green Revolution? Technology and Change in Rice-Growing Areas of Tamil Nadu and Sri Lanka. Boulder, Colorado: Westview Press. pp. 364-376.

Harriss, J.C. 1984. Social organization and irrigation: ideology, planning, and practice in Sri Lanka's settlement schemes. In: Bayliss-Smity, T.P. and S. Wanmali (eds.). Understanding Green Revolutions: Agrarian Change and Planning in South Asia. Cambridge: Cambridge University Press. pp. 315-338.

Hasan, M.a.s.u.d.-U.L. 1960. Law and principles of basic democracies. Lahore, Pakistan: Social Service Foundation.

Jayawardene, J. 1986. The training of Mahaweli turnout group leaders. In: Kanday (ed.). Participatory Management in Sri Lanka's Irrigation Schemes. Digana, Sri Lanka: International Irrigation Management Institute.

Karunanayake, M.M. 1982. Some issues in irrigation management in settlement schemes in Sri Lanka. In: Wimaladharma, K. (ed.). Land Settlement Experiences in Sri Lanka. Colombo: USAID and the Ministry of Lands and Land Development.

Karunatilake, T.H. 1986. Farmer participation in water management in the Mahaweli Project. In: Kanday (ed.). Participatory Management in Sri Lanka's Irrigation Scheme. Digana, Sri Lanka: International Irrigation Management Institute.

Leach, E.R. 1961. Pul Eliya: a village in Ceylon. Cambridge University Press. p. 169-171.

Lundqvist, J. 1986. Irrigation development and central control: some features of Sri Lankan development. In: Norland, I. et al. (eds.). Rice Societies: Asian Problems and Prospects. Studies on Asian Topics No. 10. Scandinavian Institute of Asian Studies. Curzon Press: The Reverdale Co.

Malhotra, S.P. 1982. The warabandi and its infrastructure. Publication No. 157. Central Board of Irrigation and Power. New Delhi: Malcha Marg, Chanhyapuri.

Moore, M.P. 1980. Approaches to improving water management on large-scale irrigation schemes in Sri Lanka. Occasional Papers. Colombo, ARTI.

Moore, M.P. 1981. The sociology of irrigation management in Sri Lanka. Water Supply and Management. 5:117-133.

Moore, M.P. et al. 1983. Space and the generation of socio-economic inequality on Sri Lanka's irrigation schemes. Marga. 7(1):1-32.

Moore, M.P. 1984. Categorizing space: urban-rural or core-periphery in Sri Lanka. Journal of Development Studies. 20:102-122.

Oberst, R.C. 1986. Legislators and representation in Sri Lanka: the decentralization of development planning. Boulder, Colorado: Westview Press.

Perera, J. 1985. Change and settlement: a portrait of a Sri Lankan village. Colombo: Agrarian Research and Training Institute. p. 33-34.

Pieris, R. 1956. Sinhalese social organization. Colombo: Ceylon University Board Press.

Scudder, T. and K. Wimaladharma. 1981-85. The accelerated Mahaweli programme (AMP) and Dry Zone development: some aspects of settlement. Reports 3, 4, 5.

Shyamala, A. 1986. State interaction in irrigation development: the village irrigation rehabilitation project. In: Kandy (ed.). Participatory Management in Sri Lanka's Irrigation Schemes. Digana, Sri Lanka: International Irrigation Management Institute.

Uphoff, N. 1985a. People's participation in water management: Gal Oya, Sri Lanka. In: Garcia-Zamor, J.C. (ed.). Public Participation in Development Planning and Management: Cases from Africa and Asia. Boulder, Colorado: Westview Press.

Uphoff, N. 1985b. Fitting projects to people. In: Cernea, M. (ed.). Putting People First: Sociological Variables in Rural Development. World Bank, Oxford University Press.

Uphoff, N. 1986. Getting the process right: improving irrigation water management with farmer organization and participation. A Working Paper at Cornell University for the Water Management Synthesis II Project. Ithaca, NY: Cornell University.

Uphoff, N. and R.D. Wanigaratne. 1982. Local organization and rural development in Sri Lanka. In: Uphoff, N. (ed.). Rural Development and Local Organization in Asia. India: MacMillan.

Uphoff, N. and C.M. Wijayratne. N.D. Optimum participation in water management: issues and evidence from Sri Lanka. Ithaca, NY: Cornell University. Mimeo.

Wade, R. 1979. The social response to irrigation: an Indian case study. Journal of Development Studies. 16(91):3-26.

Wade, R. 1980. India's changing strategy of irrigation development. In: Coward, E.W. (ed.). Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences. Ithaca, NY: Cornell University Press.

Wade, R. 1982. The system and administrative and political corruption: canal irrigation in South India. The Journal of Development Studies. 8(3):287-325.

