A Case Study of Irrigation Water Management at Kaudulla Irrigation Scheme and Development of Water Management Alternatives for the Dry Zone of Sri Lanka

by

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(ABSTRACT)

A case study was conducted at the Kaudulla irrigation system in the dry zone of Sri Lanka. The principal objective of the study was to perform a comprehensive evaluation of the system in operation with primary focus on identifying major constraints to effective irrigation management through a multi-disciplinary research approach.

Inadequate control facilities and neglected maintenance of the channel system were the major problems affecting irrigation management. Other constraints identified were the lack of motivation among management personnel and insufficient funds available for maintenance, which were dependent on constraints external to the system, namely the national economic and political environment. The delicate economic status of a majority of the farmers, grassroot level political environment and the economic vicissitudes of the entire country have resulted in the formation of vicious economic cycles that has contributed to a break down in the institutions essential for an engineering system to function effectively.

Irrigation management alternatives were developed on the basis of generating motivational incentives to the management personnel and

financial resources to sustain the technical capability of the engineering system to effectively distribute the irrigation water. Techniques for integrating these aspects into new community organizations in addition to existing organizational frame work were outlined. These procedures should assist in eliminating the major constraints to effective utilization and management of irrigation water.

This work is dedicated to my parents

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"At the University every great treatise is postponed until its author attains impartial judgement and perfect knowledge. If a horse could wait as long for its shoes fixed and would pay for them, in advance, our blacksmiths would all be college dons"-G.B.Shaw in Man and Superman - A Comedy and A Philosophy (1935).

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The views expressed in this work are the sole responsibility of the author and not necessarily the views of those organizations or individuals who supported the study.

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1.0 CHAPTER ONE : INTRODUCTION

1.1 STATEMENT OF THE PROBLEM

Development of irrigation facilities is central to the economic progress of many of the developing countries in the Asian region. In Sri Lanka, land development and provision of irrigation facilities as a prerequisite to population resettlement and agricultural development have received the highest priority in the drive to promote economic development. However, many of the older irrigation development projects have failed to provide the intended benefits of these irrigation development facilities in terms of productivity and effective utilization of irrigation water. Instead, increasingly heavy public investments are being made to support these irrigation facilities for their continued functioning due to poor management of irrigation water both at the system level and at the farm level. The aim of this chapter is to provide background to this problem, summarize the need to study the problems with associated irrigation management, and define the overall objective of the research study.

1.2 BACKGROUND INFORMATION

Sri Lanka is a tropical island located within the latitudes of 6° and 10° N of the equator. The greatest length and width of the island is 270 miles and 140 miles, respectively. The total land area of the country is 25,332 square miles (6.36 million hectares). The population estimated in 1971 was 12.6 million (Rep. Sri Lanka, 1972) and now estimated to be around 14.5 million (UNFPA, 1980).

The economy of the country is primarily agrobased with export of oriented crops, tea, rubber and coconut predominating the plantation industry. Rice, the staple food of the population, and other subsidiary food crops and minor export crops consisting of spices and condiments form the rest of the agro industry.

As with many other developing countries, agricultural development is of primary importance to the economy of Sri Lanka. The food production sector has been neglected in the past because of the emphasis on highly organized and heavily commercialized plantation crops, which formed the major foreign exchange source. Growing population pressure and the heavy dependence on imported food and essential commodities to meet the increased demand for food, necessitated a serious movement to revitalize the food production sector of agriculture. Self-sufficiency in rice production and subsidiary food crops has become an important national objective.

1.2.1 RAINFALL AND CLIMATOLOGICAL ZONES

The climate of the country is characterized by high temperature (80° to 82° F) and relative humidity with a monsoonal rainfall pattern. Three major climatological zones, based primarily on rainfall considerations (Figure 1 on page 10), can be identified in the country. The wet zone, located in the southwestern part of the island, receives about 3,753 mm of average annual rainfall and occupies about 1.54 million ha. The intermediate zone, located between the wet and the dry zones, receives about 1,905 millimeters of rainfall annually and has a land area of 0.85 million hectares. The dry zone, located in the southeastern and northwestern parts of the island, receives about 1,869 millimeters of rainfall annually and accounts for the remaining 60 percent of the total land area. The term dry zone is more applicable in terms of these prolonged dry spells rather than the amount of rainfall received (Figure 2 on page 11). The dry zone receives a higher annual rainfall than areas classified as dry in a geographic sense[1].

The gently undulating land surface forms a series of interconnected micro catchments and a catenary toposequence of soils (Panabokke, 1967). The soils are formed out of weathered laterites and primarily consist of Reddish Brown Earths. Three distinct classes of soils can be further identified based on the drainage conditions. The well drained soils occupy

---

[1] According to geographic classification areas receiving mean annual rainfall, less than 762 mm (30 inches) are considered as dry areas.

the ridge areas of a valley while low humic gley soils, which are poorly drained, occupy the low lying areas. The latter category is ideally suited for the culture of lowland rice. The imperfectly drained soils, which are transitional in drainage conditions, occupy the area between the well-drained and poorly-drained soils.

1.2.2 PROSPECTS FOR AGRICULTURE DEVELOPMENT

In terms of increasing agricultural productivity by increasing the cultivable area, the wet and the intermediate zones offer limited opportunities. This is mainly because plantation crops, half the total rainfed lowland rice cultivation, and about two-thirds of the total population of the country occupy these regions. The potential for increasing agricultural productivity, therefore, lies in the intensification of the already cultivated land rather than to increasing the area under production. In comparison, the dry zone offers the best prospects for expanding agricultural land . At present, only about half the potential land area of the dry zone is under systematic agriculture. The comparatively lower population density (Figure 3 on page 12) complements the current efforts to bring new land into cultivation and resettle population in the dry zone from the already congested wet zone areas.

1.2.3 WATER AS A CONSTRAINT TO DRY ZONE AGRICULTURE

Water has been a major constraint to agriculture development in the dry zone. During the Maha season (wet season), rice can be grown with little or no supplementary irrigation because rainfall is normally both adequate and well distributed. The Yala season, however, is characterized by meager, poorly distributed rainfall. Substantial supplementary irrigation is required to grow a successful crop of rice.

Agriculture flourished in the dry zone during the ancient times. Climatic limitations to sedentary agriculture were well understood by the ancient civilization as evidenced by the presence of many ruins of ancient irrigation schemes. Thus, the development of irrigation is a prerequisite for the agricultural development and repopulation of the dry zone.

Since the country gained its independence in 1948, successive governments have concentrated their efforts to develop agriculture in the dry zone. In recent years, an ambitious program to augment the present irrigation water supply to the dry zone has been undertaken. Diversion of a major river (Mahaweli) to provide this water has received national priority.

Irrigation development in the dry zone is founded on the remnants of the ancient system of irrigation reservoirs (tanks) and their ancient network of irrigation canals. Reconstruction and rehabilitation of these irrigation tanks, land development, and resettlement of landless people was the initial phase of the dry zone development. The current development phase consists of augmenting the supply of irrigation water to these tanks through the diversion of the largest river (Mahaweli) to provide a stable water supply for year round cultivation and development of land for new settlements.

1.2.4 THE PROBLEM OF EFFECTIVE IRRIGATION MANAGEMENT IN SETTLEMENT SCHEMES

During the initial phase of dry zone development, the socioeconomic and political emphasis was upon the reconstruction of ancient irrigation works and establishment of population settlements. This was partially dictated by growing population pressure, landlessness and the favorable trade balance of the post-war economy of the country at that time. As a result, very little or no attention was paid to the management or the actual end use of water by the farmers. The outcome was a host of problems in the management of irrigation water. Overuse and wastage of irrigation water by the farmers with better access to irrigation water, in some schemes two to three times the actual requirement of growing a crop of rice (Chambers, 1975), became typical of many of the older settlement schemes. Consequent poor yields obtained by less fortunate farmers due to water shortages resulted in a growing income discrepancy among the farmers.

Damages to the irrigation channels and water control structures by the farmers with water problems resulted in an increased maintenance expenditure. These added to the already overly burdened economy of the country due to the unfavorable trade balance of the economy during the 1960s and 70s and increasingly heavy investments (Table 1) made on new irrigation development activities.

Irrigation management for higher productivity levels and realization of full benefits of investments on irrigation has become a major national concern owing to these implications. Numerous remedial measures were implemented to alleviate some of these problems and to exploit the high yielding potential of the available technology. However, these irrigation settlements continue to show poor performance in terms of productivity of water and providing the intended benefits to the farmers benefited by these schemes.

1.2.5 NEED FOR IRRIGATION MANAGEMENT RESEARCH

Irrigation development in the dry zone and introduction of new high yielding varieties have greatly contributed to narrow the gap between the demand and production of rice in the country (Figure 4 on page 13). However, these new high yielding varieties require higher levels of management, which includes proper management of water to achieve production potentials. Further, examination of the rice production statistics (Table 2) indicates that the Yala season productivity to be about one third of the Maha season. Thus, research into irrigation management to develop better water management, alternatives, has a twofold contribution to agricultural productivity. First, it will enable the achievement of the full production potential of the new improved varieties and more efficient utilization of land with water shortages. Second, better management of water and resulting productivity would enable a more equitable distribution of income among farmers, thereby, leading to the realization of full benefits of irrigation development schemes in the dry zone.

1.3 OBJECTIVES AND CONTENTS OF THE THESIS

The principle objective of this research was to evaluate irrigation management of a selected major irrigation scheme in the dry zone of Sri lanka. Both system level and farm level irrigation management were studied from a multi-disciplinary research approach to identify constraints on effective management, distribution, and productivity of irrigation water. Based on a comprehensive evaluation of existing systems, a feasible water management strategy was proposed for the dry zone of Sri Lanka.

For the case study analysis, a representative irrigation scheme (Kaudulla Irrigation Scheme) in the dry zone of Sri Lanka was selected. The objectives of the study were as follows.

1. To evaluate a representative irrigation system while in operation,

2. To identify significant technical and socio-economic constraints, and

3. To develop effective water management alternatives.

The next chapter (Chapter II) contains a review of literature. Chapter III presents the selection of an irrigation scheme in the dry zone, preliminary problem diagnosis, and the specific objectives of the research to meet the principal objective of the study. Chapter IV is a discussion of the methodology employed in the field investigation. Chapter V presents the results of engineering, agronomic, economic and sociological aspects of the research study, followed by Chapter VI with a discussion of feasible alternatives needed for a successful water management strategy. Chapter VII contains a summary of results. The final chapter (Chapter VIII) is the conclusions and recommendations based on the findings of the study.

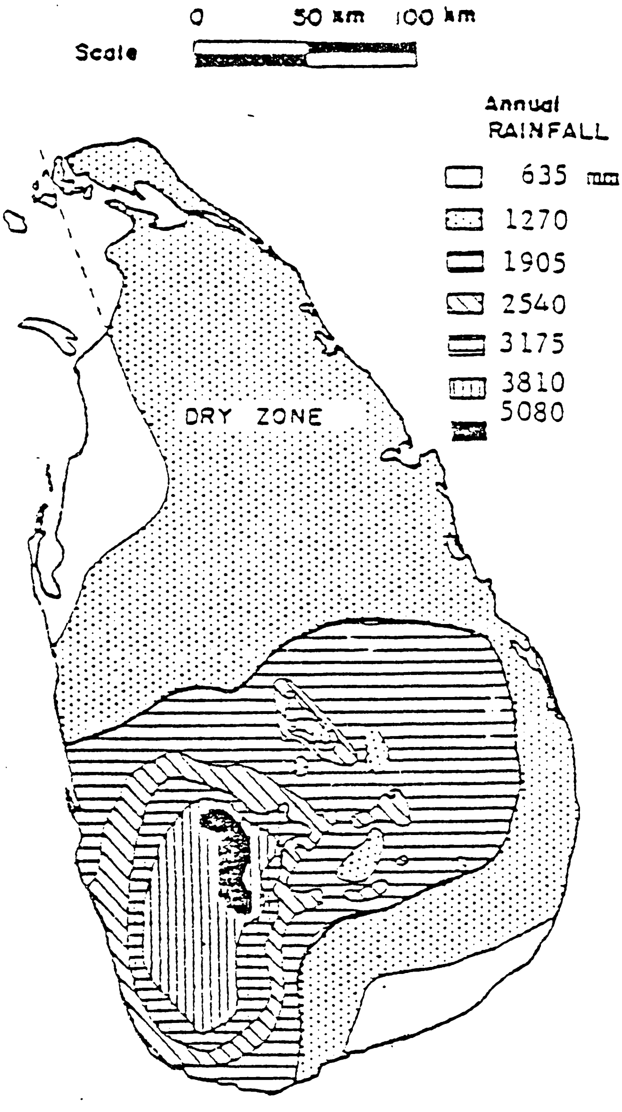

Figure 1. Map of Sri Lanka illustrating isohyets of mean annual rainfall and climatological zones (Source: Jhonson, 1969).

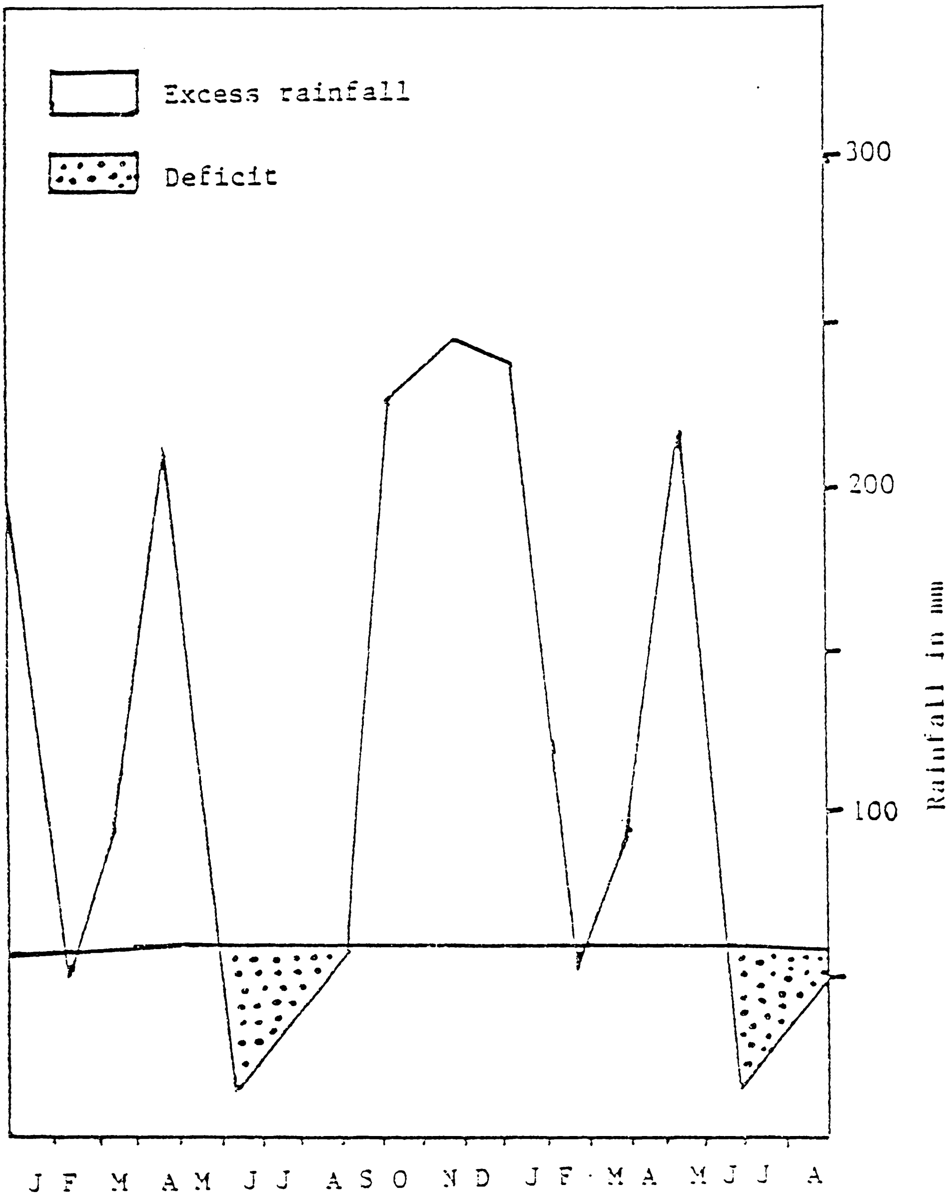

Figure 2. Rainfall distribution pattern in the Dry Zone of Sri Lanka (Source: Domros, 1974).

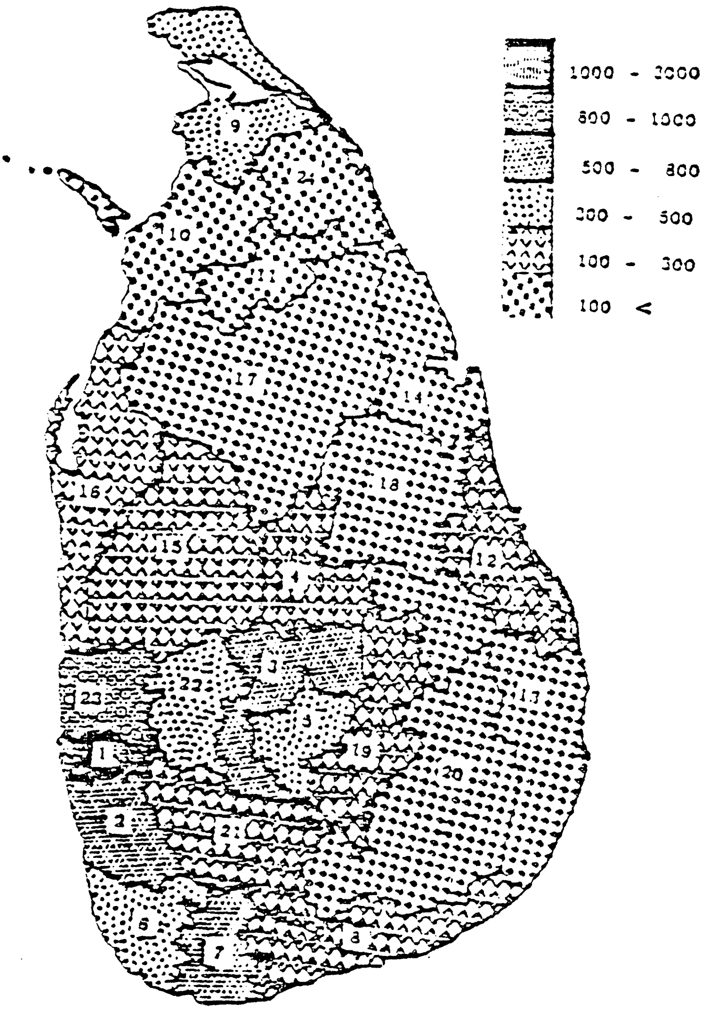

Figure 3. Population density distribution (Source: Department of Census and Statistics, 1981).

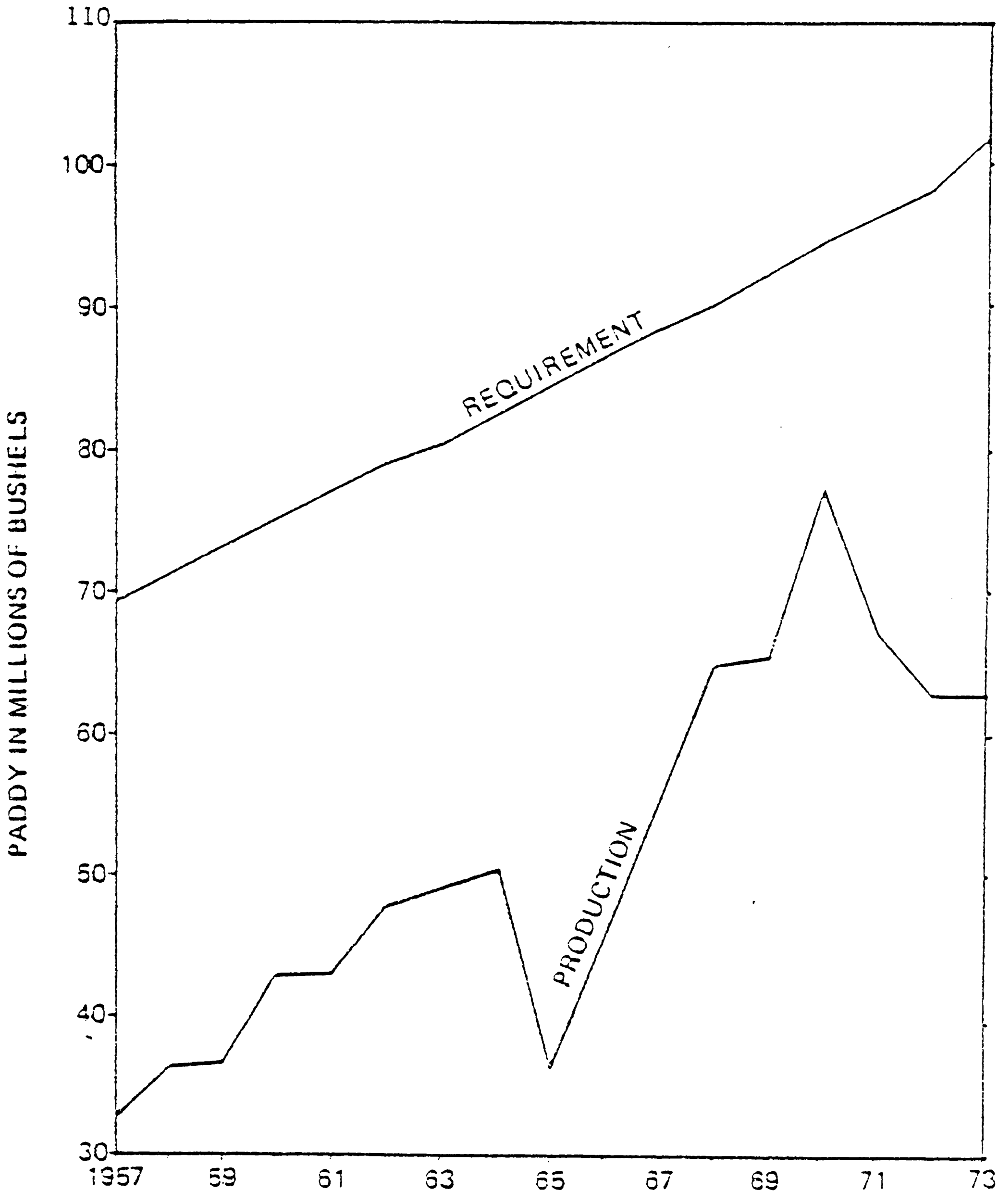

Figure 4. Sri Lanka: Gap between production of paddy and estimated requirement (Source: Dias, 1977).

Table 1. Expenditure on Irrigation in Sri Lanka (Source: Economic Review Sept/Oct. 1980).

Year	Capital Expenditure (Rs. million)	Total Expenditure (Rs. million)	Total Government Expenditure (Rs. million)	Expenditure on Irrigation as % of Total Government Expenditure
1973	28.042	37.540	5459	0.69
1974	39.229	51.429	6386	0.81
1975	46.239	60.862	7783	0.78
1976	43.883	59.128	9314	0.63
1977	52.001	84.781	9760	0.87
1978	144.391	198.382	18853	1.05
1979	313.182	402.184	17729	2.27
1980	431.554	539.031	21182	2.54

Note: For 1979 and 1980 the values given are the estimated values.

Note: A U.S. $ is approximately Rs.26.00.

Table 2. Paddy Production Statistics in Sri Lanka (Source: P.Peebles, 1982).

Year	Total Production (Thousands of Bushels) Maha Season	Year	Total Production (Thousands of Bushels) Yala Season
1949-50	14,300	1950	7,700
1950-51	12,400	1951	9,600
1951-52	18,400	1952	10,500
1952-53	13,200	1953	8,700
1953-54	19,300	1954	11,800
1954-55	21,200	1955	14,000
1955-56	19,400	1956	8,100
1956-57	20,200	1957	11,080
1957-58	21,200	1958	15,400
1958-59	21,900	1959	14,500
1959-60	26,300	1960	16,700
1960-61	27,100	1961	16,000
1961-62	30,200	1962	17,800
1962-63	31,600	1963	17,600
1963-64	32,100	1964	18,400
1964-65	32,100	1965	13,200
1965-66	30,700	1966	15,000
1966-67	34,900	1967	20,000
1967-68	43,500	1968	21,100
1968-69	46,962	1969	18,898
1969-70	49,492	1970	27,955
1970-71	41,560	1971	25,335
1971-72	42,327	1972	20,574
1972-73	42,004	1973	20,896
1973-74	52,629	1974	24,165
1974-75	34,458	1975	20,857
1975-76	42,278	1976	17,756
1976-77	54,833	1977	25,554
1977-78	61,626	1978	28,979
1978-79	66,800	1979	25,100

2.0 CHAPTER TWO : LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND OF DRY ZONE AGRICULTURE

Modern irrigation development in Sri Lanka is founded on the remnants and ruins of ancient irrigation works existing in the dry zone. Recorded history reveals that these ancient irrigation works once supported a thriving agricultural community in the dry zone over a millennium (Nicholas and Paranavithane, 1961; Ray 1960a; Ray 1960b). The focus of the following sections, which is primarily of technical interest, will be on the technological, organizational and management aspects that contributed to the success and productivity of these ancient systems. Every attempt will be made to avoid the bias introduced due to legends and myths surrounding these ancient irrigation works with the aim of presenting useful insights relevant to the present.

2.1.1 THE ANCIENT IRRIGATION TECHNOLOGY

The origin and the development of the ancient irrigation technology is surrounded in mystery. The work of Parker (1909) and Broheir (1934) has shed more light on the basics underlying the construction and development of the reservoirs and channel network affiliated with irrigation.

The ancient agricultural community, which is referred to as the hydraulic civilization (Wittfogel, 1957), had a profound understanding of the limitations imposed on agriculture by the dry zone environment. Their consideration of water and not the land as the limiting resource (Leach, 1961) perhaps is the foundation of success of irrigated agriculture in the past. The seasonal nature of water shortages were overcome by the ingenious use of dry zone topography. The gently rolling topography formed a series of interconnected micro catchments providing ideal conditions for surface storage and gravity irrigation.

The initial phase of irrigation began with the construction of temporary weirs and anicuts across perennial streams that diverted water into a system of contour channels (Figure 5 on page 41). The diverted water was used to irrigate low lying areas cultivated to rice. Upland areas were used to cultivate subsidiary food crops (Broheir, 1934).

The mastery of impounding water to form storage reservoirs (tanks) was followed by the invention of sluice gates and the access tower (Bisokotuwa: valve pit) for the controlled release of water for irrigation (Parker, 1909). The method of building a reservoir was to seek out a valley from which the water could escape only on one side. An earthen dam or a bund was constructed across the valley to retain water (Williams, 1956). Construction of larger reservoirs followed with centuries of experience gained in building small reservoirs.

The emphasis on water as a scarce resource can be further seen by the intricate arrangement of these reservoirs for the reuse of irrigation water. Located at slightly differing elevations the spill waters and drainage from one reservoir was collected into another lower down even during seasons with plentiful water supply (Broheir, 1934). An important milestone of the hydraulic civilization was construction of larger reservoirs and transbasin canal systems to augment the smaller supply tank networks rather than for direct irrigation purposes[2]. The technical skill at the disposal of ancient engineers is demonstrated by these transbasin canals with slopes less than 6 inches to a mile (Gunawardene, 1971) and the construction of spillways, sluice gates and access towers of the reservoirs (Parker, 1909; Broheir, 1934).

The irrigation networks spread throughout the dry zone by the turn of 12th century prior to the decline of hydraulic civilizations. North central (Anuradhapura kingdom) and northeastern (Pollonnaruwa kingdom) areas of the dry zone were characterized by large scale irrigation works with the longest river (Mahaveli) feeding these irrigation works conveying additional water through diversion canals. The southeastern dry zone was characterized by predominantly medium scale and minor irrigation reservoirs. There is no evidence to show that all irrigation systems functioned at any one time. Rather, foreign invasions and internal feuding resulted in abandonment and periodic repairs during the reign of different kings (de Silva, 1981).

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[2] D. L. O. Mendis, Civil Engineer and scholar of ancient irrigation works. Personal communication.

The irrigation works no doubt required a high degree of technical skill, organization and mobilization of massive human and other resources. But the argument that such organization centered the political power in the hands of the king and his bureaucracy (Wittfoggel, 1957) does not seem valid, at least, in the early stages of irrigation development in Sri Lanka. Instead of a centralized despotism, it was more a quasi-feudal society with power devolving on the king, monastic institutions and feudal landlords (de Silva, 1981). The kings developed major public works and in return, revenue was collected from produce of the land, usually one-sixth (Nicholas and Paranavithane, 1961; Codrington, 1926) and the use of irrigation water. Private land owners to whom belonged the right to income from such sources (Economic Review, 1980) as in the case of southeastern dry zone, and development of minor irrigation works was also prevalent at the time. Instead of a single annual crop, large scale irrigation works ensured the production of two or three crops a year, and the resulting agricultural surplus was adequate to sustain a large section of population not engaged in agriculture, and to maintain a vibrant and dynamic civilization (de Silva, 1981).

An irrigation reservoir formed the nucleus of a village that was the basic unit upon which the social hierarchy was based. The system operated on a traditional value system based on religion, caste consciousness, and kinship. It was these strong village level institutions that provided the resilience to survive the periods of political instability due to foreign invasions from India and internal feuding (de Silva, 1981).

People who practiced farming belonged to a single caste in a village. This in turn made management decisions of agricultural operations more effective since these farmers formed a socially homogeneous group. Decisions pertaining to agricultural operations and water management were made by the most experienced and probably the largest land owner among the farmers. This leader was referred to as "Gamarala" (Village headman). This name is identified along with "Vel Vidane" (Irrigation manager) which is a term adopted during the period of British rule (Leach, 1961). His decisions were respected by other farmers because of his knowledge due to a legacy of handed down experience. His duties involved collection of taxes, settling of disputes, supervision of irrigation water allocations and maintenance of the channel system. The tendency of many authors to consider documents of different era side by side has clouded the issue of how exactly these institutions functioned (Leach, 1961). However, Leach's work throws more light on tenurial arrangements of ancient tradition, which considered water and not the land as the scarce resource.

The most striking example of this understanding was the "bethma" (shared) cultivation, which is still in existence among farmers of "Purana" villages (villages formed by the original settlers of the dry zone). During a low rainfall season, cultivation was limited to a more effectively manageable, smaller area instead of the entire area. Some farmers, however, had to forgo temporarily their ownership of land for that particular season and help others by joining the farming operations of the limited area. A proportionate share of harvest, determined by the land ownership, went to each farmer (Abeysinghe, 1980). According to this popular belief, there had to be an extraordinary understanding amongst the ancient Sinhala farmers for such an arrangement to work. Leach refutes this explanation. Rather, his studies explain a technically and logically more acceptable form of "bethma" which would have been the basis of ancient practice. According to Leach, tenurial arrangements are based on equal rights to a share of water.

In its simplest form, the cultivable land area under a tank is divided into several irrigable tracts. In each of these tracts, individual farmers had their own share of land based on a proportionate share of water. During water scarce seasons (depending on then available water supply), any of these holdings could have been cultivated with least friction among farmers because each farmer had his own share of land within the cultivated tract. Though Leach does not claim that this, indeed, was the traditional practice, these arrangements show that ancient planners were well aware of the social implication of their irrigation layouts. For further details of land tenure in ancient villages, see Leach (1961) and Obeysekere (1967).

The other organizational feature of interest in the ancient systems is the "Rajakariya" (king's service). This institution made it obligatory for the farmers to participate in the maintenance of tank bund, irrigation canals and field fencing (Leach, 1961) that kept the irrigation systems in good operational form.

Prior to the decline of the hydraulic civilization, there was an increased tendency towards centralizing authority along the lines of Wittfoggelian argument (Ludoyvsky, 1967). Beginning from late 1300 AD over a period of many centuries, a progressive deterioration of the management of these systems occurred which was attributed to over centralization of administration, internal feuds among the nation's rulers, epidemics of malaria, and invasions from India (which further disrupted the stability).

The neglect was total during the nearly 500 years of Portuguese, Dutch, and British domination. The internal turmoil during this period did not allow people to concentrate on management of these systems or food production. People migrated from the less habitable dry zone areas to population centers in the upcountry areas of the wet zone. The jungle took over the dry zone leaving only a few "Purana" villages scattered around a few functional tanks. In 1815, the British took over the rule of the country. With this change, a new era of agricultural industry came and was monopolized by the heavily commercialized plantation agriculture in the wet zone areas (de Silva, 1981). During this period, agriculture in the dry zone was largely ignored. Only a subsistence form of agriculture was practiced in the "Purana" villages that persisted.

The earliest attempts to re-establish settlements in the dry zone date back to 1890. A few settlements were started in the Kala Wewa area.

However, these settlements were total failures due to epidemics of malaria. Aided settlements were first started in 1932 with slow progress primarily because of the incidence of malaria. In 1939, resettlement programs increased with expanded assistance from the state and a unit farm size of 5-acres of irrigated lowland and 3-acres of upland. The pace of successful dry zone settlements increased with the eradication of malaria in the mid 1940s. Since gaining independence, successive governments have placed increased priority on irrigation development and repopulation of the dry zone, but have overlooked the management aspects of irrigation. The current problems of water management, a consequence of this neglect, will be considered in the next section.

2.2 PROBLEMS RELATED TO WATER MANAGEMENT IN THE DRY ZONE SETTLEMENTS

Developments in social, economic, and administrative areas since the country gained independence in 1948, and complex effects on various aspects of water management in the dry zone will be discussed in the following text.

As mentioned previously, the primary focus of the redevelopment of the dry zone, during its initial phase, was the rehabilitation and resettlement of landless peasants. Many of the current water use problems derive from the rapid resettlement, and the subsequent breakdown of the social cohesion and ecological adaptation of the settlers to the dry zone environment.

The new settlers that came to the dry zone were a heterogeneous group. The selection process was was not carefully thought out. As a result, while some had a farming background, others were the outflow of densely populated urban areas. Often during the early phase, settlers were selected on the recommendation of the village headman. Undesirables were recommended in order that the village could be rid of them, and persons actually owning land or other property were certified to be landless in the process (Farmer, 1957). Over the years these new settlers formed social factions based on area of origin, caste, economic standing, and political orientation. While there is some social intercourse among these factions, there is little or no social integration among the newcomers and the "Purana" villagers (Farmer, 1957).

Ecologically, the wet zone from which these new settlers came is quite different from the dry zone. Scarcity of water supply for rice cultivation rarely occurred in the wet zone except under extreme drought conditions. Therefore, settlers who had previously been farmers were not ecologically adapted to the new environment. Indiscriminate use of irrigation water by the farmers, having better access to irrigation water, resulted in inequity of water distribution along irrigation canals. Over-use of irrigation water at farms located close to upper reaches of an irrigation canal resulted in water shortages on those farms located farther down the irrigation canal (Chambers, 1977). Consequently, farmers located at the lower reaches of irrigation canals became economically disadvantaged. Irate farmers frequently damaged the irrigation system, and frequent disputes occurred over water allocations. The government attempted to overcome this problem by organizing the farmers into cultivation committees (C.C) and other voluntary organizations such as multi-purpose cooperative societies. Among these farmer organizations, the C.C's undertook the responsibilities of the traditional "Vel vidane" system that was abolished by the government in 1958 with the introduction of the Paddy Lands Act.

A C.C represented a single large irrigation tract or a group of smaller tracts. Officers elected by all the farmers, for example, officials of the Irrigation Department and related government bureaucracies with the chairmanship of the Government Agent (GA), were responsible for decisions such as the cultivation calendar, priorities of water allocation, timing of water releases, and the appointment of water managers among farmers from different parts of the irrigation tracts. In addition, these committees were legally empowered to take action against offenses such as delays in maintenance or repair of farm irrigation canals, non-adherence to the cultivation calendar, etc.

The organizational aspects of the C.Cs had a theoretically sound footing except for several factors that undermined effectiveness. Final decision making rested largely in the hands of the bureaucracy. However, farmers who were economically, politically, and socially more powerful who were already in leadership positions of other voluntary organizations, gained the offices of C.Cs and manipulated activities to gain their own ends. As a result, the majority of farmers in new settlements showed little or no enthusiasm towards organized efforts to better their situation. This lack of enthusiasm, and social and political differences among farmers, interfered with scheduling water releases, prioritizing of water allocations, maintaining and repairing farm irrigation canals, and scheduling cultivations (Rust and Moore, 1984). Staggered cultivation operations frequently resulted in poor water management.

Fragmentation of the irrigated land holdings that has occurred over the years is another problem which poses engineering difficulties for the effective functioning of an irrigation system (Farmer, 1957). In the process of designing irrigation systems and allocating land, fragmentation of allotments among family members of farmers was not anticipated. With new family members joining the farming operations, most of the irrigated lowlands were fragmented. A single irrigation turnout supposedly designed to irrigate a single allotment had to cater to a number of fragments owned by farmers with different economic means. The result was an additional cause for over-use of irrigation water and wastage owing to delayed cultivations.

Plant breeding during the early 1960's resulted in the introduction of new varieties that were expected to improve yields for the dry zone farmers. These improved varieties, however, required more intensive management in order to realize their full yield potential (Dias, 1977). For farmers accustomed to traditional varieties, these additional management requirements presented a further economic burden. The majority of the farmers did not possess the means to buy the fertilizers, herbicides, and other chemicals required for pest and disease control (Harriss, 1977). Instead, farmers adopted management practices within their economic means. The result was lavish use of irrigation water to control weeds instead of expensive herbicides and tedious manual control methods. Below average yields and higher water applications were the consequences of these practices.

Preoccupied with the goal of achieving self-sufficiency in rice production, the government adopted various policy measures to help farmers overcome their economic difficulties. Economic packages, such as cultivation loans and subsidies for fertilizers and chemicals, were offered to farmers to induce them to adopt higher levels of management. In implementing these policies, the host of problems that followed in other areas of management were not anticipated. Instead of using these programs as intended, farmers found quick ways to obtain money for their consumption purposes through the cultivation loans and the sale of fertilizers and chemicals at higher prices. During the cultivation season, they got into further indebtedness by borrowing money from local money lenders (Jogaratnam, 1971). Thus, rather than becoming self reliant as intended, these policies caused increasing dependence on the government to solve the economic problems of the farmers (Farmer, 1957).

As a result, farmers have taken for granted that the government will continue to provide these programs.

The indebtedness of farmers caused difficulties in maintaining strict cropping schedules. Limitations of capital caused difficulties of hiring power sources and labor during land preparation. The delayed cultivation operations had a two-fold effect on the use of irrigation water. Irrigation water allocations had to be extended beyond the regular cultivation season, leading to wastage and shortages. This left inadequate time for maintenance and repair of the distribution system, which resulted in poor distribution efficiency.

Other government policies such as guaranteed price structure and well established marketing and disposal facilities for rice had a discouraging effect on the cultivation of the less water-consuming upland crops. In addition to the disadvantage of not having established marketing conditions, these upland crops required more intensive water and other management practices. Because of these reasons, well-drained irrigated areas allocated to upland crops also were cultivated to lowland rice by the farmers. These well-drained soils required large quantities of water to cultivate lowland rice, resulting in wastage of water. Thus, subsidiary upland crops remain largely limited to rainfed "Chena" cultivations practiced by the farmers.

Most of the remedial measures adopted by government became sensitive issues due to their political implications. For example, provision of free irrigation water to the new settlements was adopted as an inducement to the farmers to establish their farms. When problems of over-use and wastage of irrigation water occurred, implementing a policy of water taxation became a major politically sensitive issue pertaining to the settlement policies of the government. In addition, monitoring difficulties, and administrative and organizational requirements made the taxing policy economically unattractive (Economic Review, 1980).

Along with settlement policies, the Irrigation Ordinance was introduced to ensure more effective water use and irrigation administration. The Irrigation Ordinance empowers various government agencies involved in dry zone development work to prosecute offenders involved in misuses, water thefts, damages to irrigation structures, and illegal encroachments, etc. The poor coordination and interaction of these government agencies, which often duplicated responsibilities, made it difficult to determine the jurisdiction of these offenses. The slowness in legal proceedings has discouraged officers in making use of these legal provisions. Over several years of lax administration, the Irrigation Ordinance lost its effectiveness. The officials who represented the various government agencies providing the institutional facilities have failed to develop the trust and rapport with the farmers to carry out their services effectively. Because of a higher social and educational standing, cultural background tends to prevent the government officials from working closely with the farmers to obtain a better understanding of their problems. Thus, the outlook and attitudes of the government officials often conflict with interests of the farmers. As a consequence, decisions made by these officials often are viewed with doubt and mistrust by the farmers. Political interventions have diluted the authority of these officers and frequent transfers between locations make their services less effective (Rust and Moore, 1984). Thus, overall implementation of plans to effect better use of water were not very successful. A more detailed discussion of these problems, particularly, the sociological aspects, is found in Moore(1980a) and Moore (1980b).

2.3 PROBLEMS RELATED TO WATER MANAGEMENT IN NEW SETTLEMENT SCHEMES

Problems similar to those reported in older settlements are being reported in the new settlements under the Mahaweli development scheme (Tilakasiri,1983; Schudder and Wimaladharma, 1983; Siriwardene, 1981). The World Bank Supervision Mission Report (1982) indicated that there was a growing inequality in land alienation among the settlers. The reason stated was the inaction by authorities to curb illegal leasing. Further, this aspect was counter productive in terms of the original egalitarian philosophy of the resettlement but did not necessarily affect the level of productivity. Group action was proposed as a possible solution. Also, the report indicated the need to re-examine the calculations made for the feasibility studies based on observations of water shortages during the 1980 and 81 Yala seasons. The report further stated that the establishment of social infrastructure was lagging behind in comparison with the land development and irrigation infrastructure.

Similar inequalities in distribution of income achieved through favorable access to water, loans and other facilities were reported by Wanigaratne (1979), Siriwardene (1981), and Tilakasiri (1983). As remedial measures, the new settlements have organized farmers into smaller turnout groups. In Gal Oya, similar intervention is underway and is termed a participatory approach to farmer organization (Wickramasinghe, 1980; Wickramasinghe and Van Der Velde, 1981). The emphasis in both types of farmer organizations is to train and educate farmers to increasingly participate in the operation and maintenance of irrigation systems through self reliance. Wimaladharma (1980), however, cautions about the danger of over playing the success of these farmer organizations. He reported a progressive decline in attendance despite farmer organization.

2.4 RESEARCH DEVELOPMENTS IN WATER MANAGEMENT

Irrigation is considered as the key to agricultural development in many of the developing countries in the Asian region. Despite considerable investment in irrigation in the 1970s, there has been no significant increase in the total cultivated area in a number of countries. Though new cultivated areas were established, others were abandoned or required rehabilitation. Not all developed areas are farmed nor are all farmed areas harvested because water control is incomplete or because of deficient water management (World Water, 1981). Many of the irrigation projects continue to show performance well below the expectations of optimistic planners.

Poor performance of existing irrigation schemes is a result of either 1) unrealistic goals with too short a time frame to achieve them or 2) designs which are inappropriate for the prior precedents in the physical and institutional environment or 3) management of the facilities without prior precedents of the full utilization of investment or a combination of these that have gone into planning (Early, 1981).

False assumptions are a common cause behind the failure of schemes to work as expected. Assumptions about farmer behavior are superimposed on readily definable benefits and tend to make the cost-benefit and hydraulic designs appear higher than reality. Many irrigation plans have too ambitious end-goals for the problem, and worst, almost none explore the problems of transition and a feasible pace needed to achieve the end goals (World Water, 1981). In many of the irrigation projects, the tendency is to veer away from the traditional practices because they are preceived to be inefficient. In doing so, the emphasis has been on change rather than working within the existing institutional environment or adaptations based on indigenous relations (Levine, 1981). Thus, many irrigation projects recommend public institutions similar to that found in developed countries irrespective of their applicability. Since the structural components of many of these systems are predetermined, which limits the choice of management methods, the problem is to search for an appropriate management strategy to make the system work (Early, 1981). It is unlikely that few future projects will receive unquestioned approval if they use conventional engineering and economic cost-benefit criteria. Such design factors are usually unrealistic because they ignore social and environmental impact analysis, careful assessment of technologies, and an analysis of the direct and indirect externalities involved (Weiner, 1975).

Crops cannot be grown on water alone; thus, it is necessary to consider other management inputs that go into crop production in order to improve productivity. One of the greatest problems about water management is the intricate interactions between social, institutional and technical issues. No single professional discipline can provide an adequate grasp of the issues (Moore, n.d.). The multidisciplinary nature of water management issues is reflected in the definition of water management given by Clyma et al. (1977). "Water management in agriculture is a process by which water is manipulated and used in the production of food and fiber. Water management is then not a discipline based any more upon agricultural extension nor is it a single focus on water resources, institutions, laws, irrigation facilities, soils or cropping systems. Water management is manifest in how these resources and tools are combined to provide water for plant growth," (Clyma et al., 1977).

The present trend in water management research is towards action research. Unlike discipline based research which focus, diagnose and analyze the problem, action research involves a multi-disciplinary approach to linked interventions and studies designed to improve irrigation (Chambers and Lenton, 1981).

2.5 RESEARCH FINDINGS AND EXPERIENCES IN WATER MANAGEMENT

A significant growth in the understanding of the problems of water management occurred during the last decade. These findings have greatly contributed to the development of research methodologies and guidelines for future research into water management.

Research findings in the Philippine irrigation systems indicate that most of the farm-level problems of water management are the result of problems of allocation and distribution of water in the main system which is beyond the control of the farmers. There is little opportunity for improvements at farm-level unless improvements in allocation and distribution of irrigation water in the main system are made to provide a dependable supply of water to the farmers (Wickham and Valera, 1978). Other studies also have shown that considerable improvements in performance can be achieved by better allocation and distribution in the main system (Tabbal and Wickham, 1978; Early, 1981). The priority focus on research to improve main system management is justifiable based on these findings. However, farm-level problems are also a part and parcel of the problem of poor system performance. Therefore, irrigation system management concerns should take the holistic approach in which problems existing at all levels of the system will receive their due attention (Buhiyan, 1981).

Among alternative approaches to main system management, rotation irrigation, has received considerable research attention due to its success in some of the countries. In its simplest form, rotational delivery of irrigation water is the intermittent application of irrigation water by which water losses will be reduced without having adverse yield effects (Levine et al., 1976). Taiwan is one of the few countries where rotational irrigation has proved to be a successful alternative to improve irrigation system performance. Studies in the Philippines comparing rotational and continuous delivery have shown no significant difference between the two except the additional cost involved in rotational irrigation. Both types of irrigation showed improvement in performance over traditionally irrigated areas, which was attributed to greater water control at irrigation turnouts giving water deliveries closely tailored to crop and soil needs (Wickham et al., 1974).

Controlled release of water at the turnouts is a key factor for improved water utilization. Studies conducted in Taiwan have revealed that there are a number of external and system characteristics required for the successful introduction of rotation irrigation. The external characteristics identified were:

1) a water deficit approximating 25 percent of normal practice in the area;

2) political commitment to the change; and
3) adequate financial resources for implementation and subsequent operation.

The system characteristics identified were:

1) physical facilities that provide measurement and control to the level of farmers group responsibility; and
2) management patterns that provide a well organized operating groups and effective communication between the farmers and the system personnel (Levine et al., 1976).

These findings suggest that successful application of a management alternative is possible only if the physical and institutional environment is conducive. Because of the specific nature of management alternatives, researchers have been cautious about generalizing their research findings. Studies on operation (Tabbal and Wickham, 1978; Chada, 1981), economic and financial environment (Taylor, 1978), and social environment (Hafid and Yamani, 1978; Dozina et al., 1978; Hutapea et al., 1978) under a range of conditions have been recommended to better understand the nature of the problem.

2.6 RESEARCH METHODOLOGIES AND GUIDELINES

Chambers and Lenton (1981) discussed the difficulties involved in action research methodology and the guidelines necessary to overcome these difficulties. A successful research process should have the following characteristics (Chambers and Lenton, 1981; Early, 1981; Buhiyan, 1981):

1) problem diagnosis and analysis along with effective monitoring and evaluation procedure;
2) viable solution selection; and
3) implementation and evaluation.

Other important characteristics are the interdisciplinary team work, training and communication program linked to implementation, and team/agency collaboration which will increase the utility of the research process (Chambers and Lenton, 1981).

Problem diagnosis involves obtaining feed back information from the farmers and agency personnel to identify their problems, and eliciting their views, and assessing the performance of the system with readily applicable performance indicators (Early, 1981). Irrigation system performance could be assessed by efficiency, equity, and productivity.

Water use efficiency is the most commonly used indicator of the system efficiency (Buhiyan, 1981). Water use efficiency is defined as the ratio of water actually used by the crop (evapotranspiration) to the total water supplied. The problem of estimating water use efficiency lies with the difficulty of determining the crop evapotranspiration and seepage and percolation losses. Only rough estimations can be made based on pan evaporation or evapotranspiration formulae. In rice irrigation seepage and percolation losses can be estimated by procedures discussed by Giron and Wickham (1974). If soil requirements are also included along with crop requirements, a more easily measurable indicator of efficiency can be developed (Goonasekere, 1978). Productivity performances can be measured by the following:

1) water delivered;
2) area irrigated;
3) yield; and
4) income.

The productivity performance can be measured at either on the farm,or on an outlet, or at higher levels of aggregation (Lenton, 1981). Some of the productivity performance indicators discussed by Lenton (1981) are as follows:

1) water delivery performance;

2) area performance;

3) yield performance; and

4) income performance.

The measurements needed for determining these indicators are the actual area irrigated [A],irrigable area [A*], total volume of water delivered [V], the volumes of water delivered [V(t)] during each week (t) of the cropping season, total yield (Y) over area A, and the net income (I) generated in area A.

$$\text{Water delivery performance} = \Sigma \text{ ----} \frac{k(t) \times q^*(t)}{q(t)}$$

where:

k(t) = the weighing factor indicating relative importance of water at different stages of crop growth

$q(t) = V/A$

$q^*(t) = V(t)/A$

n = number of weeks in the cropping season.

Area performance = Σ A/A*

Yield performance = Σ Y/Y*

Income performance = Σ I/I*.

where:

Y^* = yield obtainable in area A given optimum amounts of irrigation and input levels.

I^* = net income obtainable in area A for Y^*

Equity performance can be measured through the variability of productivity performance indicators at different areas or farms within the outlet and the command area (Lenton, 1981). Once the problems of the system are diagnosed, management alternatives which provide solutions to the problems could be identified and tested. This testing involves actual field trials with farmers and irrigation personnel to select the alternatives that can be implemented (Early, 1981).

In implementing the tested alternatives, a unit of implementation is selected so that full range of personnel of the irrigation agency are involved, that is from the source of water down to the client farmer and the performance of the system relative to performance parameters are monitored and evaluated (Early, 1981).

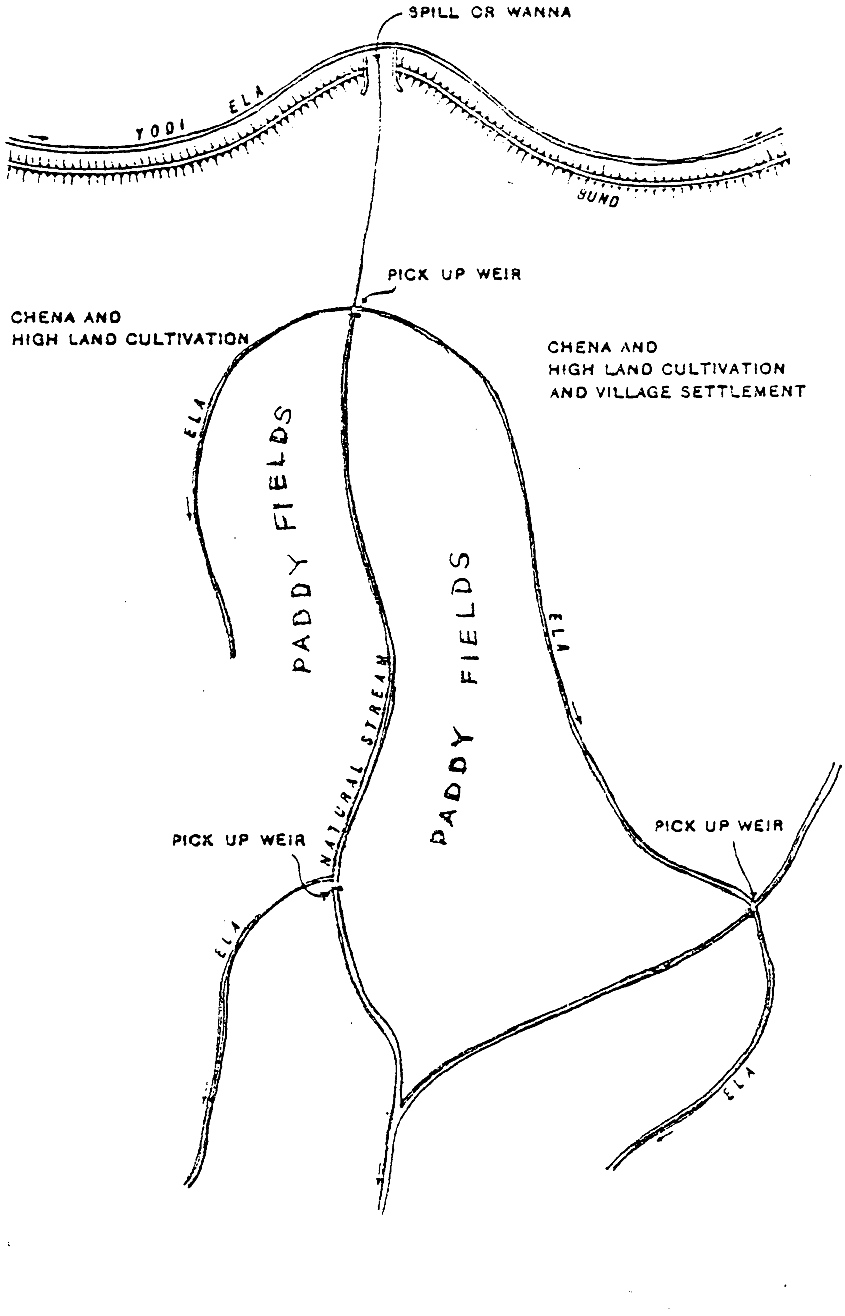

Figure 5. Canal net work and reuse of drainage water in ancient irrigation canal system (source: Ceylon Survey Department, 1945).

3.0 CHAPTER THREE : PRELIMINARY PROBLEM INVESTIGATION

3.1 SELECTION OF A REPRESENTATIVE IRRIGATION SCHEME FOR STUDY

For the purpose of this study, the Kaudulla irrigation scheme located in the northeastern part of the dry zone was selected (Figure 6 on page 70). Selection of Kaudulla as the location of the study was justified based on several considerations. At present the system at Kaudulla irrigates over 4050 hectares (10,000 acres). The complete scheme is planned to irrigate over 12,150 hectares (30,000 acres). Parts of the already developed area have been in operation over a period of two decades (see Figure 7 on page 71). This and the comparatively large area of the scheme provides an opportunity to study a large class of problems in water management which are representative of other irrigation schemes in the dry zone. Further, a part of the command and the planned expansions of irrigable land depends on an augmented water supply to Kaudulla through Mahaweli diversion scheme under system "D" development. Thus, research findings on the already operating system would provide useful insights to the effective future rehabilitation and management of the system. The on-going water balance research study of the Wallingford Institute (UK) and the Department of Irrigation (Sri Lanka) at Kaudulla would provide a data base for comparison. Also, the Department of Irrigation has plans for establishing a Water Management Training Center at Kaudulla which may provide opportunities for implementing some of the findings of this study.

3.1.1 HISTORICAL BACKGROUND OF KAUDULLA SCHEME

The Kaudulla reservoir was first constructed in the third century AD during the reign of King Mahasena. The reservoir was originally constructed by erecting an earthen dam connecting adjoining hillocks across the Kaudulu Oya main drainage. Gal Oya and Aluth Oya catchments also contributed to the drainage inflow to Kaudulu Oya during that time. During the sixth century the reservoir catchment underwent extensive modifications. A diversion channel [Minneriya Kantalai Yoda Ela (MKYE)] linking Minneriya reservoir to the south, and Kantalai reservoir to the north of Kaudulla was constructed across the catchment during this period. This infers that the ancient Kaudulla tank, which was comparatively smaller then than the present tank, faced the possible risk of flood damage during monsoonal rains.

The above inference can be demonstrated with the help of available data. The Aluth Oya and Gala Oya catchments drain areas of 64 square kilometers (25 square miles) and 128 square kilometers (80 square miles), respectively (Holmes et al., 1981). The present catchment of Kaudulla is about 81 square kilometers (31.5 square miles)[3] . A total land area of 35,368 hectares (87,360 acres) formed the catchment of Kaudulla when

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[3] Mr.Ranasinghe, Maintenance Officer, Kaudulla Stage I.

it was first constructed. With a derived runoff coefficient of 0.3 and average Maha season rainfall of 1270 mm (Holmes et al., 1981), the runoff generated by this entire catchment amounts to 13,450 hectare meters (109,000 acre feet) of water. This is even more than the present capacity (12,834 hectare meters or 104,000 acre feet) of the reservoir. Therefore, the construction of MKYE served a dual purpose during the ancient times. It not only protected Kaudulla from flood damage, but also conveyed the excess runoff to Kantalai augmenting the supply there. Therefore, the past success of Kaudulla as an irrigation scheme depended on the effective functioning of MKYE. When MKYE failed, Kaudulla also was damaged as suggested by the subsequent repairs reported on Kaudulla during the eleventh and twelfth centuries. During the period of foreign domination, the reservoir fell into disrepair and was in a ruined state until it was restored in 1958.

In 1958, the Kaudulla reservoir was enlarged to its present capacity of 12,834 hectare meters. During the process, the old MKYE was enlarged and reconstructed. The command area was expanded to over 4,050 hectares with an additional 8,100 hectares planned for future development. These developments were planned in three stages. Stage I, which more or less conforms to the ancient command with a design area of 1924 hectares (4,752 acres), was completed first in 1962. Subsequently, an additional higher level sluice was constructed to irrigate the Stage II and III areas. Stage II, with a design area of 2,403 hectares (5,935 acres) (Figure 7 on page 71), was completed in 1972 pending an augmented water supply to the reservoir under the Mahaweli diversion scheme.

Mahaweli diversion water issues to Kaudulla reservoir began in 1976. The water from Mahaweli is routed via Ambanganga from Bowatenne to the Minneriya tank. The Spill waters from Minneriya is first conveyed via MKYE to Kantalai, and any excess is then spilled from MKYE to Kaudulla. These developments and their implication will be discussed under the problem diagnosis (Section 3.2).

3.1.2 THE COMMUNITY AT KAUDULLA

The community at scheme Kaudulla chiefly consists of landless peasants by the various parts of the country. The farmers were settled in the scheme as early as 1958. The farmers who got displaced from Minneriya and Pollonnaruwa schemes during 1957 floods were given lands in the scheme area prior to its development. Most of these farmers had previous farming experience. In addition, spill-over population from Minneriya, and landless people from the central province and coastal areas formed a part of the settlers.

Traders from various parts of the country, and officers and their families from government bureaucracies form the balance of the community. The community is, indeed, a heterogeneous population with their roots in different areas of the country. Caste consciousness operates beneath the surface but seemingly is not an important factor in forming social strata. Rather, the economic and political groupings of people seem to play a prominent role in forming social strata. A socioeconomic survey would provide better insights to problems of sociological origin.

3.1.3 THE IRRIGATION ADMINISTRATION

The irrigation system at Kaudulla is managed by the government Department of Irrigation. The administration office is located in Minneriya along Kandy Minneriya Roadway at a distance of approximately 19 - 24 kilometers (12 - 15 miles) from Kaudulla. The Regional Deputy Director is stationed in Pollonnaruwa, which is an additional 12 miles from from Minneriya. A senior Irrigation Engineer (IE) is responsible for administration and water management decision making at Kaudulla. Details of the administrative hierarchy of the Irrigation Department (ID) are given in Figure 8 on page 72. The ID is responsible for the issue and management of water along main channels and the distributories up to the field channels. In addition, maintenance of the channels and roadways along channels, and supervision of irrigation issues, fall within the jurisdiction of the ID. Vel Vidanes (Water managers) appointed by farmers' vote are responsible for the water control and distribution along field channels.

Major water management decisions such as the cultivation calendar and irrigation issues are made at the cultivation committee meeting. This meeting is headed by the Government Agent (GA) for the district (Pollonnaruwa) who is the secretary to the District Minister under the present system. These meetings are attended by the Member of Parliament

(MP) for the area, Assistant Government Agent (AGA) for the area, the IE and his assistants, Agricultural Development Authority, Extension Officers (EOs) of the Department of Agriculture, and the representatives appointed by the farmers. Once the cultivation calendar is determined by the cultivation committee meeting, irrigation issues become the sole responsibility of the ID.

3.2 PROBLEM ASSESSMENT

Having selected Kaudulla as the representative scheme, the next attempt was to assess whether there are serious problems of water management at Kaudulla. For this purpose the officials of the ID and farmers were interviewed. From the information gathered it was evident that there are system and management defects in both the system and at farm level. The next step involved confirming these defects through personal observations which will be discussed in the following section.

3.2.1 PRELIMINARY PROBLEM IDENTIFICATION

This section presents a discussion of water management problems and constraints identified at the Kaudulla irrigation scheme. The discussion draws heavily from the experience gained by living within the scheme area for a period of nearly one year. The opportunity to observe the system in operation, together with many discussions with the officials of the ID and the farmers, provided valuable insights to water-related problems.

The problems of water management at Kaudulla stem from the accumulation of many causes and their effects. Both intentional and unintentional priorities and policies of different political administrations, state agencies, and even the actions of farmers have compounded the problems to the present state. Therefore, no attempt is made to identify any particular administration or individual(s) as responsible for these problems. Rather, the aim of the discussion is to identify the causes of problems and probable effects. Hopefully, a correct evaluation would provide a better understanding of the situation, which would enhance efforts to overcome the management difficulties involved in better management of the system to improve the productivity of irrigation water.

The general nature of the water management problems in many of the irrigation schemes in Sri Lanka is well documented (Chambers, 1975; Moor, 1980). Also, it is well established that more often farm level water management is related to the reliability and distribution of irrigation water within the supply system (Wickham and Valera, 1978). Exactly how the reliability and water distribution in the supply system is affected is the problem of engineering interest. Available water supply for irrigation and its management and control in the channel system are the major problem areas in this connection. Kaudulla is a good representation of these problem areas both at systems level and at farm level. Let us first consider the more important water supply constraint found at Kaudulla.

3.2.1.1 Water supply constraints at Kaudulla

When the ancient Kaudulla tank was restored in 1958, the capacity of the reservoir and its potential irrigation command was increased with plans for future expansion. In a previous section, the discussion demonstrated that as an independent system the Kaudulla tank has the potential for irrigating the expanded command during both seasons of the year. At the time of this restoration work, the old existing MKYE was enlarged and reconstructed with the intention of conveying any excess runoff from Kaudulla and spill water from Minneriya down to Kantalai reservoir. However, later developments in priorities of irrigation water allocation among Minneriya, Kaudulla, and Kantalai tank systems restricted the potential of Kaudulla to function as an independent system.

Kantalai, being a major sugar producing area, receives a higher priority for irrigation water over Kaudulla in the larger macro economy of the country. As a consequence, the MKYE channelled all the runoff from the upper catchment of Kaudulla and spill water from Minneriya to Kantalai. When Kantalai requirements are met, the excess water is allowed to spill into the Kaudulla system. This essentially made Kaudulla a sub-system of a larger system consisting of Minneriya, Kaudulla, and Kantalai. These developments did not affect the Stage I of the Kaudulla scheme, which more or less conforms to the ancient command. Therefore, Stage I of this scheme enjoys a guaranteed supply of irrigation water during both seasons of a year. Thus, Stage I of the scheme was completed and became operational in 1962. But the planned area for Stage II needed an augmented supply of water.

The Mahaweli diversion scheme, which had its inception in the the mid-1960s, was expected as the source of augmented supply. Thus, pending Mahaweli water supply, Stage II of the scheme was completed and put into operation in 1971. Farmers were settled in the Stage II area even prior to its completion because settlement of landless peasants in the dry zone was the major political and economical issue at the time. Although farmers were settled and Stage II became operational, Mahaweli water reached the Kaudulla scheme only in 1976. The system then had been in operation with a major water supply constraint during Yala seasons for nearly five years. Even at present, the Mahaweli supply to Kaudulla is irregular as shown by 1980, 81, and 82 Yala seasons, which did not receive Mahaweli supply. This situation will continue until the Mahaweli diversion scheme is completed and water allocation priorities are sorted out. Let us first consider the effect of this constraint on the system, from the time Stage II of the system became operational.

3.2.1.2 Effect on Stage II of the scheme

Of the operational scheme area at Kaudulla, Stage II farmers were the most affected by limited water supply during Yala seasons. The Maha season of a year is largely rainfed with little supplementary irrigation requirement for lowland rice. Therefore, it is possible to grow a rice crop in both stages of the scheme area during the Maha season. The Yala season with its meager rainfall, requires heavy supplementary irrigation to grow lowland rice. Without an augmented water supply, only Stage I of the scheme area could raise a crop during Yala, even after Mahaweli began its supply to Kaudulla. In some Yala seasons, water was not released to Stage II. In Other Yala seasons, water was released for both stages but a short supply during mid-season resulted in crop failure in Stage II. During one Yala season, water was released to Stage II for growing other field crops.

Growing other field crops during Yala season is not very appealing to the farmers because, unlike rice, the cost of production and the management involved without a guaranteed market provided little or no incentive. Therefore, Stage II farmers and their families must survive with the income from one Maha season to the next Maha season cultivation. This has aggravated their poverty situation. As a solution to this problem, the 'bethma' (shared) system of cultivation was introduced during problem Yala seasons. The intention was to provide some form of economic relief to Stage II farmers. While this alleviated the economic problems to some extent, a host of other problems related to water management began surfacing upon implementation of this system.

The 'bethma' system was discussed in detail in Chapter II. Let us examine the effects of application of this system of water management in the Stage I of the present system.

3.2.1.3 The 'Bethma' cultivation and effects of its introduction to Kaudulla

Stage I of the system, which did not experience water problems during both seasons, was put under 'bethma' system during water scarce Yala seasons. When this system was introduced to the present Kaudulla system, with its socially heterogeneous community, it had its own adverse side effects. Stage I farmers have achieved some form of economic stability by the cultivation of both seasons over a year for a period of nearly a decade before Stage II became operational. With the introduction of 'bethma' during water scarce Yala seasons, for once they had to forgo their land ownership temporarily and share it with strangers. They resented the 'bethma' system because it was economically disadvantageous to them. Nevertheless, they were legally bound to share their land. Because of this resentment, some Stage I farmers purposely deprived the Stage II farmers their supply of water when 'bethma' was practiced during Yala seasons, which resulted in below average yields for some farmers.

There is social friction between these two groups of farmers due to disputes over the water supply. Stage II farmers even resort to damaging field channels and associated irrigation structures to obtain their water supply. They are less concerned because they do not own the land. Thus, by the end of each Yala .season field channels have considerably deteriorated affecting the water distribution. Repair of these damages is conveniently ignored by Stage I farmers who pass the blame on to the Stage II farmers.

The irrigation department with its limited maintenance funds and resources is unable to attend to all such repairs. The result has been a progressive deterioration of field channels with resultant wastage of water, especially towards the tail end of the channel system. Some Stage II farmers, because of the long distances they have to travel in order to cultivate and safeguard their crop, obtain a lump sum of money from Stage I farmers and forgo their cultivation. Therefore, some of the Stage II farmers do not get the benefits as intended by 'bethma' cultivation.

3.2.1.4 Future implications of water supply constraint at Kaudulla

Kaudulla at present is a sub-system of the larger Mahaweli, Minneriya, and Kantalai systems. Once the Mahaweli scheme is completed and water allocation priorities sorted out, the water supply constraint at Kaudulla is expected to be eliminated. Nevertheless, the water availability for Yala season cultivation at Kaudulla will essentially depend on the effective overall management of water in the Mahaweli, Minneriya, and Kantalai systems. If there is wastage or poor management in any one of these systems, the effects will be reflected in Kaudulla during Yala seasons, particularly in Stages II and III of the scheme areas. Also, better water management in Stage I of the scheme during water-scarce Yala seasons is important because wastage in Stage I area implies reduced supply of water for the rest of the scheme area.

3.2.2 THE PROBLEMS IDENTIFIED IN THE CONVEYANCE SYSTEM

3.2.2.1 Design related problems

The irrigation water conveyance system at Kaudulla had been designed as a continuous flow system. The advantages are its simplicity and economy of construction. The need to control and measure the water supply in the channel system, except at a few key locations, was not considered essential at the time of rehabilitation of the ancient scheme. As was mentioned in earlier sections, there are very few water control structures along the main channel of Stage I. The few that are present are either non-functional or the channel has eroded badly leaving the structure in the middle without any useful purpose. The question is, what has gone wrong?

The engineering aspect of the system would function properly, provided design specifications are correct and the conditions under which the system was designed to operate remain unchanged with the passage of time. It is necessary, then, to examine these design considerations and the changes that have occurred with the prolonged operation of the system. The basic design involves assumptions based on average observed data on the soil types, farm level irrigation requirements, channel losses, and topography and other related factors. Based on this information, the gross water requirement at the sluice is determined in order to design the type and shape of cross sections and the gradient to carry water with non-erodible velocities in the main channel system.

The size and shape of the turnouts from the main channel are designed based on the gross water requirement at the turnout area and the design depth of water in the main channel. Such a design should operate without any problems as long as the design depths are maintained so that correct discharges occur at each of the turnouts. This implies the correct design discharges in the channel system and regular maintenance of the channels are necessary requirements. The factors that contributed to the changes in these conditions and thereby affected proper distribution of water are considered next.

3.2.2.2 The illicit cultivation of highlands and reservations and its effect

When any irrigation system is designed by the Department of Irrigation, a certain portion of land is placed in highland allotments. This is mainly to provide homesteads for the farmers. Along irrigation channels, drainage channels, and roads, a portion of land is also reserved for channel and road maintenance. Legally, none of these lands is allowed to be cultivated or placed under irrigation. The original design layout of Kaudulla system also conformed to this pattern. When the system was put into operation, farmers gradually began encroaching upon set aside road and channel reservations and turning them into lowland paddy lots. Also, the highland allotments with access to irrigation water, were turned into paddy lots. No action could be taken against the offenders since this issue became increasingly politicized with time. The irrigation department had to turn a blind eye to these activities because of the increasing political and social pressure imposed on attempts to curb these activities.

The effect of inaction on the conveyance system are many. With increased turnout areas due to illicit cultivations, more water had to be delivered to each turnout area. Inadequate control facilities existed to allow for increased discharges in the main channel which sometimes resulted in overtopping the free board. The result was erosion of the channels and enlargement of channel sections. The larger the channel section, the larger the quantity of water released as issues to maintain the design depths. On the other hand, proper channel maintenance could not be carried out because of encroachments.

The problems with upstream channels caused a different set of problems in the tail ends. If 20 percent more land was cultivated in the upstream area, 20 percent of the downstream lands suffered shortages. When the downstream farmers had problems with water, they resorted to damaging the irrigation structures to obtain water. This has disrupted the effective distribution of water in the tail end sections of the channel system and a consequent reduction in productive performances.

