SYSTEM H OF THE MAHAWELI DEVELOPMENT PROJECT, SRI LANKA: 1983 DIAGNOSTIC ANALYSIS

WATER MANAGEMENT SYNTHESIS PROJECT

WMS REPORT 20

SYSTEM H OF THE MAHAWELI DEVELOPMENT PROJECT, SRI LANKA: 1983 DIAGNOSTIC ANALYSIS

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ACKNOWLEDGMENTS

The second Sri Lankan Workshop on Diagnostic Analysis of Farm Irrigation Systems was conducted at the Agricultural Research Station at Maha Illupallama, Sri Lanka, from June 16 to July 23, 1983. It was jointly sponsored by the Water Management Synthesis Project; the Consortium for International Development; the United States Agency for International Development and the United Nations Childrens Fund in collaboration with the Mahaweli Authority of Sri Lanka.

Mr. Jayatissa Bandaragoda, Executive Director of the Mahaweli Economic Agency of the Mahaweli Authority of Sri Lanka made the inaugural address at the opening of the training program. Mr. Bandaragoda's continued interest and active support of the program is much appreciated.

The effort put in by Joe Alwis, Henry Gamage and G.R. Chandrasiri in planning, organizing, and seeing the training program through its various stages is much appreciated. G.R. Chandrasiri especially worked very hard in spite of other committments. He was unable to visit Colorado State University to write the final report as he had another assignment in Kuala Lumpur.

The trainees, except for two, were from the Mahaweli Authority of Sri Lanka. The co-trainers, some of whom were workshop leaders in the previous program, made very useful contributions to the program. Our grateful thanks are due to both the co-trainers and the trainees for giving their valuable time for the benefit of the program.

We had a number of guest lecturers whose presentations were very relevant and useful to the program. Our thanks are due to them.

We wish to thank the Deputy Director of Research, Agricultural Research Station, Maha Illupallama for allowing us to use his In-Service Training Center for our program. We also wish to thank the Resident Project Manager, MASL, Galnewa for providing us with vehicles and allowing us to carry out our field study in his project area.

We are indeed most grateful to the support staff of the Water Management Synthesis Project, Fort Collins, Colorado for the very efficient manner in which they assisted us to write this report. Mary Ann Moore and Kathleen Kilkelly very quickly and competently read our manuscripts and edited them. The typing done by Sandy Wunch, Mary Lindburg, and Janelle Armentrout was quick and neat. Thank you.

The ready cooperation of the farmers in the study area is greatly appreciated. Only with their cooperation was it possible to conduct this training program successfully.

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Coordinator

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ABSTRACT

A Diagnostic Analysis Workshop was held June 16 to July 23, 1983 at the In-Service Training Center in Maha Illupallama, Sri Lanka. The objective of this professional development workshop was to introduce the concepts and procedures used to conduct interdisciplinary investigations of existing irrigation systems. A total of 32 participants were chosen by the Mahaweli Authority and formed into five interdisciplinary teams. Each team consisted of an agronomist, irrigation engineer, on-farm engineer, economist, sociologist, and a women in development participant. These teams were chosen from specific Mahaweli Project areas to ensure their cooperative efforts in continued problem identification. Two weeks of classroom and video instruction were followed by a week of field data collection and analysis, and additional time for report preparation.

This report presents the data and conclusions from the workshop. Because the program was intended as a training exercise rather than a research project, data collection was necessarily limited. However, due to the efforts of the participants, it was felt that the results of the workshop were of sufficient value to warrant presentation.

The primary findings from the workshop included:

(1) The adoption of the bethma system by the Mahaweli Authority, due to drought, appeared to be successful in alleviating many of the problems associated with past Yala seasons.

(2) Although the D-channels appeared to be capable of delivering the designed amount of water, measured water issues showed much variability in water control. Overall, control structures of D-channels that were observed seemed to be in good condition.

(3) Under issues measured in F-channels may have been associated with the bethma system. Conveyance losses from F-channels were considered to be high. Poor maintenance of the F-channels was apparent.

(4) Elevated watertables were associated with inefficiencies in the irrigation system and poor subsurface drainage.

(5) High soil salinity was responsible for the abandonment of certain allotments.

(6) Heavy weed infestations and low fertilizer applications in paddy were attributable to unreliable water supply.

(7) Chili production was limited by the poor water management practices of the farmer as well as inefficient water delivery and drainage.

(8) When interviewed both men and women perceived that the inadequacy and unreliability of water was a constraint to crop production.