Wimaladharma, K.P. 1986. Participatory management in irrigation projects: the unfinished experiment in Sri Lanka. In: Kanday (ed.). Participatory Management in Sri Lanka's Irrigation Schemes. Digana, Sri Lanka: International Irrigation Management Institute.

APPENDIX K

GLOSSARY OF ABBREVIATIONS AND TERMS

ad hoc	for the particular purpose at hand, without reference to wider application
APC	Agricultural Productivity Committee
cusec	cubic feet per second
de facto	actual operation
DENSITY	a variable: the number of irrigators per acre along a distributary
DRWS	a variable: seasonal water supply for each sample distributary command area
FARMSIZE	a variable: the size of the sample farms
gamsabhava	village tribunal
ganga	river
grama sevaka	a government officer
gramodaya mandalaya	village development council
ha	hectare
IMD	Irrigation Management Division
INVEST	a variable: the rupee investment in fertilizer and chemicals per acre for each sample farm
Kachcheri	district government agent's office
kanna	cultivation meeting
km	kilometer
LOCATION	a variable: location of the 82 sample farms in terms of head/tail position, slope, and soil criteria
maha	wet season; October to March

pradeshiya mandalaya	regional development council
rata subhava	a special council summoned by important citizens and officials in the Kandy-Kingdom district when a local gamsabhava could not come to a resolution
Rs.	rupees
TENANCY	a variable: percent of tenant irrigators below the distributary headgate
UPN	United National Party
USAID	United States Agency for International Development
vel vidane	elected official within Agrarian Services, who distributes water at the distributary level in an irrigation system
WEEDS	a variable: weed problems found on each sample farm
WUA	water users association
yala	dry season; April to September
yaya	paddy
yaya palaka	paddy tract manager

APPENDIX L

LIST OF WATER MANAGEMENT SYNTHESIS PROJECT REPORTS

WMS 1	Irrigation Projects Document Review Executive Summary Appendix A: The Indian Subcontinent Appendix B: East Asia Appendix C: Near East and Africa Appendix D: Central and South America
WMS 2	Nepal/USAID: Irrigation Development Options and Investment Strategies for the 1980s
WMS 3	Bangladesh/USAID: Irrigation Development Options and Investment Strategies for the 1980s
WMS 4	Pakistan/USAID: Irrigation Development Options and Investment Strategies for the 1980s
WMS 5	Thailand/USAID: Irrigation Development Options and Investment Strategies for the 1980s
WMS 6	India/USAID: Irrigation Development Options and Investment Strategies for the 1980s
WMS 7	General Asian Overview
WMS 8	Command Area Development Authorities for Improved Water Management
WMS 9	Senegal/USAID: Project Review for Bakel Small Irrigated Perimeters Project No. 685-0208.
WMS 10	Sri Lanka/USAID: Evaluation Review of the Water Management Project No. 383-0057.
WMS 11	Sri Lanka/USAID: Irrigation Development Options and Investment Strategies for the 1980s
WMS 12	Ecuador/USAID: Irrigation Sector Review
WMS 13	Maintenance Plan for the Lam Nam Oon Irrigation System in Northeast Thailand
WMS 14	Peru/USAID: Irrigation Development Options and Investment Strategies for the 1980s

WMS 15	Diagnostic Analysis of Five Deep Tubewell Irrigation Systems in Joydebpur, Bangladesh
WMS 16	System H of the Mahaweli Development Project, Sri Lanka: 1982 Diagnostic Analysis
WMS 17	Diagnostic Analysis of Farm Irrigation Systems on the Gambhiri Irrigation Project, Rajasthan, India: Volumes I-V
WMS 18	Diagnostic Analysis of Farm Irrigation in the Mahi-Kadana Irrigation Project, Gujarat, India
WMS 19	The Rajangana Irrigation Scheme, Sri Lanka: 1982 Diagnostic Analysis
WMS 20	System H of the Mahaweli Development Project, Sri Lanka: 1983 Diagnostic Analysis
WMS 21	Haiti/USAID: Evaluation of the Irrigation Component of the Integrated Agricultural Development Project No. 521-0078.
WMS 22	Synthesis of Lessons Learned for Rapid Appraisal of Irrigation Strategies
WMS 23	Tanzania/USAID: Rapid Mini Appraisal of Irrigation Development Options and Investment Strategies
WMS 24	Tanzania/USAID: Assessment of Rift Valley Pilot Rice Project and Recommendations for Follow-On Activities
WMS 25	Interdisciplinary Diagnostic Analysis of and Workplan for the Dahod Tank Irrigation Project, Madhya Pradesh, India
WMS 26	Prospects for Small-Scale Irrigation Development in the Sahel
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