3.2.2.3 The effect of bathing spots and buffalo watering

The channel net work of an irrigation system in the dry zone serves a dual purpose. It irrigates the fields and also provides the domestic water supply for the farming community. The Kaudulla system is a typical example. When the channel system was designed, no provisions were made to provide each farm family with a lined bathing spot (which would have been practically impossible). At the time of construction, perhaps, mechanization of land preparation was expected to replace buffaloes. Therefore, the system was not designed to cater to large herds of buffaloes. Thus, enlargements in the channel which did not conform to the designed section of the main channel was left for the purpose of watering the few buffaloes owned by farmers.

During the last decade, an energy crisis has changed the emphasis on mechanization. Farmers reverted to the extensive use of buffaloes for land preparation, with a disastrous effect on the main channels. Each farming family began using sections along the main for bathing. The farmers who were allowed to water their buffaloes at those predetermined spots, began watering buffaloes at more convenient points along the channels. Regular human and animal traffic at these points has eroded the channel sections, which have enlarged with time. These alterations in channel sections also have contributed to the changes in design depths and channel discharges. Some measurements that illustrate this change at different channel sections along the main channel are given in the Table 3.

3.2.2.4 Problems with water control structures

In the distributory system, especially along field channels, masonry structures were built for water control. Most of these structures are constructed across the channel downstream of a field outlet. The purpose was to head up water to maintain the required discharge at the outlet by constricting the flow. This particular design constrains the flow to half the bottom width of the channel. Most such structures do not perform any useful purpose at present because water flows around these structures leaving them in the middle. The cause for this was investigated. Many downstream farmers interviewed felt that these constrictions reduced the flow along the channel. Therefore, they dug around the structure to increase the downstream flow. Another cause was the passage of water through crab holes which gradually erode from the embankment around the structure. The flow through the field outlet was reduced because the water head necessary to maintain the required discharge has been substantially decreased. The problem with the design of these structures is that proper allowances was not given to needed carrying capacities of the channels during rainy periods and to the influence of manipulation by farmers.

3.2.2.5 Institutional limitations on effective water management

Similar to irrigation schemes in other parts of the dry zone, Kaudulla is located in a remote area. At Kaudulla, most of the basic facilities such as domestic water supply, electricity, transportation, and marketing facilities, which are the necessary inducements to the technical staff to stay within the scheme area, are deficient. In order to provide some of these facilities, the Kaudulla administrative office was located at Minneriya by the highway near the Minneriya reservoir, which is over 15 miles from the Kaudulla scheme area. Ironically, the Minneriya reservoir is managed by the ID office located at Hingurakgoda town which is 3 to 4 miles away from Minneriya Reservoir and 8 to 10 miles from Kaudulla. Since the scheme proper is located a significant distance from the ID office, with subsequent transportation difficulties, proper supervision of the technical staff involved in the actual management of water is a problem.

There are no incentives for the officers of government bureaucracies to get involved in better management as salaried employees. There is an indifferent attitude towards productive work among many of the employees. Their enthusiasm is further dampened by political interference at various levels. Most adopt the policy of doing the amount of work that gives them the least troubles in decision making. Also, the wages they receive are insufficient to meet their economic and social demands. Therefore, it is understandable that some officers in the various government institutions practice paddy cultivation to supplement their incomes. Field level officers of the Land Commissioners Department, Department of Agriculture, District Administration, Department of Irrigation, and Banking sector and police are some examples. Part-time paddy cultivation may improve their economic status, but it interferes with impartial performance of their duties. Their preoccupation with private cultivations hardly provides them time to get involved in irrigation system management.

Frequent transfers is another problem. During the period from June 22, 1982 to June 22, 1983, Kaudulla had three irrigation engineers. Either they were promoted or transferred to more convenient locations upon request. Because of these transfers, they developed little familiarity with the management of the scheme or developed no interest in understanding the problems existing in the scheme. These comments demonstrate how the social and economic constraints of the larger economy of the country can affect the management and administration of an irrigation scheme.

3.2.2.6 Limitation imposed on system maintenance

The priority of most political administrations in recent years has been to develop new irrigation facilities. The maintenance of functional schemes has remained more or less neglected. Investments on maintenance of existing systems carry no political glamour. However, the argument that these development activities will later require higher investments due to inflation has justified priority on new development activities. Therefore, the essential fact that inflation equally affects the rehabilitation costs of existing systems, a consequence of poor maintenance, is presently being overlooked. Perhaps, rehabilitation of these schemes may require much heavier investments in the future.

Insufficiency of the available maintenance funds is one of the major constraints affecting management of irrigation water at Kaudulla. Each year the management experiences diminished allocations and the maintenance capability of such allocations. Often, minor repairs are neglected to make the best use of the available funds. The result is continued deterioration of the channel system, which is the main stay of better control and distribution of water. Consequently, this has increased the unreliability of supply and inequality of water distribution within the system. In Stage I of the scheme, this is especially noticeable along the main channel and towards the tail ends of the distributory channels.

3.2.2.7 System efficiency from irrigation administration point of view

The measure of performance of Kaudulla as an irrigation system, used by the ID is the water duty at the sluice. The water duty is determined by the total water issued at the sluice for a season divided by the design area of the scheme. Based on the water duties for the period from 1978 up to 1981 (Holmes et al., 1981), Kaudulla can be considered as a model scheme among most of the irrigation systems found in the dry zone. Unfortunately, this measure of performance does not indicate the equity of distribution of irrigation water or the actual productive performance of the scheme because the high yields obtained by the top enders mask the low yields obtained by the tail enders. Thus, such an indicator effectively masks the inefficiencies in water distribution and income disparities among farmers when the total system is viewed.

3.2.3 FARM LEVEL MANAGEMENT PROBLEMS

Farm level water management problems are caused either by actions of the farmers or defects in the system at the farm level. Some of these defects originated during the initial planning stages or at implementation stages. Let us first consider the actions of farmers that have contributed to management problems.

3.2.3.1 Tampering of the pipe outlets

Complaints made by tail end farmers of longer distributory channels and field channels revealed an interesting practice of the head end farmers, often linked to illicit encroachments. Most farmers openly admitted that they have added close to an acre of additional land from road, channel or drainage reservations. The majority of these farmers have their fields at the outer fringes of an irrigation tract. Irrigation of this additional land requires higher inflow rates. Lowering the pipe entrance enabled them to increase the effective head in the channel thereby increasing the discharge. These illicit practices have increased the inflow into their fields considerably, but have deprived the farms at the distal ends of their fair share of irrigation water. The tail enders must delay their cultivation operations, which implies that water issues have to continue even after the scheduled cultivation season.

3.2.3.2 Poor maintenance at head ends of field channels

Maintenance of a canal section adjoining a farm is the responsibility of the owner of the farm. Most farmers close to the head ends of field channels neglect their share of such responsibility. They are less concerned because, irrespective of the condition of the cleaning of the channel, water reaches their fields. This practice has reduced the flow along the field channels. Often, the downstream farmers have to clean those parts of the field channels in order to obtain their supply of water. Frequent disputes over such issues present difficulties of any organized attempt to have better water utilization at the farm level.

3.2.3.3 Practice of leasing farm allotments

It was mentioned in a previous section that some officers practice rice cultivation. Not having land of their own, most of these officers lease land from farmers. Other such lease holders are the local traders, officers of the law enforcement service (police), and school teachers. Most of the time, land is leased out by farmers to settle loans. Other more established farmers resort to this to gain other advantages. Because of these involvements, often other malpractices of these farmers, such as encroachments and illicit tapping, are overlooked. Also, there is an indirect effect. Often the officers of government services prefer to lease land closer to the water source. Thus, their impressions on the performance of the system is favorable since they themselves do not experience any problems. Therefore, the real problem of inequalities of water distribution often remain unnoticed.

3.2.3.4 Drainage reuse and its effects

In any irrigation system drainage, reuse of irrigation water is a positive aspect of the irrigation system. There is extensive drainage reuse within the Stage I of Kaudulla. This is one of the ways tail end farmers of longer distributories obtain their water supply. However, problems are developing due to this practice. During the Yala seasons, most tail end farmers along longer D channels block the natural drainage using earth and stick dams. This is practiced because some FCs do not convey any water if they are too long. The water collected is used to irrigate their fields. The problem of this practice is their failure to remove these temporary structures during the Maha seasons. Impeded drainage during the Maha season often damage the crop or reduce their yields.

3.2.3.5 Distance to the farmland from homestead

It was previously mentioned that highland allotments for homesteads and irrigated lowland allotments formed two separate blocks in a single irrigation tract. In Stage I of Kaudulla scheme area, there is an inconsistency in the allocation of highland and lowland allotments of irrigation tracts among farmers. For example, farmers having lowland allotments in tract 2 have their homesteads in tract 1, while farmers having their homesteads in tract 2 have their fields in tract 7, etc. Thus, most farmers have to travel a long distance—2 to 4 miles—to cultivate their fields. This is a major problem in relation to farm level water management because it is difficult to persuade the farmers to travel long distances, for careful management of water. Also, most farmers prefer to use a large stream size to rapidly flood their fields. Therefore, the practice is to stay overnight in small huts constructed in the fields to block other field inlets until a satisfactory stream size is obtained. This practice often leads to disputes over water. Any improvement to farm level management becomes a difficult task with such a constraint.

3.2.3.6 The `Vel Vidane' (water manager) system

The Vel Vidane' (water manager) system is a remnant of the colonial irrigation administration rather than the ancient custom (Leach, 1961). During ancient times, water management was the responsibility of the Vel Vidane. The Vel Vidane, in the past, was a powerful person, often a village elder much respected by the community because of his experience and social status. The present system is yet another variation of this ancient system. Under the present system, depending on the size of the irrigation tract, one or several Vel Vidanes are appointed by the vote of farmers in the tract. His duties are to oversee the distribution of water in the channels of his area of responsibility, settle disputes among farmers, and report to the irrigation officers of major problems in distribution. His services are paid in kind (often 1-2 bushels depending on the size of allotment) by the farmers at the end of a season.

The problem with the present Vel Vidane system is that most often the post has some social prominence and political significance. Thus, canvassing for the post is on this basis rather than to perform a service. Also, there are differences in the number of allotments in each Vel Vidane's area of responsibility which determines his income. Thus, there is competition among Vel Vidanes to distribute water and often the more powerful gets the upper hand. Thus, farmers complain that because of this competition some Vel Vidanes neglect their duties. Other farmers complain that, once appointed, their Vel Vidanes cater only to their favorites and to farmers who pay a bribe. Often the farmers with water problems are a minority in a given tract. Thus, they do not have the voting power to appoint a Vel Vidane to represent them. The farmers with water problems often expressed a preference to have the ID laborers manage the water distribution in the field channels. These are some problems identified with the Vel Vidane system introduced for water management in field channels.

3.2.3.7 Farms located at higher elevation than the field channel

Irrigation tracts 7 and 8 of Stage I of the scheme show that some field channels are located at a lower elevation than the fields that they are supposed to irrigate. Information gathered from the owners of these fields indicated that construction of these channels had been carried out by private contractors. According to the design, channel beds were to be raised by filling so that the channel could command the fields. During construction, instead of filling, the contractors have installed drop structures in order to avoid earth filling and compaction of the channel bed. There was inadequate supervision during the construction phase and these practices were overlooked. As a consequence, the channel runs at a lower elevation than the fields. This has created many problems. In order to obtain water for their fields, farmers have installed their own pipe outlets even across roads. Others resort to blocking these channels with straw and other material to increase the water head in the channels. Especially towards the tail ends of tracts 7 and 8, water distribution is in a chaotic situation because of this practice and other related damages done by farmers to get their water supply.

3.3 AN OVERVIEW

Most of the problems and constraints discussed in this section that affect water management at Kaudulla are not very apparent. As reported, at main channel level, the head, middle, and tail end differences in water distribution are not very evident (Holmes et al., 1981). Also, the water duties that are reportedly lower should be still lower if one takes into considerations the encroachments. Water duties determined at the sluice will not reflect the water duties at the head, middle, and tail ends of distributories or field channels. Existence of these differences will have to be validated by monitoring.

Lastly, from a systems point of view, the technological system is constrained at design stage by the ecosystem and by the larger socioeconomic system of the country. It is clear how the social, political, and economic systems have violated the design constraints of the technological system, and the discipline demanded by the technological system due to conflict of system and social interests has collapsed. Also, it is clear that this conflict of interest has crippled the effective functioning of the system and negated the welfare intended for a part of its beneficiaries. The challenge presented by this set of conditions is to arrive at an effective strategy of water management that will work within the given constraints, so that some equity in the distribution of water and distribution of economic welfare among the farming community can be achieved.

3.4 NATURE OF EXISTING WATER MANAGEMENT PROBLEMS

There are two schools of thought regarding the general nature of existing water management problems. The irrigation system managers (mostly engineers) emphasize that most such problems are at the farm level. Therefore, they advocate education, training and organization of farmers to achieve better water management at the farm level to overcome the problems. The other school of thought is that the system causes most of the farm-level problems. The argument they present is that, when the water supply becomes unreliable due to defects in the technical system, its management and operation, the farmers react to the situation by using as much water as possible when water is available. Therefore, the implication is that water supply should be first made reliable by removing the management and system defects in order to solve the problems at the farm level. Both arguments seem to have substance with respect to current water management problems observed at Kaudulla. More often, as seen in the preliminary investigation, it is a combination of both, complicated by the influence of other extraneous factors.

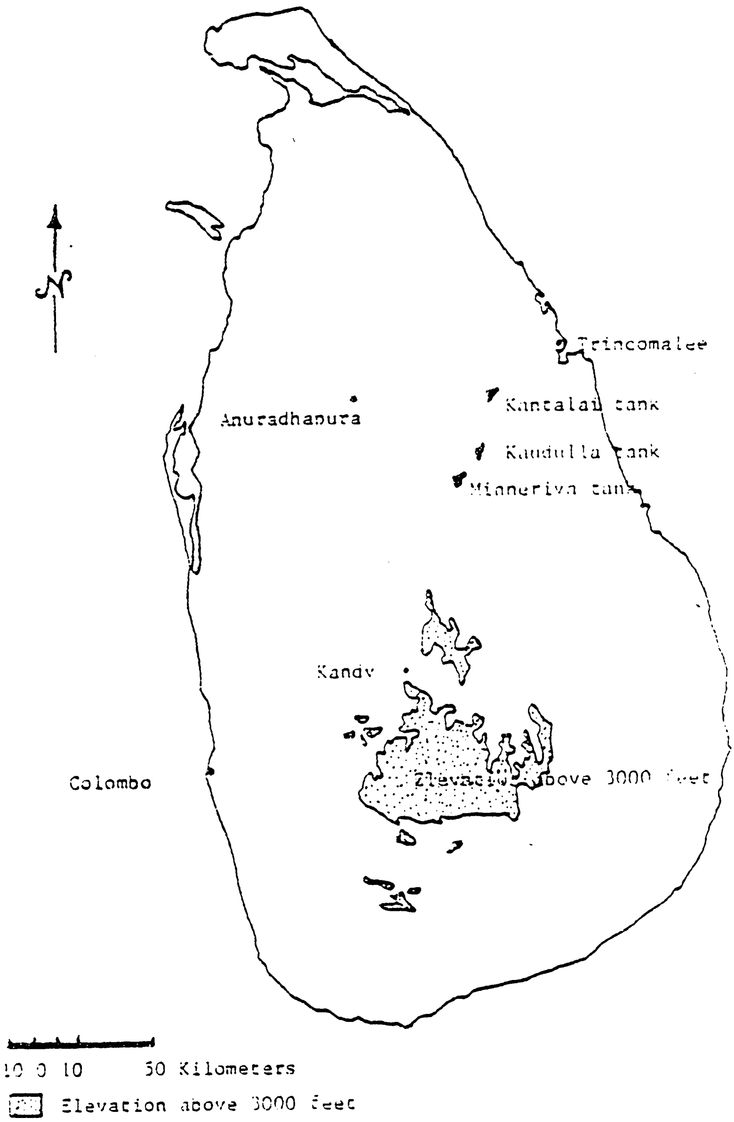


Figure 6. Map of Sri Lanka showing location of Kaudulla reservoir in the northeastern dry zone.

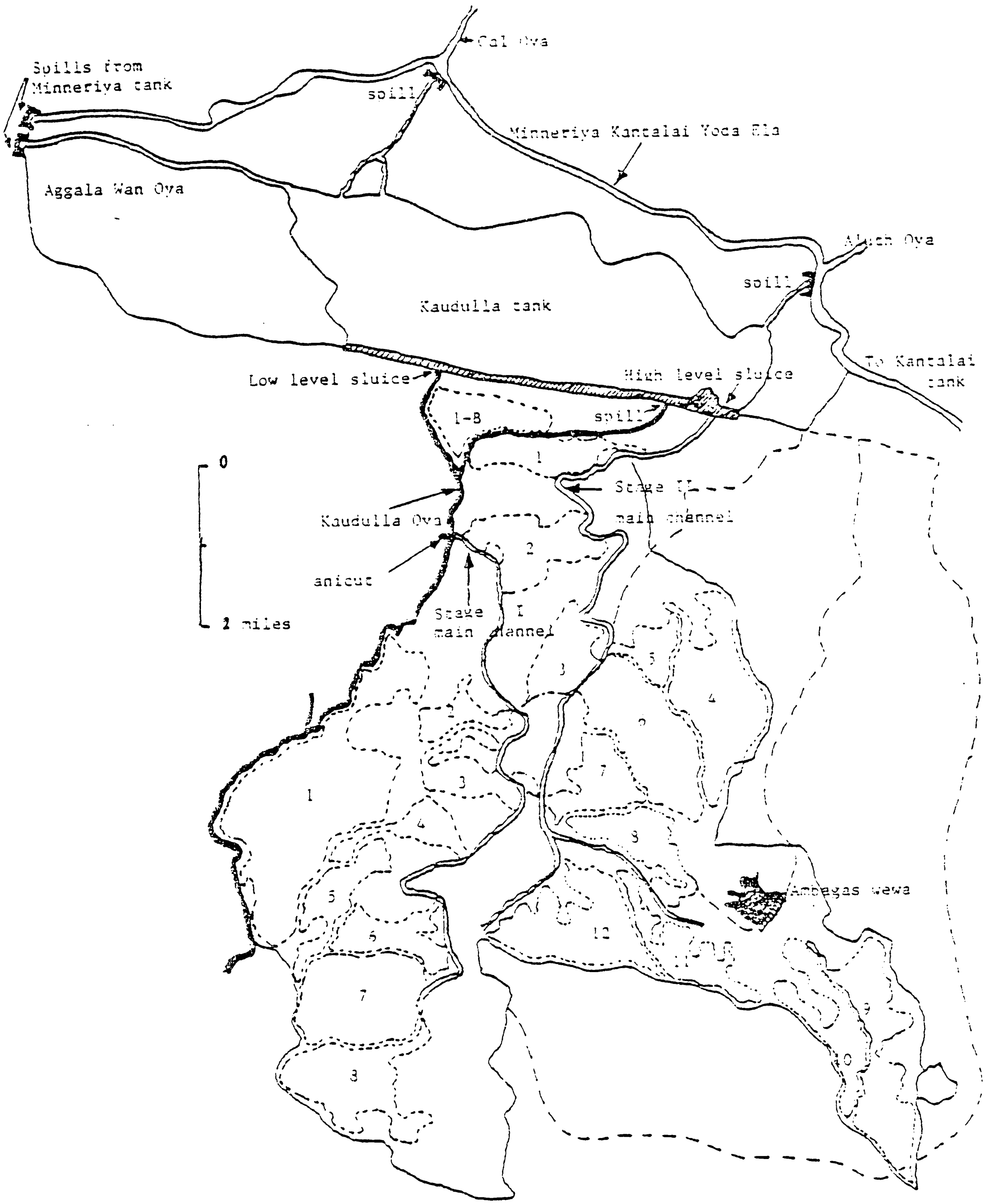


Figure 7. Reservoir and main channel system layout of Kaudulla irrigation scheme.

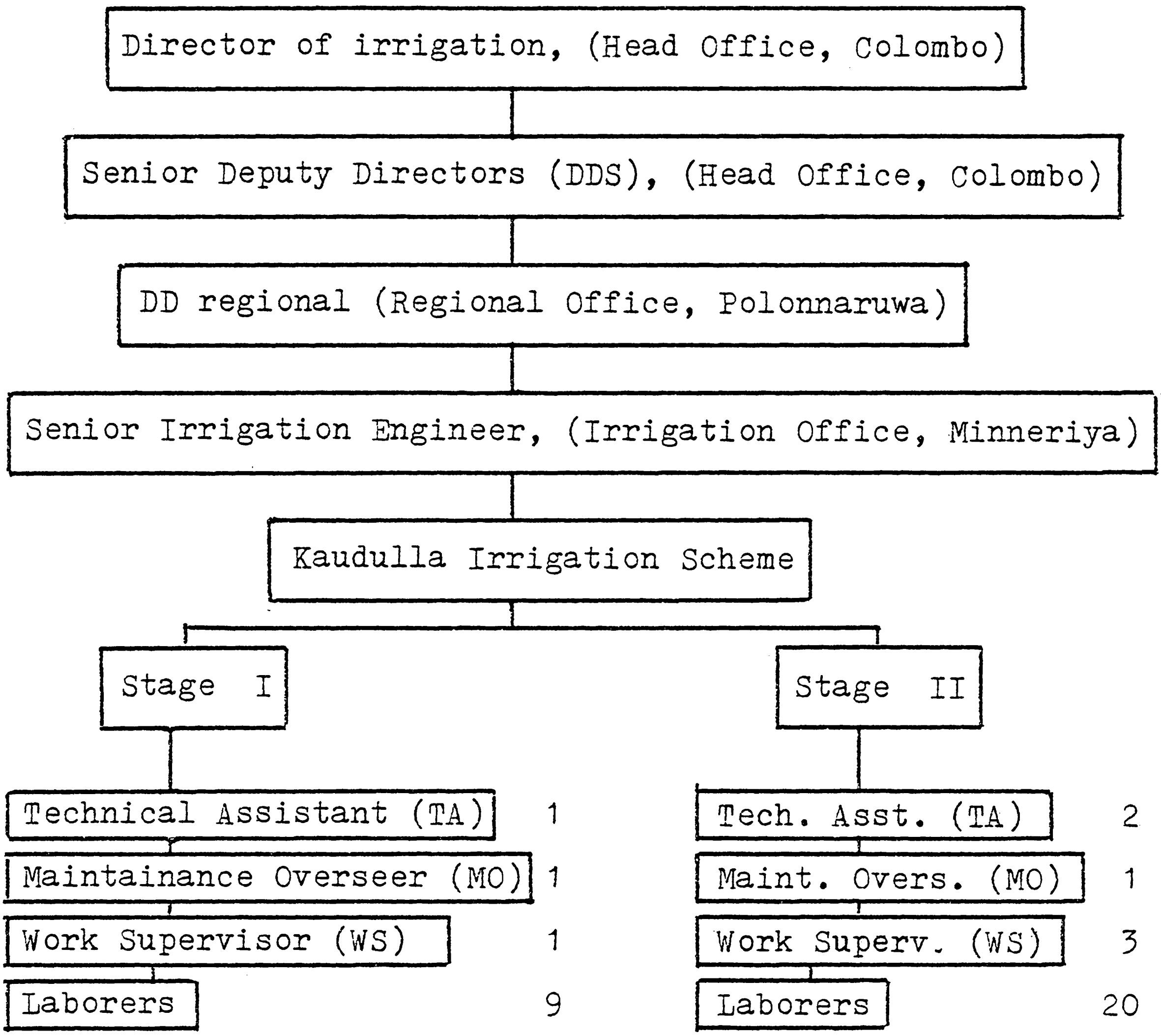


Figure 8. Adminsitrative organization of the Department of Irrigation at Kaudulla.

Table 3. Measured widths along main channel of Stage I. Kaudlla Irrigation scheme.

Location	Width of main channel ft	Height of average water mark ft
D-1 offtak	18.00	3.16
D-2 offtak	18.00	3.16
D-3 offtak	18.25	3.16
D-4 offtak	31.00	2.00
D-5 offtak	43.00	1.58
D-6 offtak	29.00	2.67
D-7 offtak	37.00	2.58
D-8 offtak	18.00	2.00
D-9 offtak	24.00	2.58
FC-4 offtak	20.42	2.92
D-10 offtak	58.00	2.83
T-7 offtak	4.42	2.00
T-8 offtak	3.08	2.00

4.0 CHAPTER FOUR : METHODOLOGY

4.1 INTRODUCTION

This chapter contains a discussion of the methodology adopted for field data collection following the selection of the Kaudulla irrigation system as the location of the study. Evaluating the system in operation and identifying technical factors constraining effective distribution and use of water was achieved by monitoring irrigation flows in both the channel system and at farms. The procedure adopted to identify agronomic and economic constraints affecting productivity of water at farm level also are presented in section. Social factors affecting the organization and management of irrigation water of the entire irrigation system was identified by a sociological investigation.

The preliminary investigation conducted during the 1982 Maha (wet) season provided valuable insights to the nature of irrigation management problems at Kaudulla but, it was difficult to select the fields for monitoring without also investigating a dry season cultivation. For this reason, the data collection process during 1983 Yala season was limited to monitoring water distribution along the main channel system, establishing stage discharge relations, field surveys, and interviewing farmers to select locations for farm level monitoring and agronomic data collection. Nevertheless, three selected tracts were closely observed for the progress of land preparation in relation to water distribution and other problems related to production at the farm level. Many problems were encountered and mistakes were made during the first season of data collection. These are discussed in Appendix B to benefit others who may attempt similar field investigations.

During the Maha season, where water was abundant, data collection was abandoned because a) water was not a constraint to production during this season and b) difficulties of retaining the field personnel without permanent employment security required recruitment of new personnel for field data collection and training during the Maha season. Therefore, data collection had to be limited to two Yala seasons. During the 1984 Yala season, most of the field problems encountered during the previous Yala season were corrected.

4.2 PROCEDURE ADOPTED FOR MONITORING THE DISTRIBUTION SYSTEM

Problems of water distribution in the main distributory system requires monitoring irrigation flows. The main channel and the rest of the conveyance system were planned based on design depths to maintain the appropriate discharge rates into offtake points from the main channel. The design depth can be converted to appropriate discharge rates if the geometrical properties of the offtake points are known. The Kaudulla

Stage I channel system has a rectangular underflow gate at the head and gated pipe outlets at distributory offtake points.

The method of monitoring involved daily measurement of water depths at the upstream end of the selected offtake points. The main channel offtake point from the Kaudulu Oya into which the Stage I sluice discharges has three rectangular underflow gates, each having 0.9144 meter by 1.219 meter (3 feet by 4 feet) cross sectional dimensions. It was observed that flow into the channel was regulated by opening the low level sluice gate to a particular height rather than controlling the gates at the head works of the channel. In fact, one gate was non-operational and the other two were never operated. Thus, once the flow was set for a particular day, the discharge rate through the head works did not change appreciably until the next day when the sluice setting was changed to adjust for the lowered reservoir water level. This was an advantage because a single observation taken at this point could reliably estimate discharge into the main channel.

At other offtakes, this procedure could not be followed. The observations taken at these points at any given time are only reliable during the first month of water distribution for the land preparation period. Thereafter, the management adopts a form of rotational (Mura Watura) issues, when offtakes along the main channel were closed or opened in a rotation. This practice was mainly done to reduce the clamor of the farmers located at the tail ends due to insufficient water supplies. Secondly, there was no fixed time of opening or closing gates. The openings and closings depended entirely on the irrigation laborer who attended to these duties and the amount of clamoring done by the farmers. Occasionally, it was observed that when a reading was taken the gates were fully open, and on the return trip the gate completely closed or vice versa. Frequent observations were impossible due to limitation of resources and available personnel. Nevertheless, these observations were made in order to understand the distribution pattern of water along the length of main channel.

4.2.1 OBSERVATION PROCEDURE AT THE HEAD OF MAIN CHANNEL

During the off season when the channel was closed a bench mark was established at the channel bottom along the upstream wall of the structure. This was done during the off season when the channel was closed. During the first season of observation, a meter stick was used to measure daily the distance to the water surface from a specific point above the bench mark. These observations were then reduced to actual water depth by using the distance from the bench mark to the point of measurement. During the second season of observation, a vertical scale was painted along the upstream wall, which provided a simple direct measurement. The daily observations of water depths were directly read from this scale. The observations made at this point were limited to a single upstream water depth measurement. The reasons for making a single observation are discussed in section "Rating curve for main channel offtake" on page 80

4.2.2 MONITORING PROCEDURE FOR DISTRIBUTORY OFFTAKES ALONG MAIN CHANNEL

As previously mentioned, the monitoring procedure at these locations were not as simple as the monitoring at the main channel head works. All the offtake points were gated pipe outlets of varying diameters. During the first observation season, bench marks also were established at each of these structures and the distance to the water surface was measured from a fixed point on the structure vertically above the bench mark using a meter stick. These observations then were reduced to actual water depth using the distance from the bench mark to the fixed point. Initially, observations were limited to a measurement of water depth with the assumption that it is possible to use simple orifice discharge equations to compute the discharge into these offtakes, but continued observations during the first season proved otherwise. It was observed that each of these pipe outlets were either submerged or free flowing. This meant that simple upstream head measurement were not sufficient in the case of submerged pipe flow. Instead, it was necessary to measure the difference in water elevation to compute the discharges into the offtakes. Also, during the rotational issues, the outlet gate settings were at different positions which changed the discharge for a given water depth. In order to account for this and to improve the accuracy of estimates the following procedure was adopted during the second season.

A second bench mark was established at the discharge end of the pipe outlet which was at the same elevation as the first bench mark. Then an additional measurement was taken at the discharging end so that observations could be reduced to differences in water levels, for example, in the case of submerged outlets. Secondly, it was observed that most of the gates could not be completely opened due to construction defects. Therefore, the gate adjusting rod heights were measured when each opening was completely closed by the flap and when it was at maximum open position. Thereafter, daily observation of the gate adjusting rod heights were also noted at each offtake to determine the actual flow area contributing to the discharge.

4.2.3 DISCHARGE RATING OF CHANNEL SECTIONS

It was necessary to establish discharge relationships for each of the monitoring locations. The only practically feasible method available was current metering. During the first Maha season, several such ratings were conducted along the main channel to determine the discharge along the channel. A relatively uniform channel reach was selected wherever possible. Each section was divided into a minimum of ten subsections so that each subsection carried no more than approximately 10% of the total discharge as recommended by USDI Water Measurement Manual(1974). At each of the subsections, boundary depths and the depth at the center were measured. Three velocity measurements at 0.2, 0.6 and 0.8 of the depth were taken for each subsection. Each measurement ranged from 30 to 180 seconds in duration.

There were many difficulties encountered in these ratings. First, considerable time and personnel resources were needed to conduct a single calibration. Often it took over 6 hours per section to conduct one such calibration. Second, once the irrigation issues started, it was not possible to obtain a complete range of stage discharge relations, which are essential for accurate estimation of discharge. This was mainly because these adjustments were beyond control and practically infeasible during water issues. However, the number discharge ratings were limited to available resources.

4.2.4 RATING CURVE FOR MAIN CHANNEL OFFTAKE

It is possible to apply the orifice equation to the flow through rectangular underflow gates. The orifice equation is given by

$$Q = \sqrt{2gH}$$

where

Q is the discharge rate in cubic meter per second,

g is the acceleration due to gravity 9.81 m/second/second, and

H is the effective hydraulic head in meters. In the case of a free flowing orifice, effective head is the water level above the center of the orifice and, for a submerged orifice, effective head is the difference in water elevations at the inflow and outflow ends of the orifice.

The problem with applying the orifice equation is that, first, it is necessary to estimate the discharge coefficient. Second, it is necessary to know the variation of discharge coefficient with the effective head. Third, the effective head should be at least twice the height of the opening (Bos, 1976; USDI Water Measurement Mannual,1974). Dias (1984) studied the variation of the discharge coefficient with the change of effective head at Kaudulla. Selecting the underflow gate at the head of main channel, which functioned as a submerged orifice, He conducted a number of calibrations and found that the discharge coefficient varied as a negative exponent of the effective head. However, estimations tended to large errors when effective head was small. Also, it was not possible to estimate discharge when the flow regime changed from orifice flow to weir flow under low flow conditions. In addition, it was difficult to measure the downstream water level with a reasonable accuracy without a stilling well due to the turbulent flow condition. Because of these limitations, a simple relationship between the upstream water depth and discharge through the orifice was derived through regression analysis. This procedure was possible because there was no downstream control altering the stage discharge relationship.

In order to account for the transitional flow condition, two separate regression curves were fitted to the two portions of the discharge rating (Figure 9 on page 89). The upper portion of the curve had nine data points and lower portion had only one data point. The lower curve was fitted with the assumption that no discharge occurs at zero water depth and taking the lowermost data point of the upper curve in the absence any other reliable method of estimation.

4.2.5 ESTIMATION OF DISCHARGES THROUGH DISTRIBUTORY OFFTAKES

As mentioned in an earlier section, all distributory offtakes from the main channel are gated pipe outlets. Estimating discharges through distributory offtakes proved much more difficult with the orifice equation. Larger distributories had more than one pipe outlet. Further, gate settings affected the discharge coefficient in addition to the effect of variations in the hydraulic head. Calibration results indicated that the variations due to effective head in these cases are much smaller compared to variations due to the gate setting.

The circular flap (Figure 10 on page 90) presented an additional problem of estimating effective flow area. Cross checking indicated estimation errors as large as 16% due only to effective flow area. To overcome these problems, two procedures were adopted. First, gate flaps were traced for different diameter pipe outlets and an equation was fitted to establish a relation between percent flow area and percent gate opening. From this relationship the effective flow area for a given gate setting was calculated (Figure 11 on page 91). Second, a curve was fitted for the relationship between percent gate setting and discharge coefficient given by Bos (1976) for meter gate by adjusting the slope of a logarithmic curve fitting (Figure 12 on page 92). Next an average discharge coefficient was established for each offtake using calibration results (Table 4). This average discharge coefficient was substituted for the intercept of the derived relationship assuming that slope remains the same. This relationship thus provided the average discharge coefficient as the maximum discharge coefficient when the gate opening was 100%. The results were cross checked with discharge ratings to evaluate errors in discharge estimations (Table 5). The maximum error of estimation was less than ±15%. This was assumed as a satisfactory estimation in the absence of other reliable methods.

4.2.6 ESTIMATION OF FLOW INTO TRACT 7 AND TRACT 8

The main channel at Tracts 7 and 8 bifurcates into two branch channels. The channel leading to tract 7 has an overpass bridge immediately below the main channel while the branch channel to tract 8 carries water through a lined section. Both have flume sections with drops carrying water at high velocity creating much turbulence. These conditions made it impossible to select suitable sections for a discharge rating due to badly deteriorated downstream channel conditions. The only possible alternative for discharge ratings was upstream along the the main channel which was lined and had a rectangular section. In order to estimate flow, discharge ratings were made and, using Manning's equation, ratios of square root of slope and roughness coefficient were calculated. These values were assumed to vary between the highest obtained value of 1.15 and lowest value of 1.08 for highest and lowest flow ratings, respectively. Hydraulic radius and area were calculated using water depth values and the channel width. A correction factor was added to the cross sectional area calculated from channel geometry to account for bottom irregularities. Manning's equation was applied to compute the discharge for a given water depth using the above procedure.

4.3 SOCIOLOGICAL INVESTIGATION

A sociological investigation was conducted by S.Goonasekere during the 1982 Maha season and the 1983 Yala season as a completely independent study. For this study, the Irrigation Engineer, his technical staff, the local administrative authorities, bank managers, water tenderers, and the farmers were interviewed. Most of the conversations were recorded for later verification with the permission of the person interviewed and a guarantee of anonymity. This data was separately analyzed for the sociological investigation.

4.4 FARM LEVEL INVESTIGATION

4.4.1 WATER PROBLEM IDENTIFICATION FOR ENTIRE STAGE I

It was difficult to determine water distribution problems during the Maha season due to above normal rainfall and irrigation water availability. Therefore, during the first Yala season (1983), and while monitoring water distribution along the main channel, a separate survey of the Vel Vidanes (water tenderers) was conducted to identify Stage I water problems of the scheme. All Vel Vidanes were interviewed to find the problem farms in his area of responsibility. Then, the individual farmers identified were interviewed to find the nature and magnitude of their problems. Only Stage I was considered for this purpose because it was representative of the entire scheme with respect to different size farm allotments (3 acre and 2 acre farms). Also, the limited available resources precluded conducting the study over the entire scheme.

4.4.2 SELECTION OF TRACTS AND FARMS FOR OBSERVATION

During the first Yala season (1983), and while the above survey was in progress, distributory channel Nos. 2, and 4 of tract 2, and field channel No. 15 of tract 7 (see Figure 17 on page 147 for irrigation channel and tract layout) were observed for progress of land preparation and farmer water management problems. During the 1984 Yala season, irrigation tracts 2, 3 and 8 were selected for farm level monitoring based on the survey conducted in the previous Yala season. Along each tract the distributory was sectioned into head, middle and tail based on the distance from the main channel. Then a field channel from each section was randomly selected. Each field channel also was divided into head, middle, and tail sections based on the distance from the distribotory measured along the field channel. From the farms irrigated by each of these sections, 2 farms were randomly selected for observations (see Figure 13 on page 93; Figure 14 on page 94; Figure 15 on page 95; and Figure 16 on page 96). Thus, from each tract, three field channels were selected. There were a total of eighteen farms, six farms to each field channel for observation. Initially, 54 farms were selected for farm level observations. As the figures indicate, the selected farms are marked with symbols in Figures 13,14 and 15.

4.4.3 INFLOW/OUTFLOW MEASUREMENTS FROM FARMS

Portable fiberglass trapezoidal flumes were used to measure water inflows and outflows from the fields. Each farm had several inflow and outflow points, which made continuous daily observation of inflow-outflow impossible. In order to reduce the work load, nine farms from each tract were selected for these measurements, and only periodic observations for inflow and drainage outflows were made (see Appendix B for field problems).

4.4.4 FLUME CALIBRATIONS

The trapezoidal flumes used for farm level measurements were small V type trapezoidal flumes constructed to the dimensions described by Robinson and Chamberlain (1958). The head discharge relationship is given by

$$Q = 1.55\ h^{2.58}$$

where h is the upstream head measurement in feet and Q is the discharge rate in cubic feet per second. A separate calibration of the flumes was carried out by Ajantha(1984) to establish head discharge relationships. He found, that for lower flows, a common relationship can be used for all flumes without appreciable error in excess of (±15% of estimation). The relationship established for the flumes is given by

$$Q = 0.009\ h^{2.32}$$

where Q is the discharge in liters per second and h is the upstream head measurement in centimeters.

4.4.5 AGRONOMIC AND ECONOMIC SURVEY

During the 1983 Yala season, a questionnaire approach was attempted to gather economic and agronomic aspects of farm level productivity. This was not successful and was subsequently abandoned (see Appendix B for a discussion of problems). As an alternative, it was decided to select a few farmers and record selected information based on answers to a few questions obtained during daily field visits. In addition, farmers not in the above group, were interviewed to obtain a qualitative assessment of the problems. The following information was given priority for assessing agronomic and economic practices of the farms.

1. Land preparation with respect to cultivation schedule and cost,
2. Power sources and cost,
3. Labor requirements and cost,
4. Method of planting, source of seed and cost,
5. Intercultivation operations and cost,

6. Harvesting, cost, and yield.

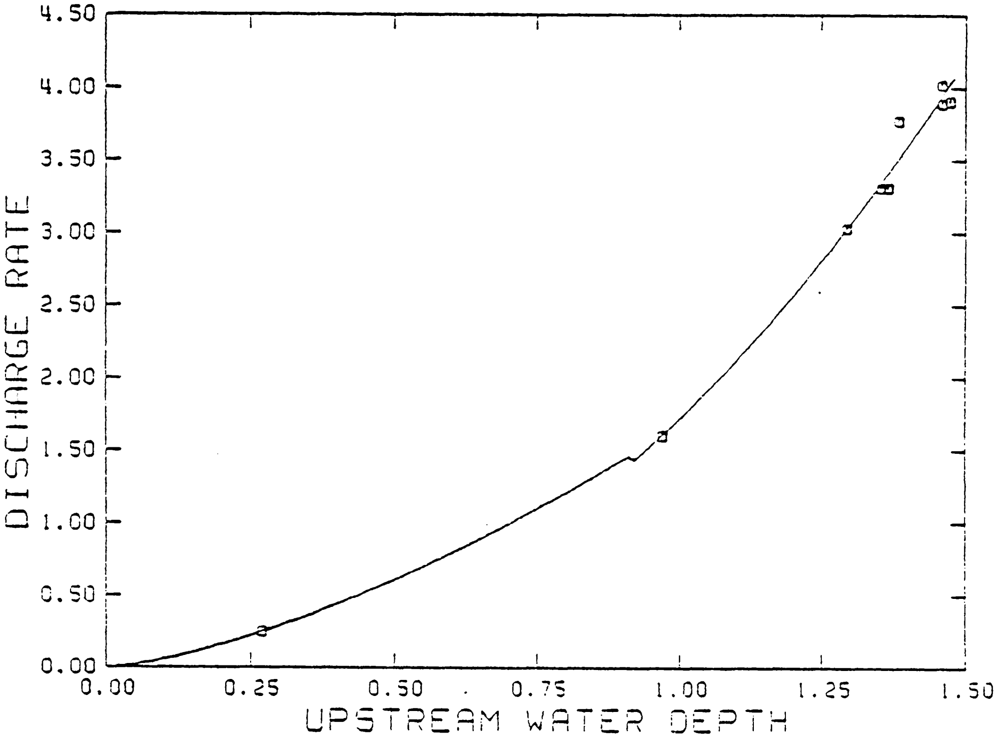


Figure 9. Stage discharge relationship of the main channel head work control structure. Kaudulla irrigation scheme Stage I.

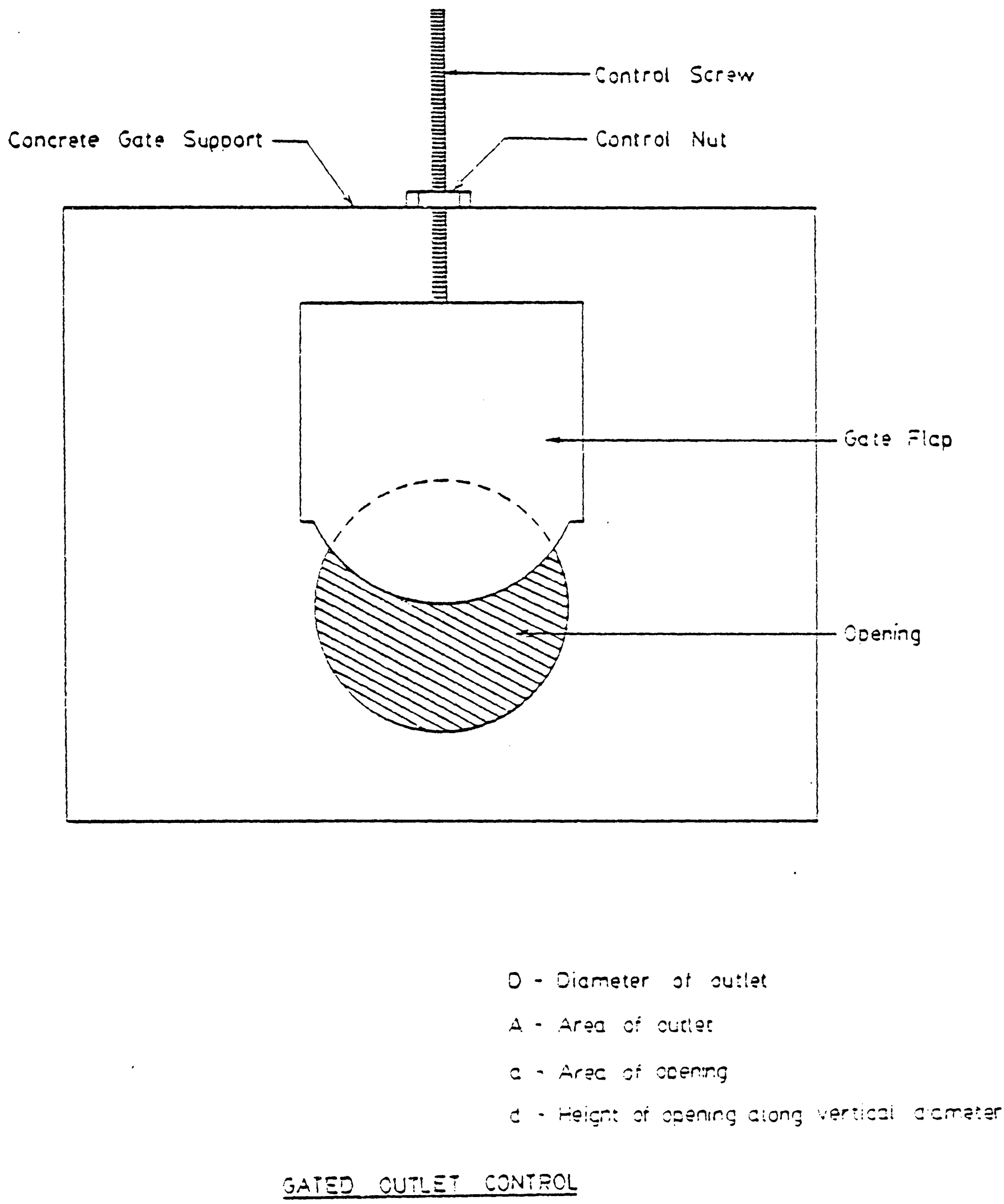
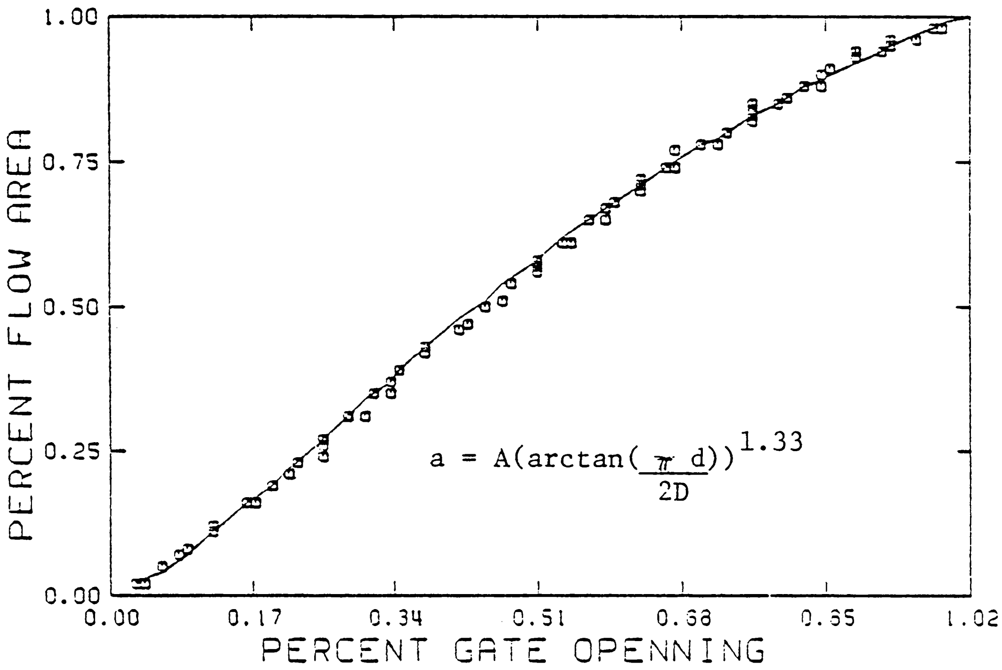
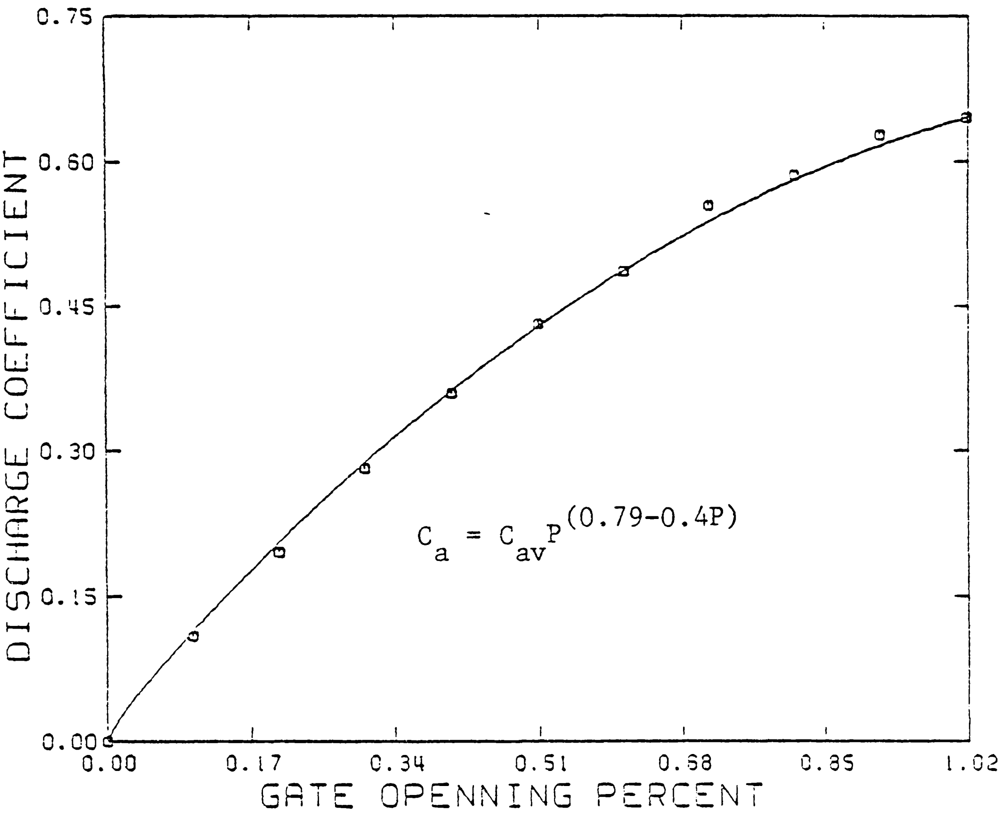


Figure 10. A gated pipe outlet with circular gate flap used as typical discharge control structures at Kaudulla Stage I.



Where A = Total flow area when gate is fully opened,
a = Effective flow area at a given gate setting,
d = Height of gate setting
D = The diameter of pipe outlet

Figure 11. The relationship between percent flow area and percent gate opening for gated pipe outlet.



Note: The derived relationship is of the form

$$C_a = C_{av} P^{(0.79-0.4P)}$$

C_a = actual discharge coefficient

C_{av} = average maximum discharge coefficient

p = percent gate setting

Figure 12. The derived relationship between discharge coefficient and percent gate setting(source of data: Bos, 1976).

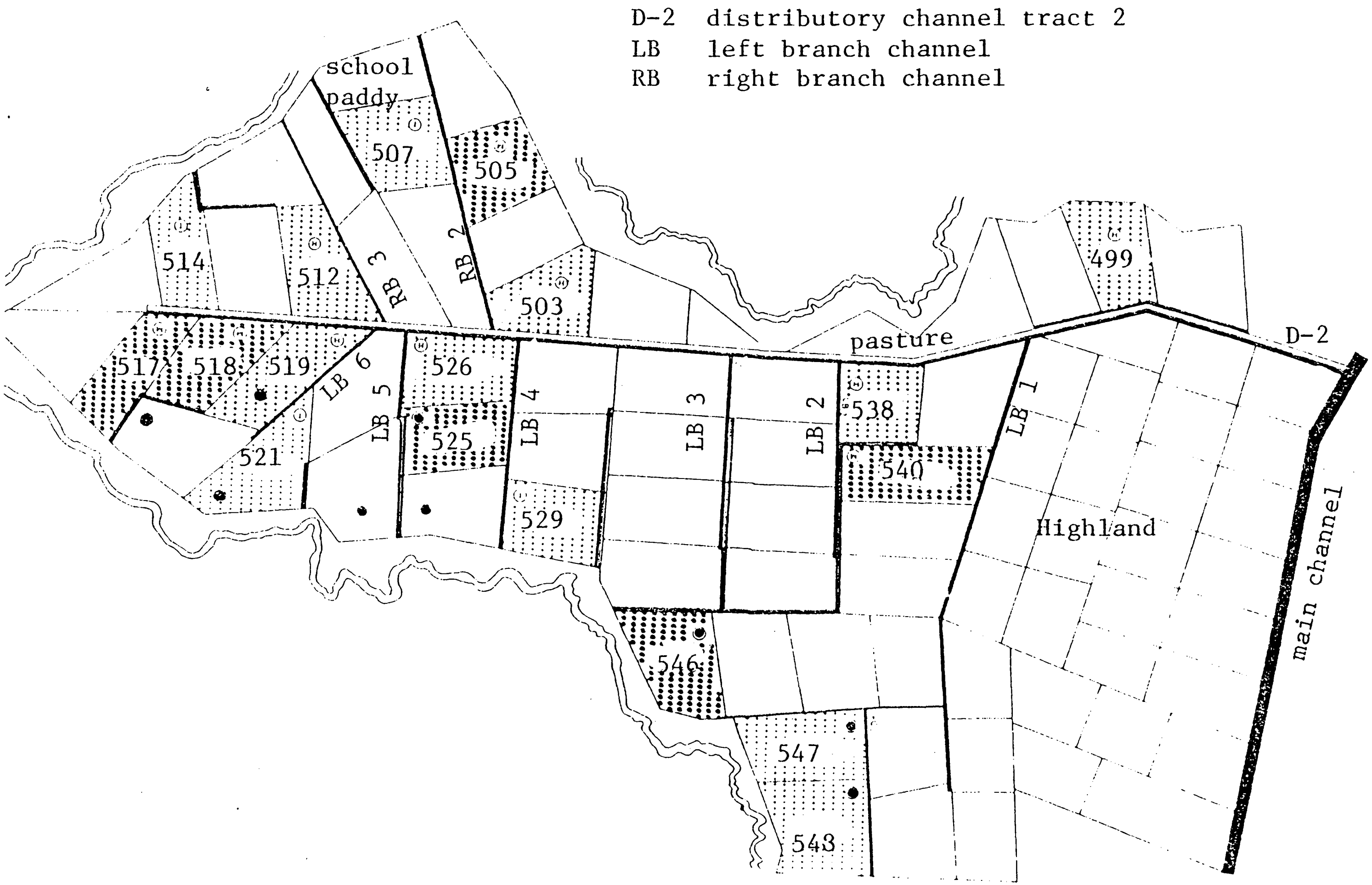


Figure 13. Tract No. 2 farm allotments and irrigation layout. The selected farms for observation are marked with symbols. (source: blocking out plans of the Department of Irrigation, Kaudulla, Sri Lanka)

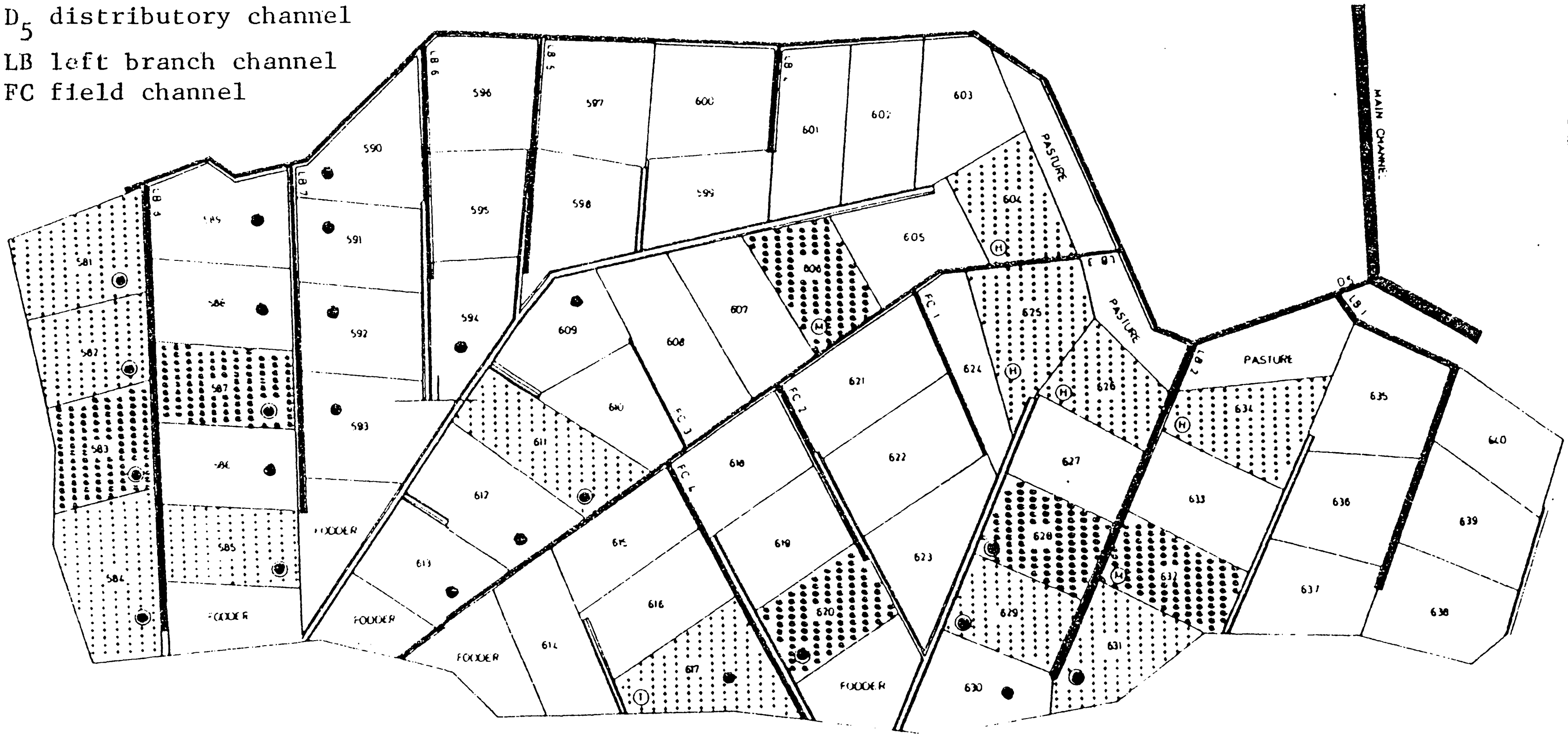


Figure 14. Tract No. 3 farm allotments and irrigation layout. The selected farms for observation are marked with symbols. (source: Blocking out plans of the Department of Irrigation, Kaudulla, Sri Lanka).

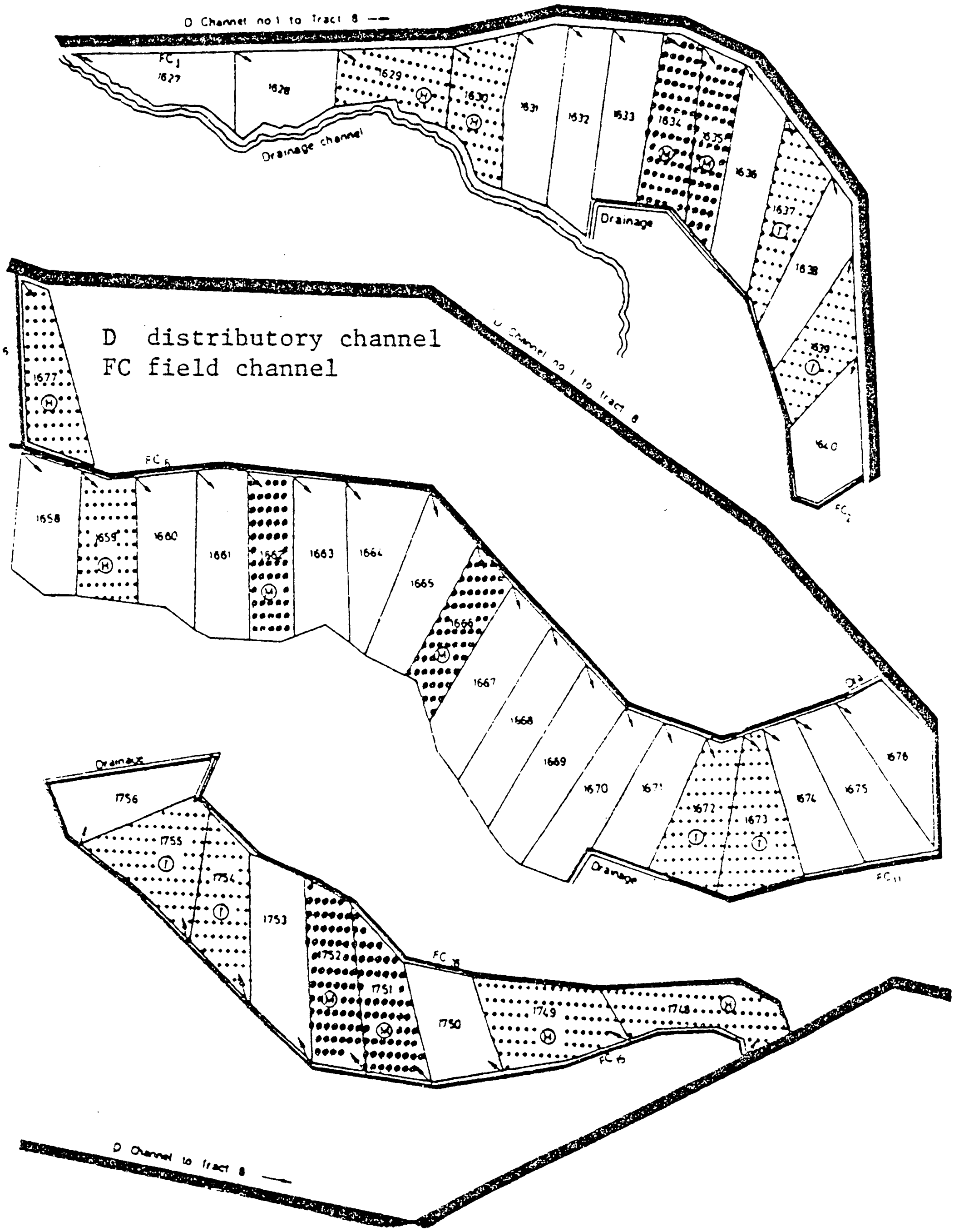


Figure 15. Tract No.8 farm allotments and irrigation layout. The selected farms for observation are marked with symbols. (source: Blocking out plans of the Department of Irrigation, Kaudulla, Sri Lanka).

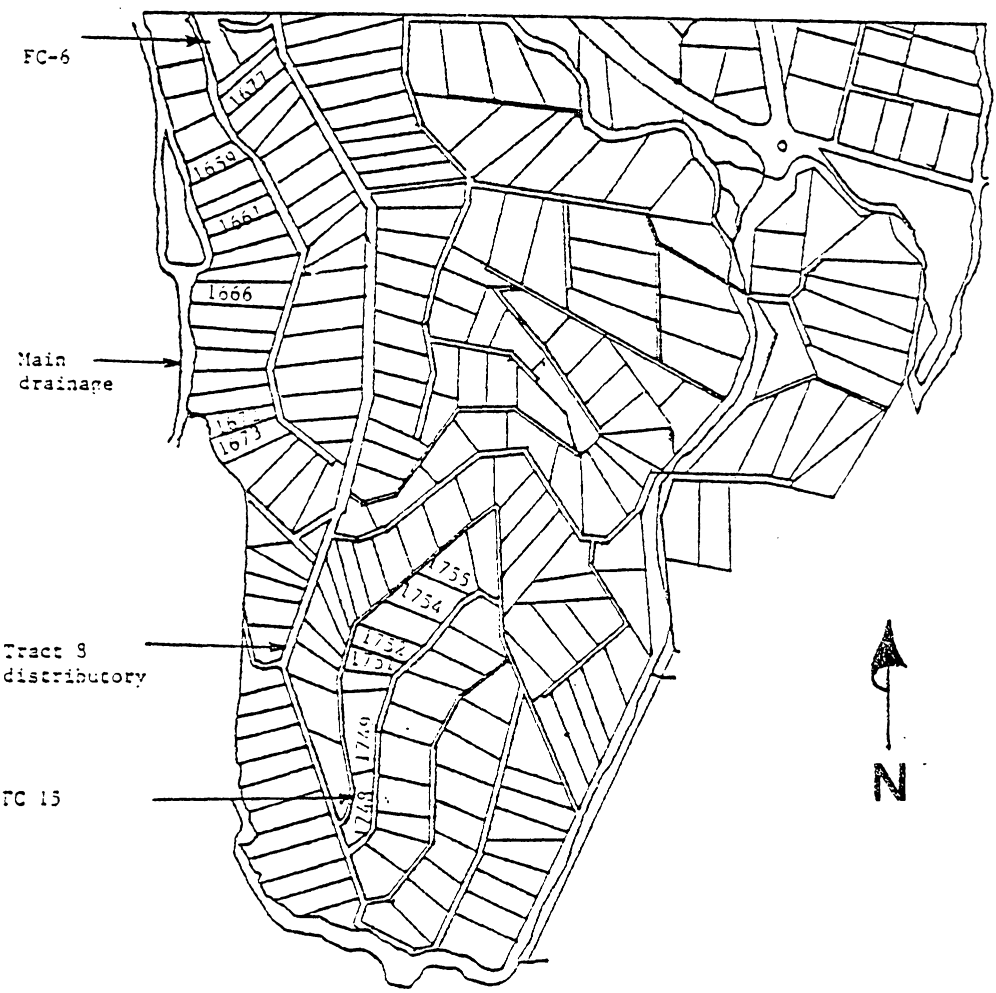


Figure 16. Tract 8 farm allotments and irrigation layout. The selected farm allotments are marked with symbols. (Source:Blocking out plans of the Department of Irrigation, Kaudulla, Sri Lanka).

Table 4. Discharge coefficients used to estimate discharges at D Channel offtakes and areas commanded by the offtakes. Kaudulla, Stage I.

Channel Offtake	Discharge Coefficient	Acres	Area Hectares
Main channel (MC)	-	4331.0	1753.4
Field channel - 1 (FC - 1)	0.556	33.0	13.4
Distributory - 1 (D - 1)	0.455	1521.0	615.8
Distributory - 2 (D - 2)	0.556	162.0	65.6
Distributory - 3 (D - 3)	0.790	30.0	12.1
Field channel - 2 (FC - 2)	0.550	27.0	10.9
Distributory - 4 (D - 4)	0.780	63.0	25.5
Distributory - 5 (D - 5)	0.419	180.0	72.9
Field channel - 3 (FC - 3)	0.447	21.0	8.5
Distributory - 6 (D - 6)	0.557	9.0	3.6
Distributory - 7 (D - 7)	0.458	12.0	4.9
Distributory - 8 (D - 8)	0.530	228.0	92.3
Distributory - 9 (D - 9)	0.550	324.0	131.2
Field channel - 4 (FC - 4)	0.550	28.0	11.3
Distributory - 10 (D - 10)	0.780	272.0	110.1
Tracts 7 & 8 (Tr 7 & 8)	-	1421.0	575.3

Table 5. Percent error of the predicted discharge rates using orifice equation relative to the measured discharge rates.

Location	Discharge rate in cubic meters/sec.		Error %
	Observed	Predicted	
Main channel head	0.248	0.248	0.00
	1.603	1.608	+ 0.30
	3.030	3.029	- 0.03
	3.310	3.346	+ 1.00
	3.310	3.346	+ 3.00
	3.770	3.512	- 6.80
	4.020	3.943	- 1.90
	3.890	3.949	+ 1.50
	3.907	4.033	+ 3.20
D - 1	1.301	1.300	- 0.07
	1.211	1.260	+ 4.00
	1.329	1.320	- 0.07
	0.915	0.930	+ 2.00
	1.020	1.070	+ 5.00
D - 2	0.341	0.312	- 8.50
	0.257	0.269	+ 4.60
	0.114	0.120	+ 5.20
	0.308	0.281	- 8.70
	0.311	0.304	- 2.20
	0.321	0.291	- 9.30
D - 3	0.036	0.036	0.00
	0.058	0.052	-10.30
	0.040	0.041	+ 2.50
	0.048	0.054	+12.50
	0.043	0.046	+ 6.90
D - 4	0.110	0.110	0.00
	0.071	0.081	+14.20
D - 7	0.035	0.036	+ 2.86

5.0 CHAPTER FIVE : FIELD MONITORING AND OBSERVATIONS

5.1 DESCRIPTION OF STAGE I-KAUDULLA IRRIGATION SCHEME

Stage I of the Kaudulla irrigation scheme consists of a designed irrigable acreage of approximately 1879 hectares (4642 acres). Water to this irrigation command is released via the low level sluice of the reservoir. Irrigation water is first released into the Kaudulu Oya main drainage which is then diverted into the stage I main channel by a pickup anicut about 4 km (2.5 miles) downstream from the reservoir. The irrigation command consists of eight irrigation tracts (see Figure 17 on page 147). The size of irrigation tracts and farm allotment sizes within tracts are given in Table 6.

The main channel of the system is approximately 12 km (7.5 miles) in length. The designed shape of the channel is trapezoidal with a bottom width of 4.572 m (15 ft) with side slopes of 1:1 and a maximum depth of 1.372 m (4.5 ft). The channel is earthen except at the places of distributory offtakes and the overpass road bridges where small sections are lined with masonry. The main channel has a control structure at the head about 200 m from the anicut built into an overpass road bridge with three rectangular underflow gates each 0.9144 m by 1.219m (4 ft by 3 ft). A section, approximately 3 meters in length downstream from the bridge, is lined with masonry to conform to the designed channel shape. Each gate opening is provided with screw type sliding wooden gates to control the flow through the structures. The measured bedslopes along the main channel range from 0.0001 to 0.0021 (Appendix C Table C1). The right bank of the main channel serves as a road and the left bank is bordered by the paddy fields of stage II or highland allotments. The runoff and drainage from the areas bordering the left bank flow over the bank into the main channel. The entire main channel is laid along the contour and receives a considerable amount of drainage from the irrigated tracts of Stage II of the scheme(see Plates 4 and 5 of Appendix D).

The distributory channels are at right angles to the main channel. Usually, they either follow the slope or the contours. The discharge control structures are gated circular pipe outlets with pipe lengths of 6.7 m (22 ft) across the length of the road way. The pipe diameters range from 0.61 m (2 ft) to 0.15 m (6 in) depending on the size of the irrigated tract (see Table 6). The gates are controlled by raising or lowering of a screw stem attached to the gate flap. At the heads of the last two irrigated tracts (tracts 7 and 8), the main channel bifurcates into two distributory channels. The head control structures of the two distributories are flume type drop structures while the upstream stretch is lined with masonry to form a rectangular cross section. In the original design there were only 14 distributory offtakes from the main channel. Subsequently, 3 other (FC-1, FC-2, and FC-3) offtakes have been added to supply encroachments and areas in tracts that could not be commanded by the distributories. These will be referred to as field channels (FCs), and those in the original design as distributory channels (D), irrespective of their relative sizes.

5.1.1 IRRIGATED TRACTS OF KAUDULLA STAGE I

The irrigation channel system of Stage I is typical of continuous flow irrigation design. There are few functional, if any, flow control structures along the main channel. Tract sizes varied considerably (see Table 6) with tracts closer to the reservoir having farm allotments consisting of 3 acres. The tracts further from the reservoir have both three acre farms and 2 acres with a larger proportion of the latter. Tract 1-B, consisting of 148 hectares, was not included in the study area. It was located immediately below the reservoir and irrigation was provided by the sluice spillway. The farmers of this particular tract did not experience any water problems primarily because of seepage from the reservoir.