(9) Maintenance of the F-channels was not regularly practiced by most farmers and may have been further aggrevated by the _bethma_ partner's lack of long-term commitment.

(10) In order to obtain some measure of water control some farmers used illegal methods such as taking water out-of-turn, blockage of field channels, and opening turnout gates.

(11) Both men and women indicated a generally high level of satisfaction with the community and the resettlement experience.

(12) Although extension and institutional services were generally perceived as adequate by men, women noted that although they were interested in topics such as water management, crop varieties, and agrochemical use, they had not been provided these institutional services.

(13) Women participated in the majority of activities associated with crop production, and in addition, were responsible for the care of additional vegetable gardens for home consumption or supplemental income.

(14) Most families have dug wells on their homestead for convenience, but these appear to be unreliable and inadequate during the _Yala_ season.

(15) Farm interviews revealed seasonal labor shortages especially in the cultivation of non-paddy crops.

(16) Many farmers had defaulted on low interest government loans, primarily due to crop failures in successive drought years, making them ineligible for future low interest loans. Because of this, many farmers borrowed considerable amounts from relative, friends, or private traders.

(17) Although government sponsored marketing programs were available, many farmers preferred to use private traders.

I. INTRODUCTION

A. Purpose of Diagnostic Analysis Workshop

The importance of irrigated agriculture in Sri Lanka is increasing, especially with the implementation of the Accelerated Mahaweli Development Program. In the wake of increased irrigation facilities comes increased problems, not only in the construction of the infrastructure and distribution of water, but also relative to the identification of the various irrigation problems and their prioritization.

The Water Management Synthesis Project at Colorado State University conducted a professional development workshop on the Diagnostic Analysis of Farm Irrigation Systems from June 16 - July 23, 1983. The Diagnostic Analysis Workshop objectives are to introduce the participants to the concept of an interdisciplinary approach in the identification of problems. The program was designed to give the participants an understanding of the concepts, principles and procedures used in Diagnostic Analysis. The training program consisted of lectures and video films in the classroom, data collection in the field, and preparation of reports.

B. Background of the Accelerated Mahaweli Development Program and System H

System H is the first area to be settled under the Accelerated Mahaweli Development Program. The scheme started in 1975 with the settling of approximately 500 familes in the area. This program of settlement was accelerated from 1978 by the new government.

System H is an irrigated settlement scheme where a total of 24,000 families will ultimately be settled. The project area consists of a total of 43,725 hectares, of which 29,150 hectares will be settled under the Accelerated Mahaweli Development Program (Figure 1).

Within System H itself there are four old colonization schemes. They are Kandalama, Kagama Kattiyawa, Usgala Siyambalangamuwa and Rajangana are shown in Figure 1 as: H-6 and H-8; H-3; H-10; and H-11 and H-12; respectively. These older areas comprise a total area of 14,575 hectares, and are all over 25 years old. The Mahaweli Authority is not involved in the total management of these old schemes, but assists in specific functions such as water management, marketing, and community development.