Tract 1 is the largest tract coming under the command of the main channel with a designed area of 616 hectares (1521 acres). Other tracts along the main channel are less than 122 hectares in size, except tracts 7 and 8, which contain areas of 325 hectares and 250 hectares, respectively. The total lengths of D channels and field channels serving each of the tracts are presented in Table 7. Again, typical of the older system design, long D and FC channels serve almost all tracts.

5.1.2 SYSTEM DESIGN CRITERIA

The main channel and distributory channel systems were designed on the basis of a design discharge. The design discharge rate used by the Department of Irrigation (Blocking Out Plans, Kaudulla Stage I) was 2.33 liters per second per hectare (1 cubic foot per second per 30 acres). The design rate can be calculated by considering 1.83 meter (6 feet)[4] water depth as the Yala season water requirement including land preparation. Assuming a 90 day irrigation duration, including the land preparation period of 30 days[5] , the depth of 1.83 meters can be converted to a daily discharge rate equivalent to the 2.33 liters per second per hectare. If conveyance losses are assumed to be 15%, the discharge requirements at the main channel head work and the distributory offtakes can be computed. Table 6 presents the daily discharge rates required at the offtakes.

It is necessary to mention that, according to the Blocking Out Plan (BOP), the study area consisted of 4276 acres (1879.3 hectares) but the addition of FC-1, FC-2, and FC-3 to tracts 1, 2, and 3 increased the area to 4357 acres (1764 hectares). However, the irrigated area still may be higher considering encroachments to road, channel, and drainage

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[4] The dry season crop requires about 6 acre feet of irrigation water including land preparation.

[5] After land soaking and the first plowing, water is impounded for two weeks to rot the weeds. Second plowing and the third plowing take another two weeks prior to planting.

reservations. A rough estimate of the illegally cultivated area is approximately 700 acres (284 hectares), which is about a 15% increase over the original design area. If this entire area is to be provided with a continuous supply of irrigation water, then the minimum discharge rate at the head of main channel, assuming a 15% conveyance loss, should be approximately 4.72 cubic meters per second. If the encroached area is included, then the minimum discharge rate must be 5.43 cubic meters per second. During the land preparation period, when all farms require water, the main channel must carry this amount of water for the supply to be adequate.

5.1.3 THEORETICAL WATER BALANCE FOR FARM LOTS AND IRRIGATED TRACTS

Based on the design discharge rate and assumed values for evapotranspiration, seepage and percolation losses, it is theoretically possible to compute an approximate water balance for individual farm lots and irrigated tracts.

Assuming average evapotranspiration, seepage and percolation (S&P) rates of 8 mm per day(Holmes et al., 1979) and 8 mm per day (Goonasekere, 1978), respectively, the net loss due to surface drainage from a paddy area can be calculated. The design discharge rate, when converted to mm per day, is equal to 20 mm. The surface drainage loss becomes 4 mm per day or 0.46 liters per second per hectare. Using these values, surface drainage rates from individual tracts can be computed with an assumed value of 30% contribution from the S&P values. Table 8 gives the values computed for individual tracts. The data indicates that during a 90 day period, about 8000 acre feet drains from the Stage I scheme area. If this drainage is reused at the same design value of 6 acre feet per acre, it can be shown that another 1300 additional acres could be irrigated. A rough estimate of encroached acreage[6] increase the scheme area an additional 283 ha (700 ac). Additionally, about 200 to 250 ha (500 to 600 ac) outside the Stage I boundary are being encroached and cultivated using drainage water. As for Kaudulla, this rough estimate indicates the potential possibility of reusing drainage water and deserves serious consideration to systematize the currently existing practices by the farmers.

The reported values of S&P (Appendix C Table C18), which were determined by field ponding tests in the three soil drainage classes (Holmes et al., 1980), indicate a large variation among field plots located on well-drained, imperfectly drained, and poorly drained soil categories. Also, the values reported are very high in well-drained and imperfectly drained soils. Holmes et al.(1980) attribute the high values partly to high lateral seepage. This is generally the case with ponding tests because ponded fields tend to have a higher hydraulic head than surrounding fields. The actual percolation and seepage losses must be

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[6] Mr. Ranasinghe, Maintenance Officer, Kaudulla, Stage I

much less than field ponding tests because lateral seepage recharges fields further down slope of a tract.

Having developed the technical background, specific results are discussed in the succeeding sections. In the discussion, data presented will be supported with on site observations which often were not quantifiable and sometimes were qualitative in nature.

Monitoring the irrigation flows in the main channel system was continued for two successive Yala (dry) seasons. It was anticipated at the initiation of the study that these two seasons would be representative of typical dry seasons at Kaudulla. However, the unusually high rainfall (see Figure 18 on page 148 and Figure 19 on page 149) that occurred during 1983/84 Maha (wet) season and during the February- March period prior to 1984 Yala season, caused considerable flood damage to the Maha season crop, the irrigation channel system, and the fields. The Yala season (1983) can be considered as a typical dry season but the 1984 Yala season was atypical. The greatly damaged channel system , inadequate time period to carry out repairs prior to the cultivation season, and economic losses faced by farmers owing to crop failure made the 1984 Yala totally unrepresentative. However, these misfortunes provided a unique opportunity to study the effect of excessive rainfall on the channel system, water distribution, and the economic effects on farm level productivity.

5.1.4 GENERAL OBSERVATIONS ON THE TWO SEASONS

As mentioned previously, the 1983 Yala season can be considered as a typical dry season at Kaudulla. There was very little rainfall (see Figure 18 on page 148) during the cultivation period amounting to only 150.9 millimeters. Thus, the entire scheme was dependent on the irrigation water supply. However, at the commencement of the Yala season, the reservoir had sufficient water storage (see Table C19 of Appendix C) to cultivate the entire acreage of the scheme. The cultivation calendar that was determined during the Cultivation Committee meeting is presented in Table 9. According to the cultivation calendar, the scheduled date for the first issue of irrigation fell on the 18th of April. However, the actual water issues began on the 11th of April and continued uninterrupted. This strategy was followed to meet the domestic water requirements of the farmers celebrating the Sinhala new year which fell on the 13th of April. For purposes of this study, the irrigation period was assumed to begin the 18th of April for the 1983 Yala season until the end of water issue. Therefore, if the water issues during the 11th to 17th also are taken into consideration, the total volume of water issued for the season would have been higher.

In contrast, prior to the 1984 Yala season, the heavy rainfall (see Figure 18 on page 148 and Figure 19 on page 149) caused disastrous floods. There was uncertainty at the beginning of the season about retaining the large volume of water in the reservoir because a heavy leak developed in the reservoir dam. Further, most of the flood damages to the diversion anicut and main channel system had not been repaired. However, the pressure from the farmers and the political authority resulted in proceeding with the cultivation operations and irrigation issues. The Cultivation Calendar decided for the season is given in Table 10. The breached anicut bank and the main channel were hurriedly repaired to meet seasonal irrigation issues. Although the date of the first irrigation issue was scheduled to begin on the 18th, the tank continued to spill. Repairs to the right bank of the anicut continued well into the season. The anicut gates were frequently opened to lower the water that was building at the anicut to prevent water flowing over the sand bags and causing a breach. As a result, the water flow was erratic in the main channel system from April 18th to April 22nd. Therefore, the irrigation issues for the the 1984 Yala season issues were assumed to begin on the April 22nd. Much of the repairs to the damaged distributory and field channels remained unattended because of insufficient time and as a result water distribution was chaotic during the entire season.

5.1.5 WATER DELIVERY RATE AT THE HEAD OF MAIN CHANNEL

During both seasons,only two monitoring locations along the main channel carried continuous flow. These locations were at the head of main channel and at the head of tracts 7 and 8, respectively. The rest of the monitoring locations at distributory offtakes were subjected to a rotational irrigation issue after the first 30 days of the season. Daily discharge rates computed at the head of the main channel for the two Yala seasons are presented in Figure 20 on page 150 and Figure 21 on page 151 respectively. Detailed data for the 1983 and 1984 Yala seasons are given in Table C3 of Appendix C. During the entire season, the gates of the control structures at the head of the main channel were not operated as a flow control measure. Instead, water issues to the main channel were regulated by adjusting the low level sluice gate of the reservoir each day. Thus, it was possible to estimate the volume flow during a day with reasonable accuracy (±15%) because the discharge rate did not change appreciably at the sluice during a period of 24 hours until when the gate setting was readjusted to account for the lowered water level in the reservoir.

The horizontal line, Figure 20 on page 150 and Figure 21 on page 151 , indicates the originally required design discharge rate. These results show that during the first 22 days of continuous issues of the 1983 Yala, the main channel carried a discharge rate greater or equal to the design rate only 10% of the time. As indicated by Figure 21 on page 151, that during the first 30 days of continuous supply for land preparation, the system delivered a discharge rate above or equal to the required design discharge for the 1984 Yala season only 13% of the time. The lower supply rates during land preparation period for both seasons, coupled with the observations of a poorly maintained channel system, supports tail end farmers claim of insufficient water.

Comparison of the discharge rates at the the main channel head for the two seasons (Figure 20 on page 150, and Figure 21 on page 151) shows that, on the average, the 1984 Yala discharge rates were higher than the 1983 Yala season. These high rates were mainly due to an attempt by management to lower the reservoir water level to avoid a possible breach in the reservoir dam rather than an attempt to provide adequate supplies to the farms. Moreover, during the 1984, higher discharge rates had to be released to maintain the design depths in a greatly eroded and widened main channel to force at least some water into severely flood damaged tail reaches.

The only other point that had continuous flow during the entire duration of a season is at the tract 7 and 8 junction. The computed daily discharge rates at tract 7 and 8 junction for the 1983 and 1984 seasons are given in Figure 22 on page 152 and Figure 23 on page 153, respectively. The total number of days that the discharge rates at these locations exceeded or equalled the design rate was 22% and 26% for the 1983 and 1984 Yala seasons, respectively. Table C17 of Appendix C presents detailed data for this monitoring location. Further, the results show a greater fluctuation in discharge indicating the unreliability of the supply. On most days, only a trickle of flow reached the tail ends of tract 8 while on a few days the flow depths were at bankfull (see Plate 27 of Appendix D). A mass flow balance along the main channel at each distributory was calculated to determine the reasons for discharge fluctuations.

Discharge computations for other distributory and field channel offtakes are presented in Tables C4 through C16 in Appendix C. Once the rotational schedule started, the supplies at these locations were regulated to allow more water to move through the main channel. The rotational schedule did not conform to any pattern. Rather, opening and closing depended largely on the demands of the farmers of a particular tract.

5.1.6 MASS FLOW BALANCE ALONG THE MAIN CHANNEL

The discharge from each distributory or field channel offtake was successively subtracted from the discharge rate at the head of the main channel to obtain the water flow rate past each distributory offtake. The results for the 1983 and 1984 Yala seasons are given in Tables 11 and 12. A negative balance, occurred for most of the 1983 Yala season. Despite a positive balance for the 1984 Yala, the discharge rates past the D-10 offtake were below design values. The calculated flow rates at Tract 7 & 8 junction were non-zero but discharge rates have greater fluctuation (Figure 22 on page 152 and Figure 23 on page 153).

The computed mass flow balance during the the 1983 Yala indicate a deficiency of water to the tail end even with a rotational practice. The discharge rate in the main channel during the 1983 Yala season was insufficient to provide irrigation water up to FC-3 as shown in Table 12. Between the head of main channel up to D-1 offtake, past D-2 offtake, and between FC-3 and D-7 offtakes there was considerable inflow into the main channel. The largest contribution entered the main channel between FC-3 and D-7 offtakes where drainage from Stage II irrigated area crossed through the main channel (see Plates 4 and 5 of Appendix D). There is a spillway with gates built into the right bank of the main channel at the point of drainage crossing to spill excess drainage into a natural drainage channel. Thus, rather than the efforts of rotation, it was this large amount of drainage entering the main channel which compensated for the deficiencies in the main channel flow rates, and appears to account for the high flow rates observed at the Tract 7 & 8 junction. Water spilling from the main channel into natural drainage often was observed during the season. Since this drainage inflow depended on Stage II water distribution, it accounted for the considerable fluctuation of daily discharge rates observed at the Tract 7 & 8 monitoring location.

This brings another issue into light. That is, if adequate control structures are to be built at this particular location, more effective reuse of the drainage water entering the main channel is possible, thereby, reducing the discharge requirements of the main channel.

5.1.7 IRRIGATION DELIVERY PERFORMANCE.

Although it was possible to estimate the flow rates within the channel system, it was not so easy to estimate the system performance criteria (Lenton, 1981) presented in Chapter 2. For example, area performance criterion required estimation of actual area irrigated so that the ratio of actual area irrigated to irrigable area provides the area performance of individual tracts for all of Stage I. However, because of encroachments and the difficulty of accurately determining the total area encroached, it was not possible to evaluate this criterion. In this regard, the area performance of Kaudulla Stage I is greater than 100% because farmers actually irrigate a greater area than the design irrigable area of the scheme. Similarly, evaluation of delivery performance criterion requires a weighting factor for each time period considered to account for relative importance of water to the crop during the period. Two factors complicated the evaluation of this criterion. First, the actual requirements of water during each time period considered must be known. This involves estimation of evapotranspiration and field requirements due to seepage, percolation and ponding. Second, the most important stage of growth for computing the relative importance also must be known. In general, for rice, the tillering, panicle initiation and grain filling are critical stages of growth affecting yield, which determines the importance of water during each stage. Also, at the initial period of seedling growth, standing water is required to suppress weeds until plants develop sufficient cover. Thus, if water is used to control weeds then this stage also could affect the yields. Therefore, the stage of growth selected will influence the magnitude of the weighting factor, thus affecting the evaluation criterion. This fact can be simply illustrated by assuming pan evaporation to represent evapotranspiration and adding a constant value to represent seepage and percolation. The water requirement of each week can then be computed. Table 13 presents the weighting factors computed by using relative water requirements with respect to each time period considered.

A simpler and more practical criterion can be developed by considering the design discharge rate. For the purposes of this study the criterion is termed as Design Delivery Performance (DDP). The DDP is defined as follows,

$$DDP = \frac{V(t)}{V^{*}(t)}$$

where V(t) is the volume of water delivered during each time period and $V^{*}(t)$ is the volume of water required for each time period according to the design discharge·rate. This criterion reflects the ability of the system to deliver the designed rate of discharge to the location under consideration. A DDP greater than 1 reflects excess supply, and a value of DDP less than 1 reflects insufficient water delivery. The advantage of using DDP is that, first, it is easier to compute with simple field measurements and the base value (design discharge rate) remains constant irrespective of the stage of growth. Second, it reflects the design capability of the channel system and control measures. Third, it reflects the technical efficiency of the physical system and the rotational issues practiced at Kaudulla. The disadvantage is, it does not reflect ability of the system to meet actual field requirements, that is crop and soil needs. However, in monitoring the technical system, the primary aim was to determine its technical capability. Also, the design discharge value used for Kaudulla is currently in use for almost all new irrigation schemes. Therefore, the use of DDP as the evaluation criterion was justified for the purpose of the study.

The computed weekly and the average DDP values for the two seasons for all monitored locations are given in Tables 14 and 15. The values at the main channel head were calculated by considering only the areas irrigated by the rotational schedule.

The computed results indicate that the water supply at the main channel head was insufficient to meet the design values throughout the season. The same is true for the D-1 and tract 7 & 8 offtakes. The water supply at the D-5 offtake was inadequate during the crop growing period. The values were close to unity at the D-10 offtake indicating that the delivery rates were at designed values. The rest of the D channel offtakes, especially the smaller tracts, show excess water delivery even with the rotational issue indicating an ineffective rotational schedule.

The seasonal average DDP values were low for D-1, D-5 and tract 7 & 8 offtakes and indicate considerable water problems at the tail ends of those tracts. D-2, FC-2, D-7, and D-9 offtakes were in excess of 50% of the seasonal water requirement while the water requirement at FC-3 and D-6 was generally over 100% of the seasonal requirement. However, excess supplies at the head of a distributory offtake does not necessarily guarantee adequate supply to the tail ends. Observations indicated that much of the water was used up at the head reaches.

5.1.8 WATER DUTY AT MONITORED LOCATIONS

Water Duty (WD) as defined by the Department of Irrigation was calculated as the ratio of the total volume of water delivered to the area irrigated. This is a simple computation and the Department of Irrigation uses the volume issued at the reservoir sluice and the design acreage of the system for computing WD values. For each of the monitored locations, WD was computed by estimating the total volume of water delivered to the location and the design area commanded by the offtake. The results are given in Table 16. The WD values computed would have been lower if the actual area cultivated had been taken into consideration but this was not possible within the framework of the present study. Also, the 1983 Yala season discharge estimates did not take into consideration the gate settings. As a result, WD values probably were overestimated. However, higher values at the monitored locations do not always mean that tail ends of the canals received an adequate water supply because of poorly maintained distributory and field channels and inadequate control facilities along these channels.

The results for the 1983 Yala show that water duties at main channel head, D-1, and D-5 channels were less than 4 feet. Considering the total area irrigated, lower water duties at main channel and D-1 channel suggest that the system is incapable of delivering sufficient water to the entire design area. The lower WD values at the D-5 offtake is noteworthy because this channel is located halfway along the main channel. At this location, the channel was much wider than design, which lowered water elevation considerably, thereby, lowering the discharge into the tract. This is shown by the results of the 1984 Yala season. Highest water duties were observed for smaller tracts and the D-2 channel best reflects this observation because it had the most favorable location. The high values observed at D-6, D-7, and D-8 locations occured mainly because of the drainage water entering the main channel at a point closer to these offtakes. Thereafter, the water duties decreased towards the tail end of the main channel.

WD values for the 1984 Yala were much higher in comparison to the 1983 Yala. This condition was mainly because the main channel carried a larger volume of water throughout the season. However, the lower water duty at FC-1, when compared to 1983 season, can be attributed to over estimation due to not accounting for gate opening and the greatly widened channel section at this location (see Plate 3 of Appendix D) after floods, which reduced the effective head. The rest of the pattern is more or less similar to the previous Yala season.

The 1984 Yala results bring another fact to light. A greater volume of water is required to irrigate the same area when the channel system gets badly deteriorated. In general, results for both seasons showed an increase in WD towards D-6 through D-10 which thereafter tapers off. Similar results were observed by Holmes et al. (1981) who attributed the increase in WD values to the drainage inflow into the main channel. Also, WD values estimated at the head of distributories are of little value in estimating system performance since they do not reflect system capability of delivering water to the tail end section of irrigated tracts. The D-4 channel, a smaller irrigated tract with a relatively longer D channel, is a good example. The irrigation supply delivered at the head of the channel was above the design value. However, the farms at the tail end of the channel had difficulty in obtaining adequate irrigation supplies. Field observations during the 1983 season showed that it took a period of almost a week before the farmers at the tail end received sufficient irrigation water(see Plate 20 of Appendix D). Much of the water was wasted through damaged control structures, weakened channel bunds at the head reaches, and, finallym, discharges into tract drainage leaving a mere trickle to the tail ends. Large volumes of drainage water, flowing along the tract boundaries, were observed during both seasons. In fact, beyond the t boundary of tract 8, an area of approximately 200 - 320 hectares was cultivated reusing the drainage water during both seasons, while the tail end section of tract 8 experienced severe water problems.

5.1.9 PHYSICAL CONSTRAINT IDENTIFIED IN THE MAIN CHANNEL

The main channel rating results showed that flows closer to 4 cubic meters per second came to near bankful capacity of the channel. Observations showed that high rates of flow caused water to over top the design section (See Plate 2 of Appendix D). In order to find the cause for this problem, the measured bottom width of 4.572 m, top width of 7.31 m, and design side slopes of 1:1 were used to calculate cross-sectional area. Then, an average velocity of 0.46 (see Appendix C Table C49) meters per second obtained from a discharge rating downstream of the main channel head control and 4 cubic meters per second discharge rate were used to calculate the cross sectional dimension required for the above discharge using the continuity of flow equation. For design side slopes of 1:1, the bottom width required at a maximum depth of 1.372 m is 4.97 m (16.3 feet) compared to the measured value of 4.57 m (15 feet). However, the section is not capable of conveying the design volume if the average velocity of flow is below 0.49 meters per second.

The velocity of flow through the underflow gate can be calculated using the orifice equation. The calculated velocity for a differential head of 10 cm, 0.5 discharge coefficient, and submerged flow gave a flow velocity exceeding 2 meters per second. Therefore, the observed reduction in velocity and excessive width of the channel section must be a result of an inadequate channel transition causing erosion of the channel bed and deposition downstream. The reduced depth downstream results in backwater buildup and lower velocity at the transition. A plot of channel cross-sectional profile based on design section, and that of a discharge rating about 15 meters downstream from the gate is given in Figure 24 on page 154, and confirms this observation. Similar observations were made at almost all channel transitions at overpass bridges (see Appendix D Plates 2,6, and 7). The main channel needs desilting and adequate protection measures to avoid erosion and widening of the main channel at channel transitions.

There were insufficient spillways built into the right bank of the main channel towards the tail end. Inadequate control structures along the main channel, in combination with lower carrying capacities of the distributories, was the cause for much of the deterioration of the distributory channels to tracts 7 and 8 (see Plates 26, 27, 28, 28, 30, 31, and 32 of Appendix D), which significantly disrupted the distribution to the tail ends during an irrigation season. This was the result of uncoordinated maintenance of the system because of insufficient maintenance funds. The response to this situation by farmers was to further damage the system to obtain their irrigation supply. Consequently, the irrigation system was ceaselessly exploited with neglected maintenance resulting in poor distribution of irrigation water.

5.1.10 ROTATIONAL IRRIGATION IN STAGE I

During both seasons of the study, following the first 30 days of continuous issue to meet land preparation requirements, a rotational irrigation issue was in effect. The rotational issue was supposedly four days of irrigation issues to a particular distributory offtake followed by a three day period of non issue during a given week. The reason for the rotational issue was to provide adequate supplies to the tail end sections of the main channel. However, as the mass flow balance showed in the previous section, the rotational issue did not operate satisfactorily. There was no regular pattern to the rotation or the duration of the rotation as indicated by the blanked areas of the columns in Tables C3 through C17 of Appendix C.

There were several reasons for this irregularity in the rotational issues. In some of the D offtakes, either there were no gates or the gates were broken. Particularly during the 1983 Yala season, there were no screw gates for the D-1 offtake. These gates were subsequently installed prior to the 1984 Yala season. During the entire 1983 Yala season, the offtake was closed by sliding the gate flap into the slot. This task was difficult when water was flowing in the channel. During both seasons, a gate at the D-10 offtake was broken and during the 1984 Yala the gate of FC-4 offtake was broken.

Often pressure was exerted by farmers on field level irrigation personnel. At the Fourth Mile Camp, where some of the Technical Assistants and Work Supervisors stayed, it was observed that farmers constantly complained of irrigation supply during every day of the first three months of the season. In some cases, the farmers' clamoring was justified. As an example, the D-4 offtake feeds a long channel relative to the number of farms irrigated. Thus, it took considerable time for water to reach the tail ends because of inadequate upstream control and overuse by the upstream farmers.

The problem was further aggravated by the poor retention of the impounded water due to light texture (reportedly sandy clay, Arunapriya, 1983) of the soils. The farmers at the tail ends constantly complained to the irrigation officials to release additional water. Lastly, it was observed that in some tracts farmers used modified two wheel tractor mud wheels to open the gates illicitly. Therefore, the rotational issue did not function as designed.

In the three tracts selected for the study, rotation was impossible due to lack of control structures. The damaged channel banks and the few functional controls were not sufficient to even attempt such an issue. Therefore, even though the monitoring indicated more than adequate supplies at the head of an offtake it did not relieve the water problems of farmers at the tail ends.

A more rational rotation of distributory offtakes could be designed if one could evaluate all possible non repetitive combinations to select those most suitable. As the number of distributory offtakes increases, the number of possible combinations also increases exponentially. However, some combinations are not practical because of conveyance losses. By defining an upper and lower bound for the flow regime in the main channel the search for preferred rotational strategies becomes manageable. In the case of Stage I, a case of continuous flow in the main channel, rotational strategies were attempted for only the larger seven offtakes of the total of 17 distributory offtakes (see Appendix C Table C21). The design discharge rate needed at tract 7 and 8 offtakes was 1.32 cubic meters per second. The sum of all design discharge rates for small distributories amounts to a flow rate of only 0.21 cubic meter per second. Allowing for the increased area and losses, a lower bound discharge value of 2 cubic meters per second was assumed and the combinations falling within the minimum and maximum were determined using a computer program. Using these combinations and spread sheet simulation, a rotation was designed to ensure minimum flow adjustment in the main channel.

The rotation is based on two days of non-issue and four days of issues to the largest tracts (D-1 and tracts 7 and 8). For smaller tracts rotation is three days of issues and 3 days of non-issue in a given six day period. The flow rates in the main channel range from 2.2 cubic meters per second to a maximum value of 3.3 cubic meters per second after adjusting for conveyance losses and additional area under cultivation (Table 17). The combination of channels retains a minimum flow rate of 2 cubic meters per second. By setting up control structures at the largest drainage inflow point to the main channel between D-5 and D-9 channels, the flow rates in the main channel can be further adjusted to utilize drainage flow more effectively. Further, if the rotation is practiced for a 90-day period, the water duty at the head of the main channel can be effectively reduced to about 1.5 m (5 feet) to effectively irrigate all the designed area. However, if rotational issue is to be successful, the distributory and field channel system must function properly because the rotation can only deliver water in correct quantities to the head of a distributory.

5.1.11 MAINTENANCE OF THE CHANNEL SYSTEM

Poor physical maintenance of the channel system and inadequate control facilities were found to be the most important technical constraints identified at Stage I of Kaudulla. Table 18 gives the annual maintenance allocations for 1982 through 1984. According to the IE, the largeest proportion of this allocation must be used for wages of field laborers, travel expenses and requisition of supplies. After allowing for the above expenditure, only about Rs.300,000 to 400,000 remain for actual maintenance. The remaining funds were not sufficient to cover even the minor repairs. The result was a poorly maintained channel system. Farmers have damaged the channels particularly towards tail ends (see Plates 26 and 28 of Appendix D) to obtain their water supply perpetuating a vicious cycle of poor system maintenance and consequent irrigation problems.

5.1.12 CHANNEL LINING AS A REHABILITATION ALTERNATIVE

The poor physical condition of the channel system, a major factor constraining irrigation distribution, can be improved by lining the channels. The costs were estimated based on design discharge rates required in the main and distributory channels and a discharge rate of 1.5 cubic feet per second for field channels. The design parameters considered are also given in Table 19. The cost estimate (Table 19) indicates this would be a costly alternative if the entire channel system was to be lined. Since most of the distribution problems were found to be the main distributory channels, lining only the channel transitions and badly deteriorated section may be a more feasible economic alternative.

With regard to channel lining, Abeysekere (1983) found in a tank modernization effort that lining actually increased the cost of maintenance. This will be especially be true if the farming community continues to damage the system to obtain irrigation water. Thus, any proposal to improve channels with lining should pay close attention to these constraints.

5.2 FARM LEVEL OBSERVATIONS

5.2.1 SURVEY RESULTS OF WATER PROBLEMS IN STAGE I

The survey that was conducted to study the irrigation problems in Stage I of Kaudulla showed that about 31% of the farmers complained of serious irrigation problems (Table 20). The largest number of farmers experiencing irrigation problems were found to be in larger tracts, namely, tracts 1, 4, 6, 7 and 8. Surprisingly, tract 3, a relatively small tract, served by four distributory offtakes also showed 46% farmers having serious water problems. Observations revealed that poorly maintained channels and inadequate control measures were primarily responsible for these problems. Farms with irrigation problems will continue to increase unless a program to rehabilitate and maintain the distributories and field channels is instituted. Farmers at the tail ends of larger tracts particulary experienced water problems during two periods. First , They had to delay land preparation until upstream farmers finished land preparation. Second, they experienced drainage problems, especially during Maha seasons. Thus, the tail enders seem to be disadvantaged regardless of the seasons.

5.2.2 FARM LEVEL INFLOW OUTFLOW MONITORING RESULTS

Farm level monitoring proved to be the most difficult task. The monitoring was complicated by the many inflow and outflow points into a single farm. Further, with fragmented farm plots it was difficult to keep track of inflow and outflow into individual plots. Results were also complicated by the unreliability of a single daily observation. However, to have more than one observation per day was practically infeasible. Farmers adjusted their inflow and outflow during the course of the day as they visited their fields. This situation was evident towards the tail ends. Most tail end farmers kept night watch and often obtained some irrigation water during nights, when none was available during day time. Nevertheless, the monitoring was conducted to obtain, at least, some information on the relative ease and quantity of water received. Results are given in Tables C22 through C27 of Appendix C for 9 farms monitored in each of the selected tracts. As the data shows, it was not practical to obtain daily inflow-outflow measurements. It is difficult to draw any conclusions without a continuous monitoring procedure, however, the farms in tracts 2, 3 and head ends of tract 8 had higher inflow rates and much larger drainage flows compared to the farms monitored at the tail end of tract 8 (Lot numbers 1748, 1752 etc, Figure 15 on page 95 and Figure 16 on page 96). tract 8 tail end farms had days of considerable inflow rates which more or less coincided with higher flow rates at the tract 7 and 8 distributory offtake (see Table C17 of Appendix C). In tract 8, particularly during day time, there was very little inflow. However, this can be misleading because these farmers kept night watch and obtained some water during nights. It was difficult to observe unsaturated and completely dry field conditions during the entire season at these locations. As a result, it was not possible to apply any of the indices such as stress days (Wickham and Valera, 1978) or Water Availability Index (Wijeratne,1980) and relate them to the yields. The effects of water shortages to these farms often result in poor quality land preparation, ineffective weed control and staggering of cultivation. Staggering of cultivation indirectly affects yield due to higher pest populations affecting the crop. In addition, top dress fertilizer, such as urea, looses effectiveness due to volatilization if the fields do not have sufficient moisture during the day time.

5.2.3 SUBDIVISION AND LEASING OF FARMS AND ENCROACHMENTS

Among the farms selected for study, there was a substantial subdivision of land in individual farms. This was especially the case in farms of tract 2 and 3. However, in tract 8, the farms selected did not show any subdivision. Six farms out of the 18 selected were cultivated by other farmers in addition to the owners in tract 2. Similarly, eight out of eighteen farms were subdivided in tract 3. This fragmentation complicated the data collection procedure. Most farms were subdivided among family members while some portions of the farms were cultivated on a share basis (Ande cultivation) in tract 2. A portion of one farm was mortgaged to settle loans obtained by the farmer. A single farmer in tract 8 cultivated additional land that was mortgaged to him by another farmer. The tendency for subdivision was higher among the farms in tract 2 and 3 because the farm sizes were larger (3 acres) and these farms had encroached additional land from channel and road reservations. Farmers interviewed in tract 8 revealed that the smaller farm size (2 acres) compelled them to lease or mortgage the entire acreage rather than fragmenting.

The practice of leasing, fragmentation and mortgaging, though illegal at least in theory, seemed to be generally accepted by the farming community.

5.2.3.1 Land Leasing, Mortgaging and Sharing

The farmers have many different arrangements to lease, mortgage, and share their subdivided farms. One system of share cultivation (Ande cultivation) is equal sharing where the owner and the rentor share the costs and produce equally. However, most farmers who share land on this basis complained that most often owners did not meet their obligations.

Those farms showed poor yields as a consequence of lower investment levels.

Another variation of sharing is the "Poronduwa" (Promisory) system where the owner agrees to share a fixed portion of produce without any cost sharing. The owners share usually amounts to 1500 kg of paddy per hectare (30 bushels per acre) depending on the season and accessibility of the farm to irrigation water. Most owners obtained one third of the produce per acre from the rentor.

The land is generally leased at a flat rate of Rs.1500 per hectare (Rs.600 per acre) per season. Most often land is leased by officers of the government bureaucracy or traders. In tract 2, several police officers and a field officer of the Land Commissioners Department leased land during the 1984 Yala season.

Mortgaging the land is generally done by farmers with financial difficulties. A hectare is mortgaged at values ranging from Rs.5000 to Rs.12400 per acre per season. Usually, instead of paying interest on a loan, farmers often provide their labor to the mortgage holder to cultivate the land.

5.2.3.2 Encroachments into road, channel and drainage reservations

Among the tracts selected for the study, tract 2 and 3 had the most encroached land area. In tract 8, farmers had encroached land but sacrificed some land to construct a threshing floor and a small hut to keep night watch for irrigation water. Most land was found to be encroached by the farms bordering a tract and encroachments ranged from as little as 0.1 hectare to nearly 1 hectare.

The overall increase in cultivated lands was about 15% over the designed acreage for the 54 farms selected for observation. If this value is projected over the entire Stage I design acreage, in excess of 300 hectares were cultivated to paddy by illegal encroachments. This value closely agrees with the rough estimate made for all channel, road and drainage reservations.

Towards the tail end of the main channel, encroached area was irrigated by illicit siphoning from the main channel (see Plate 8 Appendix D). The farmers, as a consequence, brought into cultivation almost all the reservation land in the scheme area. They made maximum utilization of available land but at the expense of irrigation water supply to the other farmers. Consequently, the originally planned area has been significantly increased, which has caused problems at the tail ends.

A problem with cultivation of drainage reservations is the gradual loss of productive land due to erosion. The unprotected surface drainage outlets from these encroached cultivations have eroded the banks of natural drainage channels, enlarging the channel resulting in a gradual loss of farm land.

These practices show that the institutions that were assumed to function during the planning and implementation of irrigation projects have ceased to exist or to function as planned which has severely impaired management of the system.

5.2.4 LAND PREPARATION AND SOWING IN RELATION TO CULTIVATION CALENDER

During the 1983 Yala season, the farms irrigated by distributory channels D-2, D4 and FC-15 of tracts 2, 3 and 7, respectively were observed to evaluate the progress in land preparation up to plant establishment. The results of these observations are given in Figure 25 on page 155 through Figure 27 on page 157. As shown in the figures, all farms completed their plant establishment prior to the rotational irrigation issue during the 1983 Yala season. In D-2, a few farmers took longer for plant establishment because they transplanted the crop. Generally, the seedlings were uprooted from the nursery after about a month. Therefore, they could delay the land preparation until the plants were mature enough for transplanting. In contrast, the delay in sowing observed in D-4 farms was due to inadequate water supply to the tail end farms. The tail end farmers complained that the upstream farmers did not clean the canals. As a consequence, the water flow rate was inadequate to the tail ends. The tail end farmers had to clean the upstream reaches to convey sufficient flow rate to the tail end farms. The farmers in FC-15 of tract 7 also faced similar problems. They started land preparation late but completed plant establishment within a week form the first land preparation operation to avoid running into rotational irrigation issue which would have created further difficulties.

Similar observations during 1984 Yala season for tracts 2, 3 and 8 are given in Figure 28 on page 158 through Figure 30 on page 160. In comparison to 1983 Yala season, there was considerable staggering in both tracts 2 and 8. tract 3 farmers completed their plant establishment well within the period stipulated by the cultivation calendar.

Staggering observed in tract 2 was not a result of water shortage. Primarily, there was uncertainty at the beginning of the season to proceed with the cultivation season, because there was doubt about retaining the large volume of water in the reservoir and proceeding with cultivation due to the leaks that sprung in the reservoir dam. However, at the cultivation meeting it was decided to proceed with the Yala cultivation.

Most farmers had financial problems due to flood damages during the previous Maha season and opted to delay until sufficient funds were acquired. Others transplanted and therefore delayed land preparation operations. The farmers who started earlier planted longer duration varieties, which were not recommended for the Yala season. A few others delayed leasing their land and waited for a better offer. In comparison, tract 3 farms were mostly fragmented and a single lot was cultivated by several farmers on a share basis and were able to complete their operations within the stipulated period. In tract 8, following the initial unceratinty about Yala season cultivation, farmers had to delay their operations until sufficient water reached the tail ends. This was particularly the case with the observation farms along FC-15 of tract 8. Still others had financial difficulties or operations were delayed due to sickness in the family. Though the pattern for tract 2 and tract 8 were similar, the staggering was due to many different reasons. In fact, plant establishment extended well beyond the stipulated period by the cultivation committee and delayed the rotational issue schedule.

5.2.5 FARM LEVEL IRRIGATION MANAGEMENT PRACTICES

Of the farm level water management practices, irrespective of the location, most farmers diverted the entire stream size available to them into a single plot for land soaking. Thereafter, they completed the plowing operations, plot by plot, utilizing the available stream size effectively. A few farmers in tract 2 adopted both broadcast seeding and transplanting. This was done to avoid seed rot in fields with poor drainage. These areas were transplanted to overcome the problem. Some farmers faced with water difficulties also resorted to transplanting so that they could gain time to obtain sufficient water for land preparation. These observations show that most farmers adapt to the difficulties they encounter in the field. During the growing stages of the crop, almost all farmers spent 2 to 3 hours a day impounding or draining water and weeding their plots. However, the total labor utilized in the process was difficult to asses because the duration and practices varied from day to day. Most tail end farmers in tract 8 kept night watch in small huts constructed in their fields. During nights they closed the upstream farm inlets to convey additional water down to their fields. This was a frequent source of conflicts among farmers because upstream farmers too kept night watch in these tracts.

It was difficult to defferentiate between the irrigation problems due to overuse at head reaches or short supply to tail ends of a channel. In the case of FC-6 which was selected for observation in tract 8, the farms at the beginning and the end of the channel did not experience water problems. Particularly, the tail end farms obtained water directly from the main channel through an additional pipe outlet. Therefore, it was the farms in the middle that experienced irrigation difficulties because the flow rate in the channel was largely used up at the head reaches while the tail end supplies could not be conveyed upstream along the channel. Similarly, along FC-15 of tract 8, it was the farms located at the head of the channel (Lot 1748) which had serious irrigation problems. The tail end lots of the channel received sufficient water from surface drainage and also from an additional channel constructed by farmers which conveyed water to the middle lots. However, the water from these sources could not be conveyed upstream and the field channel itself could not convey sufficient water to the head because the distributory channel was damaged and did not carry sufficient water.

Most farmers having farms on the right bank of the channel damaged the distributory and conveyed water across the road to their fields (see Plate 26 of Appendix D).

A majority of tail end farmers complained of large diameter pipes feeding upstream reaches which drew more water to upstream reaches and the indifference shown by those farmers to control their supply even when they did not need water.

They complained of malpractices of the irrigation field personnel. One such malpractice reported was the issue of large diameter pipes to some farmers. These pipes were installed at their own cost. However, farmers claimed that these officials later claimed installation charges from the Department of Irrigation. Though it was not possible to verify these claims, numerous pipe outlets laid haphazardly along roads were noticed both in tracts 7 and 8. Most farmers in tract 8 expressed willingness to a reallocation of land if the Department of Irrigation would consider redesigning the field channel layout.

5.2.6 SOURCES OF IRRIGATION WATER WASTAGE

Irrigation water was wasted during a season particularly at the beginning of a season. During both seasons of study, the irrigation issues were scheduled on the 18th of April. However, actual releases began as early as April 11 for the 1983 Yala season while the reservoir spilled during 1984. Most farmers plowed a small patch of land at an auspicious time as dictated by the custom of Sinhala new year and did not continue their land preparation until well into the third week of April. As a consequence, much of the water issued simply flowed into drainage from channels and fields during this period.

Once the land preparation operations were begun and sowing started, most farmers shut off the water supply. However, water was issued continuously during the first month and most of the water simply went into drainage until farmers impounded water when the seedlings could withstand impounding. Thus, there was a greater opportunity to save water by devising a rotational issue of water during land preparation if individual tract requirements were taken into consideration.

The other points of water wastage were the peripheral farms in head reaches of a tract. As the measurements indicated large volumes of water got into natural drainage from these farms where as surface drainage from farms located in the middle was reused by other farms lower down. It was observed that more water flowed in drainage channels at the tail end of the system than those of distributory channels. However, the same tail end farmers cultivated additional land encroached outside the tract boundary using the large drainage flow by erecting temporary stick dams across the drainage way. There were numerous such stick dams and substantial area has come under cultivation through illicit encroachment beyond the tract boundaries of the tail ends.

5.2.7 AGRONOMIC AND ECONOMIC ASPECTS OF FARM LEVEL PRODUCTION

The cultivation of 1984 Yala season was affected by the economic hardships faced by the farmers, a result of flood damages to their crop during previous Maha season. The large variability in input usage and agronomic practices due to financial hardships made the 1984 Yala season unrepresentative of a typical Yala season. A meaningful analysis would have been possible if a large sample was used. However, sample size was limited by the available resources and the practical difficulties involved in collecting the farm level data. However, an analysis was attempted with interpretation largely based on field experience gained during the two seasons.

In general, all farms selected for observation showed poor yields. The average yield per hectare for tracts 2, 3 and 8 were 2546, 2324, and 2608 kilograms with an overall average yield of 2493 kilograms per hectare. Detailed results of area cultivated, planting method, variety, duration of the variety and yield per hectare sorted on the basis of farm size and yield per hectare for the tracts 2, 3 and 8 are given in Appendix C Tables C28, C29, and C30, respectively. The overall yields were poor. However, relatively higher yields were obtained by farms that transplanted the crop in tract 2.

Considering the large number of factors contributing to yield it is difficult to attribute the poor yields to any single factor. Rather, the poor yields observed during 1984 Yala season were a combination of poor weed control, poor quality seed (almost all farmers used their own seed paddy), lower than recommended rates of application, and poor timing of application of fertilizers and agrochemicals. This is evident at least in fertilizer and chemical applications (see Appendix C Tables C31 through C39). Most farmers showed good awareness of the recommended rates of applications of fertilizer and chemicals when they were interviewed. Nevertheless, most of them complained of not having enough money resulting in either non application or poor timing of application. Particularly, agrochemicals were applied much below the rates recommended for effective response.

5.2.7.1 Costs of production

The detailed cost of production data are given in Appendix C Tables C40 through C42 for tracts 2,3 and 8, respectively. As indicated by the data, their was a wide variation in the cost of production depending on the use of family labor and power sources for land preparation. In general, transplanted farms showed a heavy hired labor costs. Also, leased farms showed greater production cost due to hired labor use. The data indicate that most small farms had negative net incomes if family labor is accounted into the calculation of costs. Thus, during the 1984 Yala season most farmers seem to barely cover their investments. This is an indication of the delicate financial situation faced by most farmers following a particularly bad season. It also explains why most farmers resort to the practices of encroachments, leasing and fragmentation to overcome financial pressures.

The total cost of production was separated into land preparation, fertilizer, agrochemicals, labor and other costs involved. These costs were expressed as a fraction of the net cost of production which included cost of employing family labor. Details of this data are given in Tables C43 through C45 of the Appendix C. There was a wide variability in these fractional costs among farms. However, the average values for individual tracts did not show a significant difference among tracts (Table 21).

Using overall averages of fractional costs and net cost of production, it is possible to calculate a net cost that would be incurred if recommended input levels and recommended varieties were used for a Yala season. Considering weedicides and fertilizer at recommended rates, the fractional costs were first subtracted from the average net cost and new costs per hectare of recommended practices were added to calculate net cost of production if recommended rates were used. The overall average net cost increased from Rs.6055 to a value of Rs.7337 per hectare (recommended fertilizer application rate is 186,93, and 124 kilograms of basal, urea, and top dress mixture @ Rs.3.50 kilogram and 9 liters of 34-DPA herbicide @ Rs.100 per liter was assumed for the calculation). Assuming Rs.2.75 per kilogram of paddy, the break even yield required will be Rs.2668 kilograms per hectare (approximately 50 bushels per acre). Projecting a conservative yield level of 5165 kilograms per hectare (100 bushels per acre) the net incomes of farmers having 3 acre and 2 acre farms will be Rs.8340 and Rs.5560, respectively. Considering reported average yields of 4132 kilograms per hectare (80 bushels per acre) for Yala season, the net incomes amount to Rs.4890 and Rs.3260, respectively.

The above calculations indicate the economic advantage of the farmers having 3 acre farms over those having 2 acre farms at any given level of production. This is a constraint built into the system by the land allocation pattern. However, extensive use of family labor in smaller farms may enable them to reduce net production cost in comparison to larger farms and thereby achieve comparable income levels. Thus, if economic disparities among farms are to be reduced the smaller farms will have to extensively use family labor for production in comparison to larger farm holdings.

5.3 HUMAN ORGANIZATION IN IRRIGATION MANAGEMENT

5.3.1 INTRODUCTION

Thus far we discussed the technical aspects of irrigation management observed at Kaudulla. The technical constraints identified offer the physical possibilities of rehabilitation. Such rectification can be justified on the basis of a cost benefit analysis. However, a cost benefit analysis assumes effective implementation of a technical rehabilitation program and organization of human resources to maintain the system and manage irrigation water to realize these benefits. Kaudulla has indeed benefited the farming community and contributed to the national production. Nevertheless, these benefits are being presently generated at increased public expenditure to maintain the system and to the economic disadvantage of a section of the farming community. The distributory system has continued to deteriorate necessitating costly rehabilitation for effective functioning and management. The aim of the following discussion is to provide insights to the social constraints and essential factors that need to be considered to develop effective irrigation management alternatives.

5.3.2 FINDINGS OF THE SOCIOLOGICAL INVESTIGATION

The report on analysis (Goonasekere, S., 1983) of the social and organizational factors constraining irrigation management at Kaudulla is given in Appendix A. The analysis reveals that the operating rules, regulations and social organization assumed at planning has not been realized in actual practice. The vicious cycles that disrupt effective management and exploit the technical system stem from the economic vicissitudes of the country as a whole. At least this aspect of the problems of irrigation management is possible to generalize because similar trends have been reported in literature even in relatively new irrigation schemes. For example, Tilakaratne (1983) reported the growing symbiotic relationships among the irrigation bureaucracy and influential farmers among the farming community. He observed a growing economic disparity amongst farming community in the Kalawewa " H " area, which is a relatively recent irrigation scheme. Poor main system maintenance, lack of motivation among irrigation management personnel, political interference, and practices of the farming community are being recognized (Moore, (1983); Rust and Moore, (1984); Schudder, (1984); Wimaladharma, (1980)) as consequence of breakdowns in the institutions that are an essential precondition for the engineering system to function. Engineering improvements to a given physical system, though situation specific, is a physical possibility. However, the effectiveness of engineering rehabilitation is limited by the human institutions which function within the politico-economic conditions of the country. The crux of the problem is to change the presently existing priority of individual economy over the moral and law that is an absolute must if the engineering system is to function effectively. The question is how to effectively address these institutional problems and integrate appropriate technical measures into the solution.

5.3.3 IMPORTANT INSTITUTIONAL ELEMENTS TO BE CONSIDERED

Recent emphasis in developing the needed institutional aspects of irrigation management has been placed on formation of farmer organizations and providing training to the management personnel in irrigation management skills together with physical rehabilitation. The training of technical personnel and organization of the farmers are unquestionably important necessary conditions but these are not sufficient conditions. The primary limitation is the assumption that given the training to the managerial bureaucracy, training and organization of the farming community, their increased participation in the irrigation management decision making process, and rehabilitation of the physical system together will somehow improve the irrigation management of a given system. Unfortunately, this somehow does not exist. Now we proceed to qualify this argument based on the sociological analysis and the experience gained at Kaudulla.

In Chapter Three and Appendix A, it was explained why economic pressure causes the irrigation bureaucracy to get involved in malpractices or show indifferent attitudes towards their responsibilities. Training these individuals alone is not a sufficient criterion for them to be motivated. The "burn out syndrome" observed by Schudder (1984) is a point to support this argument. From the point of view of irrigation bureaucracy, the extra effort required for long hours of field visits, attending to the problems and complaints of farmers, planning, distribution, measurement and control of irrigation water cannot be compensated adequately by providing training alone as an incentive. There has to be sufficient economic incentives to motivate these individuals to guarantee their active participation. However, one has to be conscious of the limitations imposed by the inability of the overburdened national economy to evolve a suitable incentive scheme. Often, an incentive scheme for the management personnel, which a necessary must, is conveniently overlooked due to the above limitation with the assumption that somehow they will be motivated in their work.

Let us now consider the farming community. In order to establish the necessary irrigation management institutions, the need to organize and train the farmers is of primary importance. However, the observation of farmers as "cautious optimizers" (Bromley, 1982) is an important fact. From the farmers point of view, if they are to forgo the traditional practice of using plentiful water supplies for growing rice, the extra effort required for careful irrigation management would require substantial benefits. This is specially the case if one considers the practical difficulties of the farming in the dry zone. Often overlooked are the real life difficulties of working long hours in the hot sun, the long distances to be travelled in order to implement these management practices, the extra labor required to carefully manage irrigation water, and the leisure time that needs sacrificing which otherwise a farmer would have employed for his personal affairs. In a practical sense, considering the delicate financial status of majority of the farmers, individual farmers would naturally weigh the advantage of new practices advocated. Therefore, the level of management advocated to achieve effective water utilization and the resulting benefits will have to be demonstrated to the farmers if these practices are to take root in a farming community.

It is noteworthy to mention the findings of Wimaladharma (1980). His findings at Kala Wewa (Mahaweli System "H") indicate that initially it was possible to form farmer organizations. However, subsequently absenteeism increased which throws doubts on the well publicized success of these organization efforts. He cautions about the danger of overplaying the success of farmer organizations. The important point is, given these constraints, how to guarantee the viability of such farmer organizations.

The next problem area is the maintenance of the channel system of an irrigation scheme. A costly physical rehabilitation process to improve the performance of an existing system is justified only if the technical system could sustain its capabilities through effective maintenance. Similar to the problem of providing incentives here again the problem is the inability of the national economy to commit adequate funds required for maintenance of the systems. Therefore, the only practically feasible alternative is to generate sufficient financial resources from the farming community and to integrate a maintenance program into farmer organizations. The positive aspect of the present irrigation policy is an irrigation levy on farmers to generate the resources for system maintenance. However, the problem is to effectively integrate a sound maintenance program into the activities of farmer organizations currently being advocated and to ensure continued success of such an attempt.

Lastly, the most important social constraint beyond the realm of engineering is the politics of irrigation. Politics in irrigation management and their implications to the developing countries is discussed by Botrall (1981). A primary cause for the break down in community institutions is the national politics in relation to irrigation. Wilson (1984), Navaratne (1984), and De Silva (1983) provide good insights into how national politics have eroded efficiency of public institutions through short sighted national policy and political favoritism. One such example is the ridiculously low irrigation levy (Wilson, 1984) that was adopted at the onset of irrigation development after independence of the country. Raising the irrigation levy to more realistic levels became a sensitive political issue due to exploitation by unscrupulous politicians. The issue was not considered favorably until recently and more realistic water rates are now being implemented to raise sufficient funds to cover the maintenance of a system. Continued priority investment in new irrigation development, which has political glamour in comparison to improving the productivity of the existing irrigation schemes, is an important point. However, from a political point of view these are more attractive short range solutions to equally pressing problems of the landless and unemployment. The primary difficulty is to incorporate politically attractive alternative solutions which would produce quick results. Unfortunately, irrigation water management is a problem that does not lend itself to producing quick results appealing to the masses and therefore the politicians.

The problem is aggravated by the permeation of national politics into grassroot level organizations. The appointment of Vel Vidanes is an example of this problem. The democratic process of appointing Vel Vidanes to represent the farming community through voting makes farmer organizations particularly vulnerable. Thus, the viability of these organizations greatly depend on eliminating these constraints.

In meting out punishment to irrigation offenses, grassroot level political interference and the slowness in judiciary proceedings has largely contributed to the breakdown in institutions. Therefore, the reforms are needed not only at the farm level or system level management as currently being advocated but also at the levels of planning and political thinking at national level. The harsh truth is, if the malpractices and corruption that disorient the institutions are tolerated due to oversight by planners and politicians, then a perpetuation of inefficiency and poor productivity will remain a major stumbling block to improve irrigation management in the country.

Some management alternatives are discussed in the following chapter and attempt to address the constraints identified by the study.

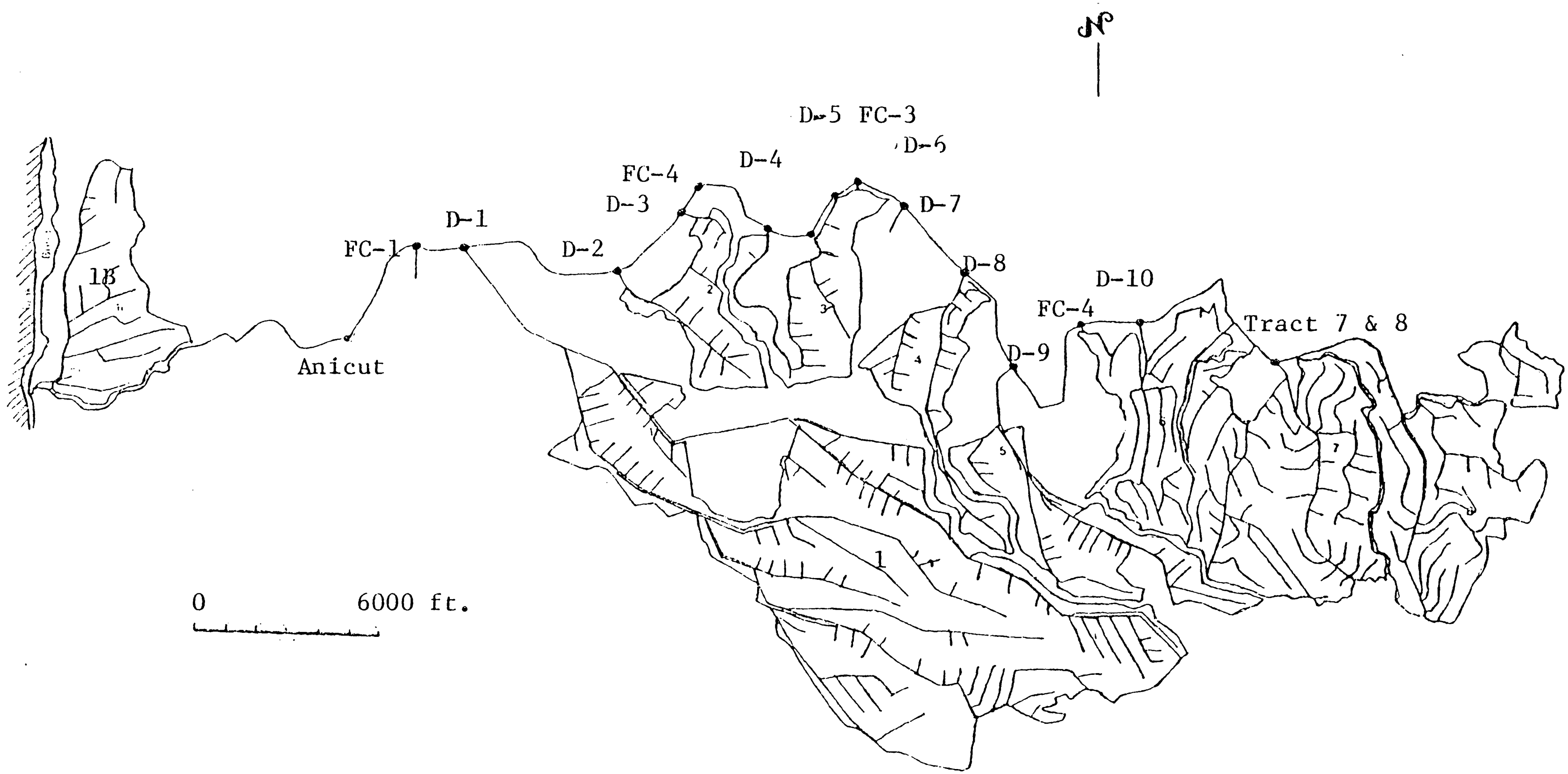

Figure 17. Stage I main channel and irrigation layout showing monitored locations along the main channel. Kaudulla irrigation scheme. (source: Holmes et al.,1981)

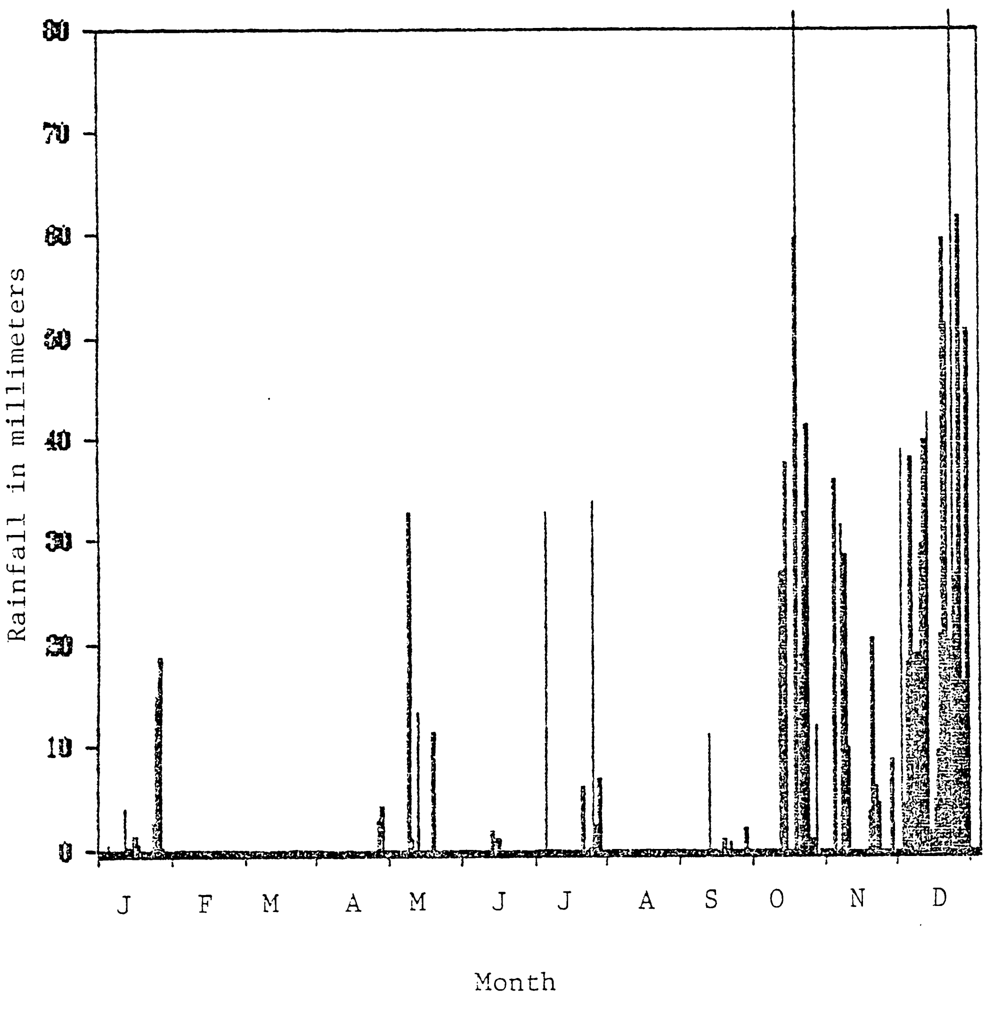

Figure 18. Rainfall distribution in 1983. Figure indicate mean value of two stations (Source:Department of Irrigation meteorology records at high level and low level sluices, Kaudulla, Sri Lanka).

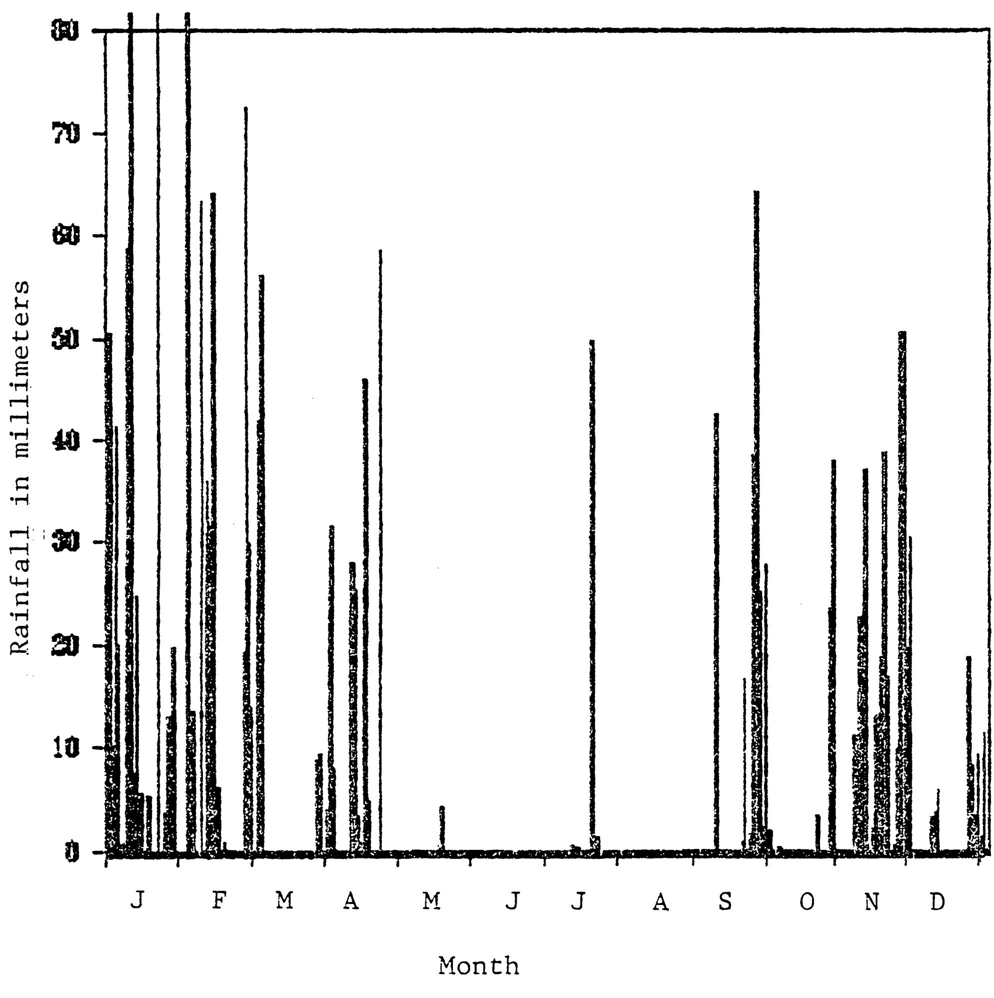

Figure 19. Rainfall distribution in 1984. Figure indicate mean value of two stations (Source:Department of Irrigation meteorology records at high level and low level sluices, Kaudulla, Sri Lanka).

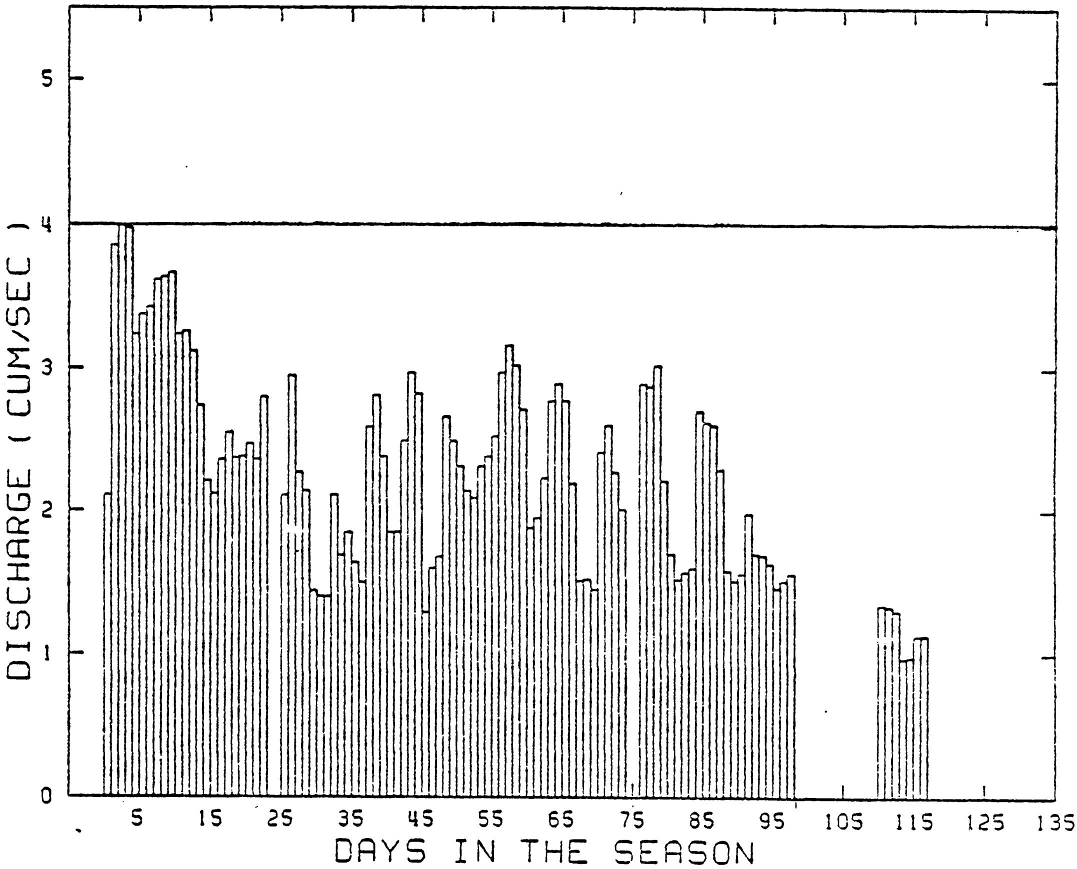

Figure 20. 1983 Yala season. Daily discharge rates in cubic meters per second calculated at the head of main channel. Stage I, Kaudulla.

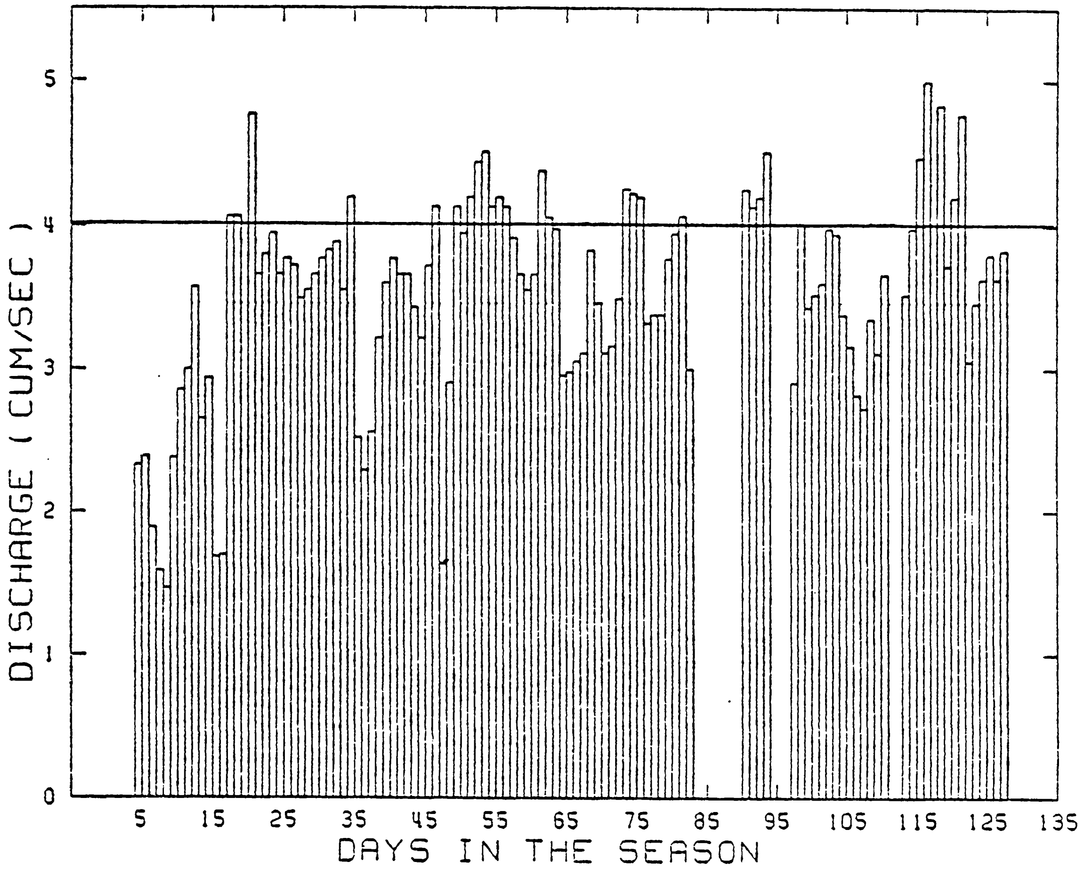

Figure 21. 1984 Yala season. Daily discharge rates in cubic meters per second calculated at the head of main channel. Stage I, Kaudulla.

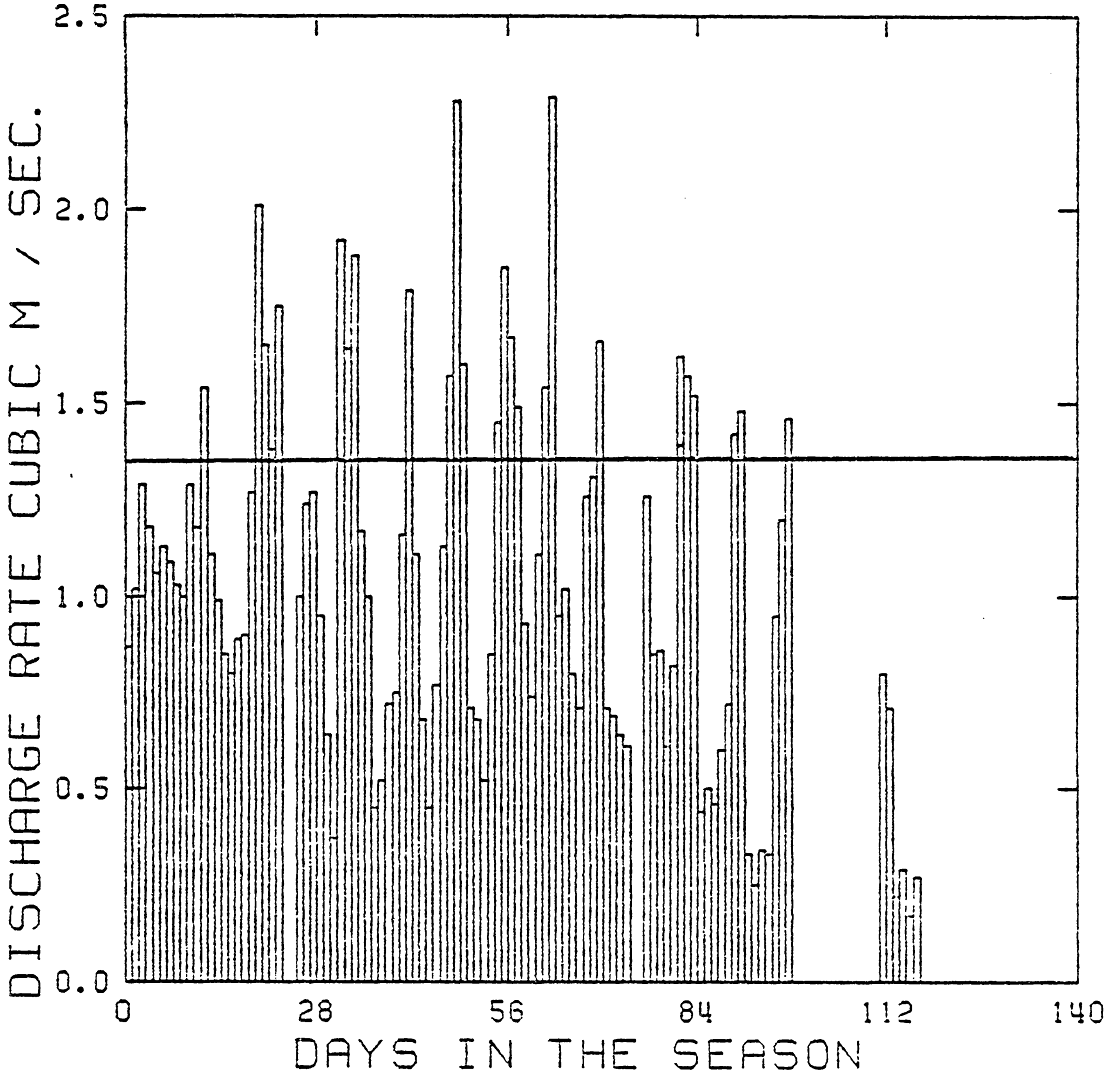

Figure 22. Tract 7 and 8 distributory offtake during the 1983 Yala season. Daily discharge rates in cubic meters per second calculated at the head of distributory oftake. Stage I, Kaudulla.

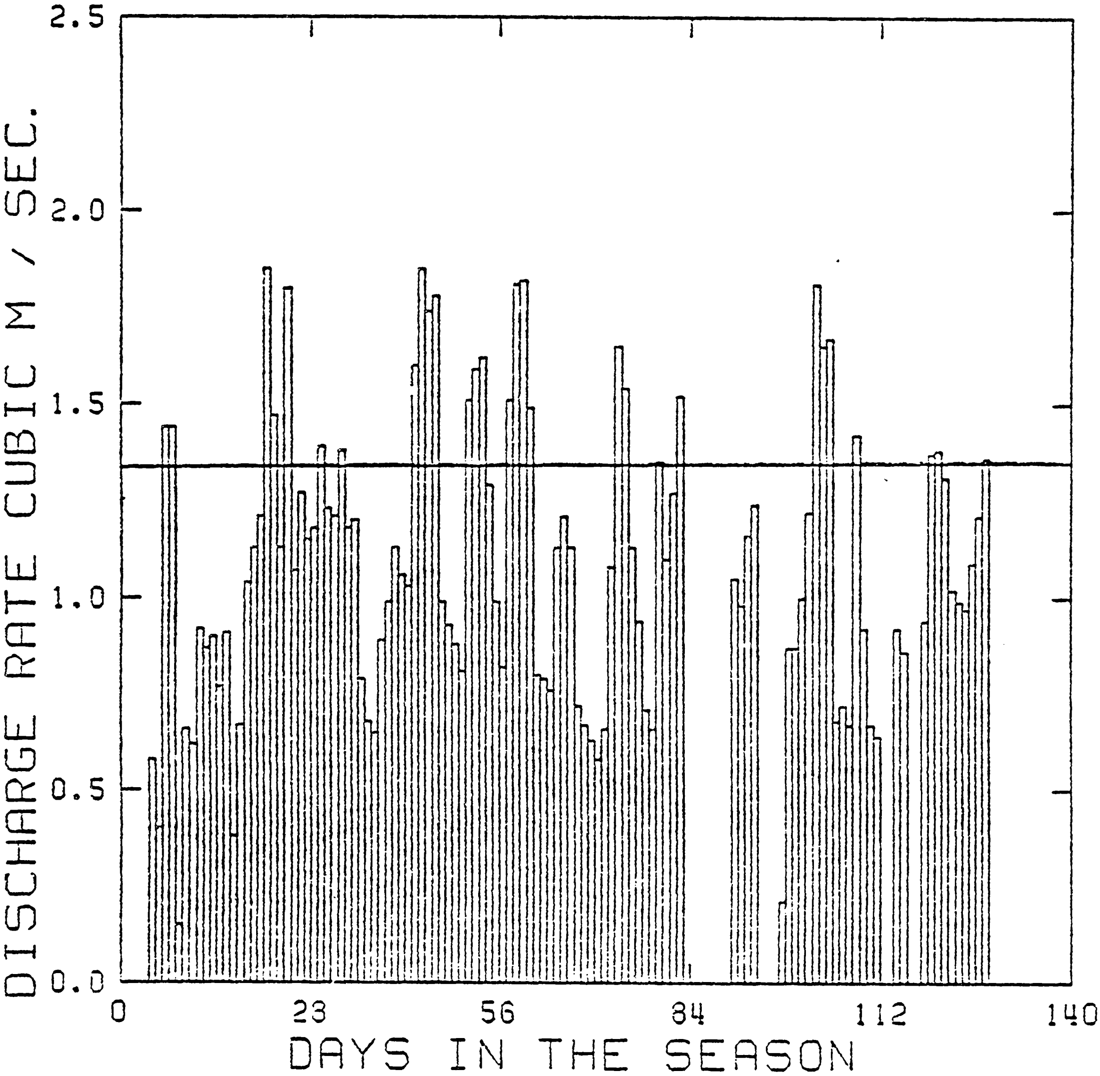

Figure 23. Tract 7 and 8 distributory offtake during the 1984 Yala season. Daily discharge rates in cubic meters per second calculated at the head of distributory oftakes. Stage I, Kaudulla.

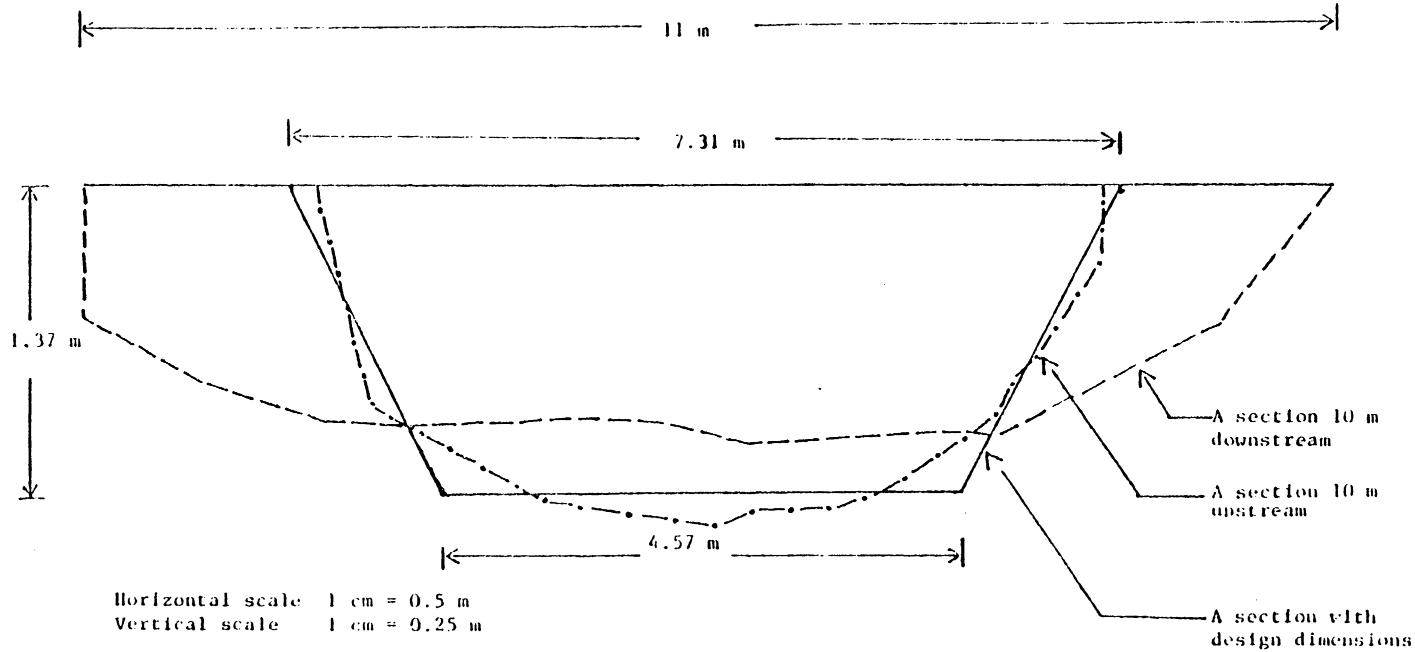

Figure 24. Comparision of design channel section with measured upstream and downstream channel sections at the head of main channel, Kaudulla, Stage I.

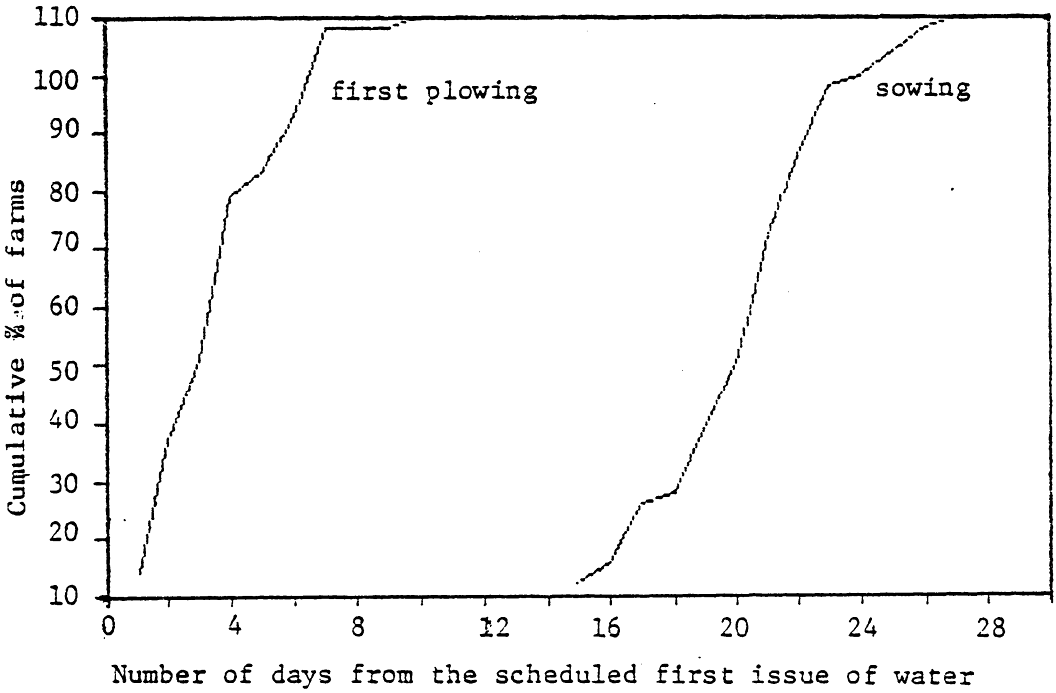

Figure 25. D-2 channel during 1983 Yala season. Cumulative percentage of farmers starting first plowing and sowing from the scheduled date of first irrigation issue in tract 2. Stage I, Kaudulla.

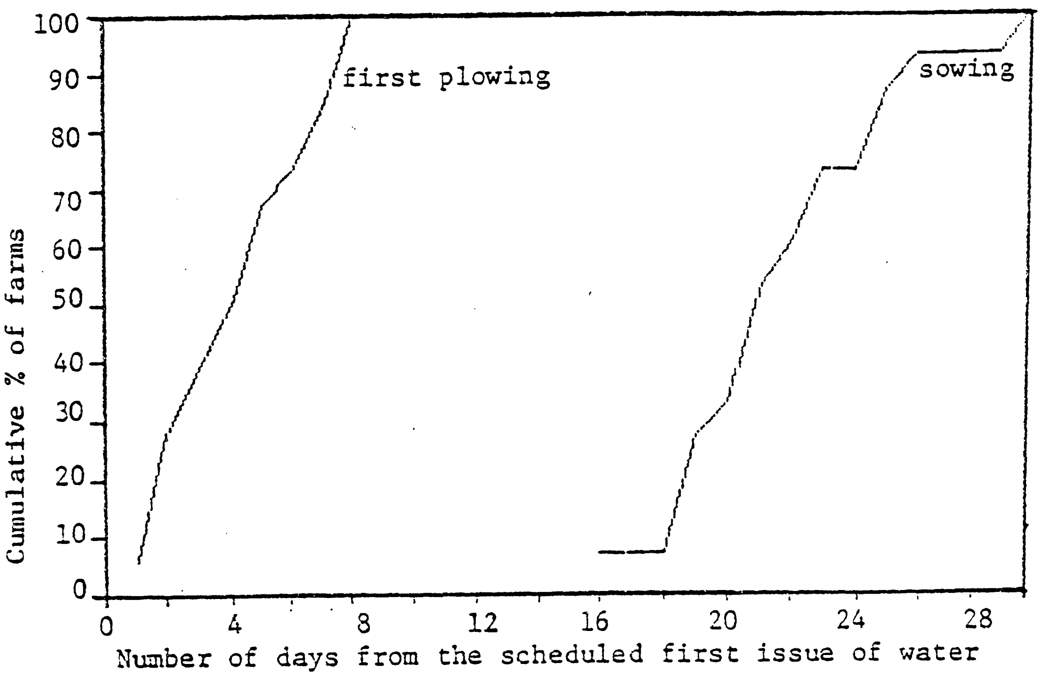

Figure 26. D-4 channel during 1983 Yala season. Cumulative percentage of farmers starting first plowing and sowing from the scheduled date of first irrigation issue in tract 3. Stage I, Kaudulla.

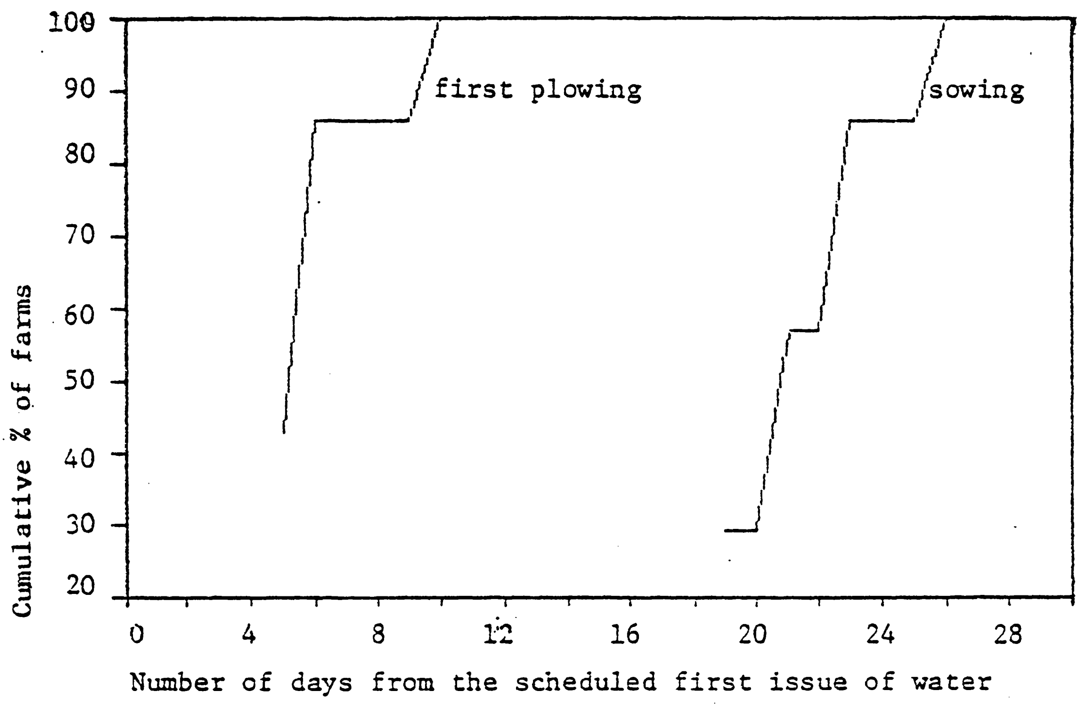

Figure 27. FC -15 channel during 1983 Yala season. Cumulative percentage of farmers starting first plowing and sowing from the scheduled date of first irrigation issue in tract 7. Stage I, Kaudulla.

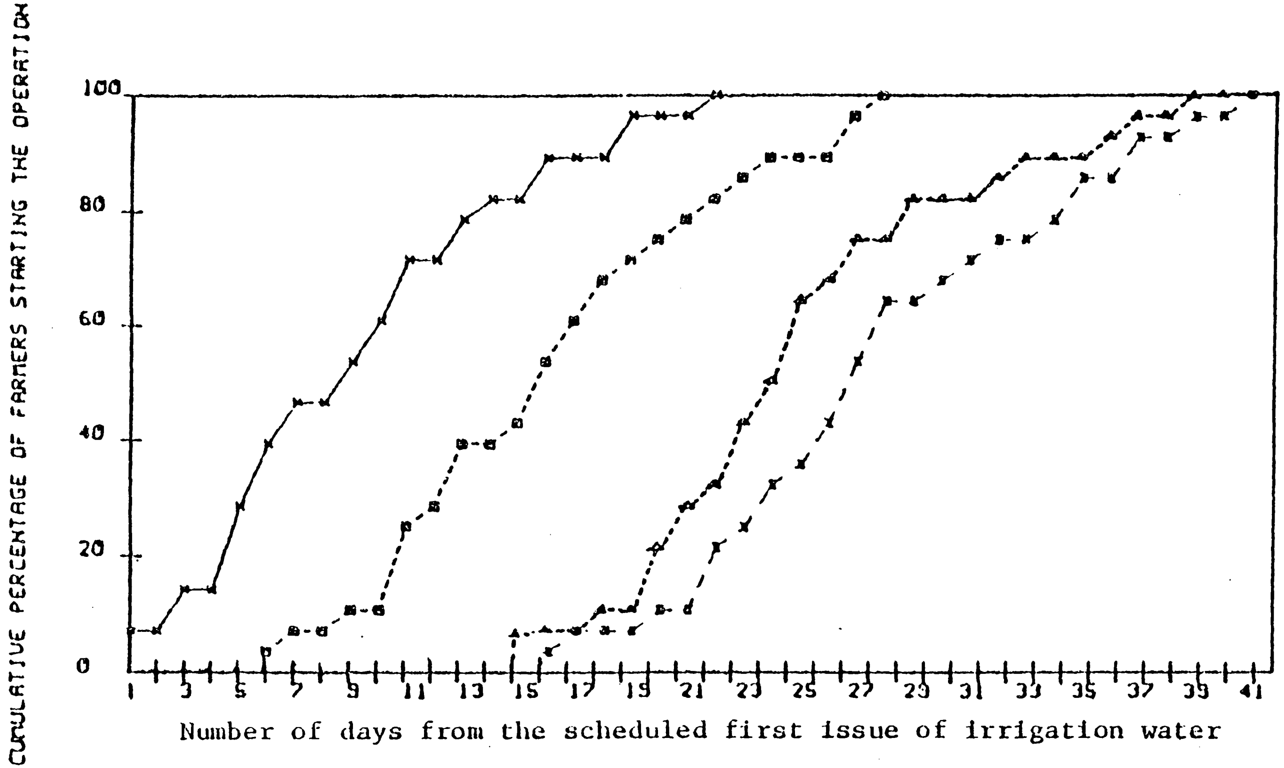

Figure 28. Cumulative percentage of farms starting land preparation and sowing in tract 2 during 1984 Yala season.

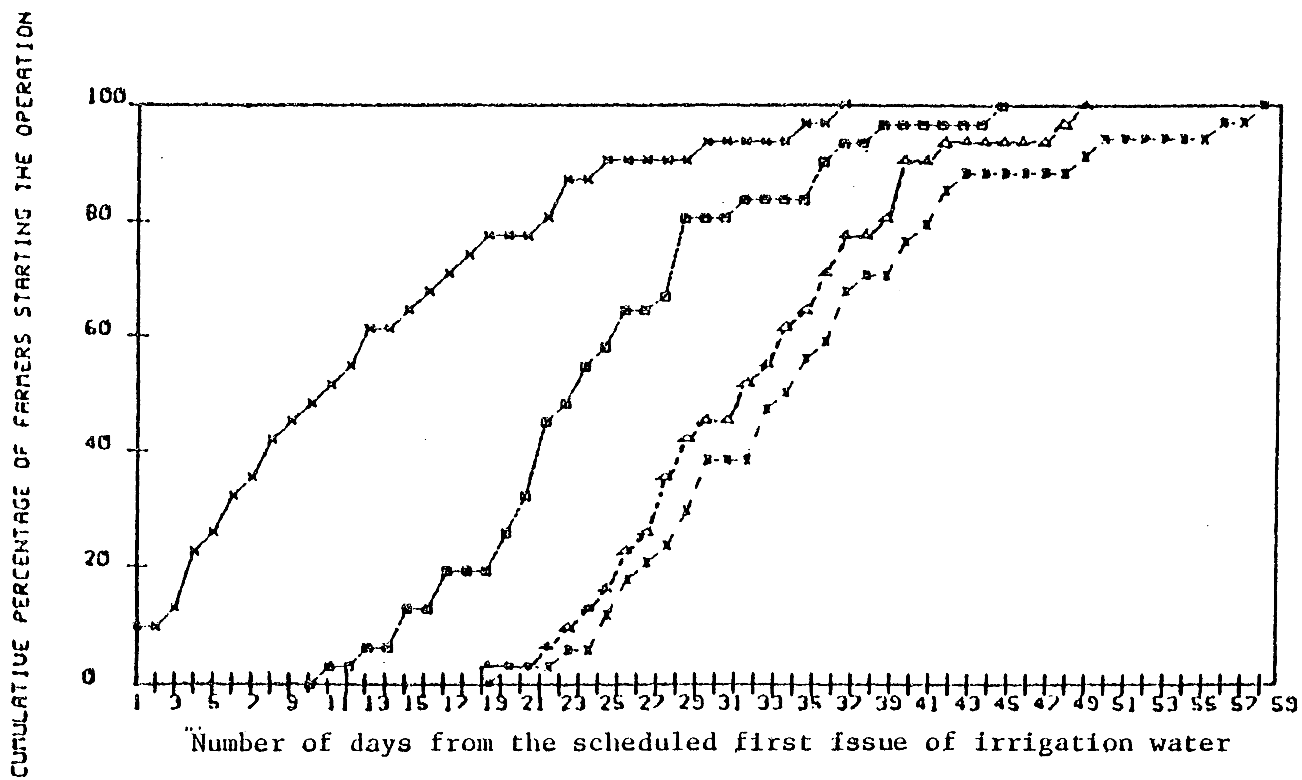

Figure 29. Cumulative percentage farms starting land preparation, and sowing in tract 3 during 1984 Yala season.

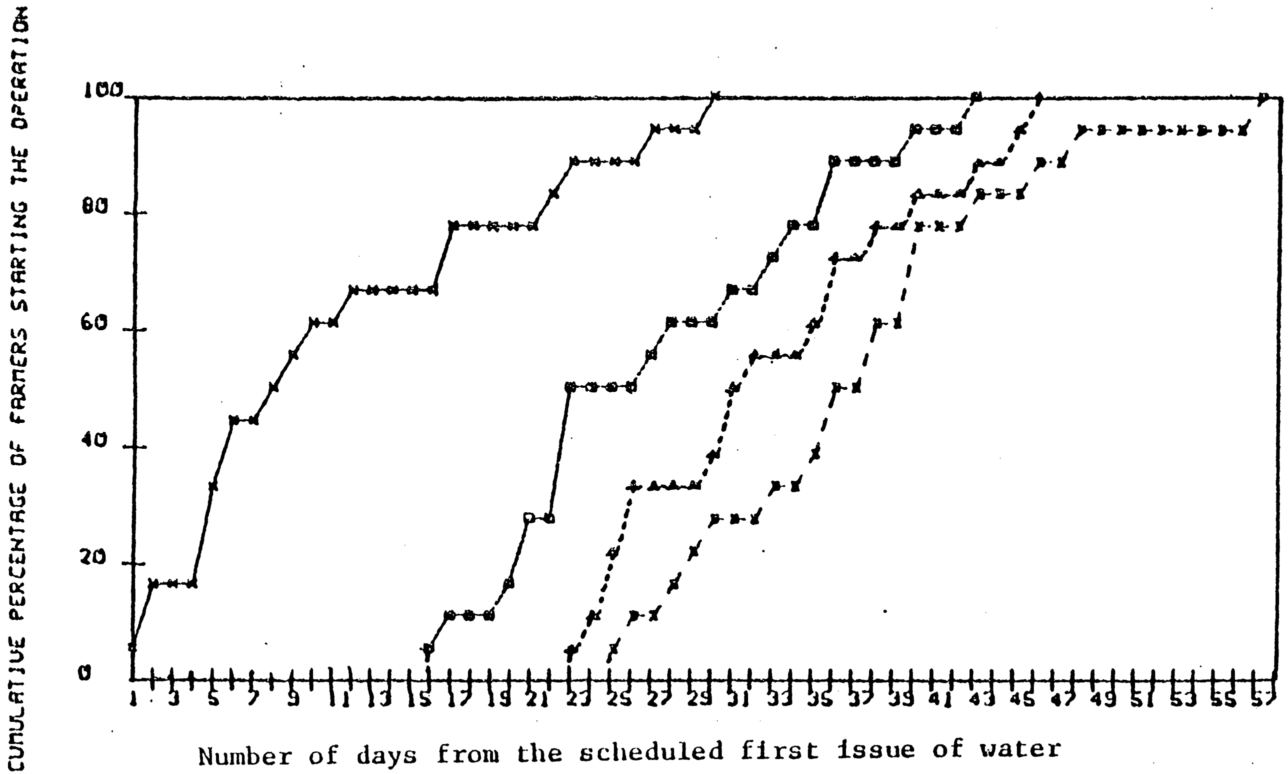

Figure 30. Cumulative percentage farms starting land preparation,and sowing in tract 8 during 1984 Yala season.

Table 6. Design discharge rates required, areas, and farm lot sizes of irrigated tracts. Kaudulla Irrigation Scheme, Stage I.

Tract No.	Name	Area Commanded		Number of Allotments		Design Discharge	
		Ac.	Ha.	3 Ac.	2 Ac.	With 15% Loss	Without Loss
1	FC1	33	13.4	11	-	0.036	0.031
1	D1	1521	615.8	507	-	1.650	1.435
2	D2	162	65.6	54	-	0.176	0.153
2	D3	30	12.1	10	-	0.033	0.028
2	FC2	27	10.9	9	-	0.029	0.025
3	D4	63	25.5	21	-	0.068	0.059
3	D5	180	72.9	60	-	0.195	0.170
3	FC3	21	8.5	7	-	0.023	0.020
3	D6	9	3.6	3	-	0.010	0.008
3	D7	12	4.9	4	-	0.013	0.011
4	D8	228	92.3	76	-	0.247	0.215
5	D9	324	131.2	108	-	0.351	0.306
5	FC4	28	11.3	-	14	0.030	0.026
6	D10	272	110.1	-	136	0.295	0.257
6	FC5	26	10.5	-	13	0.028	0.025
7	FC6	18	7.3	-	9	0.020	0.017
7	T7	784	317.4	-	401	0.850	0.740
8	T8	619	250.6	63	215	0.672	0.584
Total		4357	1764.0	933	788	4.727	4.110

Table 7. Pipe diameters, number of outlets, distributory and field channel lengths of irrigated tracts. Kaudulla Stage I.

Tract No.	Channel Offtake Name	Number of Outlets	Diameter of Pipe (in cm)	D Channel Lengths (in km)	FC Channel Lengths (in km)
1	FC1	1.0	22.86	na	na
1	D1	3.0	60.96	14.63	47.2
2	D2	1.0	45.72	1.94	3.5
2	D3	1.0	15.24		
2	FC2	1.0	22.86	na	na
3	D4	1.0	22.86		
3	D5	1.0	22.86		
3	FC3	1.0	22.86	3.57	3.76
3	D6	1.0	15.24		
3	D7	1.0	15.24		
4	D8	2.0	45.72	2.46	3.83
5	D9	2.0	45.72	1.85	6.57
5	FC4	1.0	22.86	1.27	10.47
6	D10	2.0	45.72		
6	FC5	1.0	22.86	2.4	18.02
7	FC6	1.0	22.86		
7&8	T7&8	1.0	22.86	3.37	5.08

Table 8. Theoretically derived drainage estimates for irrigated tracts. Kaudulla Irrigation Scheme, Stage I.

Tract Number	Surface Drainage in l/second
1	465.6
2	65.6
3	85.3
4	68.3
5	105.3
6	89.2
7	240.2
8	185.6
Total =	1305.1

Note: drainage outflow for a 90 day season is 1015 hectare meters (8224 acre feet).

Table 9. Details of cultivation calendar adopted during the 1983 Yala season. Kaudulla Irrigation Scheme, Kaudulla (Source:Department of Irrigation, Kaudulla Office).

Scheduled task	Target date
1.Last date to complete channel cleaning by farmers	05/04/83
2.Last date to complete channel cleaning by cultivation officers	10/04/83
3.Date of first irrigation issue	15/04/83
4.Date of last irrigation issue	05/08/83
5.Last date to complete sowing	15/05/83
6.Date to beging rotation irrigation issue	15/05/83
7.Last date to complete building fences	15/05/83
8.Last date to insure crop	10/05/83
9.Last date to report crop losses	30/07/83
10.Last date to remove tractors and buffaloes from fields	15/05/83
11.Date to re enter cattle and machinery to fields	15/08/83
12.Last date to complete harvesting	20/08/83
13.Last date to receive cultivation loan applications	05/04/83
14.Date-to begin issuing cultivation loans	15/04/83
15.Last day to repay cultivation loans	30/08/83

Table 10. Details of cultivation calendar adopted during the 1984 Yala season. Kaudulla Irrigation Scheme, Kaudulla (Source:Department of Irrigation, Kaudulla Office).

Scheduled task	Target date
1.Last date to complete channel cleaning by farmers	07/04/84
2.Last date to complete channel cleaning by cultivation officers	12/04/84
3.Date of first irrigation issue	20/04/84
4.Last date of irrigation issue	20/08/84
5.Last date of sowing	20/05/84
transplanting	10/05/84
6.Date to begin rotaional irrigation issue	10/05/84
7.Last date to complete building fences	15/05/84
8.Last date to insure crop	15/05/84
9.Last date to report crop losses	20/08/84
10.Last date to remove cattle and machinery from fields	20/05/84
11.Date to re enter cattle and machinery	05/09/84
12.Last date to complete harvesting	15/09/84
13.Last date to receive cultivation loan applications	19/04/84
14.Date to begin issue of cultivation loans	19/04/84
15.Last date to repay cultivation loans	15/11/84

Table 11. Mass flow balance along the main channel during the 1983 Yala season at the monitored distributory offtakes. Kaudulla, Stage I.

	MAIN	FC-1	D-1	D-2	D-3	FC-2	D-4	D-5	FC-3	D-6	D-7	D-8	D-9	FC-4	D-10
APRIL 18	2.11	2.11	0.98	0.71	0.68	0.63	0.54	0.39	0.34	0.34	0.32	-0.02	-0.31	-0.35	-0.61
19	3.86	3.86	2.45	2.14	2.08	2.03	1.92	1.72	1.66	1.63	1.60	1.47	1.15	1.11	0.84
20	4.00	3.93	2.49	2.18	2.12	2.06	1.95	1.72	1.66	1.63	1.60	1.24	0.90	0.86	0.57
21	3.98	3.92	2.43	2.12	2.06	2.00	1.88	1.64	1.58	1.54	1.51	1.12	0.79	0.75	0.46
22	3.24	3.18	1.76	1.44	1.38	1.33	1.22	1.01	0.95	0.91	0.89	0.50	0.19	0.15	-0.13
23	3.38	3.32	1.92	1.61	1.54	1.49	1.38	1.15	1.10	1.10	1.07	0.70	0.38	0.34	0.06
24	3.43	3.37	1.95	1.64	1.58	1.52	1.41	1.18	1.12	1.12	1.09	0.72	0.40	0.36	0.08
25	3.62	3.56	2.12	1.81	1.75	1.69	1.58	1.36	1.30	1.26	1.24	0.86	0.54	0.50	0.24
26	3.64	3.58	2.17	1.86	1.80	1.75	1.64	1.42	1.37	1.33	1.30	0.93	0.61	0.58	0.31
27	3.67	3.62	3.09	2.79	2.72	2.66	2.54	2.28	2.22	2.18	2.15	1.76	1.43	1.38	1.09
28	3.24	3.18	1.86	1.56	1.50	1.45	1.34	1.13	1.08	1.04	1.04	0.67	0.35	0.31	0.04
29	3.26	3.20	1.85	1.54	1.47	1.41	1.29	1.01	0.95	0.91	0.88	0.48	0.10	0.06	-0.26
30	3.12	3.06	2.63	2.34	2.29	2.23	2.13	1.94	1.89	1.89	1.89	1.52	1.10	1.06	0.80
MAY 1	2.74	2.69	1.87	1.60	1.54	1.49	1.39	1.22	1.20	1.16	1.13	0.78	0.34	0.30	0.05
2	2.21	2.16	1.00	0.73	0.68	0.63	0.54	0.40	0.35	0.35	0.33	-0.01	-0.43	-0.47	-0.70
3	2.12	2.06	0.93	0.66	0.61	0.57	0.48	0.34	0.30	0.26	0.24	-0.09	-0.51	-0.54	-0.77
4	2.36	2.32	1.11	0.84	0.79	0.74	0.65	0.50	0.46	0.42	0.40	0.06	-0.34	-0.38	-0.38
5	2.55	2.50	1.24	0.97	0.92	0.87	0.77	0.61	0.56	0.56	0.54	0.19	-0.22	-0.26	-0.49
6	2.37	2.31	2.31	2.01	2.01	1.95	1.84	1.84	1.84	1.84	1.83	1.45	0.97	0.93	0.65
7	2.38	2.31	2.31	1.98	1.98	1.92	1.80	1.52	1.52	1.52	1.52	1.10	0.72	0.72	0.38
8	2.47	2.47	1.23	1.11	1.11	1.05	0.93	0.67	0.67	0.67	0.67	0.27	-0.10	-0.15	-0.47
9	2.36	2.31	1.03	0.91	0.87	0.87	0.87	0.67	0.67	0.67	0.67	0.29	-0.18	-0.18	-0.58
10	2.80	2.74	1.43	1.30	1.24	1.18	1.07	0.83	0.77	0.73	0.73	0.35	-0.15	-0.15	-0.46
11															
12															
13	2.11	2.06	1.67	1.40	1.35	1.31	1.21	1.07	1.02	0.99	0.97	0.62	0.21	0.21	-0.01
14	2.95	2.89	1.54	1.25	1.20	1.20	1.20	0.99	0.99	0.99	0.99	0.62	0.16	0.16	-0.21
15	2.27	2.23	1.06	0.94	0.91	0.91	0.91	0.74	0.74	0.70	0.70	0.34	-0.11	-0.15	-0.43
16	2.14	2.14	1.57	1.31	1.26	1.22	1.13	1.00	0.95	0.95	0.95	0.61	0.21	0.17	-0.14
17	1.44	1.44	0.60	0.39	0.35	0.31	0.23	0.13	0.10	0.10	0.08	-0.24	-0.61	-0.65	-0.93
18	1.40	1.40	0.48	0.25	0.22	0.22	0.14	0.06	0.03	.00	-0.01	-0.13	-0.46	-0.49	-0.64
19	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.36	1.17
20	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.06	1.62
21	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.69	1.44
22	1.85	1.85	0.73	0.47	0.47	0.42	0.33	0.26	0.25	0.25	0.25	-0.15	-0.46	-0.50	-0.75
23	1.64	1.60	0.53	0.30	0.30	0.25	0.17	0.04	0.04	.00	-0.02	-0.36	-0.65	-0.69	-0.95
24	1.50	1.47	0.48	0.24	0.20	0.17	0.09	.00	-0.03	-0.07	-0.09	-0.40	-0.74	-0.77	-0.92
25	2.59	2.54	1.31	1.02	0.97	0.93	0.84	0.72	0.68	0.65	0.65	0.31	-0.18	-0.21	-0.39
26	2.81	2.76	1.45	1.45	1.45	1.45	1.35	1.35	1.35	1.35	1.33	0.98	0.48	0.44	0.22
27	2.38	2.33	1.10	1.10	1.10	1.10	1.01	0.87	0.82	0.82	0.80	0.45	-0.03	-0.06	-0.30
28	1.85	1.81	0.93	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.79	0.79	0.79	0.75	0.41
29	1.85	1.80	1.80	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.66	1.62	1.30
30	2.49	2.49	1.25	0.93	0.89	0.84	0.76	0.64	0.64	0.61	0.58	0.24	-0.21	-0.25	-0.51
31	2.97	2.92	1.63	1.32	1.27	1.22	1.13	0.98	0.94	0.90	0.88	0.53	0.06	0.02	-0.18
JUNE 1	2.82	2.77	1.51	1.21	1.16	1.12	1.03	0.89	0.84	0.80	0.78	0.43	-0.07	-0.07	-0.26
2	1.29	1.29	1.29	1.29	1.29	1.29	1.26	1.26	1.26	1.26	1.23	0.90	0.50	0.47	0.26
3	1.60	1.60	1.60	1.60	1.60	1.55	1.55	1.55	1.51	1.51	1.48	1.12	1.12	1.08	0.82
4	1.68	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.62	1.47	1.47	1.43	1.13
5	2.66	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.54	2.54	2.54	2.54	2.54	2.54	2.08
6	2.49	2.44	1.12	0.91	0.87	0.81	0.69	0.69	0.63	0.59	0.55	0.16	-0.45	-0.50	-0.90
7	2.31	2.26	1.06	0.73	0.69	0.65	0.56	0.44	0.40	0.37	0.34	0.01	-0.46	-0.49	-0.68
8	2.14	2.08	0.69	0.41	0.36	0.32	0.23	0.11	0.11	0.08	0.06	-0.28	-0.74	-0.74	-0.93
9	2.09	2.04	0.72	0.48	0.48	0.48	0.48	0.37	0.37	0.37	0.35	0.03	-0.40	-0.43	-0.61
10	2.31	2.31	0.99	0.99	0.99	0.99	0.99	0.85	0.85	0.82	0.82	0.82	0.82	0.78	0.56
11	2.38	2.38	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.18	1.15	1.15	1.15	1.15	1.15
12	2.52	2.47	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.19	1.19	1.19	1.19	1.19
13	2.97	2.97	1.62	1.32	1.27	1.22	1.12	1.12	1.06	1.06	1.04	0.67	0.67	0.63	0.34
14	3.16	3.16	1.77	1.47	1.41	1.36	1.26	1.26	1.21	1.17	1.17	0.80	0.80	0.76	0.47
15	3.02	3.02	1.69	1.38	1.33	1.28	1.18	1.18	1.13	1.09	1.06	0.70	-0.01	-0.04	-0.26
16	2.71	2.71	1.41	1.41	1.41	1.36	1.36	1.21	1.21	1.21	1.21	1.21	0.48	0.44	0.24
17	1.88	1.83	1.83	1.83	1.83	1.83	1.83	1.61	1.61	1.61	1.61	1.61	1.08	1.04	0.78
18	1.95	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.18	1.14	0.85
19	2.23	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.12	1.77
20	2.77	2.77	1.46	1.19	1.13	1.09	0,99	0.99	0.99	0.99	0.99	0.62	0.03	0.03	-0.21

		MAIN	FC-1	D-1	D-2	D-3	FC-2	D-4	D-5	FC-3	D-6	D-7	D-8	D-9	FC-4	D-10
	21	2.89	2.89	1.55	1.24	1.19	1.14	1.04	1.04	0.99	0.95	0.93	0.57	-0.13	-0.17	-0.38
	22	2.77	2.77	1.44	1.13	1.08	1.03	0.93	0.93	0.89	0.85	0.82	0.46	-0.26	-0.30	-0.50
	23	2.19	2.19	1.60	1.60	1.60	1.60	1.60	1.46	1.46	1.46	1.43	1.43	1.43	1.40	1.21
	24	1.51	1.51	0.89	0.89	0.89	0.89	0.89	0.78	0.78	0.78	0.76	0.76	0.76	0.76	0.49
	25	1.52	1.48	1.48	1.48	1.48	1.48	1.48	1.31	1.31	1.31	1.29	1.29	1.29	1.29	1.01
	26	1.45	1.40	1.40	1.40	1.40	1.40	1.40	1.24	1.24	1.24	1.24	1.24	1.24	1.24	1.24
	27	2.41	2.36	1.15	0.89	0.85	0.81	0.72	0.72	0.68	0.68	0.65	0.31	-0.35	-0.35	-0.54
	28	2.60	2.55	1.29	0.97	0.92	0.87	0.78	0.78	0.74	0.70	0.68	0.31	-0.38	-0.42	-0.63
	29	2.27	2.22	1.01	0.68	0.64	0.59	0.50	0.50	0.46	0.42	0.40	0.05	-0.63	-0.63	-0.89
	30	2.01	1.97	0.77	0.77	0.77	0.77	0.77	0.65	0.65	0.65	0.62	0.28	0.28	0.28	0.06
JULY	1															
	2															
	3	2.89	2.89	2.40	2.08	2.08	2.08	2.08	1.88	1.88	1.88	1.85	1.47	0.72	0.72	0.47
	4	2.87	2.87	2.44	2.15	2.10	2.05	1.95	1.78	1.73	1.69	1.67	1.31	0.59	0.59	0.21
	5	3.02	3.02	1.66	1.36	1.31	1.26	1.16	1.16	1.11	1.07	1.05	0.68	-0.05	-0.05	-0.36
	6	2.21	2.15	0.83	0.53	0.48	0.43	0.34	0.34	0.29	0.29	0.27	-0.09	-0.78	-0.81	-1.13
	7	1.70	1.70	1.29	1.29	1.29	1.29	1.29	1.17	1.17	1.17	1.16	0.82	0.82	0.79	0.49
	8	1.52	1.52	1.52	1.52	1.52	1.52	1.52	1.36	1.36	1.36	1.33	1.33	1.33	1.29	1.21
	9	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.40	1.40	1.40	1.39	1.39	1.39	1.39	1.17
	10	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.44	1.44	1.44	1.41	1.41	1.41	1.41	1.19
	11	2.70	2.65	1.37	1.09	1.04	1.00	0.91	0.91	0.87	0.83	0.83	0.49	-0.15	-0.15	-0.34
	12	2.62	2.57	1.29	0.99	0.94	0.90	0.81	0.81	0.77	0.74	0.72	0.38	-0.29	-0.32	-0.64
	13	2.60	2.55	1.29	0.99	0.95	0.91	0.82	0.82	0.78	0.74	0.74	0.40	-0.27	-0.30	-0.63
	14	2.29	2.24	0.91	0.91	0.91	0.87	0.87	0.73	0.73	0.73	0.73	0.73	0.73	0.70	0.39
	15	1.58	1.53	1.53	1.53	1.53	1.53	1.53	1.41	1.41	1.41	1.41	1.06	1.06	1.02	0.91
	16	1.51	1.47	1.47	1.47	1.47	1.42	1.42	1.24	1.24	1.24	1.23	1.23	0.53	0.53	0.43
	17	1.56	1.51	1.51	1.51	1.51	1.51	1.51	1.33	1.33	1.33	1.32	0.94	0.94	0.90	0.72
	18	1.98	1.93	0.67	0.38	0.34	0.30	0.23	0.23	0.21	0.20	0.19	-0.14	-0.80	-0.83	-0.96
	19	1.70	1.66	0.59	0.28	0.24	0.21	0.13	0.13	0.10	0.09	0.07	-0.25	-0.90	-0.93	-1.04
	20	1.69	1.65	0.59	0.28	0.24	0.20	0.12	0.12	0.09	0.06	0.03	-0.29	-0.97	-1.00	-1.06
	21	1.63	1.59	0.21	0.21	0.21	0.21	0.21	0.14	0.14	0.14	0.13	-0.18	-0.62	-0.64	-0.71
	22	1.46	1.42	0.42	0.42	0.42	0.42	0.42	0.32	0.32	0.32	0.30	0.30	0.30	0.30	0.03
	23	1.51	1.47	0.92	0.92	0.92	0.92	0.92	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.58
	24	1.56	1.52	0.96	0.96	0.96	0.96	0.96	0.82	0.82	0.82	0.80	0.80	0.80	0.75	0.75
	25															
	26															
	27															
	28															
	29															
	30															
	31															
AUGUST	1															
	2															
	3															
	4															
	5															
	6	1.34	1.29	0.61	0.37	0.33	0.30	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
	7	1.33	1.27	0.52	0.23	0.23	0.19	0.11	0.02	0.02	-0.01	-0.01	-0.33	-0.33	-0.37	-0.71
	8	1.30	1.25	0.59	0.39	0.39	0.36	0.36	0.36	0.36	0.36	0.36	0.05	-0.30	-0.30	-0.61
	9	0.97	0.93	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	-0.21	-0.24	-0.42
	10	0.98	0.98	0.98	0.98	0.98	0.98	0.91	0.91	0.91	0.91	0.89	0.56	-0.02	-0.06	-0.30
	11	1.13	1.09	0.95	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.43	0.17	0.13	-0.12
	12	1.13	1.10	0.17	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.30	-0.51	-0.53	-0.82
	13															
	14															
	15															
	16															
	17															
	18															
	19															
	20															
	21															
	22															
	23															

Table 12. Mass flow balance along the main channel during the 1983 Yala season at the monitored distributory offtakes. Kaudulla, Stage I.

		MAIN	FC-1	D-1	D-2	D-3	FC-2	D-4	D-5	FC-3	D-6	D-7	D-8	D-9	FC-4	D-10
APRIL	22	2.33	0.03	1.09	0.23	0.02	0.05	0.08	0.05	0.03	0.03	0.02	0.17	0.51	0.03	0.31
	23	2.38	0.03	0.96	0.22	0.03	0.05	0.00	0.01	0.01	0.02	0.02		0.38	0.03	0.25
	24	1.89	0.03	1.01	0.21	0.02	0.05	0.07		0.03	0.02	0.02		0.48	0.03	0.33
	25	1.59	0.02	0.97	0.20	0.03	0.05	0.07		0.03	0.03	0.02	0.28	0.57	0.04	0.42
	26	1.47		0.92	0.02	0.03	0.05	0.07		0.04		0.02	0.19	0.27	0.02	0.16
	27	2.38	0.04	1.12	0.23	0.04	0.05	0.08	0.06	0.04	0.03	0.02	0.27	0.51	0.03	0.35
	28	2.85	0.04	1.19	0.24	0.04	0.05	0.08	0.12	0.04	.00		0.26	0.47	0.03	0.31
	29	3.00	0.04		0.24	0.04	0.05	0.08	0.08	0.04	0.03	0.02	0.29	0.55	0.03	0.42
	30	3.57	0.05		0.30	0.04	0.05	0.08	0.13	0.04	0.01	0.02	0.30	0.55	0.03	0.42
MAY	1	2.65	0.04	1.18	0.25	0.04	0.06	0.08	0.06	0.04		0.02	0.27	0.51	0.03	0.35
	2	2.93	0.05	1.31	0.24	0.04	0.05	0.08	0.07	0.04		0.02	0.26	0.25	0.03	0.33
	3	1.69	0.03	1.08	0.18	0.05	0.06	0.08	0.09	0.04		0.02	0.28	0.28	0.04	0.37
	4	1.70	0.03	1.12	0.19	0.03	0.04	0.06	0.08	0.01		0.02	0.22	0.21	0.03	0.25
	5	4.07	0.06	1.43	0.28	0.04	0.06	0.09	0.09	0.04	.00	0.02	0.26	0.25	0.03	0.33
	6	4.07	0.06	1.45	0.29	0.05	0.06	0.09	0.13	0.05		0.03	0.31	0.28	0.03	0.37
	7	4.01	0.06	1.28	0.29	0.04	0.07	0.09	0.12	0.05		0.02	0.14	0.31	0.04	0.23
	8	4.77	0.06	1.29	0.29	0.04	0.06	0.09	0.12	0.05		0.02	0.14	0.31	0.04	0.23
	9	3.66	0.01	1.17	0.21	0.04	0.06	0.09	0.12	0.05	0.01	0.02	0.28	0.34	0.04	0.36
	10	3.80	0.06	1.22	0.21	0.04	0.06	0.09	0.12	0.05	0.01	0.02	0.29	0.33	0.04	0.18
	11	3.95	0.01	1.27	0.21	0.04	0.06	0.09	0.12	0.05	0.01	0.02	.00	0.33	0.04	0.18
	12	3.66	0.01	1.16	0.21	0.05	0.06	0.09	0.12	0.05	.00	0.02	0.29	0.34	0.04	0.19
	13	3.77	0.01	1.26	0.21	0.04	0.06	0.09	0.12	0.05	.00	0.02	.00	0.33	0.04	0.18
	14	3.72	0.01	1.15	0.21	0.04	0.06	0.09	0.11	0.05	.00	0.02	0.28	0.33	0.04	0.17
	15	3.49	0.03	1.14	0.21	0.04	0.06	0.09	0.11	0.05	.00	0.02	0.28	0.33	0.04	0.20
	16	3.55	0.03	1.15	0.21	0.04	0.06	0.09	0.11	0.05	.00	0.02	0.28	0.33	0.04	0.34
	17	3.66	0.03	1.18	0.21	0.04	0.06	0.09	0.12	0.05	.00	0.02	0.29	0.34	0.04	0.35
	18	3.77	0.04	1.32	0.21	0.04	0.06	0.09	0.12	0.05	.00	0.02	0.01	0.34	0.04	0.35
	19	3.83	0.04	1.36	0.21	0.04	0.06	0.09	0.13	0.05	.00	0.03	0.01	0.35	0.04	0.36
	20	3.89	0.03	1.34	0.22	.00	0.07	0.10	0.16	0.05		0.03	0.21	0.36	0.04	0.37
	21	3.55	0.03	1.27	0.21	.00	0.06	0.08	0.10	0.05	.00	0.02	0.19	0.23	0.04	0.35
	22	4.19	0.03	1.28	0.20	.00	0.06	0.09	0.10	0.04		0.02	0.19	0.23	0.04	0.35
	23	2.51	0.02	1.08	0.17	0.03	0.05	0.08	0.13	0.03	.00	0.02	0.17	0.20	0.04	0.29
	24	2.29	0.02	1.07	0.17	0.03	0.05	0.07	0.12	0.03		0.02	0.16	0.19	0.03	0.27
	25	2.55	0.03	1.08	0.17	0.02	0.05	0.07	0.12	0.03	0.01	0.02	0.16	0.19	0.03	0.26
	26	3.21	0.03	1.19	0.19	0.02	0.06	0.08	0.17	0.04		0.02	0.17	0.38	0.03	0.11
	27	3.60	0.03	1.26	0.21	0.02	0.06	0.08	0.10	0.05	.00	0.02	0.19	0.44	0.04	0.12
	28	3.77	0.03	1.32	0.22	0.02	0.06	0.09	0.12	0.05	.00	0.02	0.20	0.45	0.04	0.12
	29	3.66	0.03	1.28	0.21	0.02	0.06	0.09	0.20	0.04	.00	0.02	0.31	0.46	0.04	0.36
	30	3.66	0.03	1.27	0.21	0.02	0.06	0.09	0.19	0.04	.00	0.02	0.31	0.45	0.04	0.36
	31	3.43			0.22		0.07		0.11	0.04				.00	0.04	0.41
JUNE	1	3.21			0.22		0.07		0.13	0.05				.00	0.04	0.45
	2	3.72					0.07					0.02		0.57		0.45
	3	4.13	0.02	1.31	0.32	0.05	0.01	0.07	0.19		0.01	0.02	0.32	0.56	0.05	0.45
	4	1.64		0.82	0.19		.00	0.05	0.10	0.03	0.01	0.01	0.24	0.42	0.03	0.34
	5	2.90	0.05	0.94	0.26	0.04	.00	0.07	0.12	0.04	0.01		0.25	0.45	0.03	0.33
	6	4.13	0.05	1.31	0.27	0.04	.00	0.08	0.17	0.04	0.01	0.02	0.29	0.47	0.03	0.23
	7	3.95	0.04	1.28	0.26	0.04	.00	0.08	0.16	0.04	0.01	0.02	0.29	0.43	0.03	0.22
	8	4.19	0.05	1.34	0.28	0.04	.00	0.09	0.18		0.01	0.02			0.04	
	9	4.44	0.05	1.37	0.29	0.04	.00	0.09		0.05					0.04	
	10	4.51	0.00	1.41	.00	0.01	0.01			0.04				0.57	0.04	0.20
	11	4.13	0.00	1.36	0.28	0.04	0.01	0.09	0.11	0.04		0.02		0.46	0.04	0.19
	12	4.19	0.05	1.35	0.28	0.04	0.01	0.09	0.19	0.03	0.03	0.02	0.30	0.43	0.03	0.01
	13	4.13	0.05	1.34	0.28	0.04	.00	0.08	0.17		0.03	0.02	0.30		0.03	0.26
	14	3.92		.00	.00	0.04	0.00	0.09					0.35		0.04	0.34
	15	3.66		.00	.00								0.37	0.65	0.04	0.34
	16	3.55		.00	.00					0.03			0.37	0.64	0.05	0.35
	17	3.66	.00	1.26	0.27	0.03	0.01	0.09	0.11	0.03	0.02	0.02	0.34	0.56	0.04	0.31
	18	4.37	0.04	1.34	0.28	0.03	0.01	0.08	0.19	0.03	0.01	0.02	0.30	0.48	0.03	0.27
	19	4.05	0.03	1.32	0.28	0.03	0.01	0.08	0.18	0.02	0.01	0.02	0.30	0.00	0.03	0.26
	20	3.98	0.03	1.30	0.27	0.03	0.01	0.08	0.16		.00	0.02	0.29	0.00	0.03	0.27

Table 12. (........continued)

	MAIN	FC-1	D-1	D-2	D-3	FC-2	D-4	D-5	FC-3	D-6	D-7	D-8	D-9	FC-4	D-10
21	2.95		1.22		.00	0.01	0.08						0.00	0.04	0.31
22	2.98		1.20									0.26	0.00	0.04	0.42
23	3.06		1.22									0.26	0.00	0.04	0.12
24	3.11	0.04	1.25	0.25	0.02	.00	0.07	0.10	0.02	0.01	0.01	0.27	0.49	0.03	0.26
25	3.83	0.05	1.29	0.20	0.03	0.04	0.09	0.18	0.04	0.02	0.02	0.33	0.55	0.03	0.29
26	3.46	0.05	1.29	0.20	0.03	0.04	0.08	0.17	0.04	0.02	0.02	0.33	0.53	0.03	0.28
27	3.11	0.05	1.29	0.21	0.03	0.04	0.07	0.21	0.04	0.02	0.02	0.32	0.52	0.03	0.26
28	3.16		1.18												0.35
29	3.49	0.04	1.28										0.64		0.31
30	4.25		1.40									0.35	0.65	0.04	0.15
JULY 1	4.22		1.37						0.04	0.04	0.02	0.35	0.64	0.03	0.44
2	4.19	0.05	1.34	0.29	0.03	0.03	0.09	0.10	0.03	0.03	0.02	0.31	0.32	0.04	0.39
3	3.32	0.04	1.21	0.26	0.03	0.02	0.08	0.16	0.03	0.03	0.02	0.29	0.27	0.04	0.37
4	3.38	0.04	1.20	0.29	0.03	0.02	0.07	0.14	0.02	0.03	0.02	0.27	0.24	0.03	0.32
5	3.38	0.04	1.25		.00		0.01		0.01	0.02		0.29	0.33	0.03	0.32
6	3.77		1.33				0.03				0.02		0.01	0.04	0.42
7	3.95		1.37				0.03				0.02		0.01	0.04	0.44
8	4.07	0.02	1.38	0.32	0.04	0.02	0.10	0.16	0.05	0.04	0.01		0.01	0.04	0.45
9	3.00	0.02	1.27	0.30	0.04	0.03	0.10	0.20	0.05	0.04	0.01	0.36	0.01		0.45
10															
11															
12															
13															
14															
15															
16															
17	4.25	0.02	1.42	0.32	0.04	0.02	0.09	0.11	0.02	0.02	0.01	0.32	0.62	0.04	0.39
18	4.13	0.02	1.40	0.32	0.04	0.02	0.09	0.11	0.02	0.03	0.01	0.31	0.61	0.03	0.37
19	4.19	0.02	1.42	0.33	0.04	0.02	0.09	0.14	0.03	0.03	0.01	0.33	0.62	0.04	0.42
20	4.51	0.06	1.45									0.34	0.61	0.04	0.40
21															
22															
23															
24	2.90	0.04	1.20	0.26	0.03	.00	0.07	0.07	0.04	0.02	0.01	0.24	0.36	0.02	0.13
25	4.01	0.05	1.38	0.30	0.04	.00	0.09	0.18	0.04	0.03	0.02	0.30	0.53	0.03	0.24
26	3.43	0.05	1.31									0.33	0.58	0.04	0.26
27	3.52	0.05	0.80									0.34	0.62	0.04	0.28
28	3.60	0.05	0.80				0.10	0.17					0.03		0.32
29	3.98	0.06	0.83	0.32	0.04	0.02	0.10	0.18	0.05	0.04	0.01	0.36	0.03	0.04	0.33
30	3.94	0.06	0.76	0.32	0.04	0.02	0.10	0.19	0.05	0.04	0.01	0.36	0.03	0.04	0.32
31	3.38	0.05	0.75	0.29	0.03	0.02	0.08	0.05	0.03	0.03	0.02	0.29	0.46	0.03	0.22
AUGUST 1	3.16	0.04	0.93	0.28	0.03	0.02	0.08	0.16	0.02	0.02	0.02	0.29	0.46	0.03	0.21
2	2.82	0.04	0.78									0.28	0.45	0.03	0.22
3	2.73	0.04	0.78										.00	0.04	0.31
4	3.35	0.04	0.86									0.31	0.34	0.04	0.25
5	3.11	0.05	0.84	0.26	0.01	0.02	0.07	0.13	0.03	0.02	0.02	0.28	0.31	0.03	0.23
6	3.66	0.05	0.87	0.31	0.02	0.02	0.08	0.08		0.03	0.02	0.29	0.33	0.03	0.22
7															
8															
9	3.52	0.05	1.26	0.31	0.02	0.06	0.09	0.09		0.03		0.30	0.34		0.25
10	3.98	0.05	1.32	0.31	0.02	0.06	0.09					0.30	0.34		0.25
11	4.47	0.06		0.32			0.00								
12	5.00	0.06	1.44	0.33	0.02	0.00	0.10	0.30							
13	4.01		1.47	0.01	0.02		0.10	0.20				0.36	0.65		
14	4.83	0.06	1.49		0.02	.00	0.09	0.14	0.01			0.37	0.67	0.04	0.48
15	3.72	0.05	1.31			.00	0.09		0.01	0.01		0.34	0.59	0.04	0.45
16	4.19	0.05	1.43			.00	0.08		.00	0.01		0.35	0.61	0.04	0.46
17	4.77	0.07		0.04		.00	0.09			.00		0.38			0.54
18	3.06	0.05		0.04	0.01	.00	0.06	0.05				0.28			0.38
19	3.46	0.05	1.25	0.26		.00	0.07	0.06			0.02	0.29		0.03	0.39
20	3.63	0.05	1.21	0.28		.00	0.08				0.02	0.29	0.51	0.04	0.41
21	3.80	0.03	1.36	0.28		.00	0.08				0.02	0.33	0.63	0.04	0.42
22	3.63	0.03	1.30	0.27	0.02	.00	0.08				0.02	0.31	0.61	0.04	0.41
23	3.83	0.03	0.75			.00	0.09	0.10					0.66	0.04	0.40

Table 13. Variation of Relative Weighting factors depending on the stage of growth selected as the base value in expressing relative importance of water.

WEEK												REQ. IN MM
1	1.000	0.282	0.264	0.264	0.264	0.829	0.250	0.234	0.234	0.221	0.239	33.50
2	3.550	1.000	0.937	0.936	0.938	0.841	0.887	0.831	0.832	0.786	0.848	118.93
3	3.787	1.067	1.000	0.998	1.000	0.897	0.946	0.886	0.887	0.838	0.904	126.88
4	3.795	1.069	1.002	1.000	1.002	0.899	0.948	0.888	0.889	0.840	0.906	127.12
5	3.786	1.066	1.000	0.998	1.000	0.897	0.946	0.886	0.887	0.838	0.904	126.82
6	4.220	1.189	1.114	1.112	1.115	1.000	1.054	0.988	0.989	0.934	1.008	141.38
7	4.003	1.128	1.057	1.055	1.058	0.949	1.000	0.937	0.938	0.886	0.956	134.11
8	4.273	1.204	1.128	1.126	1.129	1.013	1.067	1.000	1.001	0.946	1.020	143.15
9	4.269	1.202	1.127	1.125	1.128	1.012	1.066	0.999	1.000	0.945	1.019	143.01
10	4.518	1.273	1.193	1.191	1.193	1.071	1.129	1.057	1.058	1.000	1.079	151.35
11	4.189	1.180	1.106	1.104	1.106	0.993	1.046	0.980	0.981	0.927	1.000	140.32
12	3.715	1.046	0.981	0.979	0.981	0.880	0.928	0.869	0.870	0.822	0.887	124.45
13	3.490	0.983	0.921	0.920	0.922	0.827	0.872	0.817	0.817	0.772	0.833	116.90
14	3.933	1.108	1.038	1.036	1.039	0.932	0.982	0.920	0.921	0.870	0.939	131.75
15	3.980	1.121	1.051	1.049	1.051	0.943	0.994	0.931	0.932	0.881	0.950	133.34
16	3.829	1.078	1.011	1.009	1.011	0.907	0.956	0.896	0.897	0.847	0.914	128.26
17	3.947	1.112	1.042	1.040	1.043	0.935	0.986	0.924	0.925	0.874	0.942	132.23
							TOTAL WATER REQUIREMENT IN ACRE FEET					7.07

Table 14. Design Delivery Performance (DDP) values during the 1983 Yala season at the distributory offtakes along the main channel, Stage I, Kaudulla.

WEEK	MC	FC-1	D-1	D-2	D-3	FC-2	D-4	D-5	FC-3	D-6	D-7	D-8	D-9	FC-4	D-10	T7&8
1	0.85	1.95	0.97	2.00	1.47	2.24	1.69	1.25	2.81	4.48	2.35	1.57	1.03	1.52	1.08	0.82
2	0.82	1.84	0.73	1.96	1.53	2.28	1.72	1.30	2.66	4.57	2.53	1.74	1.18	1.53	1.08	0.88
3	0.69	1.72	0.84	1.72	1.29	2.10	1.62	1.11	2.29	4.04	1.96	1.68	1.35	1.53	1.05	0.90
4	0.63	1.67	0.77	1.20	1.17	2.08	1.61	1.13	2.64	4.39	2.09	1.71	1.50	1.59	1.23	1.00
5	0.71		0.60	1.59	0.96	1.68	1.37	0.54	1.58	3.65	1.25	1.36	1.17	1.44	1.03	0.92
6	0.63	1.48	0.78	1.34	1.13	1.58	1.41	0.71	1.96	3.96	1.98	1.58	1.37	1.38	0.95	0.69
7	0.86	1.74	0.88	2.03	1.28	1.77	1.22	0.79	2.52	4.11	1.87	1.46	1.49	1.46	1.05	0.86
8	0.68	1.63	0.90	1.72	1.14	1.91	1.53	0.71	2.62	4.36	2.24	1.60	1.62	1.38	0.92	0.83
9	0.93	1.71	0.93	2.00	1.39	1.97	1.58	1.09	2.65	4.53	2.23	1.70	2.19	1.60	1.06	1.06
10	0.73	1.37	0.72	1.96	1.34	1.91	1.54	0.87	2.50	4.45	2.15	1.70	2.19	1.33	0.89	0.83
11	0.64	1.54	0.75	2.00	1.20	1.69	1.42	0.96	2.22	4.21	2.11	1.66	2.28	1.30	0.91	0.59
12	0.74	1.76	0.61	1.95	1.29	1.90	1.53	0.93	2.47	4.41	1.81	1.65	2.33	1.45	1.02	0.85
13	0.71	1.55	0.90	1.92	1.20	1.72	1.39	0.89	2.09	4.08	0.82	1.61	2.20	1.34	0.85	0.61
14	0.46	1.25	0.69	1.98	1.01	1.38	1.26	0.61	1.33	2.23	1.50	1.50	1.99	1.18	0.56	0.52
15																
16	0.40	1.72	0.50	1.75	0.84	1.27	1.21	0.55		3.81		1.49		1.36	1.32	0.61
17	0.34	1.26	0.42	1.31			1.17					1.41	1.23	1.24	1.00	0.25
	0.68	1.61	0.75	1.78	1.22	1.83	1.45	0.90	2.31	4.08	1.92	1.59	1.68	1.41	1.00	0.76

Table 15. Design Delivery Performance (DDP) values during the 1984 Yala season at the distributory offtakes along the main channel, Stage I, Kaudulla.

WEEK	MC	FC-1	D-1	D-2	D-3	FC-2	D-4	D-5	FC-3	D-6	D-7	D-8	D-9	FC-4	D-10	T7&8
1	0.54	0.99	0.72	1.27	1.09	1.96	1.08	0.36	1.56	2.58	1.57	1.09	1.49	1.16	1.19	0.57
2	0.81	1.41	0.85	1.56	1.37	2.10	1.31	0.51	1.79	1.38	1.85	1.25	1.22	1.22	1.38	0.59
3	0.98	1.16	0.88	1.61	1.58	2.50	1.53	0.72	2.48	0.53	2.18	0.96	1.04	1.42	0.97	1.04
4	0.91	0.82	0.85	1.37	1.53	2.47	1.52	0.69	2.42	0.31	2.15	0.77	1.10	1.44	1.09	0.92
5	0.78	0.87	0.83	1.24	0.93	2.21	1.37	0.76	1.94	0.53	1.91	0.83	0.82	1.35	1.11	0.73
6	1.21	1.01	0.89	1.39	0.80	2.50	1.47	0.85	2.32		2.07	1.17	1.11	1.44	1.26	1.02
7	0.98	1.44	0.83	1.75	1.38	0.18	1.26	0.89	2.02	1.11	1.56	1.29	1.52	1.38	1.23	0.92
8	1.35	0.84	0.95	0.79	1.15	0.16	1.15	0.92	1.74	3.09	1.86	1.56	1.80	1.50	0.94	1.07
9	0.93	0.82	0.88	1.78	0.88	0.39	1.39	0.94	1.24	1.35	1.78	1.36	0.49	1.37	1.10	0.79
10	0.94	1.44	0.89	1.41	0.88	1.17	1.31	0.97	1.74	1.91	1.51	1.48	1.84	1.26	1.05	0.65
11	1.00	1.39	0.90	1.82	1.04	0.94	0.86	0.79	1.30	3.36	1.77	1.40	0.85	1.39	1.51	0.80
12	0.90	0.66	0.93	2.03	1.38	0.99	1.67	1.06	2.48	4.36	0.63	1.66	0.02	1.62	1.77	1.05
13	1.09	0.97	0.99	2.13	1.27	0.93	1.51	0.71	1.23	3.00	0.58	1.52	2.00	1.39	1.55	0.84
14	0.93	1.54	0.77	1.85	1.18	0.03	1.40	0.82	2.11	2.94	1.53	1.40	1.39	1.22	0.96	0.63
15	0.87	1.51	0.57	1.98	1.23	0.77	1.48	0.84	1.82	3.59	1.01	1.45	0.83	1.36	1.03	0.93
16	1.14	1.58	0.75	1.96	0.57	1.54	1.09	0.61	1.55	2.91	1.71	1.36	1.08	1.18	0.92	0.61
17	1.62	1.87	0.99	0.70	0.68	0.08	1.49	1.02	0.27	0.61		1.61	2.06	1.50	1.81	0.91
18	0.97	1.15	0.68	1.42	0.30	0.09	1.10	0.46			1.90	1.42	1.98	1.39	1.58	0.86
	1.00	1.19	0.84	1.56	1.07	1.17	1.33	0.77	1.76	2.10	1.62	1.31	1.26	1.37	1.25	0.83

Table 16. Estimated water duties along main channel distributory offtakes for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

Channel Offtake	Water Duty			
	Yale 1983		Yala 1984	
	Feet	Meters	Feet	Meters
MC	3.96	1.2	5.67	1.72
FC1	7.30	2.2	6.67	2.03
D1	3.99	1.2	3.62	1.10
D2	7.70	2.3	9.04	2.75
D3	6.13	1.9	8.22	2.50
FC2	7.45	2.3	8.11	2.47
D4	6.35	1.9	8.99	2.74
D5	3.91	1.2	3.98	1.21
FC3	7.76	2.4	9.38	2.85
D6	11.2	3.4	7.71	2.35
D7	8.61	2.6	8.89	2.70
D8	7.44	2.3	7.69	2.34
D9	6.91	2.1	8.31	2.53
FC4	5.82	1.8	7.03	2.14
D10	5.9	1.8	8.51	2.59
T7&8	5.17	1.6	5.98	1.82

Table 17. Rotational Issues designe for Stage I of Kaudulla considering upper and lower bounds of flow in the main channel.

																	not adjusted	adj
	D-1	D-2										FC-4	D-10	FC-5	FC-6	T7&8	3.24	3.3
FC-1	D-1		D-3	FC-2	D-4	D-5	FC-3	D-6	D-7	D-8						T7&8	3.33	3.3
FC-1	D-1		D-3	FC-2	D-4	D-5	FC-3	D-6	D-7	D-8							2.00	2.3
FC-1	D-1		D-3	FC-2	D-4	D-5	FC-3	D-6	D-7	D-8	D-9						2.31	2.3
		D-2									D-9	FC-4	D-10	FC-5	FC-6	T7&8	2.11	2.2
		D-2									D-9	FC-4	D-10	FC-5	FC-6	T7&8	2.11	2.2
	D-1	D-2										FC-4	D-10	FC-5	FC-6	T7&8	3.24	3.3

Note: The computed water duty during a 90 day rotation issue period is 4.9 acre ft.

Table 18. Annual maintenance allocation for Kaudulla for a five year period (Source:Department of Irrigation, Kaudulla office).

Year	Category of maintenance	Allocation in Rs.
1981	Maintenance of MKYE	60,000.00
	Maintenance of EMYE	75,000.00
	Spillway maintenance Ambagaswewa	400,000.00
	Spillway maintenance of Lowlevel sluice at Kaudulla	100,000.00
	General maintenance	1,281,300.00
1982	General maintenance	1,852,094.67
1983	General maintenance	1,284,620.00
1984	General maintenance	1,099,682.00
1985	General maintenance	1,224,600.00

Table 19. Estimated costs of channel lining with reinforced concrete for the main channel and major distributory channels of Stage I. Note: Costs were calculated using trial and error solution of the cross section using design discharge rates required and an assumed depth of the channel.

Channel type	Depth ft	Bottom Width ft	Slope ft/ft	Thickness ft	Cost Rs/mile
main	4.6	15.5	0.0002	0.50	3766066.00
D-1	2.9	8.8	0.0004	0.33	1470746.00
D-2	2.3	0.4	0.0004	0.33	602468.00
D-4	1.4	0.8	0.0004	0.33	423914.00
D-5	1.7	2.0	0.0004	0.33	600172.00
D-8	2.6	1.6	0.0004	0.33	651850.00
D-9	2.6	1.6	0.0004	0.33	772628.00
D-10	2.3	1.7	0.0004	0.33	717466.00
T8-D1	2.9	2.9	0.0004	0.33	961084.00
T7-D1	2.9	4.0	0.0004	0.33	1057787.00
FC	1.2	0.8	0.0004	0.33	353070.00

Table 20. Irrigation water problems surveyed in Stage I of Kaudulla Irrigation Scheme. Yala Season 1983.