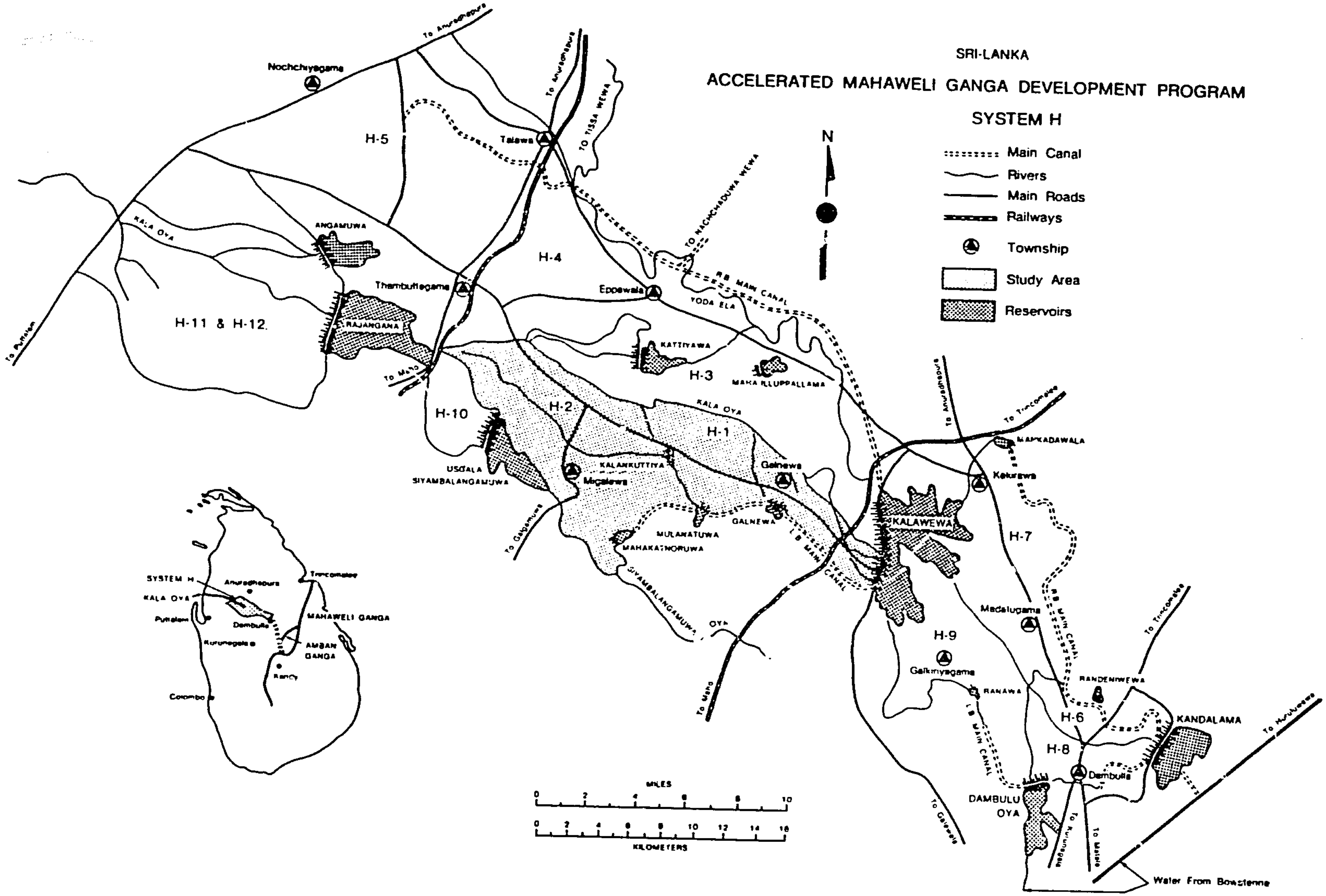


Figure 1. Location Map of Study Area for the 1983 Diagnostic Analysis Workshop in Sri Lanka

Out of a total of approximately 24,000 families to be settled in System H 22,715 families have already been settled in the area. The balance of settlement will be completed before the end of 1983.

There are three categories of settler families that have been allocated land in System H under the present scheme:

(1) Resettlers

These are people from the area who have been resettled under the new scheme. Some of these people lost land that they held in this area earlier.

(2) New Settlers

One hundred families from each electorate in the Central Province were chosen and settled here. The selections were made by the government agents concerned.

(3) Evacuees

These are people whose lands came within the Bowatanne, Victoria and Kotmale dam sites and whose lands were lost as a result of inundation.

Each settler was given an irrigable allotment of 1 hectare (2.5 acres) and a highland allotment of 0.2 hectare (0.5 acres). In instances where the settlers owned land within System H and which was taken over, they have been given up to a maximum of seven allotments in the initial stages, and now a maximum of three allotments of irrigable and highland lots. The new settlers, however, are entitled to only one allotment each.

When the settlers first arrive they are housed in temporary camps that have the basic amenities, until they construct their own dwellings on their highland allotments. The Mahaweli Authority provides them with the following assistance:

(1) An allowance of Rs. 1000 to build a house, and free transportation for them to bring their own building materials when they come;

(2) Free issues of dry rations for five members of their family for one year under the World Food Program;

(3) Free seed paddy for their first cultivation;

(4) Free agricultural implements such as <u>mammoties</u>, crow bars, axes, knives; and

(5) Free plants such as coconut, mango, and citrus for planting in their highland plots.

About 100 to 120 families are settled in a hamlet. Each hamlet is provided with a cooperative store, post box, day-care center and wherever necessary with a primary school. A village center is built to cover 8 or 10 such hamlets. A village center consists of a rural bank, registered cooperative, community training and development center, junior school, sub-post office, weekly fair and commercial allotments for the sale of consumer goods. Besides these facilities, land is allocated for persons with technical aptitudes to start industries such as bicycle repairs, tractor repairs, smithies, small scale rice mills, etc.

A township serves two to five village centers. A township consists of (in addition to the commercial services) a secondary school, rural hospital, banks, police station, marketing department, cooperative, fisheries stall, cooperative complex, fuel station and other facilities needed for an agricultural town. Plots of land are given to businessmen and entrepreneurs to set up various businesses and trades.