Tract	Channels Served	Irrigation Problems			Total Number	Acreage
		None %	Some %	Severe %		
1-B	D1-B	93	7	-	80	366
1	D1	55	12	33	487	1521
2	D2,D3	79	9	12	80	192
3	D4,D5,D6,D7	54	-	46	85	264
4	D8	70	5	25	75	228
5	D9	91	-	9	128	324
6	D10,FC-4,FC5	50	13	37	157	325
7	T7-D1	56	21	23	354	802
8	T8-D1	36	4	59	263	619
	Average	58	11	31	1723	4642

Table 21. Components of net production cost averaged for each tract and expressed as a fraction of the net prodction cost for the three tracts. 1984 Yala season Kaudulla, Stage 1

	Power Source		Control of			Labor		
Tract	Hired	Own	Weeds	Pest	Fertilizer	Hired	Family	Other
2	0.07	0.13	0.01	0.02	0.15	0.25	0.34	0.04
3	0.07	0.10	0.03	0.02	0.16	0.24	0.33	0.04
8	0.08	0.15	0.03	0.04	0.14	0.23	0.29	0.04
Average	0.07	0.13	0.02	0.03	0.15	0.24	0.32	0.04

6.0 CHAPTER SIX : IRRIGATION MANAGEMENT ALTERNATIVES

6.1 INTRODUCTION

To be successful, a water management strategy must effectively address two main problems that are common to many irrigation schemes in Sri Lanka. The first involves the uneven distribution of water between the head and tail reaches, which is a problem inherent in any given irrigation system. A solution to this problem will effectively guarantee the objectives of an irrigation system which more or less encompasses equity in distribution of water and the resulting income and other social benefits to its beneficiaries, the farming community as a whole. The second problem is the effective operation of the engineering system through proper maintenance and repair which is a necessary condition for the former to be effective. The above perception is based solely on technical or engineering considerations. However, other factors relating to management are essential to overcome engineering problems.

How can one ensure more water to the tail reaches of an irrigation system? A solution to this problem necessarily means reduction of water usage at the head reaches. This is essentially a management problem which involves the main water distribution system and the respective farms in the head reaches.

What are the preconditions for effective main system management? A primary requirement is to have well motivated and involved management personnel. The engineering system in turn should have features that ensure complete control over the flowing water in the canal system. This in effect will complement the efforts of the management to ensure effective distribution.

The effort of management alone is not sufficient without the cooperation of the farmers. Therefore, it is necessary to examine motivating factors for farmers located at the head reaches in order to manage available water effectively. This enables the system management to provide adequate water supplies to the tail end reaches. Lastly,the entire farming community needs to be motivated to be involved in maintenance, operation, and management so that the system can sustain its capability to function effectively over time. Accomplishment of this goal requires a transformation of presently existing parasitic relationships of the farming community on the irrigation system into a more symbiotic relationship so that the overall productivity of both the community and the technical system is improved.

6.2 MOTIVATION OF THE SYSTEM MANAGERS - A NEGLECTED ISSUE

Motivation of the system managers is an important element to the success of any attempt at effective water management. Unfortunately, this is an area often overlooked. Their lack of involvement is one of the root causes of poor water management found in many of the irrigation schemes in Sri Lanka. The factors that work as disincentives to the system management personnel have been discussed in the previous chapter. The system managers who are mostly engineers, consider their jobs thankless ones. They are pressured by irate farmers and politicians. They have to lead a socially isolated life in comparison to urban counterparts by having to serve in remote areas where most irrigation schemes are located. Their promotions to higher managerial rungs in the Department of Irrigation often leads to transfers to urban areas from these remote locations. Thus, without incentives or appreciation of their services, it has come to a point where most managers bide their time in their posting until a promotion provides a more desirable location.

Moore (1983) suggested an incentive scheme should be linked to their productivity. Sufficient financial incentives no doubt will be motivational. This is one form of solution but not a necessary condition. One could link a substantial incentive scheme to the productivity of these individuals, to promote their active involvement in management. What appears necessary is a substantial earning potential which would be dependent on the active performance of these irrigation system managers. In the case of irrigation, the objective is to adequately irrigate all possible land within the scheme.

A criterion can be defined where management personnel receive a financial incentive for every unit of land that is provided with adequate water. Such a criterion does not overcome the problem of managers without initiative, simply because a major portion of an irrigation system receives adequate irrigation supplies anyway. Thus, these incentives will have to be structured so that they receive more incentives for the provision of irrigation water to the tail end reaches of an irrigation system.

For the sake of argument, a hypothetical case is presented with several assumptions. We will consider Kaudulla as the model, where the system irrigates approximately 4,800 ha including encroachments. Also, this consideration involves the assumption that there is only one manager to a system. Assuming 20 percent of the land belongs to the tail end reaches of a system, it is possible to determine these incentives. If it is assumed that each ha from the tail end reaches and each ha from the head end reaches provides a manger with Rs.15 and Rs.10 respectively, as remunerations for their services for each season, best management efforts could produce a total financial remuneration of Rs.105,600 annually. This remuneration in combination with annual wages (amounts to about Rs.36,000) brings a manager's total earning potential to Rs.141,600 or an increase exceeding 300%. Implementation of such an incentive scheme must consider all management personnel in a given irrigation scheme and more realistic combinations of incentives to be practical.

It is possible that one might propound the argument that higher incentives to the management for irrigating the tail end reaches, may lead to the neglect of providing water to the head reaches. Examining the hydraulics of a gravity flow irrigation system shows that this is not possible. A sufficient hydraulic head has to be maintained throughout the channel system to adequately supply the tail end reaches. This essentially guarantees a sufficient water supply to the head reaches.

6.3 MOTIVATION OF THE FARMING COMMUNITY

Considering the motivational aspect of the farmers, it is a reasonable assumption that the farmers located in tail end reaches will be more motivated to manage their water supply than farmers located at the head end reaches of the system. What will motivate these farmers to manage the available water more efficiently? Logically, their gains will have to be more than their efforts for them to take an active part. At the head reaches it is possible to separate farmers into two categories. The farmers obtaining yields below the potential of a given variety and those farmers obtaining close to optimum yield potential. In the former case, a substantial yield increase through better management, would induce these farmers to participate actively in effective water management.

Studies have shown (Wickham and Valera, 1978) that water supplies closely tailored to soil and crop needs along with other input management can bring about substantial yield increases. This fact needs to be demonstrated to the farmers if they are to invest extra time and energy to effectively manage their irrigation supply. Therefore, there is a great need to provide an irrigation extension service at the farm level in the line of agricultural extension services. It is apparent that engineering alone cannot achieve effective irrigation water management. This aspect of irrigation extension will be further discussed in a succeeding section.

This still leaves the question of motivating the farmers who obtain optimum yield potential. Their ability to achieve optimum yield levels indicate that these farmers indeed are better managers. Nevertheless, their cooperation is very essential to any overall strategy being effective. Several alternatives are possible in this regard. A higher level technology will further increase the yield levels, and which again involves better extension services is such an alternative. Production of quality rice or seed paddy that has a higher market potential is another. This, especially, will be true if the country achieves self-sufficiency in rice production, which is a likely possibility in the near future due to expansion of the area cultivated.

6.4 IRRIGATION EXTENSION SERVICE - A CRITICALLY NEEDED ELEMENT

Undoubtedly, better management of water leads to increases in yield levels. However, unlike agricultural extension, which has effectively reached the farmers and developed their awareness about improved varieties, use of fertilizers, and agrochemicals, there has never been any attempt at demonstrating the effects of better control of water at the farm level that could improve yields of individual farmers.

The primary problem is that, unlike other agricultural production inputs, such as fertilizer and agrochemicals, the effect of controlled water is only complementary. If only water is controlled, without other input management factors, the effects will only be marginal and unlikely to produce results that would lead the farmers to adopt better water control at the farm level. This is especially true for lowland rice, which can tolerate greater soil saturation (see Musick et al., 1984 for a detailed discussion of effects of water on yield of crops). This tolerance level seems to remain a major stumbling block in promoting less water use at farm level.

Thus, providing an irrigation extension service is of primary importance if significant reduction of water use at farm level is the objective. The Department of Irrigation is capable and could effectively provide these service being the agency managing the entire irrigation system network in the country. The role of the Department of Irrigation will be further discussed in a subsequent section.

6.5 SYSTEM MAINTENANCE - A FINANCIAL CONSIDERATION

It is not necessary to emphasize the need for an effectively functional technical system. However motivated, a manager cannot achieve effective management of water in a poorly maintained system, which is the primary cause of poor water management in most Sri Lankan irrigation systems. The chief causative factor is the inability of the State to continue a sufficient financial commitment for the required maintenance of public irrigation schemes. A solution is bound by many constraints. As noted above, it is not possible to look towards the state to provide these finances and the need to work within the existing policies, institutional, and infrastructural frame work provide still another constraint.

The recent government policy of levying an irrigation tax, Rs.247 ha per season, is intended for continued technical maintenance of the system to relieve the financial burden. The idea behind this policy is that every irrigation system should generate finances for its maintenance. For this purpose, a project manager has been appointed to collect these taxes and identify important maintenance projects in consultation with farmer organizations. Subsequently, the priority projects identified will be implemented in consultation with the engineer in charge of the system.

The approach was to appoint more management personnel to a fewer number of farmers so that farmer groups would get better attention (see Figure 31 on page 210). This is the policy in the new Mahaweli settlement areas into which Kaudulla will eventually fall under the system 'D' development program. This approach relieves the financial burden of the State in providing system maintenance but it has added implications in terms of effect on management.

Increasing bureaucracy does not necessarily mean effective management. The farmers will have to go through a tier of bureaucratic layers before anything effective gets done. In addition, jurisdiction of authority is likely to be a problem. Also, additional higher managerial positions tend to add rather than reduce State expenditure. They too will encounter the same motivational problems faced by the system managers. Lastly, the finances collected must go to the treasury before disbursement for the intended purpose, which is the maintenance of irrigation systems. Thus, when these finances are returned to the system, only a small amount is available for maintenance due to mismanagement. Moreover, these problems would further alienate the farmers from their responsibilities as they have already paid for their water. Thus, in their point of view, the need for careful management does not arise.

What is lacking in this strategy is that it has failed to generate a sense of belonging among the farming community for them to consider the irrigation system as their own. Instead, to them it still is a system owned and run by the state and its bureaucracy, which is there to be exploited.

How can one circumvent this kind of problem? In the ancient system we have seen the symbiotic relationship between the farming community and the technological system, which was necessary for their survival. The community cared for and managed the system and the system provided them their livelihood. This means then developing a way of ensuring a system capable of generating its own financial means for maintenance and an incentive scheme for management personnel, thereby reducing its dependence on the larger economy of the country.

The issue of water rates paid by the farmers, which is an implemented policy of the State, is important. For our purpose, Kaudulla is considered as the model. With the assumption that all farmers pay these water rates, amounting to a sum of Rs.247 per ha per season, instead of an annual rate, the total financial resources generated amounts to Rs.2,317,600 out of the total land area irrigated (4800 ha). In addition, farmers are expected to continue the payment of Vel Vidane (water tenderer) in kind for their services, which amounts to 0.5 bushels (11 kgs) of paddy per acre. When this is counted as an expenditure by farmers for irrigation, it amounts to an additional Rs.710,400. Thus, total investment on irrigation by farmers amount to a sum of Rs.3,028,000 per annum, which is a substantial financial resource. This is over three times the annual allocation made on operation and maintenance of the entire Kaudulla scheme. These financial resources appear to be more than adequate to generate a suitable incentive scheme and still leave sufficient finances for the maintenance and other requirements of the entire scheme.

It is also possible to determine the break even yield increment needed to be achieved by individual farmers for their investment on irrigation. On a per ha basis, annual investment on irrigation by a farmer amounts to Rs.642. Considering the seasonal investment at Rs.321 per ha and price of 22 kgs (1 bushel) of paddy at Rs.60 then the break even yield increment necessary over the current yield amounts to 118 kg q(5.35 bushels) per hectare. The yield increment necessary to recover the investment will then be 236 kg (11 bushels) per hectare which is an achievable yield target if water and other management inputs are improved when the current yields (198 bushels per hectare) obtained by most farmers and the potential yielding ability (296 bushels per hectare) of most new high yielding varieties are considered.

Having discussed the potential possibilities of generating sufficient financial resources of already implemented government policy with slight modification, the question arises whether farmers are capable of paying the irrigation levy. If indeed improved management could increase current average yields to at least an average yield of 5450 kilograms per hectare, then the additional income generated per hectare to individual farms will be an additional Rs.3000. Observations at Kaudulla indicate that during the Maha season 1984/85 when the irrigation levy was first implemented at Kaudulla about 80% of the farmers have paid up the levy without any enforcement. According to the Chief Irrigation Engineer the majority of the farmers who promptly paid the levy were the farmers with water problems. Given the resulting yield improvements it is reasonable to expect the majority of farmers to comply with the irrigation levy. Positively, this is where the proposed irrigation extension service could play the most important role.

6.6 COORDINATION OF MANAGEMENT

In most large irrigation projects, the attempt always has been to coordinate activities of the entire scheme. The decisions taken by the cultivation committees provide the basis for coordination. This is convenient from the point of view of the administrative bureaucracy . In actual practice, attempts at coordination of the entire scheme have failed because they have not taken into consideration the incapability of farmer groups in different tracts to meet the demands of such scheduling. Moore (1983) correctly suggests that decisions be based on the requirements of individual irrigation tracts rather than on the basis of the entire scheme. He further points out that there is no prior planning done by the administrative authorities, which is a necessary precondition for a technical system to function effectively and smoothly.

Day to day management decisions indeed are needed but these should only provide the day to day adjustments of the operating rules and regulations of the overall management plan. There are no sets of operational rules and guidelines established for different circumstances (Rust and Moore, 1983) so that effective measures can be adopted and farmers made aware of management alternatives All decisions are made on the spur of the moment rather than based on prior planning.

These are the weaknesses of of the current practices that can be improved if decisions are based on the requirements of the individual irrigation tracts and capabilities and requirements of the respective farmers groups. Then the overall coordination of management can be achieved with minimum conflict of interests of the different farm groups. This will provide more opportunity for a larger group of farmers to voice their opinions as opposed to the present system so that majority consensus can be achieved for an overall plan of coordination. Secondly, it is far easier to coordinate agricultural credit, seed, fertilizer, and power requirements of individual tracts than attempting to coordinate the entire scheme at once. This necessarily means prior planning effort of the system managers in consultation with groups of farmers on a tractwise basis.

6.7 FARMER ORGANIZATION - A BASIS FOR ELIMINATING EXISTING CONSTRAINTS

Cooperation of farmer organizations is a subject that has been researched and debated in irrigation management for many years. The participatory approach to farmer organization has been under investigation at Gal Oya irrigation scheme by the Agrarian Research and Training Institute for several years. They reported a degree of success achieved in obtaining farmer cooperation through the participatory approach.

Considering the overall attempts at farmer organization, Rust and Moore (1983) present very good insight to the functioning of the cultivation committees and their effectiveness. He points out that active participation of the farmers has failed at Kaudulla mainly because most decision making is done by the administrative bureaucracy rather than by majority consent of the farmers. Thus, a majority of farmers feel a commitment to the decisions established by a few of their community and the administrators.

The basis of selecting farmer representatives, at least in theory, is supposed to be through a democratic voting process. Investigations of Moore (1983), Siriwardene (1981) and observations at Kaudulla show how the local power groups dominate these representations thereby disrupting the effective functioning of these organizations. Secondly, the tail enders (farmers with irrigation problems) are not adequately represented in the cultivation committee so that their problems can be effectively voiced. The result is a progressively deteriorating technical system damaged and ruined by dissatisfied farmers.

What are the alternatives available to overcome these problems? Let us consider the case of adequate representation of the tail-enders. For convenience we assume that these two groups of farmers are identified through a prior survey of a given irrigation tract. How they can be adequately represented is the question to be answered. If farmer organization is done on the tract basis, then all farmers in the tract are members of their respective farmer organization. Active committee members can be formed by representation of the two groups in equal numbers to overcome the problem of inadequate representation. For larger tracts, several such groups have to be organized to coordinate activities of the entire irrigation tract.

The next step is to examine ways of preventing formation of special interest groups in these committees and achieving active participation of all members of these organizations. What presently exists is a democratic voting process, at least in theory, but invariably and unfortunately this approach leads to disruptive factionalism and micro level politics creeping into the farmer organizations. If the procedure for selecting the committee members is done on the basis of drawing lots amongst the farmers instead of voting, this problem can be completely avoided. Also, it presents an opportunity for all members of the organization to become committee members if the term of office bearers is limited to a single cultivation season and the next set of office bearers are selected from the remaining members of the organization. The cycle then can be repeated once all farmers have served as committee members. These are alternatives which will necessitate active participation of all members of a particular farmer organization in its decision making activities at one time or another.

6.8 RESPONSIBILITIES OF FARMER ORGANIZATION

Thus far we have discussed alternative characteristics of a farmer organization. Now we turn to the responsibilities of the farmer organization for it to be effective in its functioning. Three important issues need to be addressed. First, more decision making must be done by these organization. Secondly, it is necessary to develop an awareness among the farmers that their group effort is necessary for the effective functioning of the technical system for their own benefit. Thirdly, their decisions will have to be effectively communicated to the system management for the overall coordination of the entire system management.

If the collection of irrigation rates are done by these organizations rather than a separate bureaucracy, the possibility of more farmers paying the rates may be increased. Next, if the farmer organization is allowed to make decisions on the expenditure of the funds collected, with the technical guidance of the system management on maintenance and operations, two things can be achieved. An awareness among the farmers will be developed regarding the value of paying the irrigation rates and the bureaucracy will assume the role of a guide rather than an administrator for which they are remunerated by the farmer organization. Finally, action to be taken against the offenders will have to be done by the farmers organization through majority consent so that offenders can be effectively isolated from the community for such action to be effective.

6.9 ROLE OF SYSTEM MANAGERS IN THE FARMER ORGANIZATIONS

Mere formation of farmer organizations or training the system managers to deal with farm level management problems alone is not sufficient to achieve the goal of improved irrigation management and productivity of irrigation water. Effective linkage mechanisms must be developed to facilitate coordinated action between these two different groups. This must be done within the minimal changes of the existing institutions.

We have already seen that the present system managers are burdened with more administration than real management of the system. If water management is to be effective, these managers have to be more involved with planning, control, and distribution of irrigation water than such administrative work. They need must be conversant with measurement, control, planning and distribution of irrigation water and communication with farmers. They must play a significant role in the farmer organizations for them to be effective in the management and operation of the main system. Experience at Kaudulla indicates that it is not necessary to have additional bureaucracy for the management to be effective.

What is needed is better coordination of activities and providing necessary extension demonstrations to the farmers. Again considering Kaudulla as the model, technical assistants could play a greater role by functioning as tract level managers. A single tract level manager in the case of several small tracts and more than one tract level manager in the case of larger irrigation tracts will be more appropriate. The senior engineer can then coordinate the activities of tract level managers. This is a change that can be done with minimal effect on the existing organizational structure. Further, this will avoid the conflicts in jurisdiction of authority of the presently implemented policy of appointing a separate Irrigation Manager in addition to the Irrigation Engineer and Technical Assistants who are responsible for main system management because personnel belonging to the same bureaucracy have a better chance of understanding the technicalities involved in the procedure. Also, an incentive scheme generated from irrigation levy could be effectively linked to such a scheme to motivate the management personnel involved.

A few well trained and motivated tract level managers would be more than adequate to make the day to day decisions and conduct tract level water distribution while the senior engineer coordinates the tract level activities. The tract manager's role will be to convene and chair the tract level farmer organizations and provide the necessary irrigation management extension to farmers.

There are two possible advantages. First, the tract manager would have first hand knowledge about the requirements, problems and grievances of farmers of a particular irrigation tract. Second, more effective communication could be achieved so that the understanding between management and the farmers could be developed which is paramount to the success of effective group action.

prior planning and assessment of individual tract requirements would make it easier to coordinate overall activities of the entire scheme based on different quantities and timing of water issues to these tracts.

If the possibility of staggered water issues existed, it would help to avoid overloading the main channel system during peak demand times. Catering to requirements of individual tracts results in less wastage than catering to the entire system at once. This also would mean technical improvements to the main distribution system, which in turn would necessitate the cooperation of farmer organizations of the downstream reaches because such action would only benefit them in terms of water distribution and allocation. Because irrigation management decision making responsibilities would lie with a single administrative authority (Department of Irrigation) conflicts would be minimized between farmers and authorities.

6.10 PROSPECTS OF PAY AS YOU EARN VS YOU EARN AS YOU PAY APPROACH

The current approach is that farmers have to pay an irrigation tax from the earnings from their irrigated land. This will be referred to as "Pay as You Earn" (PAYE) in the following discussion. "You Earn As You Pay" (YEAYP) refers to when farmers could earn back part of the money they pay as services rendered by them towards system maintenance. There is tremendous potential to build successful farmer organizations in the line of YEAYP rather than the current approach of PAYE. Precise details of such organizations is part of a careful planning exercise. Only a few possibilities are considered at this point. Let us consider the case of maintenance of field channels of an irrigation distribution system. So far, attempts to get farmers to do the necessary maintenance have not achieved much success. The chief problem is the non-cooperation of the farmers in the head reaches which acts as a disincentive to the others to carry out maintenance and channel cleaning work.

If the farmer organizations are allowed to collect the irrigation rates and employ farmers of the same tract to do the maintenance work by paying a remuneration from the collected funds, several advantages are present. A better quality maintenance work than at present is possible since the farmer committees will be overseeing such work. Also, there is an opportunity for the farmers to directly observe the benefits of paying the irrigation rates. The strategy provides a form of employment for those farmers who are financially needy and builds an awareness amongst the farmers that damage to the technical system costs. It also would induce the uncooperative farmers to pay the irrigation rates because at least part of the taxes are returned back to them and they could directly observe the benefits of such payments.

Next let us consider the case of maintenance of the main and distributory channel system. The work is done during the off season and if the farmers undertake the work with the guidance and supervision of the system managers then it would generate off-season employment opportunities to the farming community. These are direct benefits where impact will be felt among the farmer community by demonstrating to them that getting involved with the system maintenance is for their own benefit.

One could expand further and show other benefits of this approach with a few assumptions. In a preceding section, the amount of financial resources generated within the system were discussed. Assume that the proposed type of organization is implemented and it helped to build viable farmer organizations. As awareness of the farmers on this aspect of maintenance increases, it is reasonable to expect fewer expenses on such maintenance work. This will lead to an accumulation of capital, which can be diverted for the benefit of the community and fiscal independence of the system for most of its requirements.

Let us consider the case when the country achieves self sufficiency. To keep rice farming profitable, it is necessary to diversify cropping into other field crops requiring less water. This aspect of better water management has not achieved any significant success for two reasons. The higher capital and labor intensive nature of these other field crops in comparison to rice makes them less attractive. The lack of capital among most farmers to venture into production of these crops also has limited expansion. This problem can be solved by using the accumulated capital to provide financial assistance to the needy farmers as loans on easy terms while the farmer organization becomes the lender.

One could continue developing such feasibilities as crop insurance schemes, marketing schemes and even a scheme to pay for additional diversion water received from Mahaweli rather than getting such water free. This is just to demonstrate the tremendous potential of implementing such an approach. But one has to note with caution that more careful planning and implementation is necessary for the success of such a scheme.

6.11 ROLE OF OTHER EXISTING INSTITUTIONS.

6.11.1 ROLE OF BANKING SECTOR

If farmer organizations will collect the maintenance funds, then one could immediately see the need for financial management and the role of the banking sector in this aspect. The banking sector could offer the farmer organizations a new kind of service - an investment and accounting service. The finances collected can be invested in the bank while the banks provide the accounting services. This arrangement will be mutually beneficial to both the farmer organizations and the banks. In addition, more and more farmers will become aware of the services offered by the banking sector, which may help induce farmers to savings.

6.11.2 ROLE OF THE DEPARTMENT OF IRRIGATION

We have already seen the present role of the Department of Irrigation in management of irrigation schemes. This management more specifically had been at the reservoir level, and in the design and construction of irrigation systems. The capabilities of this department can be incorporated into the frame work of the management strategy if the

Department provides two kinds of services to an irrigation system. First, it should provide management personnel specifically trained for irrigation management. Second, it could provide major maintenance of the main channel system and designs appropriate for a particular field situation for water control and distribution. This way it could operate effectively and efficiently as the major administrative apparatus responsible for all irrigation works of the country. Ideally, it should be equipped with two separate divisions. An irrigation management unit to provide irrigation management personnel and a field engineering unit to provide design, construction and maintenance services. Considering the capabilities of the Department of Irrigation the required readjustment are minimal to incorporate these aspects to the existing institutions.

6.11.3 ROLE OF THE STATE - A BEHIND-THE-SCENE BENEFACTOR AND BENEFICIARY

The role of the state in the strategy framework is greater in organizational sense rather than financial sense. In the first place, the state must provide the basic salaries of the management personnel involved in system management. This is mainly to overcome the uncertainties in agriculture production. But this is not an added financial commitment since these employees are already being payrolled by the state. In the overall maintenance of the system and subsidies to the farming community, the state should down play its role in order to allow the farmer organizations and the system as a whole to self generate its maintenance requirements and economic incentives to the management. If the system becomes economically self sufficient in its maintenance requirements then only in the case of natural calamities such as floods or droughts will the state have to provide relief measures.

In the proposed process the state is both a behind-the-scene benefactor, and a beneficiary because of the resultant decrease in public spending on irrigation. This necessitates a strong commitment by the state to allow the administrative aspects to be independent of the political process. This is of paramount importance because the root causes the currently operating vicious cycles which promote malpractices, corruption and disincentives can be broken only at economic and political levels. Thus if the goal is to have internally self-sufficient irrigation communities the state has a greater positive role to play by eliminating grassroot level political interference to provide an environment conducive to effective management and development of viable farmers organization to realize full benefits of irrigation development in the country.

6.12 THE LONG-RANGE BENEFITS

One cannot visualize short range benefits of adopting any water management strategy that will have significant short term impact. This can be seen by the effects of many strategies adopted over the past. The best example one could quote is reported by Levine et al. (1976) in the case of rotational irrigation management in Taiwan. They have reported that the firm commitment of the government aspect has significantly improved the performance of irrigated agriculture over a period of 10 years through solid implementation and enforcement. However, one can foresee the long-range benefits of the strategy. First, it is possible to motivate the system management to play an active role. Second, it is possible for more farmers to participate in the management process thereby providing them a better environment to achieve economic independence. Thirdly, it is possible to improve the productivity of water and obtain returns to investment indirectly through reduced public expenditure on irrigation system maintenance.

6.13 ALTERNATIVES IN THE LIGHT OF SOCIO-ECONOMIC REALITIES

Thus far we have discussed a frame work of ways and means to eliminate or overcome some of the major constraints. Some of the alternatives such as motivation of engineers require drastic alterations in the functions of the existing institutions. In reality, it is difficult to achieve such changes in a bureaucratically well-entrenched institution unless there is a firm commitment on the part of the government. Also, there are conflicts within various public institutions over jurisdiction of authority, which are difficult to resolve as the functions of these institutions get overlapped due to changes in government policies.

There are other economic vicious cycles operating within a system for which alternatives are difficult to find. The best case in point is the hidden tenancies in most of the irrigation schemes. There is no practical way to represent these hidden tenants in farmer organizations even though their actions are equally important in an irrigation management plan. The only way available is to have stronger farmer organizations. Many well intended strategies have fallen through and have become disasters at the implementation stages because of these limitations. However, the existence of the technical system and the need to have irrigation management technology for better productivity too are realities. But irrigation management technology can be evolved with success through community organization only when such need is felt by a community.

In any given irrigation system it is necessary to examine where such need is felt by the farming community. Logically the possibilities of successful organization of community exists only at the tail end reaches of a system where irrigation difficulties are present. Here again another reality has to be kept in mind. Improved irrigation management does not necessarily mean increased supplies of water. Instead, it should be the reliability of supply rather than the quantity as is shown by the case of Kaudulla. Mere increase in water supply only leads farmers at the tail reaches also into overuse and wastage similar to that of farmers at the head reaches. Thus, tail ends of an irrigation system provide the best opportunity to evolve the needed irrigation management technology while improvements in the main system management could complement this effort. The proposed type of farmer organizations would be most viable in these areas of an irrigation scheme. This does not mean that farmer organization at head end reaches are infeasible. It only means that they will be slower to evolve into viable organizations.

The most important of the practical realities is the political element. The major stumbling block for any plan is the disruptive grassroot level politics in the country. The democratic political process of the country has caused the political pendulum to swing too rapidly, compelling the politicians to satisfy individual groups rather than the community as a whole. Social problems of corruption and malpractices are direct results of these practical reality. Unfortunately, this has accelerated the pendulum swing to political power thereby affecting the viability of plan implementation. If the economic development of the country as a whole is the ultimate goal, the political authorities have greater responsibility of setting the example by having well defined goals and convictions without which practical success is unlikely. The feasible alternatives for Kaudulla will be considered next in the light of these arguments.

6.14 ALTERNATIVES FOR KAUDULLA THAT COULD PROVIDE IMMEDIATE BENEFITS

The Kaudulla irrigation scheme with all of its technical defects have several advantages. The entire scheme is run by a handful of technical people, which is an advantage because a larger bureaucracy makes an incentive scheme marginal thereby reducing its success. It also has an institutionalized form of rotational irrigation issues, which can be made more effective through few technical improvements and organization. Under system 'D' development of the Mahaweli development program there is a possibility of obtaining the much needed technical improvements. We will consider the technical aspects as a priority. It can be shown that any discharge over 4 cu.m.sec discharge rate can further deteriorate the main distributory system of the Stage - I. Combining rotational issues with a few strategically placed control structures can greatly reduce the present wastage of water and unreliability of supply towards the tail end reaches.

With regard to farmer organization, initially it will be difficult to organize all the farmers in a particular tract. In the previous chapter, assessment of irrigation problems of the entire tract was presented in table form (Table 20). The problems are more serious at the tail end reaches of larger irrigation tracts. Thus, it will be more feasible and farmers will be more cooperative to form organizations. This is because there is a need among them to better manage the available irrigation water.

At Kaudulla, the tail end farmers need a reliabile water supply rather than more water. To improve the reliability of supply, the channel system and the defunct control structures must be rehabilitated. To accomplish this task, the formation of farmer organizations is needed so that farmers may plan together with the system manager on how to improve the water conveyance. Also, collection of irrigation taxes for improvements could be done through these organizations.

The most logical starting point for farmer organizations will be at this level. If these organizations are successful, it will be easier to spread the activities of improvements and better management to the upstream reaches. The perhaps the rehabilitation of the entire scheme under the system 'D'development would be possible. If physical rehabilitation comes under the purview of this program, the priority should be laid on the improvement of the existing system rather than further expansion, although the latter choice may be near the political realities. If the system is considered for expansion, long-range objectives considering the interactions of land, water and people with productivity must be developed.

With regard to future expansion, some features found in the ancient irrigation model seem worthy of consideration. The land allocation could be modified similar to ancient land tenure as described by Leach (1961). In this method, individual farmers have several plots of land distributed along an irrigation channel. This effectively guarantees participation of individual farmers in channel maintenance because poor maintenance equally affects all farmers by design. It may not be be practical if the entire scheme is considered. However, practicing such land allocation along a distributory is a possibility. This will enable practice of the "Bethma" system, which gives the least friction among farmers during water scarce seasons.

The other feature that can be incorporated to a design is extensive drainage reuse, which is the most prominent aspect of the ancient model. This can be easily incorporated into system design by running distributories down slopes and field channels along contours. Thus, field channels located at successively lower contours act as drainage interceptors from upstream reaches. Therefore, overuse in upstream reaches can be effectively reused.

Although it is difficult to generalize over the entire scheme, at least for the Stage I, irrigation management activities need to be coordinated on the basis of individual farm tracts rather than the entire scheme. For this purpose, it is necessary to organize the farmers at tract level with emphasis on the tail end reaches. The overall coordination of the water distribution then can be achieved through a rotational irrigation issue based on these tractwise requirements.

6.15 CONCLUSIONS

As the sociological investigation has shown, it is not only the farmers who need to be educated to communicate and manage their affairs effectively but a need exists for the technical, scientific community and the political administration to communicate with each other effectively, to understand the development needs of the country as a whole in relation to irrigation development, and to clarify priorities and goals to be achieved. Until this is achieved, no strategy, be it bottom up or top down in its approach, can be successfully implemented for its impact to be felt or goals to be achieved.

The strategies just presented show how a management technology can evolve through a community. If a management technology grows out of a community, the steps will be painfully slow, however, the foundation of progress will be solid because the community has been made aware of the benefits of the technology.

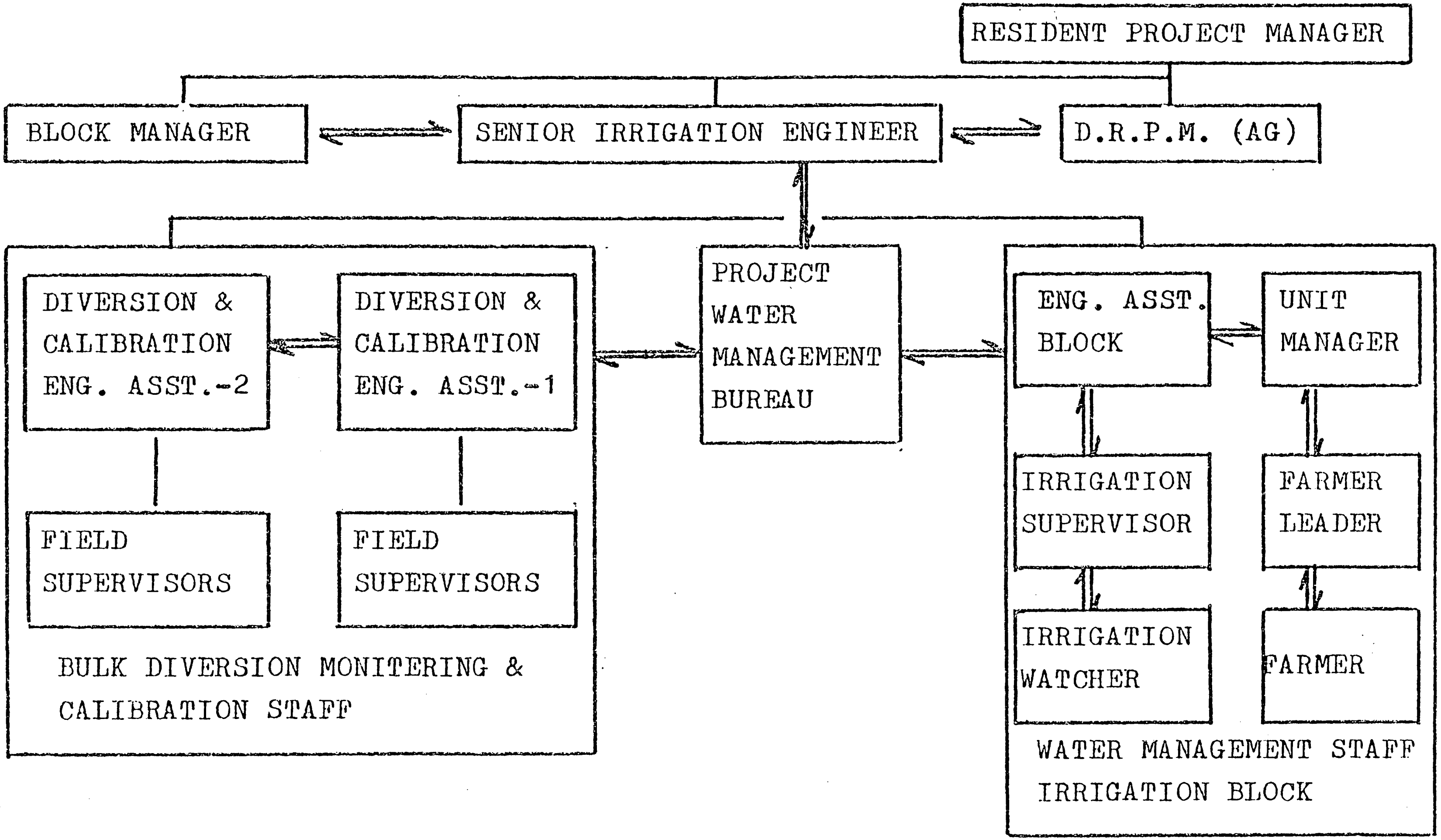

Figure 31. Water Management Organizational Chart for New Mahaweli Development Scheme. (Source: Anonymous, 1983. Mahaweli Economic Agency)

7.0 CHAPTER SEVEN : SUMMARY

The discharge rate calculated at the head of the main channel showed discharge rates below the design discharge rate for the irrigation command for both the 1983 and 1984 Yala seasons. The flow rates in the main channel, during the first 30 days of continuous issue for land preparation, met the designed values on 10% and 13% of the time for the 1983 and the 1984 Yala seasons, respectively. The discharge rates calculated for the tail end of the main channel at tracts 7 and 8 also were below the design values for the two seasons monitored. There was a greater day to day fluctuation of discharge rates at this location of the main channel. This indicate unreliability of the irrigation supplies towards the tail ends of the main channel.

The mass flow balance calculated along the main channel of Stage I showed insufficient irrigation water supply to the tail end of the system. For the 1983 Yala season, mass flow balance showed insufficient water throughout the season, although measured water depths showed positive flow rates and wide daily fluctuations. Field observations confirmed that much of the short supply as shown by mass flow balance was replenished by significant drainage inflows into the main channel. Large drainage inflows into the main channel were observed at a drainage crossing between D-6 and D-8 channels.

Evaluating delivery performance of the channel system was difficult because the weighting factor will change depending on the stage of growth selected as the base value to express the relative importance of water. This was overcome by defining a criterion to evaluate the delivery performance with a base value unaffected by the stage of growth selected. This criterion was termed Design Delivery Performance (DDP), which indicates the ability of the channel system to deliver the designed discharge rates to a given location within the system.

The weekly DDP values calculated from daily discharge rates at the head and along 15 distributory offtakes of the main channel showed a large variation in DDP values. For all larger irrigation tracts the DDP values ranged from 75% to 83% of the designed values. However, for the smaller tracts the DDP values ranged from 107% to 210% of the designed values with the exception of D-5 channel during both observation periods. The greater width of the main channel at the D-5 distributory offtakes due to erosion has lowered the water depth in the main channel resulting in lower DDP values for both seasons of observation.

The Water Duties (WDs) estimated for the main channel were 3.96 and 5.67 during 1983 and 1984 respectively. Estimated values for the distributory offtakes had a greater variation. For the smaller tracts, WD values were larger than required for the Yala season. WD values for the 1983 Yala season were significantly lower in comparison to the 1984

Yala. The high WD values observed during the 1984 Yala were primarily due to flood damage during the 1983/84 Maha season, which required higher flow rates to force water into distributories. Variation in WD values indicate that the WD evaluated for large subsections of a system are of limited value for evaluating the irrigation system performance.

Comparison of design sections of the main channel with measured sections showed enlarged channel sections and reduced depth due to both erosion and silting. These results indicate reduced carrying capacity of the main channel due to silting. Insufficient protection of the channel banks at channel transitions was a probable cause for erosion of the banks in addition to damages by animal and human traffic. Lowered water depths at distributory offtakes due to excessive widening has affected flow rates into the distributory channels.

The rotational schedule practiced at Stage I did not conform to a pattern. Estimated flow rates indicated that the rotational schedule was an ineffective measure in saving water. The effectiveness of the rotational schedule at the distributory level was reduced mainly due to lack of control at the field channel offtakes and poorly maintained distributory and field channels, which caused greater losses at head end reaches.

A rotational schedule was designed, which took into consideration a minimum flow rate in the main channel to fit a six day period. Also, the flow rate was designed to retain an approximately constant rate of flow in the main channel. If the rotation is practiced throughout the season, water duty over the Stage I area commanded by the main channel can be reduced to approximately 5 feet of water and still provide adequate water supplies. However, the effectiveness of any rotation will be reduced by inadequate control exercised at distributory and field channel levels.

Monitoring results and observations showed inadequate control facilities and poor maintenance has physically constrained the system to function effectively. Insufficient funds for providing the required maintenance was a major impediment to overcome water distribution problems at Kaudulla.

Lining as an alternative to improve the distribution system was economically not feasible due to the high investment required. However, lining only the channel transitions and control points may be a practical solution.

A survey of stage I showed that during a typical dry season about 31% of the farmers experience irrigation problems. The primary reason for these difficulties was the poorly maintained distributory and field channel system. The survey also revealed that tail end farmers experience problems during both the Yala (dry) and Maha (wet) seasons. The problems were shortages of water and excess of water during the Yala and Maha, respectively. Projecting a more conservative figure of 20% of the farms experiencing irrigation problems over the entire scheme area, approximately 865 hectares (2137 acres) in the scheme seem to suffer from irrigation problems. Thus, there is considerable potential at Kaudulla to improve the productivity of water by effective irrigation management.

Farm level monitoring proved to be a difficult task. Fragmentation of farm plots complicated the monitoring procedure. The fluctuations in inflow and outflow into farms made farm level monitoring based on a single monitoring observation unreliable. However, the results indicate more favorable inflow rates to the farms at the head reaches and greater surface drainage wastage from the farms at the periphery of the head reaches. Continuous monitoring would provide better estimates of farm level water use, however, this was not feasible.

Application of Stress Day or Water Availability Indices to evaluate farm level water problems was not possible due to night irrigation practices of farmers with irrigation problems, which complicated assessment of water shortages. Poor quality of land preparation and consequent ineffective weed control, greater pest damage due to staggering, and lower input applications due to uncertainty of water supply are pobable causes of poor productivity on these farms.

Observations on progress of land preparation showed timely land preparation by all farmers during a typical dry season (1983 Yala). However, tail end farmers completed operations from first plowing to sowing within a week indicating poor quality land preparation. However, during the 1984 Yala season there was considerable staggering as a result of economic problems faced by most farmers due to flood damages that occured during the previous Maha season.

During land preparation, farmers diverted the entire stream to a single plot at a time and carried out plowing systematically. There was no evidence of wastage during actual land preparation in most farms observed. Also they adopted transplanting along with broadcast sowing to overcome drainage problems. These practices show their own adaptation to a given situation.

Most tail end farmers kept night watch in small huts constructed in their farm plots to obtain irrigation water during nights by closing upstream farm inlets. Majority of tail end farmers agreed that sufficient water was carried by the channel, but, unregulated wastage at upper reaches resulted in shortages to their fields. Thus, they resorted to the practice of night irrigation to obtain adequate water supplies. Often this resulted in conflicts among upstream and down stream farmers.

The irrigation problems could not be identified specifically as limited to tail ends. Most irrigation problems were dependent on the the way groups of farmers obtained their water subjected to the design limitations. Irrigation water wastage was highest at the beginning of a season when farmers were busy securing money and other resources. The continuous issue over a period of one month resulted in greater wastage when most farmers completed sowing until the beginning of rotational issues. If a rotation was practiced based on individual tract requirements during this period, greater water savings could have been achieved and much of the water shortages could have been eliminated.

Sociological investigation revealed that a break down in institutions essential for an engineering system to function was a major constraint causing irrigation problems and social inequities at Kaudulla.

Similar findings from other new schemes confirmed these views enabling generalization of the social problems of irrigation over other schemes in the country.

While rehabilitation of the physical system is feasible, it could be economically justified only if the institutions necessary for the maintenance and operation of the engineering system is re-established. In order to re-establish the institutions and their effective functioning, motivation of system managers, generation of finances from the system for its maintenance, farmer organization and elimination of political constraints were considered essential pre-requisites.

8.0 CHAPTER EIGHT : CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

1. Field observations and monitoring of the irrigation flows showed that irrigation management in Kaudulla Stage I irrigation system was inefficient.

2. Inadequate control facilities and neglected maintenance of the channel system were found to be the primary reasons for ineffective water distribution at Kaudulla.

3. Improvement of irrigation water distribution through physical rehabilitation is an engineering possibility at Kaudulla.

4. Lack of motivation amongst the system management personnel also was a factor responsible for inefficient management. Lack of economic incentives for their active involvement is a primary factor responsible for malpractices and neglect of effective management at Kaudulla.

5. Inability of the national economy to provide sufficient maintenance resources or incentives was an important external factor contributing to the neglected maintenance of the channel system and lack of motivation amongst the management personnel.

6. Some of the irrigation problems experienced by the farming community were due to the system design at Kaudulla. The extremely long distributory and field channel layout, and design of drop structures were poor engineering design for the field conditions in the Kaudulla scheme.

7. Sociologically, the institutions that are essential for the engineering system to function effectively have failed to take root in the community at Kaudulla.

8. Grassroot level political and economic environment was identified as an important factor responsible for the break down of these institutions.

9. Though engineering system and other physical facilities are location specific, similar findings in relatively new irrigation schemes show that the socio-economic constraints to effective irrigation management are common to almost all irrigation schemes in the dry zone.

10. The delicate economic status of individual farmers was a principal constraint affecting the productivity at farm level.

11. An effective maintenance program requires active participation of both system management personnel and the farming community and a source of funds independent of the national economy.

12. Farm level productivity was affected by a multitude of factors. A short term study cannot specifically identify contribution of inefficient irrigation management at farm level to the productivity due to difficulty of exercising control over many of the factors. Especially the environmental and economic factors.

13. Evaluation of irrigation system performance both at system level and at farm level through a monitoring process appear deceptively simple. More often large scale monitoring is limited by available resources. As a consequence the monitoring procedure is limited to a single observation per location to overcome this limitation. However, such results are often misleading because of the inability to account for temporal variations.

8.2 RECOMMENDATIONS

8.2.1 RESEARCH RECOMMENDATIONS

1. Reliable irrigation flow monitoring, which is essential for correct evaluation of irrigation systems, was limited by difficulties of instrumentation. Research into development of low cost electronic flow monitoring devices offers a practical way of overcoming such limitations.

2. As a solution to most irrigation problems, improvements to farm level irrigation management is advocated. However, there is a need to demonstrate the benefits of these improvements to the farming community. Research is needed to create an effective irrigation management extension program focusing on how to bridge this gap in information at the farm level.

3. Farm level productivity was limited by a multitude of factors. Thus, correct evaluation of farm level irrigation management requires a large sample size and a longer observation period for meaningful interpretation of the results. However, the sample size and the duration of a study will be limited by the resources available in many instances. A long term research investigation to identify the principal factors contributing to poor productivity may provide

useful insights for development of an irrigation management extension program.

4. At Kaudulla it was observed that outside the boundary of the system the encroachments have been irrigated and cultivated by farmers through the reuse of drainage water. It was further observed that these farmers are a mix of large land holders and small holders who cultivate a large extent of land without a sophisticated irrigation system. Research into the organizational and institutional aspects of such cultivation and management practices may yield valuable information that can be extended to other schemes.

5. Farmers naturally evolved drainage reuse systems at Kaudulla. It may provide useful insights to conduct research studies to investigate farm level reuse of drainage. This may be especially beneficial to the irrigation design in new irrigation schemes.

6. Another observation at Kaudulla was the design constraints of drop and control structures. Research into design of economical and more effective flow control structures suitable for a given field situation is a needed to better define the effectiveness of these control structures. In particular, an understanding of why these structures fail and how such problems could be overcome by design

would lead to considerable savings on maintenance of these structures.

7. In almost all irrigation schemes, farmers have resorted to cultivating rice wherever possible, which requires large quantities of irrigation water. Research is need on alternative irrigation system layouts and management practices to promote cultivation of other field crops. This will be of particular importance once the country achieves self-sufficiency in rice production. Research into land allocation patterns, cultivation and management of less labor intensive substitute field crops are an important considerations.

8. Most older irrigation systems are characterized.by long distributory and field channels that cause inefficiency in water distribution. Research into how to effectively improve these systems with economical engineering redesign will be of benefit to these irrigation schemes. Perhaps alternatives such as construction of intermediate small storage reservoirs that trap both drainage and irrigation water may be worth investigation to overcome such problems.

8.3 RECOMMENDATIONS FOR KAUDULLA

1. Under the Mahaweli system "D" development program, Kaudulla will come under a program of planned expansion. However, priority should be given to the rehabilitations required in both Stage I and II of the scheme to eliminate major physical constraints affecting irrigation management in these two areas. This is important because the success of irrigating the planned Stage III will depend on effective irrigation management in the upstream reaches.

2. In the design of irrigation layout for Stage III, it would be worthwhile considering a land allocation pattern similar to the pattern of an ancient system described by Leach (1961). At least these patterns would be possible at distributory or field channel level. This would provide the possibility of compelling farmers to maintain the field channel system by design.

3. For more effective irrigation management, it may be worthwhile considering organization of farmers at individual tract level and coordinating irrigation issues based on individual tract requirements if better water utilization is the objective.

4. If tract level water requirements are derived it would be possible to extend rotational irrigation issue into the land preparation

period that would provide considerable water savings and better utilization.

5. Design of appropriate control structures along the main channels would enable more effective utilization of the drainage inflow into the main channel system to guarantee a more reliable supply towards the tail ends of the system.

6. Lining the channel transitions and provision of additional spillways may be economically more feasible. Lining these specific locations would reduce the erosion and deterioration of the channel system due to excessive flow during rainy periods and eliminate resulting distribution problems.

7. Control structures along the distributories and at field channel level are required for the rotational irrigation issue is to provide water savings and effective utilization.

8.3.1 RECOMMENDATIONS IN GENERAL

It is necessary to emphasize that technical improvements can be effective only if the institutions are re-established through community organizations. Thus, reforms at farm level or system level management alone cannot bring about improved irrigation management or productive use of water unless reforms at planning and political thinking at national level are introduced. There exists a critical need to establish effective communications between the scientific and technical community and the political authorities. Ultimate success of irrigation management is the collective responsibility of all involved considering the vast public investments that are being made in Sri Lanka.

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APPENDIX A. A SOCIOLOGICAL ANALYSIS OF THE KAUDULLA IRRIGATION SCHEME

A CASE STUDY IN TECHNOLOGICAL INVOLUTION

by

SUNIL A. GOONASEKERA[7]

A.1 INTRODUCTION

Kaudulla is an agricultural colony situated in the Northeastern region of Sri Lanka. It depends on artificial irrigation and water management. This essay attempts to investigate the interrelationships between the technology of irrigation and water management and the society of the Kaudulla colony.

A.2 THE ECOSYSTEM

The Northeastern province of Sri Lanka, because of its ecological and climatological properties, belongs to the so called 'dry zone" of the island.

The landscape is flat, and is about 200 feet above the mean sea level. Here the rainfall is restricted to the two monsoons. The Northeastern monsoon winds blow from September to December and bring

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plenty of rain. This is the "Maha Kanna" or "the season of plenty." The Southwestern monsoon winds come from late March until the end of April but yield only meager rainfall. From May to September the drought is severe (Domros, 1974). This is the "Yala Kanna" or the "season of scarcity." The mean annual rainfall is about 64 inches (Johnson, 1969). But this figure represents mainly the rainfall during the "Maha Kanna." Between the two Kannas are two spells of hot, humid weather and relentless sun which bakes the earth to brick-hardness. These climatic properties limit the flora to scrub and jungle which alone can survive the hard dry earth, heat, and high rates of transpiration and evaporation during the drought seasons.

This area is sparsely populated and the communities are thinly dispersed around small towns such as Divulankadavala and Medirigiriya. These communities are of two basic types: "purana villages" and "colonization schemes." The purana villages are ancient communities (Sanskrit:Sinhala: Purana:- ancient) which have existed from feudal times and have survived the onslaught of colonialism and the concurrent abandonment of the Raja Rata (Sanskrit:Sinhala:Raja:-of the royalty; Sanskrit:-Rashtra= Sinhala:- Rata:- country). The colonization schemes are the result of more recent attempts to resettle communities in this region. The schemes were undertaken by the government partly to minimize the steadily growing demand for agricultural land in the "wet zone," where the population pressure is high and continually increasing, and partly to increase rice production by bringing more land under cultivation. Kaudulla is one such colonization scheme.

In this ecological background any community has to solve two basic problems in order to practice sedentary agriculture. They have to find water for the Yala Kanna—the season of meager rains—and for the following drought season. They also have to struggle with the jungle, which is forever encroaching. Thus irrigation and water management become functional prerequisites of communities which depend on sedentary agriculture. Kaudulla colony is such a community.

A.3 THE TECHNOLOGICAL SYSTEM - HISTORICAL BACKGROUND

Although the Kaudulla colonization scheme is a recent entity, begun only in 1958, its irrigation system has a history which goes back to the third century of the Christian era. The ruins of a Buddhist temple and an irrigation system show that an ancient community existed here using the irrigation facility to survive the drought season. The irrigation system had the Kaudulla tank and a canal system as the mechanical devices which could be utilized to collect, store, and distribute the excess water collected from the Maha Kanna rains during the Yala Kanna and the drought spells. The Yoda Ela canal was used to transfer excess water from the nearby Minneriya tank. The entire agricultural economy of the ancient Kaudulla community depended on this technological infrastructure. Even in the modern irrigation system some parts of the old system are retained.

The tank itself, its main sluice and the Yoda Ela have been modified and improved, but are still used as they were in the ancient irrigation system.

Historical evidence is available to show how the ancient system was constructed, managed, and maintained. The ancient Sinhala law bound all citizens to work for the King, without remuneration, for a specific number of days every year. This work was known as Raja Kariya (Sinhala: Kariya&colon-work: Raja Kariya&colon- work for the royalty). One could avoid this work by paying a tax but the majority of the citizens, most of whom were peasants incapable of paying the tax, opted for the Raja Kariya. This was the labor force that was used in the construction and maintenance of the entire technological system.

The land was owned by the feudal aristocracy. It was cultivated by landless peasants who lived on it as tenant farmers, sharecroppers, and laborers. After each harvest the aristocracy collected the produce, issued shares to the cultivator peasants, preserved some for future use, retained their own shares, and sent the rest to the King as his revenue. Between the end of harvesting and the beginning of the next cycle, while the land lay fallow, new irrigation systems were constructed, and the old ones were repaired and prepared for use in the following season. The work was "Raja Kariya," organized by the landed aristocracy and performed by the peasants.

The above organization was, obviously, systematic. Any system of this type requires the cooperation of large numbers of people. They must know how the various parts are interrelated and they must have faith in the order in which the system is designed to operate. In other words, the people who work the system must be bound to it by means of an ideology, through which they are capable of reasoning out how and why the system works and the place which each individual occupies in it. The feudal model had such an ideological framework out of which men derived the meanings of their work. The land ownership, labor organization, ideology of work, religious beliefs, and technology were functionally integrated. The King had the divine right to rule and cosmic obligations to rule well, and his subjects were supernaturally obliged to serve their King and the country. The religion and morality of the times served as powerful supports for the beliefs that kept the ideology of work, rights, and duties alive. Within this ideological framework a rational thought operated that kept the system functioning.

The administration of the system had many facets, including labor organization, work supervision, irrigation and water management, cultivation organization and supervision, revenue collection and distribution, and maintenance of law and order. The landed aristocracy were the administrators and landowners simultaneously, and they had vested interests in the system. It was only by running it effectively that they could retain their land, revenue, titles, power and authority, and even their heads. Socially, they were responsible to the king; and cosmologically they were responsible to the supernatural forces which were believed to govern their existence. They were thus caught in a web of self interest and obligation.

The peasants were also bound to the system. They had to work in order to live, and work was available only within the system. They worked in order to get their share of the produce, and to retain their rights to cultivate and live on the land.

All these features of the feudal society and the engineering skills of some of its members produced the feudal technology of irrigation and water management. By technology we mean the entire culture of irrigation and water management. In other words, feudal technology of irrigation and water management consisted not only of tanks, canals, sluices, etc., but also of values, norms, and beliefs which influenced the actions that were directed towards attaining goals of irrigation and water management. Technology was a combination of gadgets, thoughts, and disciplined actions.

This system, however, collapsed. Well known historical arguments point to Tamil invasions from South India, malaria epidemics, loss of the administrative classes on the battle field, and colonialism, as the probable causes of the fall of the Raja Rata hydraulic civilization. Whatever the causes might have been, the result was the destruction of the ancient irrigation and water management technology. Either the culture vanished, leaving the devices to decay in the hands of incompetent men; or the communities migrated abandoning the tanks, the canals, and the sluices, and their old villages; or both occurred simultaneously.

Appendix A

The ancient community of Kaudulla also followed this trend and the people disappeared from the area, leaving behind only the irrigation devices they had constructed.

A.4 THE TECHNOLOGICAL SYSTEM-THE ETHNOGRAPHIC PRESENT

As mentioned before, in the 1950's, the Kaudulla tank was renovated, its canal system was reconstructed, and it was brought back to use with an entirely new community and a new administrative system. This is the beginning of the present-day Kaudulla colonization scheme.

With the new colonization scheme the tank and its canal system entered the era of modern hydraulic engineering, water management, social engineering, and administration. In the modern political system of Sri Lanka, the Kaudulla colonization scheme comes under the Medirigiriya electorate of the Polonnaruwa district.

The irrigation system that was put into operation in 1958 was a part of a larger development plan to reorganize agricultural production and community settlement in the once abandoned but renewable irrigation systems. In the modern system some of the old features were preserved. As mentioned before, these were the tank itself, its main sluice, and the direction of water distribution. But certain other features were changed in order to fit the system into the development plan. One major objective was to expand the area under cultivation so that more people could be settled and more grain could be produced. This required more water and improvement of the entire irrigation system. In order to achieve this end, the Kaudulla tank was linked to a larger network of tanks which was ultimately connected to the Mahaweli Development Scheme. Thus the Kaudulla tank was connected to the Minneriya and Kantalai tanks through the Yoda Ela canal and to the Mahaweli Development Scheme.

Within this larger system, the Minneriya tank is the central tank which operates as the main water collection and distribution center. It receives water from the Mahaweli river and from a number of feeder canals which collect water from the surrounding areas. When Minneriya is filled to its maximum capacity, the excess water is sent to Kantalai through the Yoda Ela. Kaudulla receives water when Kantalai spills over.

As such, the Maha Kanna rains are the only independent source of water for Kaudulla. However, the capacity of the entire tank has been taken into account in planning the extent of land to irrigate. The new connection with the Mahaweli Scheme is expected to increase the water level of the tank. The quantity of water available is expected to be much larger than the quantity that was available to the ancient community. Therefore, the land under irrigation has also been expanded considerably.

The implementation of the Kaudulla scheme was planned to occur in three stages. The first of these began in 1958. The second was still incomplete at the time of this study, while the third has already been projected. Our study covers only the first stage.

The aerial photographs of the first stage show that the irrigation canals are organized into three phases. Secondary canals branch off in a trellis pattern from a primary distributory canal. These secondary canals are further divided into a tertiary stage to form the field canals. These are also arranged in a trellis pattern along the secondary distributory canals so that they run through the irrigable land. The scheme aims at irrigating every plot adequately, so that the Yala crop in every field receives the necessary amount of water.

This canal system is equipped with water flow controlling devices. These devices, together with the tank, its sluices, and its canal system, constitute the technological apparatus used in the water management of the Kaudulla scheme.

A.5 THE ADMISTRATIVE APPERATUS

The above irrigation and water management system is controlled by a technological administrative organization. This is a part of the larger body of administrators who are in charge of the overall administration of the scheme. Let us now examine this technological administration.

Irrigation in Sri Lanka is administered by the Ministry of Irrigation and Land Development through the Department of Irrigation. The central office of the Department is in Colombo and is headed by the Director of Irrigation. Deputy Directors are stationed at various places throughout the island wherever artificial irrigation is in operation. The irrigation and water management of the Kaudulla scheme comes under the Deputy Director stationed in Polonnaruwa. In fact, all the irrigation and water management projects within the Polonnaruwa district come under his supervision.

The Minneriya-Kantalai-Yoda Ela-Kaudulla irrigation network is headed by a Senior Irrigation Engineer (IE) stationed at Minneriya. He is directly responsible to the Deputy Director of Irrigation at Polonnaruwa. Under the IE there are three Technical Assistants (TAs), one of whom is resident at Minneriya, while the other two are resident within the Kaudulla colony. These TAs are aided by two Maintenance Overseers (MOs). Under the latter are the Work Supervisors who control the Irrigation Laborers. Given below is a schematic presentation of this hierarchy.

Minister of Irrigation (MI)

Director of Irrigation (DI)

Deputy Director of Irrigation (DDI)

Senior Irrigation Engineer (IE)

Technical Assistants (TA)

Maintenance overseers (MO)

Works Supervisors (WS)

Irrigation Laborers (IL)

This is a technological bureaucratic administrative system which conforms to the norms of any formal bureaucratic organization. Each level has its clearly delineated area of authority. Each level can supervise the work of lower levels within the limits of its area of authority. The bureaucrat is responsible for whatever happens in his area of authority and only for that. In this hierarchy the subordinate offices must follow the instructions from the superior offices. The Kaudulla technological administration is bound by these formal rules of bureaucratic authority.

In this administrative system no individual has been recruited on the basis of kinship or personal favor—**in remarkable contrast to the feudal authority system.** All are selected according to a common set of rules that require educational performance and professional qualifications. Election by public vote is another mode of recruitment. Apart from these two modes there are no other ways to enter this hierarchy.

In this hierarchy there are no permanent positions. Individual bureaucrats move up and down the hierarchy as a result of promotions and demotions. They also move laterally by being transferred from one area to another. Some also leave the administration altogether, vacating their positions because of retirement, resignation, expulsion or death. No individual bureaucrat can thus have vested interests in his position in Kaudulla. **Contrast this with the feudal administration which depended on the vested interests of the administrators.** The transferability of the individual from area to area and positions to positions is a formal mechanism whose purpose is to guarantee impersonal, formal execution of duty. A further mechanism is the rule that no administrator can own, lease or rent agricultural property in Kaudulla.

All the duties performed by the administrators are remunerated by the central government. The Government salaries are the principal source of income for practically all the administrators. These salaries are paid irrespective of the productivity of the scheme. Contrast again the feudal condition under which the system-productivity and income were interrelated.

The modern technological administration has the authority to prosecute anyone who disturbs the smooth functioning of the irrigation and water management system. The TAs are empowered to deal with a variety of offenses, such as damaging the irrigation works, settling on or cultivating reservation land, and stealing water.

The entire irrigation system, from administration to the canals and mechanical devices, is constructed and maintained by the state, through the Ministry of Irrigation and Land Development and the Department of Irrigation. At the local level the financial administration is in the hands of the IE.

The primary goal of this entire technological administrative apparatus is to ensure irrigation of all the cultivable land that comes within the scheme.

A.6 THE COLONY

The cultivable land within the scheme was colonized under the direction of the Land Commissioner's Department. The land is cultivated by the colonists settled within the scheme. The colonists were selected by the Ministry of Irrigation and Land Development using relative landlessness as the criterion for selection.

The colonists received their lots conditionally. As long as a colonist cultivates his lot, he retains the sole ownership of it. But no colonist can rent, lease or sell his lot. In case a colonist decides to leave the colony, he must inform the relevant administrative officer that he is abandoning his lot. Until such lots are formally given to new settlers, whom the Ministry selects, they belong to the state and come under the authority of the IE.

Each colonist has been given a plot of five acres out of which three are "mada idam" (muddy land) or land suitable for paddy cultivation, and two are "goda idam" (high land) or land good for dry farming and making homesteads. Each "mada idama" is called a "kattiya" (lot) and is irrigated by a field canal.

Each colonist is given a quota of water for the cultivation of his "kattiya." But no colonist can meddle with the technological apparatus to get water. If a colonist does not get sufficient amounts of water he must inform the irrigation administration, which alone can deal with the problem. No colonist can deal with his grievances pertaining to irrigation and water management on his own.

The colonists were settled in the scheme in 1958, just as soon as the Stage 1 of the irrigation system was completed. Priority was given to peasants who were displaced from the Minneriya and Polonnaruwa irrigation schemes during the floods of 1957. In addition the second generation folk of the Minneriya colony were also settled in Kaudulla. The rest of the lots were distributed among landless peasants from Kandy, Kotmale, Polgahawela, (in the Kandyan provinces), and coastal areas. Thus stage 1 was colonized with colonists uprooted from various regions of the island.

The colonists are predominantly Sinhala Buddhists. We also found that a Christian church was being built. Around the tank there are a few fishermen and their families. They are from Wennappuwa on the Western coast. These and a few other families constitute the small Christian community. The kinship and caste connections are few if not totally absent. The traditional principles of social organization and agents of social control found in Sinhala villages are largely absent, and the principal social unit is the individual nuclear family. Each family is a unit in a larger structure in which the interrelationships with other families and other organizations are mainly formal and functional rather than personal and emotional.

This kind of resettlement scheme was intended to circumvent the traditional cultural impediments to the growth of individual entrepreneurship. In traditional villages individual entrepreneurship cannot develop since individuals have heavy social obligations to family, lineage, clan, friends etc., which prevent them from developing their economic potential. Further, in the villages most peasants are tied down to subsistence-level farming, partly because they lack capital and partly because of traditional mechanisms of social control, which reflect the conservative, non-innovative, values of the village culture. In the scheme the settlers are away from such traditional impediments and are able to work as independent entrepreneurs.

A variety of facilities exist within the scheme to organize the settlers into a farming community. The townlet of Medirigiriya has two banks, which provide credit when needed; a director of the Agrarian Services Department, to provide advices on the improvement of farming techniques; a police station, to establish law and order and provide a sense of security; a cooperative shop, to provide necessities of life at subsidized rates; and an Assistant Government Agent (A.G.A.) operating under the Government Agent (G.A.) of Polonnaruwa, to coordinate these and other civil services.

The G.A. and the A.G.A. are parts of a large bureaucratically organized system of social administration which operates in terms of many of the same bureaucratic rules that govern the technological administration. It is possible to put this social administration together with the technological administration and to consider them as a total administrative apparatus whose function is to keep the Kaudulla scheme operating. This administrative system links together the elements of ecology, engineering, agriculture, and society to form a complex whole which is the Kaudulla colonization scheme. With all these institutional relations systematically and rationally organized, Kaudulla can be considered as a model for a community.

Appendix A

The Kaudulla scheme and its administration are also linked to the legislation of the country through the local representative of the National State Assembly (up to 1972, the Parliament). Until 1977 it came under the Minneriya electorate and since then it has been a part of the Medirigiriya electorate. Kaudulla has always been represented by a Member of Parliament (M.P.) of the ruling political party. Most of its M.P.s were also cabinet ministers—especially important is the fact that Mr. C. P. de Silva, the architect of the scheme, was the Minister of Irrigation and Land Development and also the M.P. for Minneriya, when Kaudulla belonged to the Minneriya electorate. This means there has always been the presence of a powerful political element in the functioning of the scheme. The local M.P. can supervise the work of the administrators, veto their decisions, remove officials, and replace them with others. It is clear that the irrigation and water management operated under a powerful agency which, if functioned formally and effectively, could have left no room for malpractices within the scheme.

The settlers also have to perform their duties pertaining to irrigation and water management. Some of these are proscriptions while the others are prescriptions. As an irrigation official explained to us, the farmers must in no way damage the canal bunds. They are allowed to use certain places in the primary distribution canal, often near the bridges and culverts, as bathing spots. These authorized bathing spots are well constructed, paved with concrete, and designed to accommodate a fairly large crowd. The colonists are not allowed to carve their own bathing spots out of the canal bund. They may also not use the bunds for watering buffaloes except in designated places. The colonists are also prohibited from meddling with the various water management devices placed along the canal system.

In addition to the above proscriptions there are also some prescriptions. Every farmer must clear the canal that passes by his "kattiya." This involved clearing the weeds that grow on the canal banks, and removing the silt and mud which the Maha rains bring. The purpose of canal clearing is to maintain an undisturbed flow of water down every canal, which is necessary in order to irrigate every plot in the scheme.

What we presented this far is the formal scheme, i.e., the way in which the planners of the scheme organized it and intended to operate it. The ancient irrigation system was modernized to facilitate the cultivation of thousands of additional acres of paddy in order to settle more people and produce more grain. As the irrigation and water management system was completed the land was allotted, and people were brought to settle there. Then an administrative apparatus was put together to run the scheme. The scheme is like a game. It operates according to a set of rules. These rules prescribe and proscribe activities within the scheme so that all the action within can be organized into a functioning whole. As long as the players follow the rules of the game there is no reason as to why the game should collapse.

Appendix A

A.7 THE GAME

The Maha season comes and brings ample rain. Irrigation and water management during the Maha season is seldom problematic because there is usually a large surplus of water. By the end of the season, thousands of acre-feet of water accumulate in the tank. But the stored water is not sufficient to supplement the Yala accumulation to irrigate the stage I and II fields during the Yala season. Additional water must be obtained from Minneriya tank through the Yoda Ela canal. Once the appropriate water level has been established, the time is ripe to begin the Yala cultivation.

Before the cultivation season begins, the cultivation committee meets. The committee decides on the two most important dates for the season: when to issue water and when to begin cultivation. The committee is headed by the M.P., A.G.A. of Medirigiriya, the IE, his T.A.s, the officers of the Agarian Services Department, Agricultural Extension Officers, and Vel Vidanes - the farmer representatives. The members of the committee represent the formal hierarchical social organization of water management. In this organization, irrigation, water management, administration, politics and cultivation are formally and functionally integrated.

When the committee decides to issue water on a certain date, the Yala cultivation cycle begins and the farmers wait until the sluice door opens.

The "game" begins when the sluice door opens. Its goal is the irrigation of every plot of paddy land by means of methodical water management. We observed the "game" during a Maha season in 1982 and a Yala season in 1983.

We saw that the canal construction was incomplete. The canal banks were lined with concrete only up to a point. The rest of the canals had earthen banks. This, according to the Irrigation Department, was due to financial difficulties that arose when the canal system was under construction. But concrete lining for canal banks was necessary to prevent erosion during the heavy rains and during release of water from the tank.

We saw that the canals were poorly maintained. The concrete lining, where it exists, was cracked, broken, and even crumbling away. This damage was not being repaired because of financial difficulties. The other devices made of concrete and steel—the devices used to effect water management—were also in bad condition. Most of these were falling apart and incapable of rendering service. The main sluice, a few anicuts and a few gates were in good working order, but the overall state of the irrigation works was not satisfactory. But, how did the system get damaged?

We found four main causes, namely, natural causes, economic causes, sociocultural causes and administrative causes.

During the Maha season, the canal banks become eroded due to heavy rainfall. And in the hot weather, the mud banks crumble and fall apart.

This damage can be prevented by lining the canal banks with concrete or by constantly repairing the broken lining.

But the financial resources needed for completing the concrete lining and for maintenance are not available. The scheme is financially dependent on the central government which is often short of funds. The economic vicissitudes of the entire country therefore have an impact on the completion and maintenance of the canal system.

Many sociocultural factors affect the canal system. Initially, the scheme planners expected the farmers to use tractors and other such mechanical implements in the cultivation and harvesting processes. But the farmers found such implements far too expensive. They resorted to using a traditional source of energy, namely, the buffaloes. The scheme had no objections to the use of buffaloes, but was not prepared for large scale use of these animals either. The farmers were given a common plot of land where they were expected to keep their buffaloes. But, from the farmers' point of view, this land is too far away from their homes and they are worried that no one guaranteed the safety of their animals if they are kept in this common area. The farmers feel more comfortable if they keep their animals close to their homes. This is, in fact, what they do. The most convenient place to water the buffaloes is the nearby canal. However, buffaloes in the canal cause heavy damage to the canal banks. We noticed that some canal banks have been widened many yards due to buffalo watering. Each time an animal gets into and out of the canal, the bunds are broken. The interesting thing is that the farmers are not aware of this damage. The technological experts say that they are unable to stop this practice since they, too, know the difficulties of the farmers. The farmers are culturally not accustomed to living in planned communities. In their native villages they could use the streams and marshes to water their buffaloes and here, too, that is exactly what they do. They are not mindful of the fact that they are damaging a technological device upon which their cultivation is completely dependent.