A number of town centers are planned for System H. They are Galnewa, Meegalewa, Madatugama, Galkiriyagama, Eppawela, Talawa, Tambuttegama, Kekirawa and Nochchiyagama. Of these, Meegalewa, Galnewa and Galkiriyagama are entirely new towns, whereas the others were existing towns whose infrastructure has been strengthened to cater to the increased population.

Water diverted from the Mahaweli River at Kandy (Polgolla) is fed, via another diversion at Bowatenne, into three main storage tanks that serve System H. The tanks are Kandalama, Dambulu Oya and Kalawewa. An intricate irrigation network was designed to distribute water throughout the scheme.

As an irrigated agricultural settlement scheme, the emphasis is naturally on maximum agricultural production. Although there may be sufficient water, it must be managed and used properly if maximum utilization is to be made of the land cultivated.

There are two cultivation seasons. One is the Maha or main season where rain occurs during the northeast monsoon, from October to January. Irrigation water supplements the rainfed cultivations of the Maha season. The other season is the Yala, where cultivation is done from May to August and the water requirement must be met mainly from irrigation.

The main crop cultivated in this area is paddy. Almost 100% of the cultivation in Maha is paddy and the tendency is to cultivate paddy in Yala as well. However, as water is a limiting factor during the Yala season, the authorities have tried to encourage the growth of other field crops instead. Crops that can be grown successfully are: chili, cowpea, soybean, sesame, black gram, green gram, and peanut. The consumption of water in the cultivation of other field crops is much lower than for paddy. The profits that accrue from the cultivation of subsidinary food crops are equal to or more than that of paddy. An increasing number of farmers are now beginning to cultivate other field crops in Yala.

Initially, the Mahaweli Development Board was responsible for the construction work and settlement in System H. The Mahaweli Authority of Sri Lanka has now taken over the settlement functions here. Most of the construction work on the irrigation and social infrastructure is now complete and the Mahaweli Development Board, whose functions here are now limited to this work, is gradually moving to the other development areas under the accelerated Mahaweli Development program.

For purpose of management, the new settlement areas of System H have been divided into three project areas, each under a Resident Project Manager (RPM), they include:

(1) Resident Project Manager (Kalawewa) - H1,H2,H7&H9 - 12,146 hectares, 10,450 settler families

(2) Resident Project Manager (Tambuttegama) - H4 - 9,717 hectares, 7,532 settler families

(3) Resident Project Manager (Nochchiyagama) - H5 - 7,288 hectares, 4,733 settler families

Each RPM has, at project level, deputies for land administration, water management, agriculture, community development and marketing and credit. These officers, who are specialists in their fields, are responsible for that work in the project area.

Each RPM's area is divided into administrative blocks consisting of approximately 2,500 families. Here too, specialist officers in the various disciplines, function at block level under a Block Manager. At the lowest level of management, a Unit Manager is responsible for 250 farmer families. He is assisted by two Field Assistants, one for agriculture and the other for irrigation. In the Nochchiyagama RPM's area each Unit Manager is responsible for 100 farmer families and has no assistants. It is intended to reduce the number of families under a Unit Manager to 100, wherever possible.

The main purpose of the Mahaweli Authority continuing the management of this scheme after settlement is to ensure the social and economic development of the families settled here. Earlier colonization schemes have indicated that this cannot be achieved from irrigated agriculture alone, but also requires that community development occur simultaneously with the development of the land. Earlier development schemes suggest that special emphasis toward community development is necessary for success. Therefore, the Mahaweli Authority has a separate division for community services and equal emphasis is given to this work as is given to agriculture and water management.

Community development plays a very important role in the management of System H. The Community Development Division has as its main objective the social and economic development of the settlers not only as individuals but as cohesive groups.

Farmers and farmer leaders are trained regularly in agriculture, water management, marketing and credit, community development, etc. They, in turn, were supposed to carry this training to their fellow farmers. As this was not fully effective, the Mahaweli Authority has set up settler development societies in each of the hamlets. The intention now is to carry out, through these societies, all the planned programs. There are programs for family health, nutrition, sanitation, religious activities and sports. Day-care centers for children and community centres have been built for the use of the settlers and their families.

A medical unit engaged by the Mahaweli Authority is responsible for the health needs of the population in the project area. This is a supplementary program to the Department of Health's work. Each hamlet has a health volunteer from among the settlers. These volunteers treat the population in the hamlets for malaria, give first aid when necessary and distribute Thriposha and Anchor milk, which is a part of the nutrition program.