We found that there is a growing lack of involvement with the maintenance of the system at the administrative level. A very basic reason for this indifference is the financial aspect. Even if the administration surveys the system, detects the damages, and plans to repair the canals, financial difficulties render these initial efforts useless. Another serious problem is the political system. When the officials take steps to punish the farmers who damage the canals, the political leaders use their political influence to protect the offenders. The farmers know this helplessness of the administrator before the politicians, and do not cooperate with them.

The sociocultural factors that contribute to the problems of the canal system also affect the other devices that are used to effect water management. If a farmer wants extra water, or if he cannot wait until the officials release water, he destroys the water flow controlling devices in order to get water. We have seen many such structures completely wrecked by the alottees.

We moved on from the primary and secondary canals towards the field canals. At this point we found that the irrigation and water management system is in more serious difficulties.

The reservation land has been brought under illegal cultivation by squatters. Some of them even live on the reservation lots. These squatters cause considerable damage to the field canals while illegally occupying the reservation land. The reservation lots are unirrigated. The squatters who cultivate these lots steal water from the canals. There are three ways in which this is done. Some use powerful water pumps, others siphon water from canals into the reservation lots which are on a lower level, and some cut trenches from the field canals to divert the water flow. All three ways disturb water management. When water is pumped or siphoned out of the canals, the amount of water available to the allottees is reduced because, each time the sluice is opened, only a limited quantity of water is released. When the water flow is diverted by cutting trenches, in addition to loss of water, the canal bunds also get destroyed. Broken canal bunds necessarily cause water wastage while reducing the speed of the flow. When water is stolen the pressure in the canal is further reduced thereby lowering efficiency of the system.

We wanted to know why these squatters were tolerated. The officials told us that the squatters even had the audacity to threaten them. These squatters are supported by the local politicians. According to some officials, one squatter said that he worked for the M.P. during the election campaign and claimed a special right to utilize the land. These squatters are landless peasants from the neighboring areas. Some have come from the native villages of some of the allottees. They have found that they cannot get any land legally and that the reservation land can be encroached upon. They have turned to exploiting the politicians' dependence on grass root level political support in order to gain access to the land and escape the law. An irrigation official disclosed that the officials were unable to evict the squatters since the politicians protected them. Any official who attempted to interfere with them would be transferred to another area so that the squatter could remain on the land. The political power of these squatters is such that the scheme now allows them to cultivate the reservation land conditionally; they must pay a rent, they must renew their lease annually, and they must allow the irrigation officials to use the land for maintenance purposes whenever the necessity arises. But the overall problem caused by them, i.e., the obstruction of proper irrigation and water management, still remains unsolved.

We moved further along the field canals, towards the tail end. We waited and watched until water entered the tail enders' lots. It was a slow process and after a long wait the first trickle of water entered these lots.

The scheme has a technological basis which ensures, theoretically, irrigation of every plot within the scheme. Yet only a trickle entered the tail end plots. We inquired whether this was only a rare occurrence. The owners of the tail end plots informed that this was not rare at all but the usual situation. The tail enders do not get sufficient water to irrigate their fields.

We have already pointed out that natural, sociocultural, political, and economic factors operate in the background of this problem of irrigation and water management. Thus far it has been shown that the game is not played according to the rules. The farmers, the squatters, and the politicians all break the rules of the scheme. We also found that, in addition to breaking the rules, the farmers neglect their duties as well. The most important duty with regard to irrigation and water management was canal clearing. We noted that only the tail enders are observing this rule. Some middle lot owners also have cleared the canals, but only up to their own fields so that they can get their share of water. Very few upper and middle lot owners have paid any attention to canal clearing. They were satisfied with the condition of the canals as long as water flowed down to their own fields. The canals, especially the field canals, were full of weeds, silt, mud and various forms of rubbish. Often the field canals were purposely blocked by upper and middle lot owners by deliberate dumping of rubbish and concrete torn apart from the technical devices.

The officials and the farmers informed us that the unequal distribution of water resulted in much violence. When a sufficient amount of water did not enter the tail end lots, the tail enders kept night watch over the canals to prevent the upper and middle lot owners from blocking them. This led to many conflicts and ended up, a few times, in murder.

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The administration was not itself completely uninvolved in these malpractices and corruption. Their involvement was indirect, but significant. Although all categories of officials, except the Vel Vidanes, were not permitted to cultivate the land in the colony they, in fact, have been involved in cultivation. When a colonist decides to leave the scheme his "kattiya" acquires a market value. Then two kinds of people attempt to rent it from him: the "mudalalis" in Medirigiriya town and the officials. The bidding is in terms of cash or a share of the produce. The latter is, usually, one third, but this can be more. The prospective tenants are interested only in the upper and middle lots. Further, in order to avoid possible legal problems, the dealings are strictly undocumented.

The "mudalalis"—the petty traders in the town—are interested in making quick profits. The officials, however, are interested in making some extra money. The officials find it very difficult to meet many family, social, and cultural demands with the thin pay packet they receive at the month's end. The get tempted by possible extra income from the land and get involved in illegal cultivation by renting or leasing the available lots. This illegal cultivation becomes a serious problem at the level of official evaluation of the performance of the scheme. Since they cultivate the upper and middle lots they do not face the problems of irrigation which the tail enders face. The crops in their illegally rented lots are luxuriant and their incomes are good. From this they wrongly extrapolate that irrigation and water management in the scheme is successful. From their point of view the problems are caused by the corrupt political system and the ignorant farmers.

The officials, despite their involvements in these malpractices, have devised a method to inspect the canals and compel the farmers to clear them. This method is not entirely new; it has a colonial predecessor. It is known as the office of the Vel Vidane (earlier known as the farmer - representative). During the colonial period this office was hereditary. It became obsolete after the independence in 1948. Recently it was revived, in a socialist ideological frame work, for the purpose of ensuring proper distribution of facilities, especially, the irrigation facilities. Today this office is not hereditary. Vel Vidanes are now appointed by public vote. Kaudulla also adopted the same institution for the same purpose. Each tract (a series of lots along a field canal) has a Vel Vidane.

A Vel Vidane must inspect the distribution of water among the allottees, organize the allottees for canal maintenance, settle disputes among them, and prevent them from damaging the canals and other irrigation works. This work is remunerated during harvesting. Each farmer gives him a share of the produce.

But this office also became corrupt within a very short period of time. This happened through the mode of appointment in two, often interconnected, ways. Although the office is not formally associated with the party politics in the country, appointment by public vote linked it with the political parties. A Vel Vidane is almost always a supporter of the ruling party. As such he is partial to the other supporters of his party. He has to obey the leaders of the party organization at grass roots level. On the other hand, candidates to the office come mainly from among the upper and middle lot owners. There are occasions on which outsiders also contest and win but, more often, the upper and middle lot owners are elected. The latter form the numerically largest interest group. They are interested in appointing a man who can serve their purposes. This means unhindered access to water. Thus, they send a man from their own group. In both ways, the role of Vel Vidane gets trapped in favoritism.

This has contributed to poor water management. The upper and middle lot owners, with the Vel Vidane on their side, neglect their duties while exploiting the irrigation system. The tail enders, who constitute the minority in a tract, receive only a trickle of water because of this. Consequently, they also become economically depressed since their fields yield less, and the tract has become economically segmented. The economically prosperous farmers could keep the Vel Vidane on their side by bribing them. Bribery is not always a matter of money exchanging hands. Payments are made in kind as well. Reappointment itself is a kind of bribery. The office of Vel Vidane is often sought for status enhancement, too. In that case canvassing for, supporting, and voting for a particular status seeker are sufficient to maintain steady help from the candidate once he becomes the Vel Vidane.

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Further, the Vel Vidanes themselves are involved in blocking the canals. This happens when a Vel Vidane is also an allottee. We observed a case where a Vel Vidane had himself blocked a field channel to divert extra water into his own field and also to cultivate a sizable area of reservation land.

This is the empirical sociological reality of irrigation and water management in the Kaudulla irrigation scheme. The game goes on but with a plenty of foul play. We observed a an informal organization within the colony operating consciously and unconsciously, intentionally and unintentionally, in opposition to the goals of the scheme. The results are complex, and include unsuccessful irrigation and water management. It is true, as an official said, that the scheme produces a large quantity of grain each season and that the yield per acre is relatively high. But this high yield is mostly restricted to the upper and middle lots only. The tail end lots yield much less because of poor irrigation and water management. Further, the technological infrastructure—the canal system and other irrigation structures—are decaying. The point is that the scientific model used in the planning of irrigation and water management, the provision of water to all the lots without any discrimination so that the same high yield can be obtained from all the lots and the economic conditions of all the allottees can be improved, is not working to produce the desired effect. We are not competent to comment on the engineering aspects of the design. But we can confidently state that, in addition to engineering defects, if there are any, the above-mentioned sociological factors also contribute to the problems of irrigation and water management system.

A.8 THE PROBLEM

Kaudulla is not a total failure. Rather, it is a system which has gone off the track. Although its technological goal is effective distribution of water, its socioeconomic goals are to distribute the land among the landless peasants to make a contribution to the national efforts to increase the production of rice. It did produce a colony in which hundreds of former landless peasants now enjoy some standard of independent existence. It also, as the officials explained and engineers pointed out, did increase the rice production. The socioeconomic goals of the scheme have thus been at least partially achieved, but its technological goal—efficient and democratic distribution of water—remains unrealized.

The overall results are not very satisfactory. The technological system is mismanaged, over utilized, under-maintained, and decaying. The above mentioned sociological factors contributed to this unsatisfactory state of the system.

In sociological terms, Kaudulla is a poorly integrated system. Its administration, political supervision, technological needs, and individual entrepreneurship within it do not hang together. As the facts already presented clearly indicate, the sociological factors unintentionally subvert the technological system. Their relationships with the technological system are disruptive.

One cause of this problem is the lack of effective control over the uprooted peasants' economic ambition. The kindred in the village controlled them to such an extent that their individual potentialities were never realized. Their down-trodden economic condition further thwarted their individual ambitions. In the colony these inhibiting factors have been removed. The social control has been shifted from the kindred and village culture to the legal system of the country. The peasants have been able to cunningly manipulate the legal, political, and administrative systems in order to reach their private goal of profit maximization. They manipulate the political system in order to manipulate the legal and administrative systems. They know the all powerful politicians' dependence on their votes. Using that as their trump they manipulate the very rules which the politicians are supposed to guard and under which the technology and administration operate. They find ways to encroach upon reservation land, to get away with cutting trenches across the bunds, blocking the canals, evading their duties towards canal maintenance, stealing water, sub-leasing the land, and destroying the technological devices. They threaten the administrators using their political potential and exploit the politicians and the scheme.

The politicians, wanting to maintain their power, to win the next election, to weaken their rival politicians, and to fulfill their obligations to their parties, become helplessly dependent on the two sources of their power - the voters and the party. The voters are essentially the supporters of the party. The latter demands that the former be kept "satisfied." This becomes one of the basic goals of the politicians. They allow their supporters to abuse the system and threaten the administration which tries to "harass" the "innocent" farmers.

The administrators depend on their salaries. That salary—the source of their socioeconomic worth—plays an important role in their relationship with their families, kindred, and the rest of the society. As a matter of fact these salaries are never sufficient to meet all the demands from their families, kindred, and the rest of the society. The administrators therefore consider staying in their jobs as their basic goal. Even to get these meager salaries they must first keep their jobs. This is where they are most vulnerable. On the populist political platform, which has been thriving since independence, power hungry politicians encouraged the politically unsophisticated masses to disregard the bureaucratic authority by labelling the administrators as mere instruments of the people. The peasants can threaten to use their connections with the politicians—their source of political power over the administrators—to transfer the administrators to different areas and the politicians have succumbed to this peasant political power. The politicians are obliged to pamper the party supporters because the latter backed them and their party during the elections. The pressurized politicians pressure the administrators, who then step down with a sigh of resignation and indignation:

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> "Let anything happen. What can we do? How can we clash with the political authorities? Let me tell you the truth. We have to save our jobs to do everything."

The pressurized politicians make economically vulnerable administrators politically miserable. Their economic vulnerability and the already weakened administration tempt them to violate the very rules that bind them to their occupations and indulge in malpractices. They sub-lease the available land and get further trapped in the system of corruption by becoming active parts of it. This further reduces their authority since the farmers and the politicians are aware of these bureaucratic malpractices. These are the primary collusions among the disruptive elements. The very agents of the system management and maintenance are transformed into agents of mismanagement and neglect.

The neglected and mismanaged technological system has to be supported by the ever traumatized national economy, which cannot afford to allocate more money to keep up with the ever increasing costs, salaries, and inflation, and to arrest the ever advancing decay of the system. Ultimately, the system is never really maintained except for the patchwork repairs here and there. The plates amply illustrate this point.*

This is the intricate system of socioeconomic factors that affect the irrigation and water management in the Kaudulla scheme.

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A.9 THE LESSONS

What can we learn from all this? This is the most important part of our study. Something seems to be fundamentally wrong about all this. What is it?

Let us begin from the beginning. The error is built into the plan of the scheme. The planning has been mechanical only. The engineering model of the scheme assumes that there will be positive cooperation from the farmers, administrators, and politicians, and in order to satisfy these assumptions which, in fact, are the sociological prerequisites, a variety of institutions and men were put together to form the colony, assuming again that these men would think in terms of the kind of rationality involved in the planning of the scheme.

Engineering, as the instrument of men, depends on the collective human effort to be effective. The engineers can only hope that the public, administration, and government will help a technology to grow out of a model. This hope has not become fully realized. A technology has not grown out of the model employed at Kaudulla. The above ethnography shows that men of Kaudulla use a different sense of rationality in their relationship with the engineering model. The system fails to function properly because these people who now run the system have no proper understanding of the priorities of the system, or because extraneous conditions compel them to overlook the system in order to emphasize other goals. The irony is that the attainment of these other goals depends on the very thing that is overlooked. Consequently, Kaudulla never really developed a culture, a technology, to run the model.

This leads us to understand that the engineering model, its functioning, and its prerequisites are not grasped by the community of Kaudulla. They only see it as a background factor, an existential constant, to be ceaselessly exploited. The allotees do show signs of understanding when they TALK about the problems of the scheme. Unfortunately, this understanding is unrelated to their ACTIONS towards the scheme; because they are inescapably bound to a second scheme—a system of corruption—to realize their immediate goals. While planners have considered the people and their culture as constants in the background, the people have considered the scheme as a background factor.

In order to understand the engineering model and its prerequisites properly, it is necessary to understand what technology actually means. It means more than bunds, canals, tanks, annicuts, concrete, and steel. It means the rules of the system - the conditions under which a few mechanical devices are assembled, and the logic behind this arrangement. Technology does not and cannot function in a vacuum of social relations and human understanding. This sociological basis of technology has been reduced to mere assumptions at the level of planning of the Kaudulla scheme. Such models built on imaginary ground can function only in imaginary societies. When such models are put to test in the empirical societies they are bound to fall into muddles. Here is a classic contradiction between planning and implementation, between Western technology and the society of Sri Lanka and its culture.

This contradiction invites us to investigate still deeper into this problem. Why should this contradiction exist? How did it arise? The fundamental causes of the problems of irrigation and water management in Sri Lanka lie in the answers to these questions.

The contradiction exists because there is a lack of mutual understanding between the planners and the society for which they plan schemes. The logic of planning has been imported from an alien culture. Technological thinking and organization emerged out of Western historical experience, which has developed over a long time through the slow evolution of cultures, economies, science, philosophy, and ideas of social organization. Technology grew out of the analyses of the every day life of the people of these cultures. Capitalist or communist, technological thinking involves SYSTEMATIC planning and organization of resources. Technology cannot function independent of the culture, although it seemingly involves only the mechanical assemblage of devices. When Western engineering devices are transplanted into societies which have no compatible frames of reference, they do not get integrated into the society the same way they get integrated within their "mother" cultures. Rather they get sucked into the already existing cultural patterns of the adopting societies. Technological organizations from models, machines, and bureaucracies, are subverted in order to feed the native institutions and to achieve native cultural goals. This has happened in Kaudulla. Irrigation and water management devices have fallen into the fissures of politico-economic exploitation and corruption which occur to achieve different goals. While the model is western, the thinking that goes into working the model is essentially Sri Lankan - a product of the Sri Lanka politico-economic and cultural realities. The result is a technological involution. But why should this happen in Sri Lanka?

We can take a lesson from the Sri Lankan historical experience. We already outlined how an irrigation and water management technology operated within a feudal institutional frame work and how a rational line of thinking that operated within this framework made technology meaningful in the daily life of the feudal people. We discussed how that technology and ideology of socioeconomic organization had an existential importance for the feudal people.

This was in contrast to the modern colonization schemes which, in principle, reject the feudal ideology of the society. Kaudulla operates, ideally, on a socialist democratic footing, and actually, on the basis of purely mindless pursuit of immediately meaningful private goals. In Kaudulla men get organized to exploit the system rather than to work the system. Kaudulla colony depends on a technology which is not absorbed into the thoughts and actions, norms, values, beliefs, of the people. The planners of Kaudulla have assumed that the technology would naturally be absorbed by the society. They also assumed that all men operated with a common monolithic sense of rationality that existed independent of their society and culture. This shows that the planners had not understood the people for whom they were building the scheme.

This has resulted from lack of communication between science and politics in Sri Lanka. Scientific model construction occurs in a political, economic, and social vacuum. The model only deals with an inanimate world and keeps the living world of actual existing men, who, after all, are expected to work these models, as background factors, as silent constants, as monolithic independent variables. Their rationality is taken for granted as a universal human characteristic. This is a grave mistake. While men are essentially rational their rationality gets expressed in more than one way.

The peasants are rational within their own individual schemes for profit maximization. The politicians are rational within their political schemes and the administrators are rational in their strategies for socioeconomic survival. Everybody in the colony is trying to do his best to achieve his private goals. But everybody involved in the disruption of irrigation and water management is irrational from a scientific perspective in which it is not the individuals, but the system that is brought to focus. The fundamental problem is to unify these diverse elements of rationality for general good.

This goal cannot be achieved until a mutual understanding is cultivated between the planners and the society. There must be a dialogue between the planners, politicians, farmers, and administrators. The scientists must know what a people are capable of achieving under existing circumstances and the people must understand how and under what conditions a technological model can function. We take this opportunity to state that unless such a mutually educational process is launched in Sri Lanka, not only the Kaudulla scheme, not only irrigation and water management, but any institution built upon Western scientific logic cannot function to yield the expected results.

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APPENDIX B. PRACTICAL FIELD PROBLEMS AND SOME POSSIBLE SOLUTIONS

B.1 INTRODUCTION

The irrigation management study conducted at the Kaudulla irrigation scheme provided many useful insights to practical problems encountered in the field. Some problems could be circumvented, while other probelms could not be overcome because of many practical considerations. The purpose of following sections is to document these problems and present some possible solutions that may benefit such future investigations.

The problems encountered can be categorized broadly into those due to economic considerations and others due to practical instrumentation difficulties. The former category will be considered first.

B.2 LOGISTICAL PROBLEMS

A primary problem encountered was the selection of a representative study area within the Kaudulla irrigation scheme. Kaudulla was selected as the irrigation system for the case study analysis because, being a major irrigation scheme in the dry zone, it represented a large class of irrigation management problems. The available economic resources dictated the size of the study area within the scheme. Ideally, however, the entire scheme would have provide a more thourough data base. Stage I of the scheme was selected as representativeof an entire scheme. Nevertheless, even Stage I of the scheme was too large, in size, for a comprehensive monitoring procedure because of limitations of available funds and personnel.

In selecting representative irrigated tracts for the study, the size of the tracts posed various difficulties. For example, tract No. 1 of the scheme was too large for monitoring with a limited number of field personnel. This problem was overcome by purposive selection of relatively smaller irrigated tracts. However, this introduced experimental bias that was unavoidable under the circumstances.

The remote location of Kaudulla irrigation scheme posed problems of housing and transportation. Suitable housing facilities for a group of personnel to be stationed was difficult to find within the scheme area. The housing problem was overcome with the facilities offered by the Department of Irrigation at their camp site within Stage II of the scheme area. However, this introduced other disadvantages. This was particularly the case with a rural area such as Kaudulla where news travel rapidly though the grapewine. During the farm survey it was found that farmers guarded their complaints against irrigation authorities because of the above housing arrangement. To overcome the problem, required hours of patient explaining to dispel their fears and to obtain the pertinent information.

Transportation for the field personnel was another problem which was limited by available funds. In selecting monitoring locations along main channel offtakes, the long distances that had to be travelled was a serious limitation to the study. Particularly, the number of daily observations that could be made per location was limited to a single daily observation because of this limitation. It was observed that except at locations having continuous flow, significant errors in estimation can occur at other locations if a single daily observation was extrapolated.

While number of field personnel was limited by the available funds, training and retraining the field personnel over the entire duration of the study was a problem. Particularly, the short-term nature of the study for example, temporay nature of employment, resulted in re-hiring and training new personnel at the end of the first season of study. This resulted in loss of valuable time on training and familiarizing the new recruits to the scheme area.

B.3 MONITORING PROBLEMS

B.3.1 SYSTEM LEVEL MONITORING PROBLEMS

Following the selection of locations, discharge ratings were carried out at monitored locations to establish stage discharge relationships. However, the loss of gauge posts established for the purpose resulted in wasted effort and time during the 1982 Maha season. Similar loss of gauge posts was reported by Holmes et al. (1981). This problem was overcome during the 1983 Yala season by measuring the distance to the water surface form a fixed location of an offtake structure using a meter stick. This solved the problem of losing individual gauge posts at the monitored locations and simplified measurements, because, only a meter stick was required to be carried along during field visits. The measurements were subsequently reduced to water depths above the bottom lip of the outlet by measuring the distance from the fixed location to the bottom lip of the outlet at the end of the season.

During the 1983 Yala season, it was assumed that simple orifice discharge equation could be used for discharge calculation. However, this was recognized as an oversight because, it was found that some monitored locations had free flow conditions while others had submerged flow conditions. Thus, instead of a single daily observation of upstream water depths, additional measurements were required to estimate the differential head in order to calculate discharges at these locations.

All distributory offtakes had curved gate flaps. Thus, adjustment of gates necessitated a way of estimating the effective flow area contributing to the discharge from each offtake. Calculations showed that errors as large as 16% could be introduced to estimations from effective flow area alone. This problem was solved by superimposing a trace of gate lip over a circle inscribed by several different pipe diameters and measuring effective flow area for a given gate setting. Subsequently, a relationship between percent flow area and percent gate setting was established using regression analysis.

Use of orifice discharge equation at the head of main channel was not possible because of large errors introduced in the discharge estimate at smaller differential heads (Dias, 1984). Also, it was difficult to measure fluctuation in the downstream water level due to turbulence at this location. A simple stage discharge relationship was established for this location. At other monitored locations that had circular pipe outlets, calculations showed that variation in discharge coefficient with water level was not as significant as that due to gate setting. Thus, the procedure described in methodology was adopted to estimate discharge rates at these locations. However, for better accuracy, individual calibrations at each location are best suited if available funds are not a limitation.

It was not practical to monitor irrigation flows at branch channels or in the field channels. The use of portable flumes to measure flows in these channels was not possible. A simple field procedure, such as a floating cork floating could be used to estimate flows, however, without a continuos monitoring procedure, reliable extrapolation of flows over time was not possible primarily due to the poorly maintained state of the channels.

One of the original objectives of the study was to develop a network flow simulation model. However, due to difficulties of estimating drainage inflows into the channel system, this objective had to be abandoned. Most of the drainage inflow was practically impossible to measure (see Plates 4 and 5 of Appendix D). As reported by Holmes et al.(1981), some drainage inflows cannot be measured using a conventional methods such as current metering because current meters cannot be used to register stagnent flows.

B.3.2 MONITORING PROBLEMS AT FARM LEVEL

Although farm level monitoring of irrigation flows was an important part of the study, it was not very successful due to many practical problems. One problem was the number of farms that could be effectively monitored with the available field personnel. Only nine farms, could be selected for monitoring from each tract.

Many other difficulties further reduced the effectiveness of the monitored data. Farms within a tract had to be selected for monitoring. However, due to lack of any other information distance from the source had to be used as the primary criterion. Therefore, using a stratification based on distance, field channels were randomly selected form the stratified zones. However, when farms were selected from each field channel, there were only a few farms among which random selection could be done. This, added another source of experimental bias to the interpretation. Also, distance from the source is not a very good criterion for investigating water problems as discussed in chapter 5. Thus, there is a need to define better criteria to identify water problems.

The Approach adopted for identifying water problems in Stage I was as follows. Instead of interviewing all farmers, first, the Vel Vidanes were interviewed to identify farms with the most problems. Then, those farmers were interviewed in order to identify the nature of their problems. This provided better information regarding the extent of problems at the farm level. However, the long time period required to gather and analyse data prevented this information being used during the 1984 Yala season. This was because analysis of the data required a considerable time period even after reducing the sample size.

Other problem wwere the distance among farms that were monitored and the time required for levelling the flumes before measurement at each location which made regular daily observations impractical with a fewer number of field personnel.

Fragmentation of farms and the number of inflow-outflow measurement points per farm also caused much difficulty. This was further complicated by difficulties in identifying field boundaries of individual farmers who shared a farm. Some farms had several inflow-outflow points while losses form large crab holes and leaks could not be effectively measured.

Farmers' practice of adjusting inflow and outflow also affected water use estimates based on a single daily observation per farm because, these practices made extrapolation totally unreliable. Thus, the monitoring only provided an indication of relative inflow and outflow rates to and from the farms for comparison.

A practical way of obtaining reliable water use data at the farm level may require continuous monitoring of a few farms. However, instrumentation of such a procedure would have been prohibitive in cost and therfore was not possible for the study. Another approach is to use a family member of the farmer to collect the farm level monitoring data, however, in the case of Kaudulla, the greater distances form homesteads to the farms made this practically infeasible particularly, towards the tail ends of the system.

B.3.3 PROBLEMS WITH FARM SURVEYS

Conducting a farm survey was particularly difficult. The typical questionare approach had to be abandoned because, when a few farmers in a tract were interviewed, the news travelled quickly among other farmers and it was found that the data so collected was totally unreliable. Instead, the approach used was to present few questions to selected farmers during field visits. However, even this procedure presented limitations because it was not possible to meet all such farmers regularly during field visits. As a consequence, accuracy of the information was lost due to poor recollection of the farmers.

Analysis of the 1984 Yala season data indicated a large number of factors contributing to the productivity at farm level. These factors introduced a very large error term to the variability of data. Also, spread sheet analysis of data through sorting showed that if the sample size is sufficiently large then it is possible to hold a fair number of factors constant so that the variability in farm level productivity due to variables such as water availability, stress days or fertilizer could be meaningfully interpreted. However, such a procedure would have required a considerably larger sample size than that was used for the study, which was not economically feasible.

Previously conducted field surveys and research investigations also had an influence on response of farmers to such interviews. Most farmers complained that they have answered many such questions for different research teams but nothing concrete had happened to solve any of their irrigation problems. Some farmers showed a very hostile attitude to such questioning. Part of these problems were overcome by providing patient explanations and making personnel observations during field visits to verify the information obtained. Perhaps a study of longer duration may enable more reliable information of the productivity at farm level coupled with verification of the information through personal observations.

B.3.4 PROBLEMS CAUSED BY UNCERTAINITIES OF NATURE

These are problems that cannot be practically surmounted. During field investigation during the 1983 Yala season, most of the practical difficulties of monitoring were identified, and appropriate measures were planned to circumvent most such problems. However, the problems caused by floods during the 1983/84 Maha season were not anticipated. The economic situation of most farmers due to loss of their crop rendered the 1984 Yala season unrepresentative of a typical dry season in comparison to the 1983 Yala season. Also, the farm level monitoring procedure were unable to provide satisfactory information on use or productivity of water at farm level because of this unrepresentaiveness. Thus, interpretations had to be largely based on field observations of the previous Yala season and field verifications rather than actual analysis of the farm level data. The only way such uncertainities in nature can be overcome is by increasing the duration of the study, which was not possible due to time and economic restrictions.

B.4 CONCLUSIONS

The above documentation of the problems and difficulties encountered in the field hopefully, will provide useful insights to plan and conduct future investigations into irrigation management. Also, better documentation of the field problems hopefully will allow future research investigations to proceed with better preparedness.

Table C1. Discharge rates, average depths, cross-sectional areas, average velocities, slopes and mannings roughness values obtained from discharge ratings along main channel. Kaudulla Irigation Scheme, Stage I.

Discharge rate in cubic meters/s	Average depth m	Cross section area sq.m	Average velocity m/sec	Slope m/m	Mannings' roughness values
2.86	0.42	4.33	0.66	0.00210	0.041
2.28	0.32	3.22	0.71	0.00210	0.030
3.16	0.77	5.75	0.55	0.00045	0.032
2.83	0.63	6.29	0.45	0.00035	0.031
2.93	0.69	6.85	0.43	0.00035	0.035
1.61	0.50	3.79	0.43	0.00010	0.015
3.06	0.67	5.31	0.58	0.00010	0.013
3.15	0.84	5.61	0.56	0.00040	0.031
1.40	0.62	4.09	0.34	0.00040	0.043
1.35	0.54	3.71	0.36	0.00020	0.026
2.84	0.70	6.18	0.46	0.00015	0.021
0.83	0.31	2.53	0.33	0.00015	0.017
2.80	0.58	5.07	0.55	0.00018	0.017
2.59	0.65	5.85	0.44	0.00018	0.023
0.93	0.27	2.19	0.43	0.00015	0.012
1.69	0.52	3.98	0.42	0.00020	0.022
1.79	0.39	2.86	0.63	0.00020	0.012
1.32	0.33	3.31	0.40	0.00020	0.018
0.64	0.19	1.74	0.37	0.00020	0.013
0.85	0.54	2.77	0.31	0.00073	0.056
1.35	0.59	3.16	0.43	0.00075	0.045
0.93	0.45	2.72	0.34	0.00055	0.041
2.51	0.67	6.52	0.39	0.00015	0.024

Table C-2. Daily discharge rates at the head of Main Channel for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE	YALA SEASON 1983		YALA SEASON 1984	
	WATER DEPTH M	DISCHARGE CU.M/S	WATER DEPTH M	DISCHARGE CU.M/S
APRIL 11	0.76	1.13	-	-
12	1.15	2.35	-	-
13	1.16	2.36	-	-
14	1.32	3.18	-	-
15	1.48	4.13	-	-
16	1.06	1.95	-	-
17	1.14	2.31	-	-
18	1.10	2.11	-	-
19	1.44	3.86	-	-
20	1.46	4.00	-	-
21	1.46	3.98	-	-
22	1.33	3.24	1.15	2.33
23	1.36	3.38	1.16	2.38
24	1.37	3.43	1.09	1.89
25	1.40	3.62	0.97	1.59
26	1.40	3.64	0.91	1.47
27	1.41	3.67	1.16	2.38
28	1.33	3.24	1.26	2.85
29	1.34	3.26	1.29	3.00
30	1.31	3.12	1.39	3.57
MAY 1	1.24	2.74	1.22	2.65
2	1.12	2.21	1.28	2.93
3	1.10	2.12	1.01	1.69
4	1.16	2.36	1.01	1.70
5	1.20	2.55	1.48	4.07
6	1.16	2.37	1.48	4.07
7	1.16	2.38	1.47	4.01
8	1.18	2.47	1.59	4.77
9	1.16	2.36	1.41	3.66
10	1.25	2.80	1.43	3.80
11			1.46	3.95
12			1.41	3.66
13	1.10	2.11	1.43	3.77
14	1.28	2.95	1.42	3.72
15	1.14	2.27	1.38	3.49
16	1.11	2.14	1.39	3.55
17	0.93	1.44	1.41	3.66
18	0.88	1.40	1.43	3.77
19	0.88	1.40	1.44	3.83
20	1.10	2.11	1.45	3.89
21	1.01	1.69	1.39	3.55
22	1.04	1.85	1.50	4.19
23	0.99	1.64	1.19	2.51
24	0.93	1.50	1.14	2.29
25	1.20	2.59	1.20	2.55
26	1.25	2.81	1.33	3.21
27	1.16	2.38	1.40	3.60
28	1.04	1.85	1.43	3.77
29	1.04	1.85	1.41	3.66
30	1.18	2.49	1.41	3.66
31	1.28	2.97	1.37	3.43
JUNE 1	1.25	2.82	1.33	3.21
2	0.84	1.29	1.42	3.72
3	0.97	1.60	1.49	4.13
4	1.00	1.68	0.99	1.64
5	1.22	2.66	1.27	2.90
6	1.18	2.49	1.49	4.13
7	1.14	2.31	1.46	3.95
8	1.10	2.14	1.50	4.19
9	1.09	2.09	1.54	4.44
10	1.14	2.31	1.55	4.51
11	1.16	2.38	1.49	4.13
12	1.19	2.52	1.50	4.19
13	1.28	2.97	1.49	4.13
14	1.32	3.16	1.45	3.92
15	1.29	3.02	1.41	3.66
16	1.23	2.71	1.39	3.55
17	1.04	1.88	1.41	3.66
18	1.06	1.95	1.53	4.37

Table C-2.....continued

DATE		YALA SEASON 1983		YALA SEASON 1984	
		WATER DEPTH M	DISCHARGE CU.M/S	WATER DEPTH M	DISCHARGE CU.M/S
JUNE	19	1.13	2.23	1.48	4.05
	20	1.24	2.77	1.46	3.98
	21	1.26	2.89	1.28	2.95
	22	1.24	2.77	1.28	2.98
	23	1.12	2.19	1.30	3.06
	24	0.93	1.51	1.31	3.11
	25	0.94	1.52	1.44	3.83
	26	0.91	1.45	1.37	3.46
	27	1.17	2.41	1.31	3.11
	28	1.21	2.60	1.32	3.16
	29	1.13	2.27	1.38	3.49
	30	1.08	2.01	1.51	4.25
JULY	1			1.50	4.22
	2			1.50	4.19
	3	1.26	2.89	1.35	3.32
	4	1.26	2.87	1.36	3.38
	5	1.29	3.02	1.36	3.38
	6	1.12	2.21	1.43	3.77
	7	1.01	1.70	1.46	3.95
	8	0.94	1.52	1.48	4.07
	9	0.96	1.57	1.29	3.00
	10	0.97	1.60		
	11	1.23	2.70		
	12	1.21	2.62		
	13	1.21	2.60		
	14	1.14	2.29		
	15	0.96	1.58		
	16	0.93	1.51		
	17	0.95	1.56	1.51	4.25
	18	1.07	1.98	1.49	4.13
	19	1.01	1.70	1.50	4.19
	20	1.01	1.69	1.55	4.51
	21	0.98	1.63		
	22	0.91	1.46		
	23	0.93	1.51		
	24	0.95	1.56	1.27	2.90
	25			1.47	4.01
	26			1.37	3.43
	27			1.39	3.52
	28			1.40	3.60
	29			1.46	3.98
	30			1.46	3.94
	31			1.36	3.38
AUGUST	1			1.32	3.16
	2			1.25	2.82
	3			1.23	2.73
	4			1.35	3.35
	5			1.31	3.11
	6	0.86	1.34	1.41	3.66
	7	0.85	1.33		
	8	0.84	1.30		
	9	0.69	0.97	1.39	3.52
	10	0.70	0.98	1.46	3.98
	11	0.76	1.13	1.54	4.47
	12	0.77	1.13	1.62	5.00
	13			1.47	4.01
	14			1.60	4.83
	15			1.42	3.72
	16			1.50	4.19
	17			1.59	4.77
	18			1.30	3.06
	19			1.37	3.46
	20			1.40	3.63
	21			1.43	3.30
	22			1.40	3.63
	23			1.44	3.83

Table C-3. Daily discharge rates at FC-1 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983 DEPTH	% OPEN	HEAD	DIS-CHARGE	YALA SEASON 1984 DEPTH	% OPEN	HEAD	DIS-CHARGE
APRIL	18					-			
	19					-			
	20	0.685	1.00	0.37	0.06	-			
	21	0.720	1.00	0.41	0.06	-			
	22	0.632	1.00	0.32	0.06	.224	1.00	0.09	0.03
	23	0.665	1.00	0.35	0.06	.240	1.00	0.10	0.03
	24	0.664	1.00	0.35	0.06	.175	1.00	0.06	0.03
	25	0.674	1.00	0.36	0.06	.144	1.00	0.05	0.02
	26	0.673	1.00	0.36	0.06				
	27	0.617	1.00	0.31	0.06	.274	1.00	0.12	0.04
	28	0.620	1.00	0.31	0.06	.330	1.00	0.16	0.04
	29	0.646	1.00	0.33	0.06	.368	1.00	0.19	0.04
	30	0.602	1.00	0.29	0.05	.482	1.00	0.29	0.05
MAY	1	0.570	1.00	0.26	0.05	.330	1.00	0.16	0.04
	2	0.480	1.00	0.19	0.04	.395	1.00	0.21	0.05
	3	0.600	1.00	0.29	0.05	.212	1.00	0.08	0.03
	4	0.506	1.00	0.21	0.05	.244	1.00	0.10	0.03
	5	0.550	1.00	0.25	0.05	.538	1.00	0.34	0.06
	6	0.680	1.00	0.37	0.06	.541	1.00	0.34	0.06
	7	0.707	1.00	0.39	0.06	.550	1.00	0.35	0.06
	8					.550	1.00	0.35	0.06
	9	0.575	1.00	0.27	0.05	.445	0.26	0.25	0.01
	10	0.619	1.00	0.31	0.06	.491	1.00	0.29	0.06
	11					.538	0.26	0.34	0.01
	12					.437	0.26	0.25	0.01
	13	0.506	1.00	0.21	0.05	.539	0.26	0.34	0.01
	14	0.640	1.00	0.33	0.06	.430	0.26	0.24	0.01
	15	0.505	1.00	0.21	0.05	.407	0.68	0.22	0.03
	16					.426	0.68	0.24	0.03
	17					.436	0.68	0.25	0.03
	18					.510	0.68	0.31	0.04
	19					.565	0.68	0.36	0.04
	20					.455	0.68	0.26	0.03
	21					.380	0.68	0.20	0.03
	22					.395	0.68	0.21	0.03
	23	0.408	1.00	0.13	0.04	.220	0.68	0.09	0.02
	24	0.365	1.00	0.11	0.03	.308	0.68	0.15	0.02
	25	0.540	1.00	0.24	0.05	.339	0.68	0.17	0.03
	26	0.584	1.00	0.28	0.05	.413	0.68	0.23	0.03
	27	0.525	1.00	0.22	0.05	.400	0.68	0.22	0.03
	28	0.532	1.00	0.23	0.05	.497	0.68	0.30	0.03
	29	0.570	1.00	0.26	0.05	.446	0.68	0.25	0.03
	30					.404	0.68	0.22	0.03
	31	0.598	1.00	0.29	0.05				
JUNE	1	0.570	1.00	0.26	0.05				
	2								
	3					.454	0.55	0.26	0.02
	4	0.510	1.00	0.21	0.05				
	5	0.700	1.00	0.39	0.06	.378	1.00	0.20	0.05
	6	0.580	1.00	0.27	0.05	.424	1.00	0.24	0.05
	7	0.530	1.00	0.23	0.05	.375	1.00	0.20	0.04
	8	0.596	1.00	0.29	0.05	.445	1.00	0.25	0.05
	9	0.539	1.00	0.24	0.05	.485	1.00	0.29	0.05
	10					.510		0.31	0.00
	11					.465		0.27	0.00
	12	0.532	1.00	0.23	0.05	.470	1.00	0.28	0.05
	13					.449	1.00	0.26	0.05
	14								
	15								
	16								
	17	0.560	1.00	0.25	0.05	.379	0.12	0.20	.00
	18	0.575	1.00	0.27	0.05	.456	0.72	0.26	0.04
	19	0.615	1.00	0.30	0.06	.431	0.72	0.24	0.03
	20					.400	0.72	0.22	0.03
	21								
	22								
	23								

Table C-3.....continued

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	% OPEN	HEAD	DIS-CHARGE	DEPTH	% OPEN	HEAD	DIS-CHARGE
	24					.353	1.00	0.18	0.04
	25	0.452	1.00	0.17	0.04	.382	1.00	0.20	0.05
	26	0.480	1.00	0.19	0.04	.380	1.00	0.20	0.05
	27	0.510	1.00	0.21	0.05	.378	1.00	0.20	0.05
	28	0.545	1.00	0.24	0.05				
	29	0.535	1.00	0.23	0.05	.375	1.00	0.20	0.04
	30	0.494	1.00	0.20	0.05				
JULY	1								
	2					.451	1.00	0.26	0.05
	3					.354	1.00	0.18	0.04
	4					.294	1.00	0.14	0.04
	5					.329	1.00	0.16	0.04
	6	0.602	1.00	0.29	0.05				
	7								
	8					.568	0.49	0.37	0.02
	9					.422	0.49	0.23	0.02
	10								
	11	0.565	1.00	0.26	0.05				
	12	0.565	1.00	0.26	0.05				
	13	0.546	1.00	0.24	0.05				
	14	0.570	1.00	0.26	0.05				
	15	0.498	1.00	0.20	0.05				
	16	0.455	1.00	0.17	0.04				
	17	0.476	1.00	0.19	0.04	.514	0.49	0.32	0.02
	18	0.508	1.00	0.21	0.05	.492	0.49	0.30	0.02
	19	0.415	1.00	0.14	0.04	.477	0.49	0.28	0.02
	20	0.421	1.00	0.14	0.04	.541	1.00	0.34	0.06
	21	0.415	1.00	0.14	0.04				
	22	0.371	1.00	0.11	0.03				
	23	0.413	1.00	0.14	0.04				
	24	0.428	1.00	0.15	0.04	.313	1.00	0.15	0.04
	25					.478	1.00	0.28	0.05
	26					.408	1.00	0.22	0.05
	27					.412	1.00	0.23	0.05
	28					.429	1.00	0.24	0.05
	29					.558	1.00	0.36	0.06
	30					.572	1.00	0.37	0.06
	31					.380	1.00	0.20	0.05
AUGUST	1					.362	1.00	0.19	0.04
	2					.300	1.00	0.14	0.04
	3					.290	1.00	0.13	0.04
	4					.338	1.00	0.17	0.04
	5					.377	1.00	0.20	0.05
	6	0.544	1.00	0.24	0.05	.430	1.00	0.24	0.05
	7	0.628	1.00	0.32	0.06				
	8	0.470	1.00	0.18	0.04				
	9	0.444	1.00	0.16	0.04	.380	1.00	0.20	0.05
	10					.435	1.00	0.25	0.05
	11	0.448	1.00	0.16	0.04	.491	1.00	0.29	0.06
	12	0.356	1.00	0.10	0.03	.547	1.00	0.35	0.06
	13								
	14					.590	1.00	0.39	0.06
	15					.420	1.00	0.23	0.05
	16					.454	1.00	0.26	0.05
	17					.702	1.00	0.51	0.07
	18					.462	1.00	0.27	0.05
	19					.376	1.00	0.20	0.05
	20					.416	1.00	0.23	0.05
	21					.446	0.61	0.25	0.03
	22					.416	0.61	0.23	0.03
	23					.568	0.61	0.37	0.03

Table C-4. Daily discharge rates at D-1 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983					YALA SEASON 1984				
		DEPTH	% OPEN	% OPEN	% OPEN	DIS-CHRG.	DEPTH	% OPEN	% OPEN	% OPEN	DIS-CHRG.
APRIL	18	0.71	1.00	1.00	1.00	1.12	-				
	19	0.95	1.00	1.00	1.00	1.42	-				
	20	0.97	1.00	1.00	1.00	1.44	-				
	21	1.02	1.00	1.00	1.00	1.49	-				
	22	0.96	1.00	1.00	1.00	1.42	0.76	0.92	0.93	0.89	1.09
	23	0.94	1.00	1.00	1.00	1.41	0.66	0.92	0.93	0.89	0.96
	24	0.95	1.00	1.00	1.00	1.42	0.70	0.92	0.93	0.89	1.01
	25	0.97	1.00	1.00	1.00	1.44	0.66	0.92	0.93	0.89	0.97
	26	0.94	1.00	1.00	1.00	1.41	0.63	0.92	0.93	0.89	0.92
	27	1.10	1.00	0.00	0.00	0.53	0.79	0.92	0.93	0.89	1.12
	28	0.86	1.00	1.00	1.00	1.32	0.85	0.92	0.93	0.89	1.19
	29	0.90	1.00	1.00	1.00	1.36					
	30	0.84	1.00	0.00	0.00	0.43					
MAY	1	0.80	1.00	0.50	0.50	0.82	0.84	0.92	0.93	0.89	1.18
	2	0.74	1.00	1.00	1.00	1.16	0.96	0.92	0.93	0.89	1.31
	3	0.72	1.00	1.00	1.00	1.13	0.75	0.92	0.93	0.89	1.08
	4	0.78	1.00	1.00	1.00	1.21	0.79	0.92	0.93	0.89	1.12
	5	0.81	1.00	1.00	1.00	1.25	1.10	0.92	0.93	0.89	1.43
	6						1.12	0.92	0.93	0.89	1.45
	7						1.12	0.92	0.93	0.63	1.28
	8	0.80	1.00	1.00	1.00	1.24	1.14	0.92	0.93	0.63	1.29
	9	0.83	1.00	1.00	1.00	1.28	0.98	0.92	0.93	0.63	1.17
	10	0.86	1.00	1.00	1.00	1.31	1.05	0.92	0.93	0.63	1.22
	11						1.11	0.92	0.93	0.63	1.27
	12						0.98	0.92	0.93	0.63	1.16
	13	0.76	1.00	0.00	0.00	0.39	1.09	0.92	0.93	0.63	1.26
	14	0.89	1.00	1.00	1.00	1.35	0.97	0.92	0.93	0.63	1.15
	15	0.75	1.00	1.00	1.00	1.17	0.95	0.92	0.93	0.63	1.14
	16	0.73	0.50	0.50	0.50	0.57	0.96	0.92	0.93	0.63	1.15
	17	0.53	1.00	1.00	1.00	0.84	0.99	0.92	0.93	0.63	1.18
	18	0.58	1.00	1.00	1.00	0.92	0.98	0.92	0.93	0.89	1.32
	19						1.02	0.92	0.93	0.89	1.36
	20						1.00	0.92	0.93	0.89	1.34
	21						0.93	0.92	0.93	0.89	1.27
	22	0.71	1.00	1.00	1.00	1.12	0.94	0.92	0.93	0.89	1.28
	23	0.67	1.00	1.00	1.00	1.07	0.76	0.92	0.93	0.89	1.08
	24	0.62	1.00	1.00	1.00	0.99	0.74	0.92	0.93	0.89	1.07
	25	0.79	1.00	1.00	1.00	1.23	0.75	0.92	0.93	0.89	1.08
	26	0.86	1.00	1.00	1.00	1.31	0.85	0.92	0.93	0.89	1.19
	27	0.79	1.00	1.00	1.00	1.22	0.92	0.92	0.93	0.89	1.26
	28	0.86	1.00	1.00	0.00	0.88	0.98	0.92	0.93	0.89	1.32
	29						0.93	0.92	0.93	0.89	1.28
	30	0.80	1.00	1.00	1.00	1.24	0.93	0.92	0.93	0.89	1.27
	31	0.84	1.00	1.00	1.00	1.28					
JUNE	1	0.81	1.00	1.00	1.00	1.25					
	2										
	3						0.96	0.92	0.93	0.39	1.31
	4						0.57	0.92	0.93	0.39	0.82
	5						0.65	0.92	0.93	0.89	0.94
	6	0.87	1.00	1.00	1.00	1.32	0.97	0.92	0.93	0.89	1.31
	7	0.77	1.00	1.00	1.00	1.20	0.93	0.92	0.93	0.89	1.28
	8	0.93	1.00	1.00	1.00	1.40	0.99	0.92	0.93	0.89	1.34
	9	0.86	1.00	1.00	1.00	1.31	1.03	0.92	0.93	0.89	1.37
	10	0.86	1.00	1.00	1.00	1.31	1.07	0.92	0.93	0.89	1.41
	11	0.77	1.00	1.00	1.00	1.20	1.02	0.92	0.93	0.39	1.36
	12	0.81	1.00	1.00	1.00	1.25	1.01	0.92	0.93	0.39	1.35
	13	0.89	1.00	1.00	1.00	1.35	1.00	0.92	0.93	0.89	1.34
	14	0.92	1.00	1.00	1.00	1.38	1.20	0.04	0.00	0.00	.00
	15	0.88	1.00	1.00	1.00	1.33	1.14	0.04	0.00	0.00	.00
	16	0.85	1.00	1.00	1.00	1.30	1.14	0.04	0.00	0.00	.00
	17						0.92	0.92	0.93	0.89	1.26
	18						1.00	0.92	0.93	0.89	1.34
	19						0.98	0.92	0.93	0.89	1.32
	20	0.85	1.00	1.00	1.00	1.31	0.95	0.92	0.93	0.89	1.30
	21	0.88	1.00	1.00	1.00	1.34	0.88	0.92	0.93	0.89	1.22
	22	0.87	1.00	1.00	1.00	1.32	0.86	0.92	0.93	0.89	1.20
	23	0.75	1.00	0.50	0.00	0.59	0.88	0.92	0.93	0.39	1.22
	24	0.79	1.00	0.50	0.00	0.61	0.90	0.92	0.93	0.39	1.25
	25						0.94	0.92	0.93	0.89	1.29

Table C-4.....continued

DATE		YALA SEASON 1983					YALA SEASON 1984				
		DEPTH	% OPEN	% OPEN	% OPEN	DIS-CHRG.	DEPTH	% OPEN	% OPEN	% OPEN	DIS-CHRG.
JUNE	26						0.94	0.92	0.93	0.89	1.29
	27	0.78	1.00	1.00	1.00	1.22	0.94	0.92	0.93	0.89	1.29
	28	0.82	1.00	1.00	1.00	1.26	0.84	0.92	0.93	0.89	1.18
	29	0.78	1.00	1.00	1.00	1.21	0.94	0.92	0.93	0.89	1.28
	30	0.76	1.00	1.00	1.00	1.19	1.06	0.92	0.93	0.89	1.40
JULY	1						1.02	0.92	0.93	0.89	1.37
	2						0.99	0.92	0.93	0.89	1.34
	3	1.00	1.00	0.00	0.00	0.49	0.87	0.92	0.93	0.89	1.21
	4	0.84	1.00	0.00	0.00	0.43	0.86	0.92	0.93	0.89	1.20
	5	0.90	1.00	1.00	1.00	1.36	0.90	0.92	0.93	0.89	1.25
	6	0.86	1.00	1.00	1.00	1.32	0.98	0.92	0.93	0.89	1.33
	7	0.79	1.00	0.00	0.00	0.41	1.03	0.92	0.93	0.89	1.37
	8						1.04	0.92	0.93	0.89	1.38
	9						0.93	0.92	0.93	0.89	1.27
	10										
	11	0.83	1.00	1.00	1.00	1.28					
	12	0.83	1.00	1.00	1.00	1.28					
	13	0.81	1.00	1.00	1.00	1.26					
	14	0.88	1.00	1.00	1.00	1.33					
	15										
	16										
	17						1.08	0.92	0.93	0.89	1.42
	18	0.81	1.00	1.00	1.00	1.26	1.06	0.92	0.93	0.89	1.40
	19	0.68	1.00	1.00	1.00	1.07	1.08	0.92	0.93	0.89	1.42
	20	0.67	1.00	1.00	1.00	1.06	1.11	0.92	0.93	0.89	1.45
	21	0.92	1.00	1.00	1.00	1.38					
	22	0.63	1.00	1.00	1.00	1.00					
	23	0.70	1.00	0.50	0.00	0.55					
	24	0.71	1.00	0.50	0.00	0.56	0.86	0.92	0.93	0.89	1.20
	25						1.04	0.92	0.93	0.89	1.38
	26						0.97	0.92	0.93	0.89	1.31
	27						0.98	0.38	0.77	0.72	0.80
	28						0.98	0.38	0.77	0.72	0.80
	29						1.03	0.38	0.77	0.72	0.83
	30						0.92	0.38	0.77	0.72	0.76
	31						0.90	0.38	0.77	0.72	0.75
AUGUST	1						0.90	0.38	0.93	0.89	0.93
	2						0.83	0.00	0.93	0.89	0.78
	3						0.84	0.00	0.93	0.89	0.78
	4						0.95	0.00	0.93	0.89	0.86
	5						0.92	0.00	0.93	0.89	0.84
	6	0.90	0.00	1.00	0.50	0.68	0.97	0.00	0.93	0.89	0.87
	7	1.03	0.00	1.00	0.50	0.75					
	8	0.87	0.00	1.00	0.50	0.66					
	9	0.87	0.00	1.00	0.50	0.66	0.92	0.92	0.93	0.89	1.26
	10						0.97	0.92	0.93	0.89	1.32
	11	0.54	0.00	0.00	0.50	0.14					
	12	0.59	1.00	1.00	1.00	0.94	1.10	0.92	0.93	0.89	1.44
	13						1.14	0.92	0.93	0.89	1.47
	14						1.16	0.92	0.93	0.89	1.49
	15						0.96	0.92	0.93	0.89	1.31
	16						1.09	0.92	0.93	0.89	1.43
	17										
	18										
	19						0.91	0.92	0.93	0.89	1.25
	20						0.87	0.92	0.93	0.89	1.21
	21						1.02	0.92	0.93	0.89	1.36
	22						0.96	0.92	0.93	0.89	1.30
	23						1.13	0.00	0.93	0.57	0.75
	24						0.55	0.00	0.93	0.57	0.41
	25										

Table C-5. Daily discharge rates at D-2 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983			YALA SEASON 1984		
		DEPTH	% OPEN	DIS-CHARGE	DEPTH	% OPEN	DIS-CHARGE
APRIL	18	0.750	0.92	0.269	-		
	19	0.915	0.92	0.309	-		
	20	0.930	0.92	0.312	-		
	21	0.930	0.92	0.312	-		
	22	0.930	0.92	0.312	0.600	0.92	0.227
	23	0.930	0.92	0.312	0.578	0.92	0.220
	24	0.930	0.92	0.312	0.550	0.92	0.211
	25	0.930	0.92	0.312	0.508	0.92	0.197
	26	0.915	0.92	0.309	0.466	0.27	0.024
	27	0.893	0.92	0.304	0.623	0.92	0.234
	28	0.870	0.92	0.298	0.653	0.92	0.243
	29	0.915	0.92	0.309	0.647	0.92	0.241
	30	0.840	0.92	0.291	0.870	0.92	0.298
MAY	1	0.750	0.92	0.269	0.666	0.92	0.246
	2	0.750	0.92	0.269	0.639	0.92	0.239
	3	0.750	0.92	0.269	0.471	0.92	0.183
	4	0.750	0.92	0.269	0.483	0.92	0.188
	5	0.780	0.92	0.277	0.781	0.92	0.277
	6	0.893	0.92	0.304	0.844	0.92	0.292
	7	1.005	0.92	0.328	0.830	0.92	0.289
	8	0.855	0.50	0.124	0.835	0.92	0.290
	9	0.840	0.50	0.122	0.829	0.72	0.213
	10	0.900	0.50	0.128	0.829	0.72	0.213
	11				0.828	0.72	0.213
	12				0.832	0.72	0.213
	13	0.720	0.92	0.261	0.806	0.72	0.209
	14	0.825	0.92	0.288	0.809	0.72	0.209
	15	0.765	0.50	0.115	0.789	0.72	0.206
	16	0.720	0.92	0.261	0.801	0.72	0.208
	17	0.570	0.92	0.218	0.827	0.72	0.213
	18	0.615	0.92	0.232	0.828	0.72	0.213
	19				0.807	0.72	0.209
	20				0.885	0.72	0.223
	21				0.786	0.72	0.205
	22	0.720	0.92	0.261	0.775	0.72	0.203
	23	0.630	0.92	0.236	0.619	0.72	0.172
	24	0.630	0.92	0.236	0.615	0.72	0.171
	25	0.840	0.92	0.291	0.600	0.72	0.167
	26				0.704	0.72	0.189
	27				0.807	0.72	0.209
	28	0.840	0.50	0.122	0.847	0.72	0.216
	29	1.020	0.50	0.139	0.805	0.72	0.209
	30	0.960	0.92	0.319	0.790	0.72	0.206
	31	0.930	0.92	0.312	0.843	0.72	0.215
JUNE	1	0.870	0.92	0.298	0.867	0.72	0.220
	2						
	3				0.956	0.92	0.318
	4				0.494	0.92	0.192
	5				0.705	0.92	0.257
	6	0.540	0.92	0.208	0.765	0.92	0.273
	7	0.990	0.92	0.325	0.720	0.92	0.261
	8	0.780	0.92	0.277	0.809	0.92	0.284
	9	0.660	0.92	0.245	0.830	0.92	0.289
	10				0.923	0.02	.000
	11				0.813	0.92	0.285
	12				0.804	0.92	0.283
	13	0.870	0.92	0.298	0.775	0.92	0.275
	14	0.900	0.92	0.305	0.956	0.05	0.001
	15	0.930	0.92	0.312	1.010	0.05	0.001
	16				1.019	0.05	0.001
	17				0.738	0.92	0.266
	18				0.780	0.92	0.277
	19				0.781	0.92	0.277
	20	0.780	0.92	0.277	0.750	0.92	0.269
	21	0.930	0.92	0.312			
	22	0.930	0.92	0.312			
	23						

Table C-5.....continued

DATE		YALA SEASON 1983			YALA SEASON 1984		
		DEPTH	% OPEN	DIS-CHARGE	DEPTH	% OPEN	DIS-CHARGE
	24				0.691	0.92	0.253
	25				0.785	0.71	0.201
	26				0.797	0.71	0.203
	27	0.690	0.92	0.253	0.808	0.71	0.205
	28	0.990	0.92	0.325			
	29	0.990	0.92	0.325			
	30						
JULY	1						
	2				0.822	0.92	0.287
	3	0.960	0.92	0.319	0.716	0.92	0.260
	4	0.810	0.92	0.284	0.819	0.92	0.286
	5	0.900	0.92	0.305			
	6	0.900	0.92	0.305			
	7						
	8				0.948	0.92	0.316
	9				0.892	0.92	0.303
	10						
	11	0.810	0.92	0.284			
	12	0.870	0.92	0.298			
	13	0.870	0.92	0.298			
	14						
	15						
	16						
	17				0.967	0.92	0.320
	18	0.840	0.92	0.291	0.980	0.92	0.323
	19	0.900	0.92	0.305	1.026	0.92	0.333
	20	0.930	0.92	0.312			
	21						
	22						
	23						
	24				0.723	0.92	0.262
	25				0.896	0.92	0.304
	26						
	27						
	28						
	29				0.952	0.92	0.317
	30				0.978	0.92	0.322
	31				0.838	0.92	0.291
AUGUST	1				0.798	0.92	0.281
	2						
	3						
	4						
	5				0.707	0.92	0.258
	6	0.660	0.92	0.245	0.900	0.92	0.305
	7	0.840	0.92	0.291			
	8	0.540	0.92	0.208			
	9				0.922	0.92	0.310
	10				0.907	0.92	0.307
	11	0.540	0.92	0.208	0.966	0.92	0.320
	12	0.480	0.92	0.187	1.024	0.92	0.332
	13				0.965	0.16	0.014
	14						
	15						
	16						
	17				1.094	0.26	0.042
	18				0.860	0.26	0.036
	19				0.764	0.87	0.256
	20				0.848	0.87	0.275
	21				0.890	0.87	0.284
	22				0.810	0.87	0.267
	23						
	24				0.618	0.87	0.218

Table C-6. Daily discharge rates at D-3 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

		YALA SEASON 1983				YALA SEASON 1984			
DATE		DEPTH	HEAD	% OPEN	DIS-CHARGE	DEPTH	HEAD	% OPEN	DIS-CHARGE
APRIL	18	0.42	0.17	0.68	0.037	-			-
	19	0.68	0.37	0.68	0.055	-			-
	20	0.79	0.46	0.68	0.061	-			-
	21	0.82	0.49	0.68	0.063	-			-
	22	0.78	0.45	0.68	0.061	0.57	0.28	0.52	0.031
	23	0.79	0.46	0.68	0.061	0.45	0.18	0.68	0.039
	24	0.79	0.46	0.68	0.061	0.37	0.13	0.68	0.033
	25	0.78	0.45	0.68	0.061	0.52	0.24	0.68	0.044
	26	0.77	0.44	0.68	0.060	0.56	0.28	0.68	0.048
	27	0.89	0.55	0.68	0.067	0.61	0.31	0.68	0.051
	28	0.74	0.42	0.68	0.058	0.61	0.32	0.68	0.051
	29	0.86	0.52	0.68	0.065	0.66	0.36	0.68	0.054
	30	0.64	0.34	0.68	0.052	0.78	0.46	0.68	0.061
MAY	1	0.67	0.36	0.68	0.054	0.63	0.33	0.68	0.052
	2	0.59	0.30	0.68	0.049	0.60	0.31	0.68	0.050
	3	0.58	0.29	0.68	0.048	0.80	0.47	0.68	0.062
	4	0.61	0.32	0.68	0.051	0.41	0.15	0.68	0.036
	5	0.64	0.34	0.68	0.052	0.73	0.41	0.68	0.058
	6				0.000	0.80	0.47	0.68	0.062
	7				0.000	0.79	0.46	0.68	0.061
	8				0.000	0.77	0.45	0.68	0.061
	9	0.71	0.40	0.50	0.035	0.77	0.44	0.68	0.060
	10	0.75	0.43	0.68	0.059	0.78	0.45	0.68	0.061
	11				0.000	0.79	0.46	0.68	0.061
	12				0.000	0.84	0.51	0.68	0.064
	13	0.59	0.30	0.68	0.049	0.77	0.44	0.68	0.060
	14	0.66	0.35	0.68	0.054	0.75	0.43	0.68	0.059
	15	0.60	0.30	0.50	0.031	0.73	0.41	0.68	0.058
	16	0.53	0.25	0.68	0.045	0.75	0.42	0.68	0.059
	17	0.46	0.19	0.68	0.040	0.77	0.45	0.68	0.060
	18	0.51	0.24	0.50	0.027	0.77	0.45	0.68	0.061
	19				0.000	0.76	0.44	0.68	0.060
	20				0.000	0.85	0.51	0.02	.000
	21				0.000	0.73	0.41	0.02	.000
	22				0.000	0.68	0.37	0.02	.000
	23				0.000	0.56	0.28	0.68	0.047
	24	0.46	0.20	0.68	0.040	0.54	0.26	0.68	0.046
	25	0.57	0.28	0.68	0.048	0.52	0.24	0.46	0.024
	26				0.000	0.63	0.33	0.46	0.028
	27				0.000	0.74	0.42	0.46	0.031
	28				0.000	0.78	0.46	0.46	0.033
	29				0.000	0.74	0.42	0.46	0.031
	30	0.53	0.27	0.68	0.047	0.70	0.39	0.46	0.030
	31	0.64	0.34	0.68	0.052				0.000
JUNE	1	0.60	0.31	0.68	0.050				0.000
	2				0.000				0.000
	3				0.000	0.86	0.52	0.66	0.063
	4				0.000				0.000
	5				0.000	0.60	0.31	0.66	0.048
	6	0.84	0.51	0.50	0.040	0.67	0.36	0.66	0.052
	7	0.55	0.26	0.68	0.046	0.62	0.32	0.66	0.049
	8	0.55	0.27	0.68	0.047	0.72	0.40	0.66	0.055
	9				0.000	0.74	0.42	0.66	0.056
	10				0.000	0.83	0.50	0.33	0.018
	11				0.000	0.75	0.43	0.63	0.053
	12				0.000	0.71	0.40	0.63	0.051
	13	0.68	0.37	0.68	0.055	0.67	0.36	0.63	0.049
	14	0.67	0.36	0.68	0.054	0.77	0.44	0.63	0.053
	15	0.65	0.34	0.68	0.053				0.000
	16				0.000				0.000
	17				0.000	0.68	0.37	0.57	0.042
	18				0.000	0.70	0.39	0.57	0.043
	19				0.000	0.68	0.37	0.57	0.042
	20	0.63	0.33	0.68	0.052	0.66	0.35	0.57	0.041
	21	0.64	0.34	0.68	0.052	0.65	0.35	0.13	0.002
	22	0.63	0.33	0.68	0.052				0.000

Table C-6.....continued

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DIS-CHARGE	DEPTH	HEAD	% OPEN	DIS-CHARGE
	23				0.000				0.000
	24				0.000	0.57	0.28	0.52	0.031
	25				0.000	0.70	0.39	0.51	0.036
	26				0.000	0.68	0.37	0.51	0.035
	27	0.52	0.24	0.68	0.045	0.67	0.36	0.51	0.035
	28	0.58	0.29	0.68	0.048				0.000
	29	0.59	0.27	0.68	0.047				0.000
	30				0.000				0.000
JULY	1				0.000				0.000
	2				0.000	0.72	0.41	0.58	0.045
	3				0.000	0.61	0.32	0.58	0.040
	4	0.65	0.34	0.68	0.053	0.54	0.26	0.58	0.036
	5	0.58	0.29	0.68	0.049	0.62	0.33	0.07	0.001
	6	0.59	0.30	0.68	0.049				0.000
	7				0.000				0.000
	8				0.000	0.80	0.47	0.60	0.052
	9				0.000	0.87	0.53	0.61	0.056
	10				0.000				0.000
	11	0.56	0.27	0.68	0.047				0.000
	12	0.56	0.28	0.68	0.047				0.000
	13	0.54	0.26	0.68	0.046				0.000
	14				0.000				0.000
	15				0.000				0.000
	16				0.000				0.000
	17				0.000	0.74	0.42	0.60	0.049
	18	0.45	0.19	0.68	0.039	0.75	0.43	0.60	0.049
	19	0.44	0.18	0.68	0.038	0.78	0.45	0.60	0.050
	20	0.47	0.20	0.68	0.040				0.000
	21				0.000				0.000
	22				0.000				0.000
	23				0.000				0.000
	24				0.000	0.48	0.21	0.67	0.040
	25			0.10	0.000	0.65	0.35	0.67	0.050
	26				0.000				0.000
	27				0.000				0.000
	28				0.000				0.000
	29				0.000	0.79	0.46	0.67	0.059
	30				0.000	0.78	0.46	0.67	0.059
	31				0.000	0.60	0.31	0.55	0.036
AUGUST	1				0.000	0.63	0.33	0.55	0.037
	2				0.000				0.000
	3				0.000				0.000
	4				0.000				0.000
	5				0.000	0.57	0.28	0.39	0.019
	6	0.38	0.13	0.68	0.033	0.66	0.36	0.39	0.022
	7				0.000				0.000
	8				0.000				0.000
	9				0.000	0.71	0.39	0.40	0.024
	10				0.000	0.69	0.38	0.40	0.023
	11				0.000				0.000
	12				0.000	1.01	0.65	0.40	0.031
	13				0.000	0.84	0.51	0.40	0.027
	14				0.000	0.91	0.56	0.39	0.027
	15				0.000				0.000
	16				0.000				0.000
	17				0.000				0.000
	18				0.000	0.63	0.33	0.39	0.021
	19				0.000				0.000
	20				0.000				0.000
	21				0.000				0.000
	22				0.000	0.72	0.41	0.39	0.023

Table C-7. Daily discharge rates at FC-4 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DIS-CHARGE	DEPTH	HEAD	% OPEN	DIS-CHARGE
APRIL	18	0.84	0.41	0.87	0.05	-			
	19	0.97	0.52	0.87	0.06	-			
	20	1.03	0.58	0.87	0.06	-			
	21	1.07	0.62	0.87	0.06	-			
	22	1.01	0.56	0.87	0.06	0.76	0.35	0.80	0.05
	23	1.03	0.58	0.87	0.06	0.62	0.27	0.87	0.05
	24	1.05	0.59	0.87	0.06	0.69	0.31	0.87	0.05
	25	1.01	0.56	0.87	0.06	0.74	0.34	0.87	0.05
	26	1.00	0.55	0.87	0.06	0.77	0.36	0.87	0.05
	27	1.14	0.68	0.87	0.07	0.80	0.38	0.87	0.05
	28	0.98	0.53	0.87	0.06	0.80	0.38	0.87	0.05
	29	1.13	0.68	0.87	0.06	0.82	0.37	0.87	0.05
	30	0.95	0.51	0.87	0.05	0.84	0.33	0.87	0.05
MAY	1	0.91	0.47	0.87	0.05	0.83	0.41	0.87	0.06
	2	0.83	0.41	0.87	0.05	0.79	0.38	0.87	0.05
	3	0.81	0.38	0.87	0.04	0.89	0.46	0.87	0.06
	4	0.83	0.41	0.87	0.05	0.63	0.27	0.87	0.04
	5	0.87	0.44	0.87	0.05	0.91	0.46	0.87	0.06
	6	1.04	0.58	0.87	0.06	1.00	0.55	0.87	0.06
	7	1.15	0.69	0.87	0.07	0.99	0.56	0.87	0.07
	8	1.07	0.62	0.87	0.06	0.99	0.54	0.87	0.06
	9					0.97	0.53	0.87	0.06
	10	1.05	0.59	0.87	0.06	0.97	0.53	0.87	0.06
	11					0.98	0.52	0.87	0.06
	12					0.99	0.53	0.87	0.06
	13	0.82	0.40	0.87	0.05	0.98	0.53	0.87	0.06
	14					0.95	0.52	0.87	0.06
	15					0.94	0.50	0.87	0.06
	16	0.79	0.37	0.87	0.04	0.95	0.53	0.87	0.06
	17	0.69	0.30	0.87	0.04	0.97	0.54	0.87	0.06
	18					0.98	0.52	0.87	0.06
	19					0.94	0.51	0.87	0.06
	20					1.07	0.61	0.87	0.07
	21					0.94	0.49	0.87	0.06
	22	0.84	0.41	0.87	0.05	0.91	0.46	0.87	0.06
	23	0.77	0.36	0.87	0.04	0.78	0.36	0.87	0.05
	24	0.68	0.29	0.87	0.04	0.74	0.31	0.87	0.05
	25	0.76	0.35	0.87	0.04	0.73	0.30	0.87	0.05
	26					0.84	0.44	0.87	0.06
	27					0.95	0.48	0.87	0.06
	28					0.98	0.52	0.87	0.06
	29					0.93	0.44	0.87	0.06
	30	0.75	0.34	0.87	0.04	0.93	0.45	0.87	0.06
	31	0.83	0.40	0.87	0.05	0.99	0.60	0.87	0.07
JUNE	1	0.81	0.39	0.87	0.05	1.02	0.60	0.87	0.07
	2					1.12	0.66	0.87	0.07
	3	0.84	0.41	0.87	0.05	1.11	0.67	0.21	0.01
	4					0.67	0.31	0.21	.00
	5					0.60	0.22	0.21	.00
	6	1.08	0.63	0.87	0.06	0.85	0.43	0.21	.00
	7	0.76	0.35	0.87	0.04	0.83	0.41	0.21	.00
	8	0.76	0.35	0.87	0.04	0.92	0.47	0.21	.00
	9					0.93	0.50	0.21	.00
	10					1.05	0.67	0.21	0.01
	11					0.95	0.56	0.21	0.01
	12					0.91	0.52	0.21	0.01
	13	0.90	0.46	0.87	0.05	0.87	0.44	0.21	.00
	14	0.91	0.47	0.87	0.05	0.93	0.64	0.00	0.00
	15	0.88	0.45	0.87	0.05				
	16	0.85	0.42	0.87	0.05				
	17					0.93	0.52	0.29	0.01
	18					0.91	0.50	0.29	0.01
	19					0.88	0.49	0.29	0.01
	20	0.86	0.43	0.87	0.05	0.87	0.45	0.29	0.01
	21	0.87	0.44	0.87	0.05	0.87	0.43	0.29	0.01
	22	0.86	0.43	0.87	0.05				
	23								

Table C-7.....continued

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DIS-CHARGE	DEPTH	HEAD	% OPEN	DIS-CHARGE
	24					0.75	0.34	0.19	.00
	25					0.92	0.46	0.65	0.04
	26					0.89	0.45	0.65	0.04
	27	0.75	0.34	0.87	0.04	0.86	0.39	0.65	0.04
	28	0.80	0.38	0.87	0.04				
	29	0.78	0.37	0.87	0.04				
	30								
JULY	1								
	2					0.93	0.50	0.49	0.03
	3					0.81	0.39	0.49	0.02
	4	0.88	0.45	0.87	0.05	0.77	0.35	0.49	0.02
	5	0.88	0.45	0.87	0.05				
	6	0.82	0.39	0.87	0.05				
	7								
	8					1.03	0.50	0.45	0.02
	9					1.12	0.67	0.45	0.03
	10								
	11	0.76	0.35	0.87	0.04				
	12	0.75	0.34	0.87	0.04				
	13	0.75	0.34	0.87	0.04				
	14	0.79	0.37	0.87	0.04				
	15								
	16	0.91	0.47	0.87	0.05				
	17					0.95	0.52	0.45	0.02
	18	0.67	0.28	0.87	0.04	0.95	0.52	0.45	0.02
	19	0.65	0.27	0.87	0.03	0.99	0.53	0.45	0.02
	20	0.68	0.29	0.87	0.04				
	21								
	22								
	23								
	24					0.67	0.28	0.09	.00
	25					0.92	0.47	0.09	.00
	26								
	27								
	28								
	29					1.02	0.51	0.43	0.02
	30					1.03	0.50	0.43	0.02
	31					0.82	0.40	0.43	0.02
AUGUST	1					0.81	0.38	0.42	0.02
	2								
	3								
	4								
	5					0.73	0.33	0.44	0.02
	6	0.58	0.23	0.87	0.03	0.87	0.42	0.44	0.02
	7	0.67	0.29	0.87	0.04				
	8	0.61	0.24	0.87	0.03				
	9					0.91	0.45	0.89	0.06
	10					0.91	0.45	0.89	0.06
	11								RAIN
	12					1.05	0.65	0.00	0.00
	13								
	14					0.97	0.53	0.14	.00
	15					1.06	0.65	0.14	.00
	16					0.98	0.53	0.14	.00
	17					1.12	0.69	0.14	.00
	18					0.75	0.37	0.14	.00
	19					0.83	0.43	0.14	.00
	20					0.99	0.51	0.14	.00
	21					1.03	0.52	0.14	.00
	22					0.99	0.49	0.14	.00
	23					1.06	0.64	0.14	.00

Table C-8. Daily discharge rates at D-4 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DIS-CHARGE	DEPTH	HEAD	% OPEN	DIS-CHARGE
APRIL	18	0.79	0.50	0.93	0.094	-			
	19	0.92	0.63	0.93	0.105	-			
	20	0.99	0.70	0.93	0.110	-			
	21	1.03	0.73	0.93	0.113	-			
	22	0.96	0.67	0.93	0.108	0.61	0.45	0.93	0.088
	23	0.98	0.69	0.93	0.110	0.39	0.25	0.04	.000
	24	0.99	0.70	0.93	0.110	0.44	0.30	0.92	0.071
	25	0.97	0.68	0.93	0.109	0.49	0.34	0.93	0.077
	26	0.96	0.67	0.93	0.108	0.52	0.37	0.92	0.079
	27	1.09	0.80	0.93	0.118	0.56	0.40	0.92	0.083
	28	0.94	0.64	0.93	0.106	0.55	0.39	0.92	0.082
	29	1.09	0.79	0.93	0.118	0.57	0.41	0.91	0.083
	30	0.91	0.62	0.93	0.104	0.58	0.42	0.91	0.084
MAY	1	0.86	0.57	0.93	0.100	0.58	0.42	0.92	0.085
	2	0.78	0.49	0.93	0.093	0.54	0.38	0.92	0.081
	3	0.76	0.48	0.93	0.092	0.65	0.48	0.92	0.091
	4	0.80	0.51	0.93	0.095	0.39	0.25	0.92	0.066
	5	0.82	0.53	0.93	0.096	0.66	0.49	0.92	0.092
	6	1.00	0.71	0.93	0.111	0.76	0.59	0.92	0.100
	7	1.10	0.81	0.93	0.119	0.74	0.57	0.92	0.098
	8	1.04	0.74	0.93	0.114	0.74	0.57	0.92	0.098
	9					0.73	0.56	0.92	0.098
	10	0.99	0.70	0.93	0.111	0.74	0.56	0.92	0.098
	11					0.74	0.57	0.87	0.092
	12					0.74	0.57	0.88	0.094
	13	0.79	0.50	0.93	0.094	0.73	0.55	0.88	0.092
	14					0.71	0.54	0.93	0.097
	15					0.69	0.52	0.93	0.095
	16	0.76	0.48	0.93	0.091	0.70	0.53	0.93	0.096
	17	0.65	0.38	0.93	0.082	0.72	0.55	0.93	0.098
	18	0.62	0.35	0.93	0.078	0.72	0.55	0.93	0.098
	19					0.71	0.54	0.93	0.097
	20					0.82	0.64	0.93	0.106
	21					0.63	0.46	0.93	0.090
	22	0.81	0.53	0.93	0.096	0.66	0.49	0.93	0.093
	23	0.73	0.45	0.93	0.089	0.54	0.38	0.93	0.082
	24	0.64	0.37	0.93	0.081	0.48	0.33	0.93	0.076
	25	0.73	0.45	0.93	0.089	0.47	0.32	0.93	0.075
	26	0.82	0.53	0.93	0.096	0.59	0.43	0.93	0.087
	27	0.79	0.50	0.93	0.094	0.62	0.45	0.93	0.089
	28					0.73	0.56	0.93	0.099
	29					0.67	0.50	0.93	0.094
	30	0.71	0.43	0.93	0.087	0.66	0.49	0.93	0.093
	31	0.79	0.51	0.93	0.094				
JUNE	1	0.77	0.48	0.93	0.092				
	2	0.72	0.44	0.50	0.037				
	3					0.70	0.53	0.73	0.071
	4					0.43	0.29	0.73	0.053
	5					0.52	0.36	0.93	0.080
	6	1.04	0.75	0.93	0.114	0.60	0.43	0.93	0.087
	7	0.72	0.44	0.93	0.088	0.57	0.41	0.93	0.085
	8	0.72	0.45	0.93	0.088	0.65	0.48	0.93	0.092
	9					0.66	0.49	0.93	0.093
	10								
	11					0.69	0.52	0.93	0.095
	12					0.64	0.47	0.93	0.091
	13	0.87	0.58	0.93	0.101	0.61	0.45	0.92	0.087
	14	0.88	0.59	0.93	0.102	0.69	0.52	0.91	0.093
	15	0.85	0.56	0.93	0.099				
	16								
	17					0.68	0.51	0.91	0.092
	18					0.64	0.47	0.91	0.089
	19					0.62	0.46	0.91	0.087
	20	0.83	0.54	0.93	0.097	0.61	0.45	0.91	0.086
	21	0.83	0.55	0.93	0.098	0.62	0.46	0.91	0.087
	22	0.84	0.55	0.93	0.098				
	23								
	24					0.48	0.33	0.93	0.076

Table C-8.....continued

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DIS-CHARGE	DEPTH	HEAD	% OPEN	DIS-CHARGE
	25					0.65	0.48	0.93	0.092
	26					0.58	0.42	0.92	0.085
	27	0.72	0.44	0.93	0.088	0.51	0.36	0.93	0.079
	28	0.77	0.49	0.93	0.092				
	29	0.75	0.47	0.93	0.090				
	30								
JULY	1								
	2					0.68	0.51	0.93	0.094
	3					0.56	0.40	0.93	0.084
	4	0.83	0.54	0.93	0.097	0.50	0.35	0.93	0.078
	5	0.85	0.56	0.93	0.099	0.71	0.54	0.27	0.013
	6	0.80	0.51	0.93	0.095	0.71	0.54	0.40	0.027
	7					0.89	0.71	0.40	0.031
	8					0.78	0.60	0.93	0.103
	9					0.86	0.68	0.93	0.109
	10								
	11	0.72	0.44	0.93	0.088				
	12	0.74	0.46	0.93	0.090				
	13	0.72	0.44	0.93	0.088				
	14								
	15								
	16								
	17					0.69	0.52	0.93	0.095
	18	0.63	0.36	0.93	0.080	0.70	0.53	0.93	0.096
	19	0.62	0.35	0.93	0.079	0.71	0.54	0.93	0.097
	20	0.65	0.38	0.93	0.082				
	21								
	22								
	23								
	24					0.42	0.28	0.93	0.070
	25					0.65	0.48	0.93	0.092
	26								
	27								
	28					0.79	0.61	0.93	0.104
	29					0.79	0.61	0.93	0.104
	30					0.81	0.63	0.93	0.105
	31					0.56	0.40	0.93	0.084
AUGUST	1					0.55	0.39	0.93	0.083
	2								
	3								
	4								
	5					0.48	0.33	0.93	0.076
	6	0.55	0.29	0.93	0.072	0.61	0.45	0.93	0.088
	7	0.65	0.38	0.93	0.082				
	8								
	9					0.64	0.47	0.93	0.091
	10	0.58	0.32	0.93	0.074	0.65	0.48	0.93	0.092
	11					0.72	0.55	0.93	0.098
	12					0.79	0.61	0.93	0.104
	13					0.87	0.69	0.93	0.110
	14					0.73	0.56	0.93	0.099
	15					0.82	0.64	0.84	0.094
	16					0.72	0.55	0.84	0.087
	17					0.89	0.71	0.84	0.099
	18					0.49	0.34	0.84	0.069
	19					0.58	0.42	0.84	0.076
	20					0.64	0.47	0.84	0.081
	21					0.71	0.54	0.84	0.086
	22					0.69	0.52	0.83	0.084
	23					0.81	0.63	0.83	0.092
	24								0.000
	25					0.74	0.57	0.83	0.087

Table C-9. Daily discharge rates at FC-3 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DIS-CHARGE	DEPTH	HEAD	% OPEN	DIS-CHARGE
APRIL	18	0.75	0.25	0.97	0.15	-			
	19	0.88	0.48	0.97	0.20	-			
	20	0.94	0.60	0.97	0.23	-			
	21	0.97	0.68	0.97	0.25	-			
	22	0.89	0.50	0.97	0.21	0.22	0.02	0.97	0.05
	23	0.92	0.57	0.97	0.22	0.08	.00	0.97	0.01
	24	0.93	0.60	0.97	0.23				
	25	0.91	0.54	0.97	0.22				
	26	0.91	0.53	0.97	0.22				
	27	1.00	0.77	0.97	0.26	0.26	0.03	0.86	0.06
	28	0.89	0.50	0.97	0.21	0.40	0.11	0.86	0.12
	29	1.04	0.89	0.97	0.28	0.31	0.05	0.86	0.08
	30	0.85	0.40	0.97	0.19	0.43	0.14	0.86	0.13
MAY	1	0.82	0.35	0.97	0.18	0.26	0.03	0.36	0.06
	2	0.74	0.24	0.97	0.14	0.30	0.05	0.86	0.07
	3	0.72	0.21	0.97	0.14	0.33	0.06	0.86	0.09
	4	0.75	0.24	0.97	0.15	0.31	0.05	0.86	0.08
	5	0.78	0.29	0.97	0.16	0.34	0.07	0.86	0.09
	6					0.44	0.15	0.86	0.13
	7	1.04	0.92	0.97	0.28	0.40	0.11	0.86	0.12
	8	1.01	0.80	0.97	0.27	0.40	0.11	0.86	0.12
	9	0.88	0.47	0.97	0.20	0.40	0.11	0.86	0.12
	10	0.95	0.63	0.97	0.24	0.41	0.12	0.86	0.12
	11					0.42	0.13	0.86	0.12
	12					0.42	0.13	0.86	0.12
	13	0.75	0.24	0.97	0.15	0.40	0.11	0.86	0.12
	14	0.89	0.49	0.97	0.21	0.38	0.10	0.86	0.11
	15	0.81	0.33	0.97	0.17	0.39	0.10	0.86	0.11
	16	0.71	0.19	0.97	0.13	0.39	0.10	0.86	0.11
	17	0.61	0.10	0.97	0.09	0.41	0.12	0.86	0.12
	18	0.59	0.08	0.97	0.09	0.41	0.12	0.86	0.12
	19					0.43	0.14	0.86	0.13
	20					0.50	0.22	0.86	0.16
	21					0.37	0.09	0.86	0.10
	22	0.78	0.28	0.50	0.06	0.35	0.08	0.86	0.10
	23	0.71	0.19	0.97	0.13	0.44	0.15	0.86	0.13
	24	0.60	0.09	0.97	0.09	0.41	0.12	0.86	0.12
	25	0.68	0.16	0.97	0.12	0.40	0.11	0.86	0.12
	26					0.51	0.23	0.86	0.17
	27	0.74	0.23	0.97	0.14	0.37	0.09	0.86	0.10
	28					0.41	0.12	0.86	0.12
	29					0.58	0.34	0.86	0.20
	30	0.68	0.16	0.97	0.12	0.56	0.30	0.86	0.19
	31	0.74	0.23	0.97	0.14	0.39	0.10	0.86	0.11
JUNE	1	0.73	0.22	0.97	0.14	0.44	0.15	0.86	0.13
	2								
	3					0.55	0.29	0.86	0.19
	4					0.35	0.08	0.86	0.10
	5					0.42	0.13	0.86	0.12
	6					0.51	0.23	0.86	0.17
	7	0.68	0.16	0.97	0.12	0.49	0.20	0.86	0.16
	8	0.68	0.16	0.97	0.12	0.54	0.27	0.86	0.18
	9	0.65	0.13	0.97	0.11				
	10	0.73	0.22	0.97	0.14				
	11					0.38	0.10	0.86	0.11
	12					0.56	0.30	0.86	0.19
	13					0.52	0.24	0.86	0.17
	14								
	15								
	16	0.76	0.27	0.97	0.15				
	17	0.91	0.54	0.97	0.22	0.38	0.10	0.86	0.11
	18					0.35	0.29	0.86	0.19
	19					0.54	0.27	0.86	0.18
	20					0.50	0.22	0.86	0.16
	21								
	22								

Table C-9.....continued

DATE		YALA SEASON 1983 DEPTH	HEAD	% OPEN	DIS-CHARGE	YALA SEASON 1984 DEPTH	HEAD	% OPEN	DIS-CHARGE
	23	0.75	0.25	0.97	0.15				
	24	0.66	0.14	0.97	0.11	0.40	0.11	0.78	0.10
	25	0.79	0.31	0.97	0.17	0.58	0.34	0.78	0.18
	26	0.79	0.31	0.97	0.16	0.56	0.30	0.78	0.17
	27					0.54	0.27	0.99	0.21
	28								
	29								
	30	0.70	0.19	0.97	0.13				
JULY	1								
	2					0.35	0.08	0.91	0.10
	3	0.87	0.45	0.97	0.20	0.48	0.19	0.91	0.16
	4	0.81	0.34	0.97	0.17	0.43	0.14	0.91	0.14
	5								
	6								
	7	0.70	0.18	0.97	0.12				
	8	0.78	0.29	0.97	0.16	0.47	0.18	0.93	0.16
	9	0.80	0.32	0.97	0.17	0.54	0.27	0.93	0.20
	10	0.78	0.29	0.97	0.16				
	11								
	12								
	13								
	14	0.71	0.19	0.97	0.13				
	15	0.67	0.15	0.97	0.12				
	16	0.82	0.35	0.97	0.18				
	17	0.83	0.37	0.97	0.18	0.37	0.09	0.93	0.11
	18					0.37	0.09	0.93	0.11
	19					0.42	0.13	0.93	0.14
	20								
	21	0.54	0.05	0.97	0.07				
	22	0.64	0.12	0.97	0.10				
	23	0.65	0.13	0.97	0.11				
	24	0.73	0.21	0.97	0.14	0.32	0.06	0.77	0.07
	25					0.58	0.34	0.77	0.18
	26								
	27								
	28					0.49	0.20	0.93	0.17
	29					0.50	0.22	0.93	0.18
	30					0.52	0.24	0.93	0.19
	31					0.25	0.03	0.71	0.05
AUGUST	1					0.47	0.18	0.93	0.16
	2								
	3								
	4								
	5					0.41	0.12	0.95	0.13
	6					0.30	0.05	0.95	0.08
	7	0.61	0.10	0.97	0.09				
	8								
	9					0.32	0.06	0.95	0.09
	10								
	11								
	12					0.70	0.59	0.95	0.30
	13					0.54	0.27	0.95	0.20
	14					0.43	0.14	0.95	0.14
	15								
	16								
	17								
	18					0.42	0.13	0.44	0.05
	19					0.48	0.19	0.44	0.06
	20								
	21								
	22								
	23					0.71	0.61	0.45	0.10

Table C-10. Daily discharge rates at D-5 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DISCH.	DEPTH	HEAD	% OPEN	DISCH.
APRIL	18	0.44	0.32	1.00	0.05	-			
	19	0.56	0.45	1.00	0.05	-			
	20	0.61	0.50	1.00	0.06	-			
	21	0.65	0.54	1.00	0.06	-			
	22	0.59	0.47	1.00	0.06	0.28	0.17	1.00	0.03
	23	0.61	0.49	1.00	0.06	0.13	0.02	1.00	0.01
	24	0.62	0.50	1.00	0.06	0.21	0.10	1.00	0.03
	25	0.62	0.51	1.00	0.06	0.30	0.18	1.00	0.03
	26	0.59	0.47	1.00	0.06	0.34	0.22	1.00	0.04
	27	0.71	0.59	1.00	0.06	0.33	0.22	1.00	0.04
	28	0.58	0.46	1.00	0.06	0.31	0.19	1.00	0.04
	29	0.72	0.61	1.00	0.06	0.37	0.26	1.00	0.04
	30	0.54	0.43	1.00	0.05	0.32	0.21	1.00	0.04
MAY	1	0.50	0.39	0.50	0.02	0.33	0.22	1.00	0.04
	2	0.43	0.31	1.00	0.05	0.30	0.19	1.00	0.04
	3	0.39	0.27	1.00	0.04	0.39	0.27	1.00	0.04
	4	0.42	0.31	1.00	0.05	0.13	0.01	1.00	0.01
	5	0.45	0.34	1.00	0.05	0.40	0.29	1.00	0.04
	6					0.50	0.38	1.00	0.05
	7					0.47	0.35	1.00	0.05
	8					0.48	0.37	1.00	0.05
	9					0.47	0.36	1.00	0.05
	10	0.62	0.51	1.00	0.06	0.47	0.35	1.00	0.05
	11					0.47	0.35	1.00	0.05
	12					0.49	0.37	1.00	0.05
	13	0.43	0.32	1.00	0.05	0.44	0.32	1.00	0.05
	14					0.44	0.33	1.00	0.05
	15					0.44	0.32	1.00	0.05
	16	0.39	0.27	1.00	0.04	0.45	0.33	1.00	0.05
	17	0.28	0.17	1.00	0.03	0.46	0.35	1.00	0.05
	18	0.25	0.14	1.00	0.03	0.48	0.36	1.00	0.05
	19					0.51	0.40	1.00	0.05
	20					0.56	0.44	1.00	0.05
	21					0.44	0.33	1.00	0.05
	22	0.47	0.35	0.50	0.02	0.41	0.30	1.00	0.04
	23					0.26	0.14	1.00	0.03
	24	0.27	0.16	1.00	0.03	0.24	0.12	1.00	0.03
	25	0.36	0.24	1.00	0.04	0.21	0.10	1.00	0.03
	26					0.33	0.22	1.00	0.04
	27	0.41	0.30	1.00	0.04	0.47	0.36	1.00	0.05
	28					0.48	0.37	1.00	0.05
	29					0.39	0.28	1.00	0.04
	30					0.38	0.26	1.00	0.04
	31	0.43	0.32	1.00	0.05	0.50	0.39	0.89	0.04
JUNE	1	0.43	0.32	1.00	0.05	0.55	0.43	0.89	0.05
	2								
	3	0.46	0.35	1.00	0.05				
	4					0.28	0.17	1.00	0.03
	5	0.65	0.53	1.00	0.06	0.36	0.24	1.00	0.04
	6	0.71	0.60	1.00	0.06	0.32	0.20	1.00	0.04
	7	0.37	0.25	1.00	0.04	0.41	0.29	1.00	0.04
	8								
	9					0.57	0.45	0.84	0.05
	10					0.47	0.36	0.84	0.04
	11					0.38	0.27	0.84	0.04
	12					0.35	0.24	0.84	0.03
	13	0.53	0.42	1.00	0.05				
	14	0.55	0.43	1.00	0.05				
	15	0.51	0.39	1.00	0.05				
	16					0.46	0.34	0.67	0.03
	17					0.37	0.26	0.67	0.03
	18					0.36	0.25	0.67	0.03
	19					0.32	0.21	0.67	0.02
	20								
	21	0.49	0.37	1.00	0.05				
	22	0.48	0.37	1.00	0.05				
	23								

Table C-10....continued

DATE	YALA SEASON 1983				YALA SEASON 1984			
	DEPTH	HEAD	% OPEN	DISCH.	DEPTH	HEAD	% OPEN	DISCH.
24					0.20	0.09	0.91	0.02
25					0.41	0.29	0.91	0.04
26					0.39	0.28	0.91	0.04
27	0.39	0.27	1.00	0.04	0.37	0.26	0.91	0.04
28	0.43	0.31	1.00	0.05				
29	0.40	0.29	1.00	0.04				
30								
JULY 1					0.56	0.44	0.77	0.04
2					0.39	0.28	0.77	0.03
3					0.33	0.21	0.77	0.03
4	0.48	0.36	1.00	0.05	0.22	0.11	0.77	0.02
5	0.49	0.38	1.00	0.05	0.35	0.23	0.38	0.01
6	0.45	0.34	1.00	0.05				
7								
8					0.52	0.41	0.91	0.05
9					0.60	0.48	0.91	0.05
10								
11	0.36	0.25	1.00	0.04				
12	0.40	0.29	1.00	0.04				
13	0.36	0.24	1.00	0.04				
14								
15								
16								
17					0.42	0.30	0.61	0.02
18	0.29	0.17	0.50	0.01	0.42	0.30	0.61	0.02
19	0.26	0.15	1.00	0.03	0.46	0.35	0.61	0.03
20	0.30	0.18	1.00	0.03				
21								
22								
23								
24					0.39	0.28	1.00	0.04
25					0.39	0.28	0.94	0.04
26								
27								
28								
29					0.53	0.41	0.89	0.05
30					0.54	0.42	0.89	0.05
31					0.31	0.20	0.89	0.03
AUGUST 1					0.30	0.19	0.60	0.02
2								
3								
4								
5					0.64	0.53	0.60	0.03
6								
7								
8								
9								
10								
11								
12								
13								
14					0.52	0.40	0.25	0.01
15					0.57	0.45	0.25	0.01
16					0.46	0.34	0.25	.00
17								
18								
19								
20								
21								
22								
23								

Table C-11.Daily discharge rates at D-6 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

	YALA SEASON 1983				YALA SEASON 1984			
DATE	DEPTH	HEAD	% OPEN	DIS- CHRGE.	DEPTH	HEAD	% OPEN	DIS- CHRGE.
APRIL 18					-			
19	0.66		1.00	0.037	-			
20	0.72		1.00	0.038	-			
21	0.76		1.00	0.039	-			
22	0.69		1.00	0.037	0.3158		1.00	0.025
23					0.2078		1.00	0.021
24					0.2728		1.00	0.024
25	0.71		1.00	0.038	0.3858		1.00	0.028
26	0.71		1.00	0.038				
27	0.80		1.00	0.040	0.4038		1.00	0.029
28	0.69		1.00	0.037	0.3888		0.32	0.005
29	0.83		1.00	0.041	0.4348		1.00	0.030
30					0.4328		0.32	0.005
MAY 1	0.69		1.00	0.038				
2								
3	0.61		1.00	0.035				
4	0.54		1.00	0.033				
5					0.5438		0.09	.000
6								
7								
8								
9					0.5508		0.32	0.006
10	0.82		1.00	0.041	0.5458		0.32	0.006
11					0.5458		0.33	0.006
12					0.5618		0.09	.000
13	0.53		1.00	0.033	0.5458		0.09	.000
14					0.5258		0.10	0.001
15	0.69		1.00	0.038	0.5128		0.22	0.003
16					0.5278		0.22	0.003
17					0.5498		0.22	0.003
18	0.47		1.00	0.031	0.5508		0.29	0.005
19					0.5998		0.29	0.005
20								
21					0.5238		0.29	0.005
22								
23	0.60		1.00	0.035	0.3438		0.29	0.004
24	0.49		1.00	0.032				
25	0.57		1.00	0.034	0.2958		0.37	0.005
26								
27					0.5528		0.02	.000
28					0.5538		0.02	.000
29					0.4928		0.02	.000
30	0.56		1.00	0.034	0.4718		0.02	.000
31	0.62		1.00	0.036				
JUNE 1	0.61		1.00	0.035				
2								
3					0.6998		0.45	0.012
4					0.1858		0.45	0.006
5					0.3528		0.45	0.008
6	0.91		1.00	0.043	0.4228		0.45	0.009
7	0.58		1.00	0.034	0.3948		0.45	0.009
8	0.57		1.00	0.034	0.4748		0.49	0.012
9								
10	0.65		1.00	0.036				
11								
12					0.4608		0.88	0.027
13					0.4248		0.88	0.026
14	0.74		1.00	0.039				
15	0.71		1.00	0.038				
16								
17					0.5448		0.72	0.023
18					0.4568		0.50	0.012
19					0.4408		0.50	0.012
20					0.4238		0.02	.000
21	0.70		1.00	0.038				
22	0.70		1.00	0.038				
23								

Table C-11....continued

DATE		YALA SEASON 1983 DEPTH	HEAD	% OPEN	DIS-CHRGE.	YALA SEASON 1984 DEPTH	HEAD	% OPEN	DIS-CHRGE.
	24					0.3118		0.64	0.014
	25					0.4558		0.64	0.017
	26					0.4358		0.64	0.017
	27					0.4128		0.64	0.016
	28	0.63		1.00	0.036				
	29	0.63		1.00	0.036				
	30								
JULY	1					0.6478		1.00	0.036
	2					0.4928		1.00	0.032
	3					0.3908		1.00	0.028
	4	0.68		1.00	0.037	0.3318		1.00	0.026
	5	0.69		1.00	0.038	0.4718		0.70	0.020
	6								
	7								
	8					0.6258		1.00	0.036
	9					0.7158		1.00	0.038
	10								
	11	0.58		1.00	0.034				
	12	0.61		1.00	0.035				
	13	0.58		1.00	0.034				
	14								
	15								
	16								
	17					0.5048		0.80	0.025
	18	0.51		0.50	0.012	0.5058		0.80	0.025
	19	0.49		0.50	0.012	0.5638		0.80	0.026
	20	0.51		1.00	0.032				
	21								
	22								
	23								
	24					0.2128		0.96	0.020
	25					0.4808		0.96	0.030
	26								
	27								
	28								
	29					0.6358		1.00	0.036
	30					0.6608		1.00	0.037
	31					0.3888		1.00	0.028
AUGUST	1					0.3838		0.77	0.021
	2								
	3								
	4								
	5					0.3528		0.85	0.023
	6					0.4558		0.85	0.026
	7	0.51		1.00	0.032				
	8								
	9					0.4658		0.85	0.026
	10								
	11								
	12								
	13								
	14								
	15					0.6308		0.34	0.007
	16					0.6128		0.34	0.007
	17					0.8258		0.16	0.002
	18								
	19								
	20								
	21								
	22								
	23								

Table C-12. Daily discharge rates at D-7 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DIS-CHRGE.	DEPTH	HEAD	% OPEN	DIS-CHRGE.
APRIL	18	0.49	0.42	0.94	0.023	-			
	19	0.59	0.52	0.94	0.025	-			
	20	0.72	0.64	0.94	0.028	-			
	21	0.75	0.66	0.94	0.028	-			
	22	0.68	0.59	0.94	0.027	0.37	0.31	0.84	0.017
	23	0.71	0.62	0.94	0.028	0.23	0.19	0.94	0.015
	24	0.72	0.63	0.94	0.028	0.28	0.23	0.93	0.017
	25	0.71	0.62	0.94	0.028	0.43	0.37	0.94	0.021
	26	0.69	0.60	0.94	0.027	0.25	0.21	0.92	0.016
	27	0.79	0.70	0.94	0.029	0.42	0.36	0.92	0.020
	28								
	29	0.84	0.74	0.94	0.030	0.46	0.39	0.93	0.022
	30					0.45	0.38	0.94	0.022
MAY	1	0.81	0.72	0.94	0.030	0.45	0.38	0.94	0.022
	2	0.54	0.46	0.94	0.024	0.39	0.34	0.94	0.020
	3	0.53	0.46	0.94	0.024	0.49	0.42	0.94	0.023
	4	0.56	0.49	0.94	0.024	0.24	0.20	0.94	0.016
	5	0.72	0.63	0.94	0.028	0.50	0.44	0.94	0.023
	6	0.86	0.76	0.47	0.011	0.60	0.52	0.94	0.025
	7					0.57	0.50	0.94	0.025
	8					0.59	0.51	0.94	0.025
	9					0.57	0.50	0.94	0.025
	10					0.56	0.49	0.94	0.024
	11					0.56	0.48	0.94	0.024
	12					0.57	0.49	0.94	0.024
	13	0.53	0.46	0.94	0.024	0.54	0.47	0.94	0.024
	14					0.54	0.47	0.94	0.024
	15					0.54	0.47	0.94	0.024
	16					0.55	0.48	0.94	0.024
	17	0.42	0.36	0.94	0.021	0.58	0.51	0.94	0.025
	18	0.38	0.32	0.47	0.007	0.56	0.49	0.94	0.024
	19					0.62	0.54	0.94	0.026
	20					0.65	0.57	0.94	0.026
	21					0.54	0.47	0.94	0.024
	22					0.51	0.45	0.94	0.023
	23	0.47	0.40	0.94	0.022	0.38	0.32	0.94	0.020
	24	0.36	0.31	0.94	0.019	0.33	0.28	0.94	0.018
	25					0.33	0.28	0.94	0.018
	26	0.55	0.48	0.94	0.024	0.44	0.38	0.94	0.022
	27	0.53	0.46	0.94	0.024	0.55	0.48	0.94	0.024
	28	0.49	0.42	0.94	0.023	0.54	0.47	0.94	0.024
	29					0.52	0.45	0.94	0.023
	30	0.47	0.41	0.94	0.022	0.49	0.42	0.94	0.023
	31	0.54	0.47	0.94	0.024				
JUNE	1	0.53	0.45	0.94	0.024				
	2	0.50	0.43	0.94	0.023	0.80	0.71	0.77	0.023
	3	0.58	0.51	0.94	0.025	0.74	0.65	0.77	0.022
	4	0.64	0.56	0.47	0.010	0.31	0.26	0.77	0.014
	5								
	6	1.15	1.04	0.94	0.036	0.44	0.38	0.77	0.017
	7	0.49	0.42	0.94	0.023	0.42	0.36	0.77	0.017
	8	0.48	0.42	0.94	0.023	0.49	0.43	0.77	0.018
	9	0.43	0.37	0.94	0.021				
	10								
	11	0.58	0.50	0.94	0.025	0.49	0.42	0.89	0.021
	12	0.63	0.55	0.94	0.026	0.49	0.42	0.89	0.021
	13	0.58	0.51	0.94	0.025	0.44	0.38	0.89	0.020
	14								
	15	0.62	0.54	0.94	0.026				
	16								
	17					0.59	0.51	0.85	0.022
	18					0.47	0.41	0.85	0.020
	19					0.46	0.39	0.85	0.019
	20					0.44	0.38	0.85	0.019
	21	0.56	0.49	0.94	0.024				
	22	0.61	0.53	0.94	0.025				
	23	0.56	0.49	0.94	0.024				

Table C-12....continued

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DIS-CHRGE	DEPTH	HEAD	% OPEN	DIS-CHRGE.
	24	0.48	0.41	0.94	0.022	0.34	0.29	0.76	0.015
	25	0.58	0.51	0.94	0.025	0.51	0.44	0.76	0.018
	26					0.51	0.44	0.76	0.018
	27	0.49	0.42	0.94	0.023	0.50	0.43	0.76	0.018
	28	0.54	0.47	0.94	0.024				
	29	0.53	0.46	0.94	0.024				
	30	0.50	0.43	0.94	0.023				
JULY	1					0.68	0.60	0.81	0.023
	2					0.52	0.45	0.81	0.020
	3	0.65	0.57	0.94	0.026	0.43	0.37	0.81	0.018
	4	0.61	0.53	0.94	0.025	0.36	0.30	0.81	0.016
	5	0.62	0.54	0.94	0.026				
	6	0.56	0.49	0.94	0.024	0.57	0.50	0.83	0.021
	7	0.50	0.43	0.47	0.008	0.63	0.55	0.83	0.023
	8	0.60	0.52	0.94	0.025	0.66	0.58	0.39	0.007
	9	0.63	0.55	0.47	0.010	0.74	0.65	0.39	0.007
	10	0.60	0.52	0.94	0.025				
	11	0.48	0.41	0.47	0.008				
	12	0.87	0.78	0.47	0.011				
	13	0.50	0.43	0.47	0.008				
	14								
	15	0.49	0.42	0.47	0.008				
	16	0.62	0.54	0.47	0.009				
	17	0.64	0.56	0.47	0.010	0.53	0.46	0.39	0.006
	18	0.44	0.37	0.47	0.008	0.54	0.47	0.39	0.006
	19	0.41	0.35	0.94	0.021	0.60	0.53	0.39	0.007
	20	0.43	0.37	0.94	0.021				
	21	0.36	0.31	0.47	0.007				
	22	0.45	0.38	0.94	0.022				
	23								
	24	0.53	0.46	0.94	0.024	0.25	0.21	0.85	0.014
	25					0.49	0.42	0.85	0.020
	26								
	27								
	28								
	29					0.65	0.57	0.35	0.006
	30					0.66	0.58	0.35	0.006
	31					0.42	0.36	0.81	0.017
AUGUST	1					0.40	0.34	0.81	0.017
	2								
	3								
	4								
	5					0.38	0.32	0.88	0.018
	6					0.46	0.39	0.88	0.020
	7								
	8								
	9								
	10	0.40	0.34	0.94	0.020				
	11								
	12								
	13								
	14								
	15								
	16								
	17								
	18								
	19					0.43	0.37	0.88	0.020
	20					0.53	0.46	0.88	0.022
	21					0.57	0.49	0.88	0.023
	22					0.53	0.46	0.88	0.022
	23								

Table C-13. Daily discharge rates at D-8 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE	YALA SEASON 1983				YALA SEASON 1984			
	DEPTH	HEAD	% OPEN	DIS-CHRGE.	DEPTH	HEAD	% OPEN	DIS-CHRGE.
APRIL 18	0.79		1.00	0.34	-			
19	0.80		0.50	0.13	-			
20	0.88		1.00	0.36	-			
21	1.03		1.00	0.39	-			
22	1.01		1.00	0.39	0.58		0.65	0.17
23	0.92		1.00	0.37				
24	0.95		1.00	0.38				
25	0.93		1.00	0.37	0.63		0.92	0.28
26	0.94		1.00	0.37	0.29		0.92	0.19
27	1.01		1.00	0.39	0.60		0.92	0.27
28	0.92		1.00	0.37	0.54		0.91	0.26
29	1.08		1.00	0.40	0.70		0.91	0.29
30	0.89		1.00	0.36	0.72		0.92	0.30
MAY 1	0.83		1.00	0.35	0.59		0.92	0.27
2	0.77		1.00	0.34	0.52		0.92	0.26
3	0.75		1.00	0.33	0.61		0.92	0.28
4	0.76		1.00	0.34	0.38		0.92	0.22
5	0.79		1.00	0.34	0.56		0.92	0.26
6	0.93		1.00	0.37	0.75		0.92	0.31
7	1.13		1.00	0.41	0.74		0.52	0.14
8	1.08		1.00	0.40	0.73		0.52	0.14
9	0.94		1.00	0.37	0.72		0.87	0.28
10	1.00		1.00	0.39	0.74		0.87	0.29
11					0.76		0.08	.00
12					0.73		0.87	0.29
13	0.80		1.00	0.34	0.75		0.07	.00
14	0.94		1.00	0.37	0.68		0.87	0.28
15	0.88		1.00	0.36	0.69		0.87	0.28
16	0.79		1.00	0.34	0.71		0.87	0.28
17	0.69		1.00	0.32	0.73		0.87	0.29
18	0.65		0.50	0.12	0.78		0.16	0.01
19					0.82		0.16	0.01
20					0.82		0.65	0.21
21					0.70		0.65	0.19
22	1.03		1.00	0.39	0.67		0.65	0.19
23	0.76		1.00	0.34	0.54		0.65	0.17
24	0.66		1.00	0.31	0.50		0.65	0.16
25	0.79		1.00	0.34	0.50		0.65	0.16
26	0.84		1.00	0.35	0.57		0.65	0.17
27	0.84		1.00	0.35	0.72		0.65	0.19
28					0.74		0.65	0.20
29					0.66		1.00	0.31
30	0.79		1.00	0.34	0.64		1.00	0.31
31	0.82		1.00	0.35				
JUNE 1	0.83		1.00	0.35				
2	0.75		1.00	0.33				
3	0.89		1.00	0.36	0.91		0.88	0.32
4	0.97		0.50	0.15	0.50		0.88	0.24
5					0.54		0.88	0.25
6	1.05		1.00	0.39	0.58		1.00	0.29
7	0.74		1.00	0.33	0.56		1.00	0.29
8	0.74		1.00	0.33				
9	0.68		1.00	0.32				
10								
11								
12					0.61		1.00	0.30
13	0.91		1.00	0.37	0.59		1.00	0.30
14	0.90		1.00	0.37	0.84		1.00	0.35
15	0.89		1.00	0.36	0.90		1.00	0.37
16					0.90		1.00	0.37
17					0.76		1.00	0.34
18					0.61		1.00	0.30
19					0.59		1.00	0.30
20	0.92		1.00	0.37	0.58		1.00	0.29
21	0.88		1.00	0.36				
22	0.89		1.00	0.36	0.66		0.84	0.26
23					0.68		0.84	0.26

Table C-13....continued

DATE	YALA SEASON 1983 DEPTH	HEAD	% OPEN	DIS-CHRGE.	YALA SEASON 1984 DEPTH	HEAD	% OPEN	DIS-CHRGE.
24					0.48		1.00	0.27
25					0.73		1.00	0.33
26					0.71		1.00	0.33
27	0.78		1.00	0.34	0.69		1.00	0.32
28	0.92		1.00	0.37				
29	0.82		1.00	0.35				
30	0.78		1.00	0.34	0.81		1.00	0.35
JULY 1					0.82		1.00	0.35
2					0.65		1.00	0.31
3	0.98		1.00	0.38	0.55		1.00	0.29
4	0.89		1.00	0.36	0.50		1.00	0.27
5	0.91		1.00	0.37	0.57		1.00	0.29
6	0.84		1.00	0.35				
7	0.75		1.00	0.33				
8								
9					0.86		1.00	0.36
10								
11	0.74		1.00	0.33				
12	0.78		1.00	0.34				
13	0.76		1.00	0.34				
14								
15	0.80		1.00	0.35				
16								
17	0.97		1.00	0.38	0.68		1.00	0.32
18	0.74		1.00	0.33	0.66		1.00	0.31
19	0.69		1.00	0.32	0.75		1.00	0.33
20	0.73		1.00	0.33	0.78		1.00	0.34
21	0.64		1.00	0.31				
22								
23								
24					0.39		1.00	0.24
25					0.59		1.00	0.30
26					0.73		1.00	0.33
27					0.79		1.00	0.34
28								
29					0.85		1.00	0.36
30					0.86		1.00	0.36
31					0.56		1.00	0.29
AUGUST 1					0.55		1.00	0.29
2					0.52		1.00	0.28
3								
4					0.64		1.00	0.31
5					0.54		1.00	0.28
6					0.56		1.00	0.29
7	0.70		1.00	0.32				
8	0.63		1.00	0.31				
9					0.60		1.00	0.30
10	0.71		1.00	0.32	0.60		1.00	0.30
11	0.62		1.00	0.30				
12	0.51		1.00	0.27				
13					0.89		1.00	0.36
14					0.91		1.00	0.37
15					0.76		1.00	0.34
16					0.84		1.00	0.35
17					0.99		1.00	0.38
18					0.51		1.00	0.28
19					0.55		1.00	0.29
20					0.57		1.00	0.29
21					0.72		1.00	0.33
22					0.66		1.00	0.31
23								

Table C-14. Daily discharge rates at D-9 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DIS-CHRGE.	DEPTH	HEAD	% OPEN	DIS-CHRGE.
APRIL	18	0.77	1.00	0.00	0.29	-			
	19	0.85	1.00	0.00	0.31	-			
	20	0.92	1.00	0.00	0.33	-			
	21	0.90	1.00	0.00	0.33	-			
	22	0.84	1.00	0.00	0.31	0.43	1.00	0.93	0.51
	23	0.85	1.00	0.00	0.32	0.27	0.90	0.93	0.38
	24	0.86	1.00	0.00	0.32	0.44	0.90	0.93	0.48
	25	0.89	1.00	0.00	0.33	0.62	0.90	0.93	0.57
	26	0.84	1.00	0.00	0.31	0.13	0.90	0.93	0.27
	27	0.92	1.00	0.00	0.33	0.49	0.90	0.93	0.51
	28	0.85	1.00	0.00	0.32	0.41	0.90	0.93	0.47
	29	1.10	1.00	0.00	0.37	0.57	0.90	0.93	0.55
	30	0.81	1.00	0.50	0.42	0.57	0.90	0.93	0.55
MAY	1	0.84	1.00	0.50	0.43	0.49	0.90	0.93	0.51
	2	0.81	1.00	0.50	0.42	0.46	0.00	0.93	0.25
	3	0.78	1.00	0.50	0.41	0.56	0.00	0.93	0.28
	4	0.76	1.00	0.50	0.40	0.32	0.00	0.93	0.21
	5	0.80	1.00	0.50	0.42	0.47	0.00	0.93	0.25
	6	0.98	1.00	0.50	0.48	0.58	0.00	0.93	0.28
	7	1.13	1.00	0.00	0.38	0.67	0.00	0.93	0.31
	8	1.08	1.00	0.00	0.37	0.67	0.00	0.93	0.31
	9	0.97	1.00	0.50	0.48	0.68	0.98	0.14	0.34
	10	1.04	1.00	0.50	0.50	0.67	0.98	0.14	0.33
	11					0.65	0.98	0.14	0.33
	12					0.69	0.98	0.14	0.34
	13	0.78	1.00	0.50	0.41	0.65	0.98	0.14	0.33
	14	0.92	1.00	0.50	0.46	0.66	0.98	0.14	0.33
	15	0.89	1.00	0.50	0.45	0.66	0.98	0.14	0.33
	16	0.77	1.00	0.50	0.41	0.67	0.98	0.14	0.33
	17	0.69	1.00	0.50	0.37	0.70	0.98	0.14	0.34
	18	0.58	1.00	0.50	0.33	0.71	0.98	0.14	0.34
	19					0.72	0.98	0.14	0.35
	20					0.76	0.98	0.14	0.36
	21					0.67	0.71	0.14	0.23
	22	0.85	1.00	0.00	0.32	0.65	0.71	0.14	0.23
	23	0.77	1.00	0.00	0.29	0.49	0.71	0.14	0.20
	24	0.60	1.00	0.50	0.34	0.44	0.71	0.14	0.19
	25	1.00	1.00	0.50	0.49	0.44	0.71	0.14	0.19
	26	1.04	1.00	0.50	0.50	0.48	0.71	0.74	0.38
	27	0.96	1.00	0.50	0.47	0.65	0.71	0.74	0.44
	28					0.68	0.71	0.74	0.45
	29					0.60	1.00	0.57	0.46
	30	0.88	1.00	0.50	0.45	0.57	1.00	0.57	0.45
	31	0.95	1.00	0.50	0.47	0.83	0.08	0.00	.00
JUNE	1	1.04	1.00	0.50	0.50	0.92	0.08	0.00	.00
	2	0.76	1.00	0.50	0.40	0.90	0.92	0.65	0.57
	3					0.86	0.92	0.65	0.56
	4					0.50	0.92	0.65	0.42
	5					0.55	0.92	0.65	0.45
	6	1.02	1.00	0.75	0.61	0.61	0.92	0.65	0.47
	7	0.70	1.00	0.75	0.47	0.51	0.92	0.65	0.43
	8	0.69	1.00	0.75	0.46				
	9	0.62	1.00	0.75	0.43				
	10					0.81	0.69	0.93	0.57
	11					0.54	0.69	0.93	0.46
	12					0.47	0.69	0.93	0.43
	13								
	14								
	15	1.00	1.00	1.00	0.70	0.89	0.92	0.82	0.65
	16	1.07	1.00	1.00	0.73	0.86	0.92	0.82	0.64
	17	1.14	1.00	0.50	0.53	0.67	0.92	0.82	0.56
	18	1.03	1.00	1.00	0.72	0.49	0.92	0.82	0.48
	19					0.52	0.00	0.00	0.00
	20	0.78	1.00	1.00	0.59	0.60	0.00	0.00	0.00
	21	0.99	1.00	1.00	0.70	0.71	0.00	0.00	0.00
	22	1.04	1.00	1.00	0.72	0.69	0.00	0.00	0.00
	23					0.70	0.00	0.00	0.00

Table C-14....continued

DATE	YALA SEASON 1983				YALA SEASON 1984			
	DEPTH	HEAD	% OPEN	DIS-CHRGE.	DEPTH	HEAD	% OPEN	DIS-CHRGE.
24					0.40	0.99	0.93	0.49
25					0.50	0.99	0.93	0.55
26					0.48	0.99	0.93	0.53
27	0.92	1.00	1.00	0.66	0.46	0.99	0.93	0.52
28	0.97	1.00	1.00	0.69				
29	0.96	1.00	1.00	0.69	0.72	0.94	0.93	0.64
30					0.75	0.94	0.93	0.65
JULY 1					0.74	0.94	0.93	0.64
2					0.73	.00	0.93	0.32
3	1.11	1.00	1.00	0.75	0.51	.00	0.93	0.27
4	1.03	1.00	1.00	0.72	0.43	.00	0.93	0.24
5	1.05	1.00	1.00	0.72	0.46	0.41	0.93	0.33
6	0.99	1.00	1.00	0.70	0.77	0.00	0.10	0.01
7					0.85	0.00	0.10	0.01
8					0.87	0.00	0.10	0.01
9					0.78	0.00	0.10	0.01
10								
11	0.89	1.00	1.00	0.65				
12	0.94	1.00	1.00	0.67				
13	0.93	1.00	1.00	0.67				
14								
15								
16	1.01	1.00	1.00	0.70				
17					0.67	0.95	0.93	0.62
18	0.92	1.00	1.00	0.67	0.66	0.95	0.93	0.61
19	0.89	1.00	1.00	0.65	0.67	0.95	0.93	0.62
20	0.95	1.00	1.00	0.68	0.66	0.95	0.93	0.61
21	0.53	1.00	1.00	0.44				
22								
23								
24					0.23	0.95	0.93	0.36
25					0.49	0.95	0.93	0.53
26					0.60	0.95	0.93	0.58
27					0.68	0.95	0.93	0.62
28					0.91	0.19	0.11	0.03
29					0.90	0.19	0.11	0.03
30					0.92	0.19	0.11	0.03
31					0.46	0.93	0.80	0.46
AUGUST 1					0.44	0.93	0.80	0.46
2					0.42	0.93	0.80	0.45
3					0.77	0.06	0.00	.00
4					0.54	0.78	0.52	0.34
5					0.44	0.78	0.52	0.31
6					0.50	0.78	0.52	0.33
7								
8	0.62	1.00	0.50	0.35				
9	0.58	1.00	1.00	0.47	0.53	0.78	0.52	0.34
10	0.77	1.00	1.00	0.59	0.52	0.78	0.52	0.34
11	0.34	1.00	1.00	0.27				
12	0.30	1.00	1.00	0.21				
13					0.91	0.93	0.80	0.65
14					0.95	0.93	0.80	0.67
15					0.73	0.93	0.80	0.59
16					0.78	0.93	0.80	0.61
17								
18								
19								
20					0.46	0.96	0.93	0.51
21					0.70	0.96	0.93	0.63
22					0.64	0.96	0.93	0.61
23					0.76	0.96	0.93	0.66

Table C-15. Daily discharge rates at FC-4 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983 DEPTH	HEAD	% OPEN	DIS-CHRGE.	YALA SEASON 1984 DEPTH	HEAD	% OPEN	DIS-CHRGE.
APRIL	18	0.44	0.32	1.00	0.05	-			
	19	0.56	0.45	1.00	0.05	-			
	20	0.61	0.50	1.00	0.06	-			
	21	0.65	0.54	1.00	0.06	-			
	22	0.59	0.47	1.00	0.06	0.28	0.17	1.00	0.03
	23	0.61	0.49	1.00	0.06	0.13	0.02	1.00	0.01
	24	0.62	0.50	1.00	0.06	0.21	0.10	1.00	0.03
	25	0.62	0.51	1.00	0.06	0.30	0.18	1.00	0.03
	26	0.59	0.47	1.00	0.06	0.34	0.22	1.00	0.04
	27	0.71	0.59	1.00	0.06	0.33	0.22	1.00	0.04
	28	0.58	0.46	1.00	0.06	0.31	0.19	1.00	0.04
	29	0.72	0.61	1.00	0.06	0.37	0.26	1.00	0.04
	30	0.54	0.43	1.00	0.05	0.32	0.21	1.00	0.04
MAY	1	0.50	0.39	0.50	0.02	0.33	0.22	1.00	0.04
	2	0.43	0.31	1.00	0.05	0.30	0.19	1.00	0.04
	3	0.39	0.27	1.00	0.04	0.39	0.27	1.00	0.04
	4	0.42	0.31	1.00	0.05	0.13	0.01	1.00	0.01
	5	0.45	0.34	1.00	0.05	0.40	0.29	1.00	0.04
	6					0.50	0.38	1.00	0.05
	7					0.47	0.35	1.00	0.05
	8					0.48	0.37	1.00	0.05
	9					0.47	0.36	1.00	0.05
	10	0.62	0.51	1.00	0.06	0.47	0.35	1.00	0.05
	11					0.47	0.35	1.00	0.05
	12					0.49	0.37	1.00	0.05
	13	0.43	0.32	1.00	0.05	0.44	0.32	1.00	0.05
	14					0.44	0.33	1.00	0.05
	15					0.44	0.32	1.00	0.05
	16	0.39	0.27	1.00	0.04	0.45	0.33	1.00	0.05
	17	0.28	0.17	1.00	0.03	0.46	0.35	1.00	0.05
	18	0.25	0.14	1.00	0.03	0.48	0.36	1.00	0.05
	19					0.51	0.40	1.00	0.05
	20					0.56	0.44	1.00	0.05
	21					0.44	0.33	1.00	0.05
	22	0.47	0.35	0.50	0.02	0.41	0.30	1.00	0.04
	23					0.26	0.14	1.00	0.03
	24	0.27	0.16	1.00	0.03	0.24	0.12	1.00	0.03
	25	0.36	0.24	1.00	0.04	0.21	0.10	1.00	0.03
	26					0.33	0.22	1.00	0.04
	27	0.41	0.30	1.00	0.04	0.47	0.36	1.00	0.05
	28					0.48	0.37	1.00	0.05
	29					0.39	0.28	1.00	0.04
	30					0.38	0.26	1.00	0.04
	31	0.43	0.32	1.00	0.05	0.50	0.39	0.89	0.04
JUNE	1	0.43	0.32	1.00	0.05	0.55	0.43	0.89	0.05
	2								
	3	0.46	0.35	1.00	0.05				
	4					0.28	0.17	1.00	0.03
	5	0.65	0.53	1.00	0.06	0.36	0.24	1.00	0.04
	6	0.71	0.60	1.00	0.06	0.32	0.20	1.00	0.04
	7	0.37	0.25	1.00	0.04	0.41	0.29	1.00	0.04
	8								
	9					0.57	0.45	0.84	0.05
	10					0.47	0.36	0.84	0.04
	11					0.38	0.27	0.84	0.04
	12					0.35	0.24	0.84	0.03
	13	0.53	0.42	1.00	0.05				
	14	0.55	0.43	1.00	0.05				
	15	0.51	0.39	1.00	0.05				
	16					0.46	0.34	0.67	0.03
	17					0.37	0.26	0.67	0.03
	18					0.36	0.25	0.67	0.03
	19					0.32	0.21	0.67	0.02
	20								
	21	0.49	0.37	1.00	0.05				
	22	0.48	0.37	1.00	0.05				
	23								

Table C-15....continued

DATE	YALA SEASON 1983				YALA SEASON 1984			
	DEPTH	HEAD	% OPEN	DIS-CHRGE.	DEPTH	HEAD	% OPEN	DIS-CHRGE.
24					0.20	0.09	0.91	0.02
25					0.41	0.29	0.91	0.04
26					0.39	0.28	0.91	0.04
27	0.39	0.27	1.00	0.04	0.37	0.26	0.91	0.04
28	0.43	0.31	1.00	0.05				
29	0.40	0.29	1.00	0.04				
30								
JULY 1					0.56	0.44	0.77	0.04
2					0.39	0.28	0.77	0.03
3					0.33	0.21	0.77	0.03
4	0.48	0.36	1.00	0.05	0.22	0.11	0.77	0.02
5	0.49	0.38	1.00	0.05	0.35	0.23	0.38	0.01
6	0.45	0.34	1.00	0.05				
7								
8					0.52	0.41	0.91	0.05
9					0.60	0.48	0.91	0.05
10								
11	0.36	0.25	1.00	0.04				
12	0.40	0.29	1.00	0.04				
13	0.36	0.24	1.00	0.04				
14								
15								
16								
17					0.42	0.30	0.61	0.02
18	0.29	0.17	0.50	0.01	0.42	0.30	0.61	0.02
19	0.26	0.15	1.00	0.03	0.46	0.35	0.61	0.03
20	0.30	0.18	1.00	0.03				
21								
22								
23								
24					0.39	0.28	1.00	0.04
25					0.39	0.28	0.94	0.04
26								
27								
28								
29					0.53	0.41	0.89	0.05
30					0.54	0.42	0.89	0.05
31					0.31	0.20	0.89	0.03
AUGUST 1					0.30	0.19	0.60	0.02
2								
3								
4								
5					0.64	0.53	0.60	0.03
6								
7								
8								
9								
10								
11								
12								
13								
14					0.52	0.40	0.25	0.01
15					0.57	0.45	0.25	0.01
16					0.46	0.34	0.25	.00
17								
18								
19								
20								
21								
22								
23								

Table C-16.Daily discharge rates at D-10 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DIS-CHRGE.	DEPTH	HEAD	% OPEN	DIS-CHRGE.
APRIL	18	0.63	1.00	0.00	0.25	-			
	19	0.69	1.00	0.00	0.27	-			
	20	0.75	1.00	0.00	0.29	-			
	21	0.75	1.00	0.00	0.29	-			
	22	0.69	1.00	0.00	0.27	0.34	0.47	1.00	0.31
	23	0.71	1.00	0.00	0.28	0.22	0.47	1.00	0.25
	24	0.73	1.00	0.00	0.28	0.37	0.47	1.00	0.33
	25	0.66	1.00	0.00	0.26	0.58	0.47	1.02	0.42
	26	0.68	1.00	0.00	0.27	0.09	0.47	1.00	0.16
	27	0.75	1.00	0.00	0.29	0.42	0.47	1.00	0.35
	28	0.69	1.00	0.00	0.27	0.34	0.47	1.00	0.31
	29	0.86	1.00	0.00	0.32	0.57	0.47	1.02	0.42
	30	0.66	1.00	0.00	0.26	0.60	0.47	1.02	0.42
MAY	1	0.63	1.00	0.00	0.25	0.43	0.47	1.00	0.35
	2	0.56	1.00	0.00	0.23	0.38	0.47	1.00	0.33
	3	0.54	1.00	0.00	0.22	0.48	0.47	1.00	0.37
	4					0.21	0.47	1.00	0.25
	5	0.54	1.00	0.00	0.22	0.38	0.47	1.00	0.33
	6	0.71	1.00	0.00	0.28	0.48	0.47	1.00	0.37
	7	0.95	1.00	0.00	0.34	0.57	0.47	0.52	0.23
	8	0.87	1.00	0.00	0.32	0.57	0.47	0.52	0.23
	9	0.74	1.00	0.50	0.40	0.55	0.47	0.89	0.36
	10	0.83	1.00	0.00	0.31	0.52	0.50	0.38	0.18
	11					0.50	0.50	0.38	0.18
	12					0.54	0.50	0.38	0.19
	13	0.54	1.00	0.00	0.22	0.48	0.50	0.38	0.18
	14	0.68	1.00	0.50	0.37	0.46	0.50	0.38	0.17
	15	0.69	1.00	0.00	0.27	0.64	0.50	0.38	0.20
	16	0.54	1.00	0.50	0.31	0.54	0.50	0.80	0.34
	17	0.48	1.00	0.50	0.28	0.58	0.50	0.80	0.35
	18	0.36	1.00	0.00	0.15	0.56	0.50	0.80	0.35
	19	0.35	1.00	0.50	0.19	0.61	0.50	0.80	0.36
	20	0.86	1.00	0.50	0.44	0.63	0.50	0.80	0.37
	21	0.87	0.50	0.50	0.25	0.56	0.50	0.80	0.35
	22	0.60	1.00	0.00	0.25	0.57	0.50	0.80	0.35
	23	0.45	1.00	0.50	0.26	0.39	0.50	0.80	0.29
	24	0.30	1.00	0.50	0.15	0.33	0.50	0.80	0.27
	25	0.33	1.00	0.50	0.18	0.32	0.50	0.80	0.26
	26	0.39	1.00	0.50	0.22	0.42	0.50	0.11	0.11
	27	0.42	1.00	0.50	0.24	0.52	0.50	0.11	0.12
	28	0.60	1.00	0.50	0.34	0.53	0.50	0.11	0.12
	29	0.84	1.00	0.00	0.31	0.49	0.50	0.92	0.36
	30	0.66	1.00	0.00	0.26	0.47	0.50	0.92	0.36
	31	0.48	1.00	0.00	0.20	0.61	0.50	0.92	0.41
JUNE	1	0.45	1.00	0.00	0.19	0.76	0.50	0.92	0.45
	2	0.50	1.00	0.00	0.21	0.75	0.50	0.92	0.45
	3	0.63	1.00	0.00	0.25	0.73	0.50	0.92	0.45
	4	0.78	1.00	0.00	0.30	0.42	0.50	0.92	0.34
	5	0.93	1.00	0.50	0.47	0.41	0.50	0.92	0.33
	6	0.75	1.00	0.50	0.40	0.40	0.00	0.92	0.23
	7	0.45	1.00	0.00	0.19	0.37	0.00	0.92	0.22
	8	0.45	1.00	0.00	0.19				
	9	0.42	1.00	0.00	0.18				
	10	0.54	1.00	0.00	0.22	0.66	0.00	0.68	0.20
	11					0.55	0.00	0.68	0.19
	12					0.45	0.00	0.15	0.01
	13	0.75	1.00	0.00	0.29	0.41	0.00	1.00	0.26
	14	0.75	1.00	0.00	0.29	0.71	0.00	1.00	0.34
	15	0.53	1.00	0.00	0.22	0.73	0.00	1.00	0.34
	16	0.48	1.00	0.00	0.20	0.75	0.00	1.00	0.35
	17	0.63	1.00	0.00	0.25	0.61	0.00	1.00	0.31
	18	0.75	1.00	0.00	0.29	0.40	0.18	1.00	0.27
	19	1.01	1.00	0.00	0.35	0.39	0.18	1.00	0.26
	20	0.57	1.00	0.00	0.23	0.41	0.18	1.00	0.27
	21	0.51	1.00	0.00	0.21	0.53	0.18	1.00	0.31
	22	0.48	1.00	0.00	0.20	0.57	0.50	1.00	0.42
	23	0.45	1.00	0.00	0.19	0.63	0.50	.00	0.12

Table C-16....continued

DATE		YALA SEASON 1983				YALA SEASON 1984			
		DEPTH	HEAD	% OPEN	DIS-CHRGE.	DEPTH	HEAD	% OPEN	DIS-CHRGE.
	24	0.66	1.00	0.00	0.26	0.34	0.50	0.75	0.26
	25	0.69	1.00	0.00	0.27	0.40	0.53	0.75	0.29
	26					0.37	0.53	0.75	0.28
	27	0.45	1.00	0.00	0.19	0.33	0.53	0.75	0.26
	28	0.51	1.00	0.00	0.21	0.37	0.53	1.00	0.35
	29	0.62	1.00	0.00	0.25	0.47	0.53	0.73	0.31
	30	0.54	1.00	0.00	0.22	0.70	0.53	0.06	0.15
JULY	1	0.69	1.00	0.00	0.27	0.68	0.53	0.92	0.44
	2					0.52	0.53	0.92	0.39
	3	0.63	1.00	0.00	0.25	0.48	0.53	0.92	0.37
	4	1.11	1.00	0.00	0.38	0.35	0.53	0.92	0.32
	5	0.84	1.00	0.00	0.31	0.34	0.53	0.92	0.32
	6	0.84	1.00	0.00	0.31	0.61	0.53	0.92	0.42
	7	0.78	1.00	0.00	0.30	0.68	0.53	0.92	0.44
	8	0.51	0.50	0.00	0.08	0.71	0.53	0.92	0.45
	9	0.51	1.00	0.00	0.21	0.71	0.53	0.92	0.45
	10	0.54	1.00	0.00	0.22				
	11	0.44	1.00	0.00	0.18				
	12	0.87	1.00	0.00	0.32				
	13	0.89	1.00	0.00	0.33				
	14	0.83	1.00	0.00	0.31				
	15	0.80	0.50	0.00	0.12				
	16	0.60	0.50	0.00	0.09				
	17	0.54	0.50	0.50	0.17	0.52	0.54	0.92	0.39
	18	0.39	0.50	0.50	0.12	0.46	0.54	0.92	0.37
	19	0.35	0.50	0.50	0.11	0.59	0.54	0.92	0.42
	20	0.39	0.50	0.00	0.06	0.54	0.54	0.92	0.40
	21	0.41	0.50	0.00	0.07				
	22	0.66	1.00	0.00	0.26				
	23	0.80	0.50	0.50	0.23				
	24					0.13	0.05	0.92	0.13
	25					0.41	0.05	0.92	0.24
	26					0.49	0.05	0.92	0.26
	27					0.56	0.05	0.92	0.28
	28					0.77	0.05	0.92	0.32
	29					0.78	0.05	0.92	0.33
	30					0.74	0.05	0.92	0.32
	31					0.33	0.05	0.93	0.22
AUGUST	1					0.32	0.05	0.93	0.21
	2					0.35	0.05	0.93	0.22
	3					0.68	0.05	0.93	0.31
	4					0.44	0.05	0.93	0.25
	5					0.37	0.05	0.93	0.23
	6					0.35	0.05	0.93	0.22
	7	0.60	1.00	0.50	0.34				
	8	0.55	1.00	0.50	0.32				
	9	0.59	0.50	0.50	0.19	0.45	0.00	0.93	0.25
	10	0.84	0.50	0.50	0.24	0.43	0.05	0.93	0.25
	11	0.88	0.50	0.50	0.25				
	12	1.11	0.50	0.50	0.29				
	13								
	14					0.72	0.58	0.93	0.48
	15					0.61	0.58	0.93	0.45
	16					0.67	0.58	0.93	0.46
	17					0.90	0.58	0.93	0.54
	18					0.46	0.58	0.93	0.38
	19					0.48	0.58	0.93	0.39
	20					0.51	0.58	0.93	0.41
	21					0.55	0.58	0.93	0.42
	22					0.51	0.58	0.93	0.41
	23					0.50	0.58	0.93	0.40

Table C-17. Daily discharge rates at tract 7 and 8 offtake for the 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme, Stage I.

DATE		YALA SEASON 1983		YALA SEASON 1984	
		WATER DEPTH M	DISCHARGE CU.M/S	WATER DEPTH M	DISCHARGE CU.M/S
APRIL	18	0.42	0.87	-	-
	19	0.47	1.02	-	-
	20	0.54	1.29	-	-
	21	0.51	1.18	-	-
	22	0.48	1.06	0.33	0.58
	23	0.50	1.13	0.26	0.40
	24	0.49	1.09	0.58	1.44
	25	0.47	1.03	0.58	1.44
	26	0.46	1.00	0.14	0.15
	27	0.54	1.29	0.35	0.66
	28	0.51	1.18	0.34	0.62
	29	0.60	1.54	0.44	0.92
	30	0.49	1.11	0.42	0.87
MAY	1	0.46	0.99	0.43	0.90
	2	0.42	0.85	0.39	0.77
	3	0.40	0.80	0.43	0.91
	4	0.43	0.89	0.25	0.38
	5	0.43	0.90	0.36	0.67
	6	0.54	1.27	0.47	1.04
	7	0.71	2.01	0.50	1.13
	8	0.63	1.65	0.52	1.21
	9	0.56	1.38	0.68	1.85
	10	0.65	1.75	0.59	1.47
	11			0.50	1.13
	12			0.66	1.80
	13	0.46	1.00	0.48	1.07
	14	0.53	1.24	0.54	1.27
	15	0.53	1.27	0.50	1.15
	16	0.45	0.95	0.51	1.18
	17	0.35	0.64	0.57	1.39
	18	0.25	0.37	0.52	1.23
	19	0.69	1.92	0.52	1.21
	20	0.63	1.64	0.56	1.38
	21	0.68	1.88	0.51	1.18
	22	0.51	1.17	0.52	1.20
	23	0.46	1.00	0.40	0.79
	24	0.28	0.45	0.36	0.68
	25	0.31	0.52	0.35	0.65
	26	0.37	0.72	0.43	0.89
	27	0.38	0.75	0.46	0.99
	28	0.50	1.16	0.50	1.13
	29	0.66	1.79	0.48	1.06
	30	0.49	1.11	0.47	1.03
	31	0.36	0.68	0.62	1.60
JUNE	1	0.28	0.45	0.68	1.85
	2	0.39	0.77	0.65	1.74
	3	0.50	1.13	0.66	1.78
	4	0.61	1.57	0.46	0.99
	5	0.77	2.28	0.44	0.93
	6	0.62	1.60	0.42	0.88
	7	0.37	0.71	0.40	0.81
	8	0.36	0.68	0.60	1.51
	9	0.31	0.52	0.61	1.59
	10	0.42	0.85	0.62	1.62
	11	0.58	1.45	0.54	1.29
	12	0.68	1.85	0.46	0.99
	13	0.63	1.67	0.41	0.82
	14	0.59	1.49	0.60	1.51
	15	0.44	0.93	0.67	1.81
	16	0.38	0.74	0.67	1.82
	17	0.49	1.11	0.59	1.49
	18	0.60	1.54	0.40	0.80
	19	0.77	2.29	0.40	0.79
	20	0.45	0.95	0.39	0.76
	21	0.47	1.02	0.50	1.13
	22	0.40	0.80	0.52	1.21
	23	0.37	0.71	0.50	1.13

Table C-17....continued

DATE		YALA SEASON 1983		YALA SEASON 1984	
		WATER DEPTH M	DISCHARGE CU.M/S	WATER DEPTH M	DISCHARGE CU.M/S
	24	0.53	1.26	0.37	0.72
	25	0.54	1.31	0.36	0.67
	26	0.63	1.66	0.34	0.63
	27	0.37	0.71	0.33	0.58
	28	0.37	0.69	0.35	0.66
	29	0.35	0.64	0.48	1.08
	30	0.34	0.61	0.63	1.65
JULY	1			0.60	1.54
	2			0.50	1.13
	3	0.53	1.26	0.44	0.94
	4	0.42	0.85	0.37	0.71
	5	0.42	0.86	0.35	0.66
	6	0.34	0.61	0.55	1.35
	7	0.41	0.82	0.49	1.10
	8	0.62	1.62	0.53	1.27
	9	0.61	1.57	0.60	1.52
	10	0.60	1.52		
	11	0.27	0.44		
	12	0.30	0.50		
	13	0.28	0.46		
	14	0.33	0.60		
	15	0.37	0.72		
	16	0.57	1.42		
	17	0.59	1.48	0.48	1.05
	18	0.23	0.33	0.46	0.98
	19	0.19	0.25	0.50	1.16
	20	0.23	0.34	0.53	1.24
	21	0.23	0.33		
	22	0.45	0.95		
	23	0.52	1.20		
	24	0.58	1.46	0.17	0.21
	25			0.42	0.87
	26			0.42	0.87
	27			0.46	1.00
	28			0.52	1.22
	29			0.67	1.81
	30			0.63	1.65
	31			0.63	1.67
AUGUST	1			0.36	0.68
	2			0.37	0.72
	3			0.36	0.67
	4			0.57	1.42
	5			0.44	0.92
	6			0.36	0.67
	7	0.40	0.80	0.35	0.64
	8	0.37	0.71		
	9	0.17	0.22		
	10	0.21	0.29	0.44	0.92
	11	0.15	0.17	0.42	0.86
	12	0.20	0.27		
	13				
	14			0.44	0.94
	15			0.56	1.37
	16			0.56	1.38
	17			0.54	1.31
	18			0.47	1.02
	19			0.46	0.99
	20			0.45	0.97
	21			0.49	1.09
	22			0.52	1.21
	23			0.56	1.36

Table C18. Seepage and Percolation rates from paddy field ponding tests on poorly drained, imperfectly drained and well drained soils respectively at Kaudulla (Source: Holmes et al., 1980).

Low humic	Reddish Brown Earths	
gley soil	imperfectly drained	Well drained
16.1	10.8	43.9
19.2	15.4	53.0
14.4	48.0	31.2
	38.4	67.2
	24.0	57.6
	45.0	-
16.6	30.4	50.6

Table C19. Measured flow rates and hydraulic parameters of the main channel of Stage I. Kaudulla irrigation scheme.

Date	Section Width m	Flow Rate cu.m/s	Section Area sq.m	Wetted perimeter m	Hydraulic Radium	Mean Velocity m/s	S/n
16/10/82	10.60	2.76	8.39	11.03	0.76	0.33	0.39
13/04/83	11.00	3.89	10.11	11.85	0.85	0.39	0.43
16/04/83	7.00	3.31	7.58	8.07	0.94	0.44	0.46
17/04/84	10.30	1.60	5.58	10.54	0.53	0.29	0.44
14/06/84	7.35	3.91	8.36	8.44	0.99	0.47	0.47
20/06/84	7.35	4.02	8.66	8.61	1.01	0.46	0.46
22/06/84	7.22	3.03	7.48	8.21	0.91	0.41	0.43
28/06/84	7.40	3.31	7.86	8.34	0.94	0.42	0.44
29/06/84	7.40	3.77	8.01	8.47	0.95	0.47	0.49
	8.40	3.29	8.00	9.28	0.87	0.41	0.45

Table C20. Water issues recorded by the Department of Irrigation for the entire scheme during 1983 and 1984 Yala seasons. Kaudulla Irrigation Scheme. (source: Irrigation Office, Kaudulla).

Water Issues Recorded by Irrigation Department (acre ft.)										
	Yala Season 1983					Yala Season 1984				
	April	May	June	July	August	April	May	June	July	August
1		109	150	110	85		80	125	170	120
2		109	150	110	85		120	125	170	120
3		109	150	145	75		80	150	130	120
4		109	150	145	75		120		130	100
5		125	135	145	100		120	145	110	100
6		125	135	145	100		120	145	130	120
7		125	135	110	100		120	125	130	
8		125	135	110	100		120	155	155	
9		125	135	110	75		120	170		120
10		111	135	110	87		120	155		120
11			135	145	87		120	155		145
12	145	75	135	145	87		110	155		145
13	145	120	150	145			110	155		220
14	145	121	150	120			110	130		220
15	145	120	135	110			110	130		250
16	145	111	135	110	100		110	130	100	250
17	145	111	125	110			110	130	170	250
18	145	111	125	120	75		110	145	145	110
19	108	111	125	120			110	145	145	110
20	200	111	125	120		50	110	145	137	120
21	200	111	135	100		60	110	145		120
22	178	120	135	100		60	120	120		220
23	178	120	135	100		50	100	120		220
24	178	120	125	100	50	50	100	120	155	250
25	178	120	135	120	50	75	100	145	145	250
26	178	160	125		50	50	110	145	130	250
27	178	150	130		50	50	175	145	130	70
28	145	120	130			50	170	145	130	
29	145	120	130			75	170	145	130	
30	145	150	110			75	120	170	145	
31		150					120		120	

Table C21. Channel combinations and their sum discharge rates that fall within defined upper and lower boundaries of flow in the main channel, Stage I, Kaudulla Irrigation Scheme.

Channel Combination with Lower Bound of 2 and 2.5 m&	
D-1,D-2,D-5,D-8,D-9,D-10,T 7&8	2.06
D-1,D-2,D-5, ,D-10	2.01
D-1,D-2, ,D-8,D-9	2.11
D-1,D-2, ,D-8 ,D-10	2.06
D-1,D-2, ,D-9,D-10	2.15
D-1, D-5,D-8,D-9	2.13
D-1, ,D-5,D-8, ,D-10	2.08
D-1, ,D-5, ,D-9,D-10	2.17
D-1, ,D-8,D-9,D-10	2.21
D-2, ,D-9,D-10,T 7&8	2.04
D-5,D-8,D-9, ,T 7&8	2.01
D-5, ,D-9,D-10,T 7&8	2.06
D-8,D-9,D-10,T 7&8	2.10
D-1,D-2,D-5,D-8,D-9	2.28
D-1,D-2,D-5,D-8, ,D10	2.23
D-1,D-2,D-5, ,D-9,D10	2.32
D-1,D-2, ,D-8,D-9,D10	2.37
D-1, ,D-5,D-8,D-9,D10	2.37

Table C22. Measured inflow rates (in liters per second) into selected farm lots in tract 2 during 1984 Yala season. Kaudulla, Stage I.

Date	Lot Number								
	518	538	505	540	547	529	521	519	526
5/05	0.57	1.51	2.20	0.77	6.44	3.39	4.82	0.83	3.82
5/06	0.00	1.51	2.93	0.77	6.44	3.39	5.60	1.47	3.16
5/07	0.00	0.73	2.87	0.45	2.31	6.00	8.34	0.28	1.19
5/08	0.00	1.04	1.88	2.71	2.07	5.06	0.00	0.00	5.22
5/09	0.00	1.19	2.60	4.33	0.24	2.87	6.44	0.28	1.47
5/10	0.57	1.19	0.69	0.89	0.00	2.52	6.44	0.28	0.83
5/11	0.00	0.83	0.69	0.60	0.00	0.82	2.87	0.28	0.38
5/12	1.12	0.12	1.88	0.66	1.83	0.22	0.93	0.27	0.73
5/13	0.77	0.66	2.11	0.62	1.76	0.00	2.06	0.00	0.00
5/18	0.84	0.65	0.57	0.00	1.25	3.57	2.06	0.74	0.00
5/20	0.00	0.00	0.69	0.00	1.19	2.44	2.20	0.00	0.00
5/21	0.00	0.00	0.00	0.00	0.69	0.94	0.72	0.00	0.00
5/22	0.00	0.22	0.00	0.00	0.60	0.96	0.00	0.00	0.00
5/23	0.00	1.16	0.00	0.00	0.69	1.19	0.00	0.00	0.00
6/11	0.60	1.15	0.00	1.05	0.57	0.00	0.00	0.00	0.69
6/12	1.19	0.00	0.69	0.40	0.77	0.00	0.00	0.00	0.96
6/13	0.77	0.00	0.69	0.00	0.69	0.00	0.77	0.69	0.77
6/14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/17	0.69	1.20	0.82	0.88	1.18	0.00	0.43	0.69	0.57
6/18	0.74	1.90	0.00	0.41	0.88	0.00	0.69	1.47	0.77
6/19	0.45	0.77	0.00	0.77	0.88	0.77	2.06	1.47	0.57
6/21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/24	0.67	1.51	2.60	1.19	1.19	1.67	2.06	1.47	0.94
6/28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/01	1.97	0.00	0.99	0.99	2.93	3.84	2.06	0.00	2.11
7/18	2.06	2.06	0.69	1.40	1.47	3.16	1.47	2.06	1.67
7/19	2.06	1.97	0.82	1.12	1.19	2.60	1.51	2.60	2.11
7/20	0.00	0 00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/24	2.20	2.60	0.60	1.67	2.87	3.39	1.47	1.47	1.88
7/26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/29	2.06	1.88	1.15	1.47	1.67	2.55	1.19	2.20	1.47
7/30	2.20	2.06	0.77	1.40	2.06	2.06	1.40	1.63	1.47

Table C23. Measured inflow rates (in liters per second) into selected farm lots of tract 3 during 1984 Yala season. Kaudulla, Stage I.

Date	Lot Number								
	634	628	631	604	606	617	581	583	587
5/6	6.01	1.67	0.88	2.50	0.00	5.60	4.67	4.35	1.88
5/10	3.77	2.06	1.36	2.06	0.39	7.74	0.74	4.91	0.00
5/14	4.60	3.58	3.04	1.36	0.94	5.84	1.25	0.33	0.74
5/17	4.97	2.50	0.64	0.77	1.71	2.06	1.09	1.40	1.06
5/20	4.31	0.27	0.06	1.22	1.71	3.10	2.01	0.72	1.19
5/21	3.10	1.59	0.64	0.91	1.22	6.98	3.21	0.94	1.22
5/24	3.33	0.45	0.77	1.22	1.71	2.34	2.20	1.63	3.10
6/2	4.31	1.36	1.63	0.60	1.79	2.20	0.67	1.71	0.91
6/7	4.67	1.67	0.77	1.79	2.40	8.36	1.43	2.65	2.50
6/8	5.92	0.99	0.60	0.62	2.06	0.77	1.75	2.06	3.84
6/11	2.11	1.63	1.36	1.36	0.94	4.67	3.77	2.22	1.09
6/18	2.82	0.25	1.88	1.19	0.85	3.58	2.11	1.88	3.90
6/20	3.27	0.57	1.33	1.59	0.96	4.52	3.90	1.29	6.71
6/24	2.35	1.55	3.71	1.12	0.80	3.97	2.55	3.77	1.33
7/2	1.97	1.33	1.84	0.80	1.36	2.01	2.25	2.45	0.55
7/4	2.65	1.79	2.01	1.43	1.63	0.49	1.75	0.67	1.36
7/8	2.98	1.36	1.36	1.79	1.63	3.33	2.50	2.93	1.71
7/18	2.76	1.59	3.33	0.99	1.33	2.65	2.98	3.04	1.75
7/19	0.99	0.67	3.71	1.36	0.64	0.00	1.79	2.15	2.55
7/24	1.06	0.19	1.25	1.59	0.74	0.00	2.11	3.10	1.36
7/25	0.91	0.64	0.49	0.74	1.25	0.00	0.00	1.22	0.00
7/31	0.00	0.00	0.55	0.91	0.91	0.00	0.00	0.00	0.00
8/1	0.00	0.00	0.94	1.33	0.00	0.00	0.00	0.00	0.00

Table C24. Measured inflow rates (in liters per second) into selected farm lots of tract 8 during 1984 Yala season. Kaudulla Stage I.

Date	Lot Number								
	1630	1634	1637	1662	1672	1677	1749	1751	1754
5/03	2.06	0.41	3.27	1.22	0.00	0.00	1.21	0.00	2.35
5/04	0.29	0.00	0.00	0.01	0.00	0.64	0.00	1.09	0.00
5/05	1.15	0.55	1.43	0.00	0.00	1.40	0.24	0.43	0.00
5/06	0.82	1.19	0.00	2.45	0.00	0.00	0.45	0.00	1.33
5/07	1.09	2.50	0.45	0.00	0.28	0.00	3.52	0.00	0.38
5/08	0.00	3.81	0.00	1.40	0.39	1.71	5.76	0.00	2.71
5/09	0.12	3.09	0.00	0.00	0.14	0.00	1.36	0.00	1.25
5/21	0.00	0.41	0.94	0.48	0.27	0.00	0.00	0.64	0.27
5/22	0.00	0.24	1.22	1.32	0.00	1.22	0.00	1.29	0.00
6/12	0.00	0.00	0.00	0.32	0.38	0.25	0.00	0.00	0.00
6/13	3.10	0.00	0.00	0.15	0.00	1.36	0.04	0.00	0.00
6/14	5.76	0.13	4.97	0.00	0.47	0.00	0.88	5.81	0.94
6/16	5.28	1.92	5.84	1.66	0.51	0.00	2.01	2.50	0.62
6/18	0.91	2.45	0.62	0.00	0.25	1.29	0.00	0.74	0.31
6/20	0.60	0.00	1.29	0.23	0.13	0.00	0.14	0.29	0.00
6/22	0.00	0.00	0.00	0.54	0.31	0.99	0.13	0.64	0.00
6/24	0.00	0.00	0.00	0.18	0.00	0.34	0.12	0.00	0.64
6/28	1.29	0.00	0.12	0.27	0.19	0.00	0.31	0.13	0.00
6/29	0.00	0.00	0.00	0.16	0.27	0.00	0.00	0.00	0.12
6/30	0.00	0.00	0.00	0.31	0.60	0.00	1.15	0.00	0.05
7/02	0.00	0.64	0.88	0.27	0.00	0.00	0.00	0.27	0.14
7/04	0.00	0.00	0.00	0.00	0.33	0.00	0.49	0.00	0.11
7/19	1.29	0.85	0.77	0.23	0.00	0.00	0.00	0.14	0.27
7/20	0.36	0.00	0.00	0.25	0.00	0.00	1.22	0.25	0.64

Table C25. Measured drainage outflow rates (in liters per second) from selected farm lots in tract 2 during 1984 Yala season. Kaudulla Stage I.

Date	Lot Number								
	518	538	505	540	547	529	521	519	526
5/05	0.35	0.00	0.48	1.40	2.53	1.08	1.35	0.35	0.42
5/06	0.00	0.61	0.52	1.40	1.79	0.96	2.16	0.35	0.48
5/07	1.12	0.12	0.36	0.12	0.49	4.75	7.06	0.37	0.88
5/08	0.73	1.88	0.35	0.99	0.99	1.56	0.73	0.84	1.55
5/09	0.29	0.94	0.37	3.23	1.34	2.70	0.73	0.15	0.67
5/10	0.43	0.36	0.29	0.59	0.00	0.56	1.92	0.13	0.35
5/11	0.00	0.60	0.25	0.97	0.22	0.22	1.12	0.13	0.22
5/12	0.25	0.12	0.13	0.00	0.49	0.12	0.48	0.29	0.46
5/13	0.24	0.12	0.57	0.22	0.35	0.00	0.26	0.00	0.00
5/18	0.49	0.35	0.22	0.00	0.25	0.68	1.32	0.12	0.00
5/20	0.00	0.00	0.29	0.00	0.22	0.87	0.12	0.00	0.00
5/21	0.00	0.00	0.00	0.00	0.43	0.52	0.22	0.00	0.00
5/22	0.00	0.00	0.00	0.00	0.36	0.69	0.00	0.00	0.00
5/23	0.00	0.36	0.00	0.00	0.36	0.73	0.00	0.00	0.00
6/11	0.00	0.29	0.00	0.17	0.29	0.00	0.00	0.00	0.29
6/12	0.29	0.00	0.00	0.12	0.27	0.00	0.00	0.00	0.25
6/13	0.22	0.00	0.29	0.00	0.29	0.00	0.48	0.00	0.22
6/14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/17	0.12	0.00	0.22	0.24	0.38	0.00	0.00	0.00	0.00
6/18	0.12	0.38	0.00	0.12	0.95	0.00	0.24	0.43	0.35
6/19	0.00	0.25	0.00	0.12	0.22	0.00	0.36	0.27	0.22
6/21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6/30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/01	0.96	0.00	0.28	0.00	0.96	0.00	0.60	0.00	1.88
7/18	0.12	0.00	0.00	0.00	0.29	0.43	0.25	0.43	0.00
7/19	0.00	0.22	0.00	0.25	0.00	0.29	0.00	0.22	0.22
7/20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/24	0.22	0.12	0.13	0.77	0.22	0.22	0.28	0.00	0.12
7/26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7/29	0.22	0.31	0.31	0.24	0.24	0.41	0.12	0.22	0.43
7/30	0.12	0.29	0.00	0.22	0.22	0.29	0.22	0.29	0.41

Table C26. Measured drainage outflow rates (in liters per second) from selected farm lots in tract 3 during 1984 Yala season. Kaudulla, Stage I.

Date	Lot Number								
	634	628	631	604	606	617	581	583	587
5/6	1.71	0.41	4.82	0.00	0.41	0.00	0.47	5.60	0.00
5/10	0.82	0.55	0.29	0.77	0.13	0.00	0.00	4.31	2.03
5/14	0.67	0.00	1.36	0.39	0.45	1.36	0.45	0.00	0.31
5/17	0.25	1.22	0.14	0.12	0.08	0.29	0.00	0.34	0.00
5/20	0.74	0.00	0.00	0.00	0.94	1.25	0.45	0.00	0.41
5/21	0.55	0.31	0.05	0.00	0.15	1.03	1.33	0.18	0.47
5/24	0.64	0.28	0.12	0.31	0.15	0.00	0.33	0.18	0.64
6/2	0.64	0.00	0.13	0.00	0.31	0.00	0.12	0.13	0.00
6/7	0.74	0.29	0.13	0.99	0.20	4.45	0.45	0.67	0.67
6/8	1.06	0.25	0.25	0.18	0.64	0.00	0.64	0.45	0.00
6/11	1.47	0.00	0.00	0.31	0.00	0.00	0.00	0.04	0.94
6/18	1.12	0.00	0.82	0.00	0.28	0.00	0.77	0.47	0.00
6/20	0.28	0.00	0.12	0.00	0.00	0.69	0.00	0.00	0.69
6/24	0.29	0.74	0.00	0.00	0.45	0.00	0.13	0.33	0.00
7/2	0.43	0.64	0.31	0.00	0.49	0.13	0.53	0.43	0.00
7/4	0.00	0.00	0.53	0.88	0.00	0.00	0.00	0.00	0.00
7/8	0.91	0.31	0.00	0.67	0.27	0.67	0.62	0.00	0.49
7/18	0.69	0.34	0.51	0.00	0.29	0.00	0.72	0.00	0.00
7/19	0.00	0.00	0.62	0.33	0.00	0.00	0.27	0.20	0.53
7/24	0.00	0.00	0.27	0.41	0.00	0.00	0.64	0.99	0.00
7/25	0.31	0.15	0.29	0.00	0.25	0.00	0.60	0.21	0.00
7/31	0.00	0.00	0.10	0.00	0.20	0.00	0.00	0.00	0.00
8/1	0.00	0.00	0.16	0.41	0.00	0.00	0.00	0.00	0.00

Table C27. Measured drainage outflow rates (in liters per second) from selected farm lot in Tract 8 during Yala season 1984, Kaudulla Stage I.

Date	Lot Number								
	1630	1634	1637	1162	1671	1677	1749	1751	1754
5/03	0.00	5.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5/05	0.00	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.00
5/06	0.00	2.06	8.13	0.00	0.00	0.00	0.00	0.00	0.00
5/07	0.00	1.55	2.55	0.00	0.00	0.00	0.00	0.00	0.00
5/08	0.00	0.00	0.12	0.25	0.00	0.94	1.47	0.00	0.00
5/09	0.00	0.00	0.06	0.00	0.06	0.00	0.12	0.00	0.00
5/21	0.00	0.00	4.24	0.00	0.00	0.00	0.00	0.00	0.04
5/22	0.00	0.00	0.72	0.00	0.00	0.12	0.00	0.41	0.13
6/12	0.00	0.00	0.31	0.00	0.00	0.12	0.00	0.00	0.00
6/13	0.00	0.00	0.05	0.00	0.00	0.14	0.08	0.00	0.28
6/14	0.49	13.00	11.84	0.05	0.00	0.00	0.12	4.76	0.00
6/16	0.00	1.39	2.76	0.00	0.08	0.00	0.12	0.00	0.00
6/18	0.13	0.12	0.41	0.07	0.09	0.18	0.00	0.00	0.14
6/20	0.18	0.13	0.21	0.00	0.00	0.00	0.06	0.00	0.00
6/22	0.00	0.00	0.00	0.12	0.13	0.00	0.18	0.00	0.00
6/24	0.00	0.00	0.00	0.00	0.19	0.24	0.00	0.78	0.00
6/28	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
6/29	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00
6/30	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00
7/02	0.19	1.22	0.21	0.00	0.05	0.00	0.00	0.05	0.00
7/04	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.05
7/19	0.00	0.28	2.50	0.24	0.05	0.00	0.00	0.19	0.00
7/20	0.43	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.12

Table C28. Variety and duration of paddy of the selected farms sorted according to farm size and and yield in kilograms per hectare. Tract 2, 1984 Yala Season, Kaudulla Stage I

Lot No.	Extent acres	Planting Method	Variety	Duration (days)	Yield kg/ha
546c	0.50	bc	BG34-6	105	1688.6
548c	0.50	bc	BG276-5	75	1899.7
548b	0.50	bc	BG276-5	75	2110.7
546b	0.50	bc	BG34-8	75	2263.4
526c	0.50	bc	BG34-8	75	2694.5
525c	0.50	bc	BG400-1	120	2788.9
526b	0.50	tp	BG11-11	120	3772.4
525a	0.50	tp	BG34-8	75	4311.3
540b	0.75	bc	BG276-5	75	2814.3
519a	1.25	bc	BG379-2	120	1760.4
503a	1.50	bc	BG34-8	75	2694.5
548a	2.00	bc	BG34-8	75	2020.9
519b	2.00	bc	BG34-8	75	2425.1
526a	2.00	tp	BG400-1	120	2788.9
525b	2.00	tp	BG34-8	75	2829.3
503b	2.50	bc	BG276-5	75	2490.7
514	3.00	bc	BG34-8	75	2335.3
517	3.00	bt	BG34-8	75	2425.1
540a	3.00	bc	BG276-5	75	2462.5
546a	3.00	bc	BG34-8	75	2514.9
518	3.00	tp	BG11-11	120	3233.5
507	3.50	bt	BG34-6	105	3015.3
505	4.00	tp	BG400-1	120	2259.5
538	4.00	tp	BG379-2	120	2406.8
512	4.00	bc	BG400-1	120	2775.9
499	4.75	bc	BG34-6	105	2521.8
529	5.00	bt	BG400-1	120	1962.5
547	5.00	bc	BG11-11	120	2425.1
521	5.75	tp	BG11-11	120	2155.6

Table C29. Variety and duration of paddy of the selected farms sorted according to farm size and and yield in kilograms per hectare. Tract 3, 1984 Yala Season, Kaudulla Stage I

Lot No.	Extent acres	Planting Method	Variety	Duration (days)	Yield kg/ha
620c	0.50	bc	BG276-5	75	1899.7
585c	0.50	bc	BG34-6	105	2216.3
585a	0.50	bc	BG276-5	75	2638.4
611b	1.00	bc	BG34-6	105	2110.7
620b	1.00	bc	BG276-5	75	2374.6
583b	1.00	bc	BG276-5	75	2532.9
584b	1.00	bc	BG34-8	75	2964.0
581a	1.25	bc	BG276-5	75	2532.9
631a	1.25	bc	BG11-11	120	2586.8
620a	1.75	bc	BG34-8	75	2956.3
583a	2.00	bc	BG34-8	75	2020.9
585b	2.00	bc	BG34-8	75	2155.6
625a	2.00	bc	BG400-1	120	2194.9
625b	2.00	bc	BG379-2	120	2200.5
611a	2.00	bc	BG11-11	120	2425.1
584a	2.00	bc	BG276-5	75	2506.5
581b	2.00	bc	BG34-8	75	2694.5
631b	2.75	bc	BG11-11	120	2057.7
582	3.00	bc	BG276-5	75	2022.8
587	3.00	tp	BG34-8	75	2245.5
629	3.00	bc	BG400-1	120	2324.0
632	3.00	bc	BG276-5	75	2462.5
606	3.50	bc	BG34-8	75	1693.7
618	3.50	tp	BG400-1	120	2434.7
628	3.75	bc	BG34-8	75	2155.6
626	4.00	tp	BG34-8	75	2020.9
604	4.00	tp	BG400-1	120	2194.9
634	4.00	bc	BG379-2	120	2475.6

Table C30. Variety and duration of paddy of the selected farms sorted according to farm size and and yield in kilograms per hectare. Tract 8, 1984 Yala Season, Kaudulla Stage I.

Lot No.	Extent acres	Planting Method	Variety	Duration (days)	Yield kg/ha
1673	1.50	bc	BG34-8	75	2874.2
1748	2.00	tp	BG276-5	75	1583.0
1754	2.00	tp	BG34-8	75	1940.1
1630	2.00	bc	BG34-8	75	2209.5
1749	2.00	bc	BG276-5	75	2242.6
1671	2.00	bc	BG276-5	75	2321.8
1639	2.00	bc	BG276-5	75	2427.3
1677	2.00	bc	BG400-1	120	2453.2
1634	2.00	bc	BG34-8	75	2479.0
1752	2.00	bc	BG276-5	75	2638.4
1629	2.00	bc	BG276-5	75	2638.4
1637	2.00	tp	BG34-8	75	2694.5
1659	2.00	bc	CHINA	105	2892.1
1755	2.00	bc	BG34-8	75	2964.0
1751	2.00	bc	BG276-5	75	3034.2
1635	2.00	bc	BG34-8	75	3233.5
1666	2.00	bc	BG276-5	75	3746.5
1662	3.75	bc	BG34-8	75	2586.8

Table C31. Fertilizer use in kilograms per hectare sorted according to the size of farm of the selected farms in Tract 2. 1984 Yala Season, Kaudulla, Stage I.

Lot No.	Extent acres	Basal Kg/ha	Urea Kg/ha	TDM Kg/ha
546c	0.50	123.5	0.0	0.0
548c	0.50	0.0	0.0	123.5
548b	0.50	0.0	0.0	123.5
546b	0.50	0.0	123.5	0.0
526c	0.50	123.5	123.5	123.5
525c	0.50	123.5	123.5	123.5
526b	0.50	247.0	0.0	0.0
525a	0.50	247.0	247.0	291.5
540b	0.75	164.7	164.7	164.7
519a	1.25	0.0	98.8	0.0
503a	1.50	164.7	82.3	82.3
548a	2.00	123.5	30.9	92.6
519b	2.00	123.5	123.5	61.8
526a	2.00	123.5	61.8	123.5
525b	2.00	123.5	123.5	123.5
503b	2.50	123.5	74.1	123.5
514	3.00	123.5	82.3	123.5
517	3.00	102.9	41.2	164.7
540a	3.00	82.3	61.8	107.0
546a	3.00	82.3	123.5	102.9
518	3.00	164.7	123.5	123.5
507	3.50	70.6	105.9	70.6
505	4.00	92.6	92.6	108.1
538	4.00	92.6	92.6	92.6
512	4.00	123.5	123.5	108.1
499	4.75	117.0	130.0	91.0
529	5.00	74.1	98.8	74.1
547	5.00	98.8	98.8	98.8
521	5.75	0.0	64.4	64.4

Table C32. Fertilizer use in kilograms per hectare sorted according to the size of farm of the selected farms in Tract 3. 1984 Yala Season, Kaudulla, Stage I.

Lot No.	Extent acres	Basal Kg/ha	Urea Kg/ha	TDM Kg/ha
620c	0.50	0.0	123.5	0.0
585c	0.50	123.5	123.5	123.5
585a	0.50	123.5	123.5	123.5
611b	1.00	123.5	123.5	123.5
620b	1.00	123.5	185.3	123.5
583b	1.00	123.5	123.5	123.5
584b	1.00	185.3	0.0	123.5
581a	1.25	0.0	148.2	148.2
631a	1.25	197.6	197.6	0.0
620a	1.75	0.0	105.9	141.1
583a	2.00	123.5	61.8	61.8
585b	2.00	0.0	123.5	123.5
625a	2.00	123.5	61.8	123.5
625b	2.00	92.6	61.8	123.5
611a	2.00	123.5	61.8	123.5
584a	2.00	123.5	123.5	123.5
581b	2.00	185.3	216.1	154.4
631b	2.75	89.8	89.8	89.8
582	3.00	82.3	82.3	0.0
587	3.00	123.5	144.1	0.0
629	3.00	41.2	123.5	0.0
632	3.00	164.7	82.3	164.7
606	3.50	0.0	105.9	70.6
618	3.50	105.9	70.6	141.1
628	3.75	98.8	32.9	65.9
626	4.00	123.5	92.6	92.6
604	4.00	46.3	61.8	123.5
634	4.00	92.6	92.6	123.5

Table C33. Fertilizer use in kilograms per hectare sorted according to the size of farm of the selected farms in Tract 8. 1984 Yala Season, Kaudulla, Stage I.

Lot No.	Extent acres	Basal Kg/ha	Urea Kg/ha	TDM Kg/ha
1673	1.50	82.3	123.5	144.1
1748	2.00	0.0	61.8	61.8
1754	2.00	123.5	61.8	92.6
1630	2.00	61.8	61.8	92.6
1749	2.00	123.5	123.5	123.5
1671	2.00	185.3	92.6	0.0
1639	2.00	61.8	61.8	61.8
1677	2.00	154.4	92.6	92.6
1634	2.00	154.4	92.6	123.5
1752	2.00	123.5	61.8	123.5
1629	2.00	123.5	123.5	92.6
1637	2.00	123.5	123.5	0.0
1659	2.00	123.5	92.6	123.5
1755	2.00	123.5	154.4	185.3
1751	2.00	185.3	61.8	154.4
1635	2.00	123.5	92.6	123.5
1666	2.00	123.5	123.5	0.0
1662	3.75	65.9	65.9	65.9

Table C34. Pesticide application sorted by the size of farm in milliliters per acre for the farms observed in Tract 2. 1984 Yala Season, Stage I, Kaudulla.

Lot No.	Exten acres	Pesticide 1	ml/ac	Pesticide 2	ml/ac
548c	0.50				
526c	0.50				
546b	0.50				
548b	0.50	Parathion	900		
525c	0.50	Monocrotophos	900		
525a	0.50	Parathion	450		
526b	0.50				
546c	0.50				
540b	0.75	Monocrotophos	600	Parathion	600
519a	1.25				
503a	1.50	Parathion	600		
525b	2.00	Monocrotophos	225		
519b	2.00	Monocrotophos	225		
548a	2.00	Parathion	450	Azodrin	225
526a	2.00				
503b	2.50	Parathion	180		
517	3.00	Methimidophos	300		
540a	3.00				
514	3.00	Parathion	300		
518	3.00	Parathion	900		
546a	3.00	Parathion	300		
507	3.50	Methimidophos	129	Kurator	1
505	4.00	Monocrotophos	113		
512	4.00	Parathion	113	Basudin	113
538	4.00	Methimidophos	113	Aloran	25
499	4.75	Parathion	474		
529	5.00	Morithion	90		
547	5.00				
521	5.75	Parathion	78		

Table C35. Pesticide application sorted by the size of farm in milliliters per acre for the farms observed in Tract 3. 1984 Yala Season, Stage I, Kaudulla.

Lot No.	Exten acres	Pesticide 1	ml/ac	Pesticide 2	ml/ac
585a	0.50	Monocrotophos	900	Parathion	450
620c	0.50				
585c	0.50				
583b	1.00	Parathion	900		
584b	1.00	Parathion	1350		
620b	1.00	Parathion	900		
611b	1.00				
581a	1.25	Monocrotophos	1080		
631a	1.25				
620a	1.75				
611a	2.00	Monocrotophos	450		
585b	2.00				
581b	2.00	Rogor 40	450		
625b	2.00				
584a	2.00	Monocrotophos	450	Basudin	225
583a	2.00				
625a	2.00	Azodrin	500		
631b	2.75				
582	3.00				
629	3.00	Parathion	150		
587	3.00	Monocrotophos	150		
632	3.00	Parathion	300		
618	3.50	Monocrotophos	129		
606	3.50	Parathion	257		
628	3.75	Parathion	240		
634	4.00	Parathion	113		
604	4.00				
626	4.00				

Table C36. Pesticide application sorted by the size of farm in milliliters per acre for the farms observed in Tract 8. 1984 Yala Season, Stage I, Kaudulla.

Lot No.	Exten acres	Pesticide 1	ml/ac	Pesticide 2	ml/ac
1673	1.50	Monocrotophos	133		
1666	2.00	Monocrotophos	675		
1671	2.00	Parathion	450		
1634	2.00	Monocrotophos	225		
1630	2.00				
1637	2.00	Monocrotophos	225	Basudin	225
1748	2.00	Monocrotophos	225		
1677	2.00	Monocrotophos	225	Basudin	4
1749	2.00	Monocrotophos	225	Rogor 40	2025
1629	2.00	Monocrotophos	100		
1751	2.00	Monocrotophos	450	Monitor	100
1635	2.00	Monocrotophos	675		
1752	2.00	Azodrin	450		
1659	2.00	Monocrotophos	225	Azodrin	250
1639	2.00				
1755	2.00	Monocrotophos	450	Parathion	225
1754	2.00	Monocrotophos	225		
1662	3.75	Parathion	120	Basudin	

Table C37. Weedicide application sorted by the size of farm in milliliters per acre for the farms observed in Tract 2. 1984 Yala Season, Stage I, Kaudulla.

Lot No.	Exten acres	Weedicide 1	Rate ml/ac	Weedicide 2 2	Rate ml/ac
548c	0.50		0		0
526c	0.50		0		0
546b	0.50		0		0
548b	0.50		0		0
525c	0.50		0		0
525a	0.50		0		0
526b	0.50		0		0
546c	0.50		0		0
540b	0.75	34DPA	2400		0
519a	1.25	34DPA	720		0
503a	1.50	M-50	600		0
525b	2.00		0		0
526a	2.00	M-50	225		0
548a	2.00		0		0
519b	2.00	34DPA	450	-50	450
503b	2.50	34DPA	900		0
517	3.00		0		0
540a	3.00		0		0
514	3.00		0		0
518	3.00		0		0
546a	3.00		0		0
507	3.50	34DPA	771		0
505	4.00		0		0
512	4.00		0		0
538	4.00		0		0
499	4.75	34DPA	758	-50	189
529	5.00	M-50	243		0
547	5.00		0		0
521	5.75		0		0

Table C38. Weedicide application sorted by the size of farm in milliliters per acre for the farms observed in Tract 3. 1984 Yala Season, Stage I, Kaudulla.

Lot No.	Exten acres	Weedicide 1	Rate ml/ac	Weedicide 2 2	Rate ml/ac
585a	0.50	34DPA	900		0
620c	0.50		0		0
585c	0.50	M-50	1800		0
583b	1.00		0		0
584b	1.00	34DPA	3150		0
620b	1.00	M-50	450		0
611b	1.00		0		0
581a	1.25		0		0
631a	1.25		0		0
620a	1.75		0		0
611a	2.00	34DPA	900		0
585b	2.00	34DPA	900		0
581b	2.00	34DPA	450	CPA	125
625b	2.00	34DPA	1575		0
584a	2.00	M-50	1125		0
583a	2.00	34DPA	1350		0
625a	2.00		0		0
631b	2.75	34DPA	164	-50	327
582	3.00		0		0
629	3.00	M-50	600		0
587	3.00		0		0
632	3.00		0		0
618	3.50	34DPA	386		0
606	3.50		0		0
628	3.75	34DPA	600		0
634	4.00	34DPA	1350		0
604	4.00	34DPA	563		0
626	4.00	MCPA	225		0

Table C39. Weedicide application sorted by the size of farm in milliliters per acre for the farms observed in Tract 8. 1984 Yala Season, Stage I, Kaudulla.

Lot No.	Exten acres	Weedicide 1	Rate ml/ac	Weedicide 2 2	Rate ml/ac
1673	1.50	34DPA	600		0
1666	2.00		0		0
1671	2.00	M-50	450		0
1634	2.00	34DPA	500		0
1630	2.00	M-50	338		0
1637	2.00		0		0
1748	2.00		0		0
1677	2.00	34DPA	500		0
1749	2.00		0		0
1629	2.00	34DPA	225		0
1751	2.00	Prpopanil	900		0
1635	2.00	Rilof	500		0
1752	2.00	Propanil	675	-50	450
1659	2.00	M-50	675		0
1639	2.00	M-50	225		0
1755	2.00	MCPA	1350		0
1754	2.00		0		0
1662	3.75	Rilof	267		0

Table C40. Gross cost of production, net cost of production, gross income and net income in Rupees per hectare sorted according to farm size and yield for the farms studied in Tract 2, 1984 Yala Season, Kaudulla stage I

	Gross Cost Rs/ha	Net Cost Rs/ha	Gross Income Rs/ha	Net Income Rs/ha
546c	2173.60	5125.25	2470.00	-481.65
548c	1605.50	5915.65	3618.55	-691.60
548b	1506.70	6261.45	4297.80	-456.95
546b	2000.70	4853.55	4223.70	1370.85
526c	2642.90	5193.18	4767.10	2216.83
525c	2000.70	7934.88	5668.65	-265.53
526b	5014.10	11818.95	5359.90	-1444.95
525a	11050.78	13656.63	805.22	-1800.63
540b	4459.17	8682.87	3280.16	-943.54
519a	1725.05	4427.23	3116.15	413.97
503a	4610.67	6183.23	2799.33	1226.77
548a	1777.17	4738.08	3780.34	819.42
519b	2479.26	5819.94	4189.74	849.06
526a	2411.34	5035.71	5258.01	2633.64
525b	4983.23	5486.49	2797.28	2294.01
503b	3151.72	5046.21	3697.59	1803.10
514	2875.49	5516.33	3546.51	905.67
517	2947.53	7319.43	3721.47	-650.43
540a	2408.25	4248.40	4363.67	2523.52
546a	2799.33	5158.18	4116.67	1757.82
518	4417.18	6850.13	4474.82	2041.87
507	3327.02	5490.03	4965.12	2802.11
505	5606.90	5903.30	606.69	310.29
538	2321.80	5452.53	4297.03	1166.30
512	3177.04	4754.75	4456.81	2879.09
499	2888.25	4891.99	4046.60	2042.86
529	2264.06	4541.40	3132.89	855.55
547	2400.84	4940.00	4268.16	1729.00
521	4012.14	5283.65	1915.86	644.35

Table C41. Gross cost of production, net cost of production, gross income and net income in Rupees per hectare sorted according to farm size and yield for the farms studied in Tract 3, 1984 Yala Season, Kaudulla stage I

	Gross Cost Rs/ha	Net Cost Rs/ha	Gross Income Rs/ha	Net Income Rs/ha
620c	4149.60	6273.80	1074.45	-1049.75
585c	4989.40	9064.90	1105.33	-2970.18
585a	3714.88	9568.78	3540.75	-2313.16
611b	2346.50	5538.98	3458.00	265.52
620b	4353.38	6854.25	2176.69	-324.19
583b	3198.65	6749.28	3766.75	216.12
584b	4492.93	8747.51	3658.07	-596.51
581a	3295.97	6442.75	3669.43	522.65
631a	3863.08	5700.76	3250.52	1412.84
620a	1990.11	4361.31	6139.71	3768.51
583a	2534.22	6115.72	3023.28	-558.22
585b	2597.21	4900.48	3330.79	1027.52
625a	3406.13	5104.26	2629.93	931.81
625b	2752.82	5173.42	3298.69	878.09
611a	2924.48	4919.01	3744.52	1749.99
584a	3162.22	5169.09	3730.63	1723.75
581b	4278.04	6355.93	3131.96	1054.07
631b	2130.49	3742.72	3528.06	1915.82
582	1786.63	5032.63	3776.01	530.02
587	3211.00	5512.22	2964.00	662.78
629	3046.33	4752.69	3344.79	1638.43
632	4050.80	5347.55	2721.12	1424.37
606	2159.49	3465.06	2498.23	1192.66
618	5276.63	6737.45	1418.84	-41.99
628	2404.13	3777.45	3523.87	2150.55
626	2954.74	4591.11	2602.76	966.39
604	3454.91	6400.39	2581.15	-364.33
634	3149.25	4949.26	3658.69	1858.68

Table C42. Gross cost of production, net cost of production, gross income and net income in Rupees per hectare sorted according to farm size and yield for the farms studied in tract 8, 1984 Yala Season, Kaudulla stage I

	Gross Cost Rs/ha	Net Cost Rs/ha	Gross Income Rs/ha	Net Income Rs/ha
1673	2833.09	6702.76	5070.91	1201.24
1748	4254.58	6273.80	98.80	-1920.43
1754	3149.25	6885.13	2185.95	-1549.93
1630	1343.06	4909.13	4733.14	1167.08
1749	3160.37	5037.57	3006.92	1129.72
1671	3771.69	5528.48	2613.26	856.47
1639	1475.83	3732.79	5199.35	2942.39
1677	4674.48	7076.55	2071.71	-330.36
1634	3267.81	7343.31	3549.39	-526.11
1752	3622.26	7129.66	3633.37	125.97
1629	4417.60	6103.37	2838.03	1152.25
1637	4470.70	7286.50	2939.30	123.50
1659	3215.94	7445.82	4737.46	507.58
1755	4658.42	6819.67	3492.58	1331.33
1751	3889.02	6513.39	4454.95	1830.58
1635	5261.10	7329.73	3630.90	1562.28
1666	4947.41	6799.91	5355.58	3503.08
1662	1910.13	4811.56	5203.47	2302.04

Table C43. Beakdown of net cost expressed as a percentage of net cost and sorted according to the holding size for selected farms in tract 2. Stage I, Kaudulla irrigation scheme, 1984 Yala season.

	Power Source		Agrochem.		Fertilizer	Labor		Other	Net
	Hired	Own	Weed	Pest Control		Hired	Family	Costs	Cost
	%	%	%	%	%	%	%	%	Rs/ha
546c	0.14	0.00	0.00	0.00	0.07	0.1	0.58	0.04	5125.25
548c	0.00	0.13	0.00	0.00	0.06	0.1	0.60	0.03	5915.65
548b	0.00	0.12	0.00	0.05	0.06	0.0	0.64	0.05	6261.45
546b	0.15	0.00	0.00	0.00	0.08	0.1	0.59	0.04	4853.55
526c	0.19	0.00	0.00	0.00	0.21	0.0	0.49	0.04	5193.18
525c	0.00	0.19	0.00	0.07	0.14	0.0	0.56	0.04	7934.88
526b	0.00	0.13	0.00	0.00	0.06	0.3	0.45	0.02	11818.95
525a	0.04	0.08	0.00	0.01	0.17	0.5	0.11	0.01	13656.63
540b	0.06	0.04	0.09	0.07	0.17	0.0	0.45	0.05	8682.87
519a	0.00	0.11	0.06	0.00	0.07	0.2	0.50	0.04	4427.23
503a	0.28	0.00	0.02	0.03	0.16	0.2	0.25	0.06	6183.23
548a	0.00	0.16	0.00	0.08	0.16	0.0	0.47	0.05	4738.08
519b	0.00	0.30	0.04	0.02	0.16	0.1	0.28	0.03	5819.94
526a	0.00	0.18	0.01	0.00	0.18	0.2	0.34	0.05	5035.71
525b	0.32	0.00	0.00	0.03	0.20	0.3	0.09	0.04	5486.49
503b	0.07	0.06	0.06	0.01	0.19	0.2	0.32	0.04	5046.21
514	0.00	0.31	0.00	0.02	0.18	0.2	0.17	0.04	5516.33
517	0.00	0.13	0.00	0.03	0.13	0.2	0.46	0.03	7319.43
540a	0.06	0.14	0.00	0.00	0.18	0.2	0.30	0.05	4248.40
546a	0.00	0.18	0.00	0.02	0.18	0.3	0.28	0.04	5158.18
518	0.00	0.13	0.00	0.04	0.18	0.3	0.23	0.03	6850.13
507	0.00	0.31	0.05	0.02	0.13	0.3	0.08	0.04	5490.03
505	0.18	0.00	0.00	0.01	0.15	0.5	0.05	0.04	5903.30
538	0.00	0.34	0.00	0.02	0.15	0.2	0.23	0.04	5452.53
512	0.00	0.15	0.00	0.02	0.22	0.3	0.18	0.05	4754.75
499	0.05	0.11	0.06	0.03	0.21	0.2	0.30	0.04	4891.99
529	0.04	0.14	0.01	0.01	0.16	0.2	0.36	0.05	4541.40
547	0.00	0.35	0.00	0.00	0.18	0.2	0.16	0.04	4940.00
521	0.32	0.00	0.00	.00	0.07	0.3	0.24	0.04	5283.65
	0.07	0.13	0.01	0.02	0.15	0.2	0.34	0.04	6087.22

Table C44. Beakdown of net cost expressed as a percentage of net cost and sorted according to the holding size for selected farms in tract 3. Stage I, Kaudulla irrigation scheme, 1984 Yala season.

	Power Source Hired %	Power Source Own %	Agrochem. Weed %	Agrochem. Pest Control %	Fertilizer %	Labor Hired %	Labor Family %	Other Costs %	Net Cost Rs/ha
620c	0.47	0.00	0.00	0.00	0.06	0.1	0.34	0.03	6273.80
585c	0.33	0.00	0.04	0.00	0.12	0.0	0.45	0.02	9064.90
585a	0.00	0.15	0.03	0.07	0.12	0.1	0.46	0.02	9568.78
611b	0.00	0.11	0.00	0.00	0.20	0.1	0.46	0.04	5538.98
620b	0.22	0.00	0.01	0.04	0.19	0.1	0.36	0.05	6854.25
583b	0.00	0.09	0.00	0.04	0.16	0.2	0.43	0.05	6749.28
584b	0.00	0.11	0.12	0.05	0.11	0.2	0.37	0.04	8747.51
581a	0.00	0.12	0.00	0.11	0.14	0.2	0.37	0.03	6442.75
631a	0.03	0.10	0.00	0.00	0.21	0.4	0.22	0.03	5700.76
620a	0.05	0.10	0.00	0.00	0.17	0.1	0.45	0.05	4361.31
583a	0.00	0.30	0.08	0.00	0.12	0.1	0.28	0.05	6115.72
585b	0.00	0.13	0.06	0.00	0.15	0.2	0.34	0.04	4900.48
625a	0.07	0.00	0.00	0.09	0.18	0.2	0.33	0.05	5104.26
625b	0.00	0.12	0.10	0.00	0.16	0.2	0.35	0.05	5173.42
611a	0.00	0.13	0.06	0.06	0.19	0.2	0.28	0.04	4919.01
584a	0.00	0.08	0.04	0.05	0.22	0.2	0.30	0.04	5169.09
581b	0.04	0.09	0.06	0.03	0.26	0.2	0.24	0.03	6355.93
631b	0.10	0.04	0.03	0.00	0.22	0.1	0.39	0.06	3742.72
582	0.00	0.37	0.00	0.00	0.10	0.2	0.28	0.04	5032.63
587	0.00	0.10	0.00	0.02	0.15	0.3	0.32	0.05	5512.22
629	0.11	0.00	0.03	0.01	0.10	0.3	0.36	0.06	4752.69
632	0.28	0.00	0.00	0.02	0.23	0.1	0.24	0.04	5347.55
606	0.09	0.06	0.00	0.02	0.15	0.2	0.32	0.06	3465.06
618	0.06	0.03	0.02	0.01	0.14	0.5	0.19	0.03	6737.45
628	0.09	0.05	0.05	0.02	0.16	0.2	0.31	0.06	3777.45
626	0.00	0.11	0.02	0.00	0.20	0.3	0.24	0.04	4591.11
604	0.00	0.29	0.03	0.00	0.11	0.3	0.17	0.04	6400.39
634	0.06	0.07	0.10	0.01	0.19	0.2	0.29	0.05	4949.26
	0.07	0.10	0.03	0.02	0.16	0.24	0.33	0.04	5762.45

Table C45. Beakdown of net cost expressed as a percentage of net cost and sorted according to the holding size for selected farms in tract 8. Stage I, Kaudulla irrigation scheme, 1984 Yala season.

	Power Source Hired %	Power Source Own %	Agrochem. Weed %	Agrochem. Pest Control %	Fertilizer %	Labor Hired %	Labor Family %	Other Costs %	Net Cost Rs/ha
1673	0.00	0.09	0.03	0.02	0.16	0.1	0.49	0.03	6702.76
1748	0.00	0.14	0.00	0.02	0.06	0.5	0.18	0.03	6273.80
1754	0.00	0.26	0.00	0.02	0.12	0.2	0.28	0.03	6885.13
1630	0.00	0.19	0.01	0.00	0.13	0.0	0.54	0.04	4909.13
1749	0.00	0.13	0.00	0.17	0.22	0.2	0.24	0.04	5037.57
1671	0.25	0.00	0.02	0.02	0.15	0.2	0.32	0.04	5528.48
1639	0.00	0.10	0.01	0.00	0.15	0.1	0.51	0.05	3732.79
1677	0.26	0.00	0.07	0.06	0.14	0.1	0.34	0.03	7076.55
1634	0.03	0.25	0.06	0.02	0.15	0.1	0.30	0.04	7343.31
1752	0.03	0.26	0.05	0.07	0.13	0.2	0.23	0.03	7129.66
1629	0.30	0.04	0.01	0.01	0.17	0.2	0.24	0.03	6103.37
1637	0.00	0.17	0.00	0.05	0.10	0.4	0.22	0.04	7286.50
1659	0.00	0.25	0.02	0.05	0.14	0.1	0.32	0.04	7445.82
1755	0.02	0.17	0.07	0.06	0.20	0.3	0.14	0.03	6819.67
1751	0.02	0.28	0.04	0.06	0.18	0.2	0.12	0.03	6513.39
1635	0.13	0.00	0.06	0.06	0.14	0.2	0.28	0.04	7329.73
1666	0.32	0.00	0.00	0.07	0.11	0.1	0.27	0.04	6799.91
1662	0.00	0.36	0.05	0.02	0.12	0.1	0.24	0.04	4811.56
	0.08	0.15	0.03	0.04	0.14	0.23	0.29	0.04	6318.28
	0.07	0.13	0.02	0.03	0.15	0.24	0.32	0.04	6056.18

Table C46. Rainfall distribution in 1983 Yala Season. The values given are the average of two station in millimeters (Source: Department of Irrigation, Kaudulla)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	-	-	-	-	-	-	-	-	-	-	36.2	18.0
2	-	-	-	-	-	-	-	-	-	-	-	28.0
3	-	-	-	-	-	-	-	-	-	-	-	38.3
4	-	-	-	-	-	-	-	-	-	-	31.5	0.6
5	0.5	-	-	-	-	-	32.8	-	-	-	2.5	18.8
6	-	-	-	-	-	-	-	-	-	-	28.5	18.8
7	-	-	-	-	-	-	-	-	-	-	9.7	29.7
8	-	-	-	-	-	-	-	-	-	-	-	39.8
9	-	-	-	-	32.8	-	-	-	-	-	-	18.2
10	-	-	-	-	1.0	-	-	-	11.0	26.9	-	42.4
11	-	-	-	-	-	-	-	-	-	22.9	-	0.9
12	4.0	-	-	-	-	-	-	-	-	37.8	-	1.9
13	0.3	-	-	-	13.2	1.8	-	-	-	-	-	4.8
14	0.0	-	-	-	-	-	-	-	-	-	-	9.6
15	0.2	-	-	-	-	1.0	-	-	-	-	-	20.9
16	1.3	-	-	-	-	-	-	-	1.0	59.7	3.7	59.5
17	0.3	-	-	-	-	-	-	-	-	90.4	20.6	51.3
18	-	-	-	-	-	-	-	-	-	12.0	6.0	9.3
19	-	-	-	-	11.3	-	-	-	0.6	18.9	4.4	20.2
20	-	-	-	-	-	-	6.0	-	-	32.8	0.3	216.0
21	-	-	-	-	-	-	-	-	-	41.3	-	26.6
22	-	-	-	-	-	-	-	-	-	-	-	-
23	0.7	-	-	-	-	-	0.2	-	-	1.0	-	61.8
24	2.7	-	-	-	-	-	34.0	-	-	-	-	16.3
25	15.0	-	-	-	-	-	2.2	-	2.0	11.9	8.7	4.6
26	18.7	-	-	-	-	-	0.9	-	-	-	-	50.6
27	0.1	-	-	2.8	-	-	6.8	-	-	-	-	-
28	-	-	-	4.2	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	39.0	-
30	-	-	-	-	-	-	-	-	-	-	4.4	-
31	-	-	-	-	-	-	-	-	-	-	-	-
ot	43.5	0.0	0.0	7.0	58.3	2.8	82.8	0.0	14.6	355.3	195.2	806.2

Total rainfall during 1983 = 1565.0 mm
Yala Season total rainfall = 150.8 mm

Table C47. Rainfall distribution in 1984 Yala Season. The values given are the average of two station in millimeters (Source: Department of Irrigation, Kaudulla)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	37.1	-	30.0	-	-	-	-	-	-	-	-	-
2	50.5	-	13.9	4.0	-	-	-	-	-	-	-	-
3	37.2	-	-	31.4	-	-	-	-	-	0.3	-	-
4	10.1	99.8	-	7.8	-	-	-	-	-	-	-	-
5	41.5	10.8	42.0	0.9	-	-	-	-	-	-	-	-
6	20.0	13.6	56.0	-	-	-	-	-	-	-	11.0	
7	0.4	-	-	-	-	-	-	-	42.4	-	0.5	3.1
8	-	-	-	-	-	-	-	-	-	-	22.6	1.4
9	0.6	63.3	-	-	-	-	-	-	-	-	2.3	3.7
10	58.7	-	-	-	-	-	-	-	-	-	37.2	5.7
11	108.0	36.1	-	-	-	-	-	-	-	-	3.0	-
12	29.3	31.5	-	28.1	-	-	0.6	-	-	-	-	-
13	7.5	1.3	-	25.5	-	-	-	-	-	-	1.8	-
14	24.7	64.0	-	4.5	-	-	0.3	-	-	-	2.0	-
15	-	5.4	-	3.3	-	-	-	-	-	-	13.1	-
16	5.6	6.1	-	0.6	-	-	-	-	-	-	3.7	-
17	-	-	-	0.0	-	-	-	-	-	-	18.6	-
18	-	-	-	46.0	0.5	-	-	-	0.6	-	38.8	-
19	5.2	0.7	-	4.6	4.2	-	-	-	16.5	-	16.7	-
20	-	-	-	-	-	-	49.7	-	-	-	2.1	-
21	-	-	-	-	-	-	0.4	-	-	3.5	-	-
22	-	-	-	-	-	-	1.4	-	1.5	-	0.4	-
23	121.0	-	-	-	-	-	-	-	38.5	-	6.6	18.7
24	-	-	-	58.6	-	-	-	-	64.2	-	9.7	8.2
25	-	-	-	-	-	-	-	-	25.1	-	50.5	3.5
26	3.7	-	-	-	-	-	-	-	-	-	50.5	-
27	13.1	19.2	-	-	-	-	-	-	2.0	23.5	19.7	9.2
28	2.0	72.4	8.7	-	-	-	-	-	27.7	38.0	12.1	1.3
29	19.6	-	2.4	-	-	-	-	-	1.5	-	30.5	11.5
30	-	-	9.4	-	-	-	-	-	1.9	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-
	595.6	424.2	162.4	215.1	4.7	0.0	52.2	0.0	221.7	65.3	353.0	66.1

Total rainfall during 1984 = 2160.3 mm
Yala Season total rainfall = 493.7 mm

Table C48. Pan evaporation during 1983 and 1984 Yala Seasons. The values given are the average of two stations in millimeters (Source: Department of Irrigation, Kaudulla)

	April		May		June		July		August	
	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984
1	5.8	4.5	7.5	6.7	10.2	8.4	7.3	9.5	6.7	7.5
2	7.2	4.9	9.4	5.3	9.8	9.5	7.6	6.5	7.6	8.1
3	6.1	2.5	7.8	6.1	9.6	6.0	7.7	6.8	5.5	7.7
4	5.1	4.2	7.6	5.5	9.4	9.9	7.9	8.8	8.3	9.3
5	6.1	2.8	8.0	6.1	9.2	8.8	9.0	9.1	5.9	6.3
6	6.2	5.2	7.4	6.2	8.0	8.9	7.6	7.5	8.2	6.8
7	6.5	4.3	7.0	6.9	8.7	9.3	8.9	8.4	5.1	5.3
8	6.8	4.9	2.1	7.5	8.4	8.8	9.4	3.6	7.1	6.6
9	6.5	4.2	2.0	6.4	8.0	7.3	8.5	0.0	8.4	7.7
10	7.4	6.3	5.7	6.0	8.2	5.6	7.7	3.2	7.6	7.1
11	8.5	4.9	1.9	4.9	8.5	9.3	9.7	4.2	7.4	7.3
12	6.5	0.0	2.1	5.7	7.0	6.3	8.4	3.9	8.0	6.8
13	5.9	1.5	4.7	5.1	7.4	7.8	9.8	4.9	10.0	4.7
14	6.6	3.4	6.5	7.6	5.1	8.3	10.0	4.0	10.3	6.4
15	7.9	3.6	6.1	7.5	7.9	7.9	8.0	4.2	9.5	6.4
16	7.1	3.1	6.7	7.2	4.1	9.5	7.9	5.7	7.8	8.1
17	5.9	4.0	6.1	6.7	7.5	7.3	10.3	7.7	9.4	7.2
18	7.5	5.3	5.2	7.0	7.2	6.0	8.8	8.0	9.1	7.0
19	5.4	1.9	7.0	3.5	5.3	7.8	10.4	6.9	7.3	7.3
20	5.2	3.6	7.3	1.7	7.3	8.9	9.0	2.8	9.0	8.4
21	6.0	5.3	7.1	9.2	7.2	9.7	6.4	5.3	8.0	7.5
22	7.0	5.1	6.1	6.8	8.9	9.7	6.8	6.4	7.4	6.1
23	6.4	4.4	6.5	7.4	7.9	9.1	8.6	5.4	8.4	6.4
24	7.5	3.0	6.7	8.7	7.7	8.9	4.8	6.6	9.1	4.7
25	7.6	0.0	7.6	8.3	7.7	9.5	2.5	6.4	9.6	6.1
26	6.7	6.1	7.2	7.5	6.6	8.7	5.9	7.3	7.4	7.6
27	5.5	6.0	9.3	7.2	8.1	8.6	2.5	7.0	9.3	9.7
28	4.0	6.3	7.1	7.9	8.6	7.7	2.2	6.0	7.9	7.4
29	4.7	7.3	7.7	7.8	8.8	6.6	4.0	5.3	8.7	8.1
30	4.7	6.3	7.7	7.3	8.9	8.2	5.8	5.0	9.8	9.8
31			9.7	6.8			8.0	6.2	10.2	10.3
	190.0	124.7	200.6	204.3	237.4	248.2	231.0	182.6	254.2	225.6

Total Evaporation for Yala Season 1983 780.9 2.562
Total Evaporation for Yala Season 1984 862.2 2.828

Table C49. Recorded water issues of Kaudulla tank during 1983 and 1984. (source: Department of Irrigation, Kaudulla Office).

	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBE	
	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984	1983	198
1	39750	59925	27400	52000	20232	33133	18313	32200	20270	23600	20040	3050
2	39312	59313	27300	51400	20232	32533	18313	32200	21060	22880	20040	3050
3	39000	58787	27000	50800	20194	32200	18275	32150	21120	22160	20040	3040
4	38500	58085	26600	50125	20194	32000	18275	32150	21150	21920	21300	3020
5	37812	57650	26300	49675	20156	31300	18238	32100	21540	21780	21540	3000
6	37250	56950	25790	49075	20063	31450	18238	32035	22160	21800	21950	2959
7	36750	56425	25280	48700	20079	31250	18088	32000	22280	23360	22040	2920
8	36187	55725	24860	48400	18963	31500	18125	31950	22280	25040	23120	2893
9	35750	55900	24380	47800	18501	31500	17900	31900	22280	26400	24800	2855
10	35125	56425	24190	47200	19110	31450	17750	31850	22220	27100	25880	2840
11	34500	56425	28900	46450	19110	31350	17750	31800	22220	27600	27200	2820
12	34000	56337	23840	45475	18960	31150	18087	31750	22100	27700	28200	2800
13	33332	56357	23780	44575	18960	31100	18500	31700	22040	27100	29733	2780
14	32666	56357	23660	43600	18960	31000	18425	31400	21920	26600	30800	2740
15	32200	55900	23600	42812	18960	31000	18387	31200	21860	26000	32000	2720
16	31700	55812	22540	42125	18921	31000	18387	31050	21800	25520	33599	2680
17	31250	55987	22160	41575	18921	30950	18654	30700	21860	25520	36250	2640
18	30900	55925	21780	40937	18921	30900	19340	30200	21920	25280	39250	2620
19	30550	55550	21610	40500	18921	30860	19462	29466	22040	26600	40000	2600
20	30050	55550	21610	39987	18882	30750	19692	28733	22040	27150	44200	2576
21	29466	56600	21610	39437	18730	30690	19767	28050	22040	27200	53600	2552
22	28933	56687	21610	38562	18654	30625	20232	27600	21980	27250	78500	2504
23	28477	56687	21610	37500	18577	30625	20262	27100	21600	27200	80500	2492
24	28000	56600	21540	36500	18500	30900	20270	26600	20820	26800	87400	2480
25	28050	55900	21460	35625	18425	31850	20194	26000	20340	27000	94700	2528
26	27850	55375	21420	35500	18388	32000	20340	25400	20184	27800	95600	2528
27	27750	54750	20820	34750	18388	32660	20340	24800	20040	28666	97700	2564
28	27750	54300	20340	34125	18388	31950	20232	25280	20040	29200	95150	2564
29	27650	53600	20270	33732	18350	32200	20232	24730	19848	30000	95000	2480
30	27650	52900	20232	33265	18350	32200	20232	24560	20040	30200	95150	2528
31	27650	52450	20232	33199			20232				94850	2552

Plate 1. Kaudulla Oya Stage I anicut which diverts irrigation water into the main channel. The photograph was taken after the repair of flood damages during 1983 Maha season. The bund on the right was blasted to convey flood waters duringthe 1983 Maha because the radial gates could not be operated due to inadequate maintenance.

Plate 2. Overpass bridge and the flow control structure at the head of Kaudulla stage I main channel. Note the width of the channel in relation to bridge and the flooded embankments. The woman stands on the lined top of the channel.

Plate 3. Main channel of stage I at the first field channel offtake. A view from down stream. On the right are the stage II irrigated fields. These fields release large amounts of drainage water into the main channel through numerous openings cut into the channel embankment. Note the width of the channel due to erosion and the attempt by farmers to head up water by piling up obstructions in the middle.

Plate 4. A clearer view of the drainage discharge into main channel.

Plate 5. A drainage inflow point into the main channel. Notice the large amount of drainage supplementing channel flow. This point is located between D-6 and D-8 channels. If the main channel flow is regulated in combination with the drainage inflow most of the water problems to tracts 7 and 8 in Stage I can be avoided.

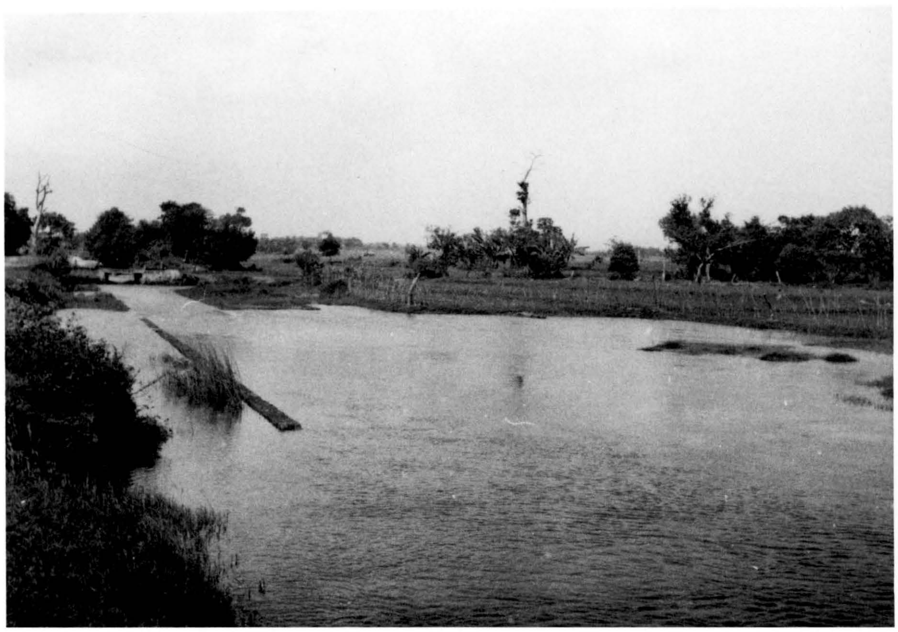

Plate 6. A downstream view of main channel from the tract 1 distributory offtake. The high velocity of flow caused by constriction at the overpass bridge and inadequate downstream bank protection at the transition has eroded and widened the channel.

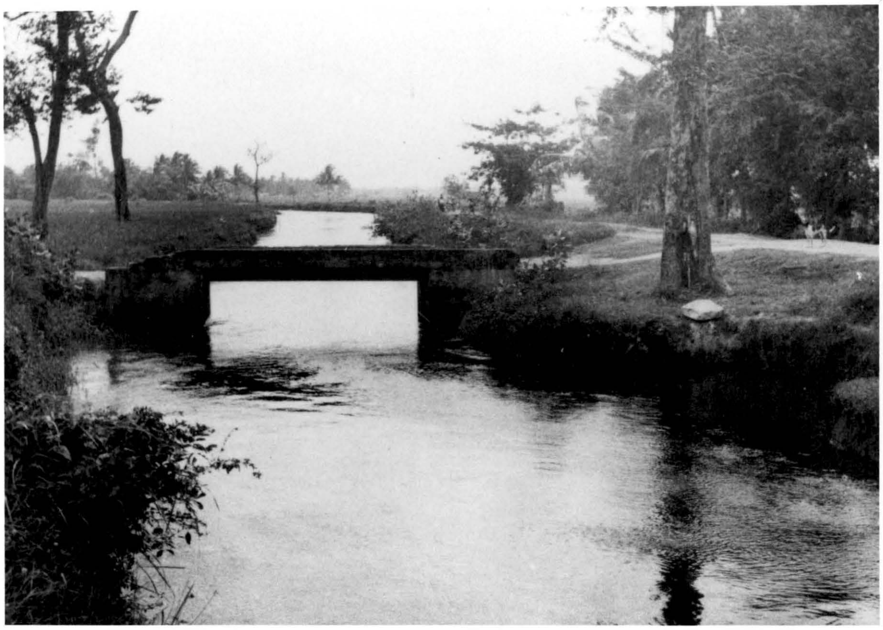

Plate 7. An upstream view of another overpass bridge along the main channel. Both upstream and down stream the banks are eroded due to inadequate protection at the transition. Note the deterioration of the channel bank on the right due to a bathing spot.

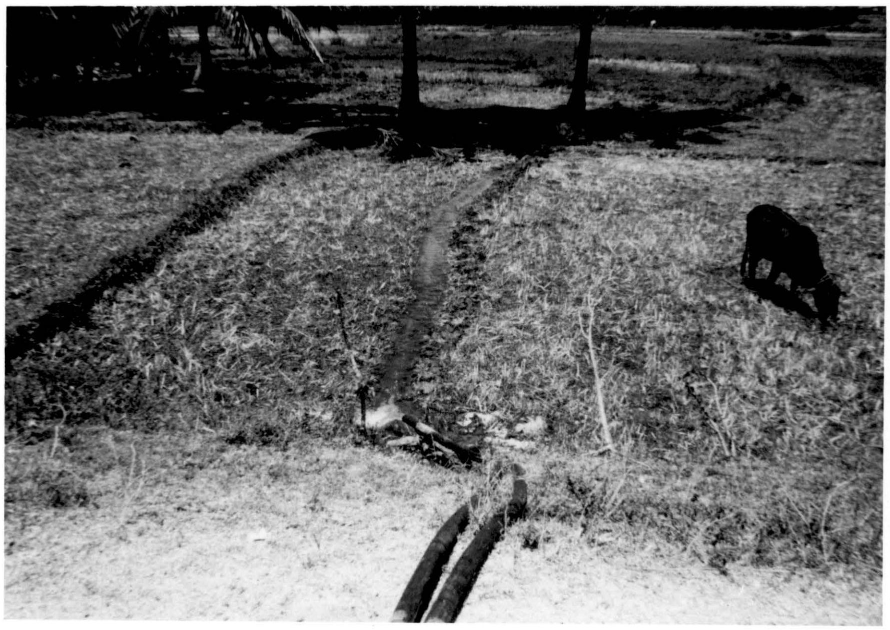

Plate 8. Illicit siphoning of water from the main channel. The field irrigated was actually the reserved area for channel and road maintenance that was encroached by farmers.

Plate 9. A trapezoidal weir constructed across the main channel. The purpose of the structure is to build sufficient head of water at low flows to provide adequate discharge through the offtake immediately upstream. However, the water flows around the structure defeating the purpose. Notice the poor quality of construction.

Plate 10. A view of the main channel at low flow. A temporary dam obstructs the flow below the log bridge. Notice the eroded banks of the channel.

Plate 11. A temporary dam constructed by farmers across the main channel to build sufficient head for the distributory offtake.

Plate 12. Upstream view of the distributory channel to tract 2. Note the water filled highland allotments cultivated to paddy. This land was cultivated during both seasons.

Plate 13. The first left bank field channel of the distributory shown in plate 12. Note again the amount of water flowing into highland allotments on the left.

Plate 14. Same channel as in plate 13 but further down stream. The left bank supposed to serve as a road and the channel lining has been damaged to obtain water to the highland on the left.

Plate 15. A midway along the distributory channel to tract 2. Note the defunct flow control structure. Water was directly obtained from the channel by opening the channel embankment. Thus, water control downstream has become impossible.

Plate 16. The road reservation encroached and converted to a paddy field in tract 2.

Plate 17. A view of the head reach of distributory channel 4. This is a relatively narrow and long distributory. The discharge from the main channel has considerably eroded the sides forming a large pool. The farm on the right has encroached the channel bank leaving hardly anything for the channel bank.

Plate 18. Same channel as in plate 17, a little further downstream. Encrachements have weakened the channel bund. A farmer obtained more water from large hole made in the channel bank.

Plate 19. Same channel as in plate 13 but downstream. Note the reduced flow which disappears further down.

Plate 20. Tail end of distributory channel 4. The picture was taken a week after water issues began in 1983 Yala season.

Plate 21. The distributory offtake No. 5. Note the greatly eroded and silted discharging end.

Plate 22. A down stream view of tract 8 distributory head work. The picture was taken soon after channel maintenance. Compare with plate 21 which was taken at the end of the season.

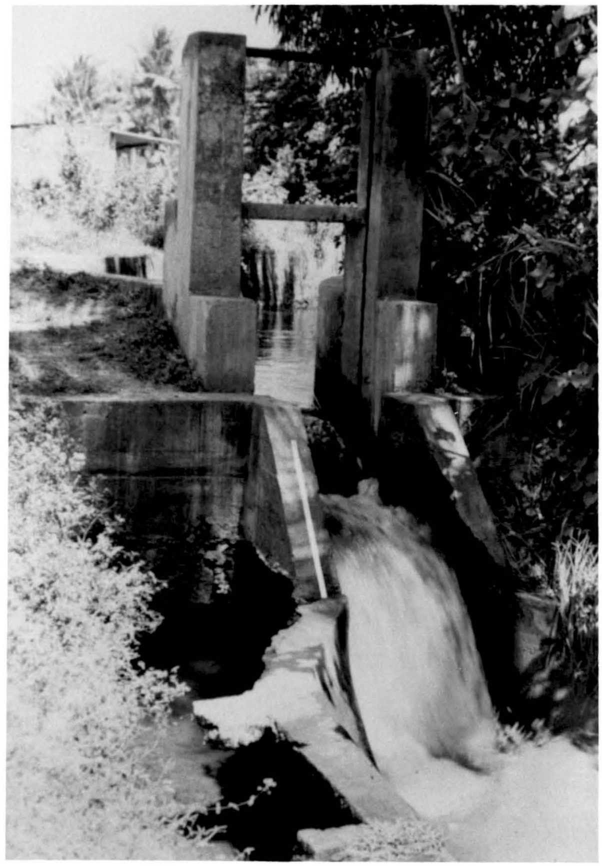

Plate 23. The same channel section as in plate 22. Note the result of patch work maintenance due to inadequate funds and supervision.

Plate 24. Same channel as in plate 22 about 20 meters down stream. The channel lining and weir type flow regulator have fallen apart. The water actually flowed over the compound of the hut in the background before getting into the channel at a point down stream.

Plate 25. This picture was taken after the channel maintenance during 1984 Yala. Note the soil piled up on the left bank of the channel to fill up eroded bank.

Plate 26. Tract 8 distributory midway along the channel. Note the damaged channel bank through which farmers obtain water across the road way. Hardly any water flows along the channel beyond this point when there is low flow.

Plate 27. This picture depicts what happens towards the tail end of the irrigation system. When farmers in the upper reaches of the system do not require water, unregulated water flowing in the channel over topped the banks flooding the roadway. Since road was at a lower elevation than the channel farmers conveyed water along and across the road way.

Plate 28. This is another picture of the tract 8 distributory about midway. The water from damaged pipe outlet laid across the road and distributory channel bank was conveyed along the road to the fields on the opposite side.

Plate 29. A drop structure in the tract 8 distributory. Note the erosion of the channel bank below the drop. The huts seen on the foreground are used by farmers to keep night watch in order to obtain their water supply.

Plate 30. Tail end view of the tract 8 distributory channel. Water distribution was chaotic in this section of the channel. Note the structure on the left which was a defunct field channel offtake. Since channel water level was at a much lower level than the offtake the farmers served by this channel had to rely on water draining from the upstream fields.

Plate 31. Flood damage to a field in tract 8 during 1983/84 Maha season. The heavy flood waters breached a large section of the channel and sand and gravel were deposited in the field making it uncultivable.

Plate 32. A defunct drop structure. Too narrow constriction to flow and inadequate upstream and down stream channel bank protection had turned it into a totally useless ruin.

Plate 33. Buffalo watering in the irrigation channel. Notice the damage to channel banks.

Plate 34. Field channel 15 of tract 7. Irrigation water has to be conveyed virtually upstream due to poor channel gradient. The head in the distributory was insufficient to push the water along the channel. The picture was take a week after the 1983 Yala water issues.

Plate 35. Cultivated drainage reservations at the tail end of tract 7.

Plate 36. A defunct drop structure. The rule of thumb used by the Department of Irrigation is to constrict the channel to half the bottom width. This done to build sufficient head for pipe outlets immediately upstream. However, during heavy rains the flow in the channel overtops the bank thus, eroding the banks and finally leaving the structure in the middle.

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