C. Objectives of this Study

The construction of the irrigation infrastructure and the settlement of farmers in the left bank area of Kalawewa has been completed. It has been noted however, that there seem to be various problems with regard to irrigation in this area, and also with regard to the agricultural practices that should follow irrigated water availability.

The problems seemed to be many, some of which were generally due to bad construction, insufficient water, poor water distribution, lack of financial resources, and lack of technological knowledge. These many problems surfaced as a result of the sporadic inquiries made by officers of various disciplines. These officers looked at the problem only from the point of view of the discipline in which he was trained and worked. If the solution seemed to lie within the perview of another discipline, it was often not addressed. As a result, this type of action may have worsened many problems.

As mentioned earlier, the objectives of this workshop were to demonstrate the effectiveness of an interdisciplinary approach using Diagnostic Analysis procedures in identifying and solving problems.

The participants were divided into five teams with each team having an agronomist, irrigation engineer, on-farm engineer, economist, sociologist and a woman in development participant (Appendix F).

Each team chose two turnouts in a distributary channel (D-channel) as the area of study. These details are given in Table 1.

Their objectives were:

(1) To foster interdisciplinary team work and to create groups of future trainers who could identify irrigation problems using Diagnostic Analysis procedures, and

(2) To identify technical and socio-economic constraints on the irrigation system.

The participants and teams were chosen such that each team represented a particular Mahaweli Project area. This would ensure that the entire team will be able to continue to work together in the future as well, both in Diagnostic Analysis and in the training of other teams in interdisciplinary problem identifying procedures.

D. Contents of this Report

Section II of this report contains a general description of the study area with regard to location, climate, soils, topography, cropping patterns, socio-economic conditions and an operational plan of the irrigation system. Section III deals with the disciplinary methodologies used in data collection and analysis. In Section IV the findings of the interdisciplinary teams are discussed. These findings are a result of the analysis of the data collected by each team and the reports written by them during the final week of the program. A summary of these findings and recommendations is given in Section V of this report. Section VI, the appendices, contains the detailed findings of the various disciplines that formed the teams. A glossary, including abbreviations, definitions of terms, and units of measure is also included in Section VI. References used in the preparation of this report follow in Section VII.

II. STUDY AREA

A. Location and General Description

The study sites for this workshop were located in the Galnewa and Kalankuttiya blocks within the Kalawewa RPM's area. Each of these blocks have approximately 2,500 farm families and have four and five irrigation blocks, respectively. The Galnewa block has a total of 15 D-channels and Kalankuttiya a total of 20 D-channels. Since this was the second workshop to be conducted in the same area, it presented an opportunity to obtain more information and data on the operation of this system. It also enabled the participants to cross check the findings of the previous workshop.

The D-channels to be studied were selected from irrigation blocks 302 and 303 of the Galnewa block; and 306, 307, and 309 from the Kalankuttiya block. Blocks 302 and 303 are at the head of the left-bank main canal of the Kalawewa reservoir, 306 at the middle, and 307 and 309 at the tail of the system (Figure 2). The details of the study sites and the teams conducting the studies are summarized in Table 1. Maps of each turnout are presented in Figures 3 through 12.

Each team was composed of personnel working in each of the Mahaweli project areas except team No. 5 which was made up of participants from systems B and G of the Mahaweli project.

Due to the drought that prevailed before the commencement of the *Yala* 1983 cultivation season, the water available for this cultivation was limited. Traditionally in Sri Lanka when there is less water than is adequate to cultivate the total land under a reservoir a *bethma* system of cultivation is adopted. In a *bethma*, the total cultivable land area is calculated, taking into account the water available for that cultivation season. This land area is then divided among the farmers depending on the landholding of each farmer. In *Yala* 1983, the Mahaweli Authority introduced a *bethma* system of cultivation in System H. Though practiced widely and traditionally in the country, it was the first time that this practice was included in the Mahaweli scheme. The distribution of the land area that each farmer was able to cultivate was facilitated by the fact that the holding size was the same for all farmers. It was decided to close some D-channels completely and to restrict water issues to only the head of some channels. This would facilitate the distribution of water and would minimize conveyance losses. Each farmer was allowed to cultivate half his allotment. Farmers whose lands were on D-channels that were closed were asked to join farmers whose allotments were to receive issues of water.

SCHEMATIC OF STUDY AREAS IN KALAWEWA LEFT BANK IRRIGATION SCHEME (H1 & H2)

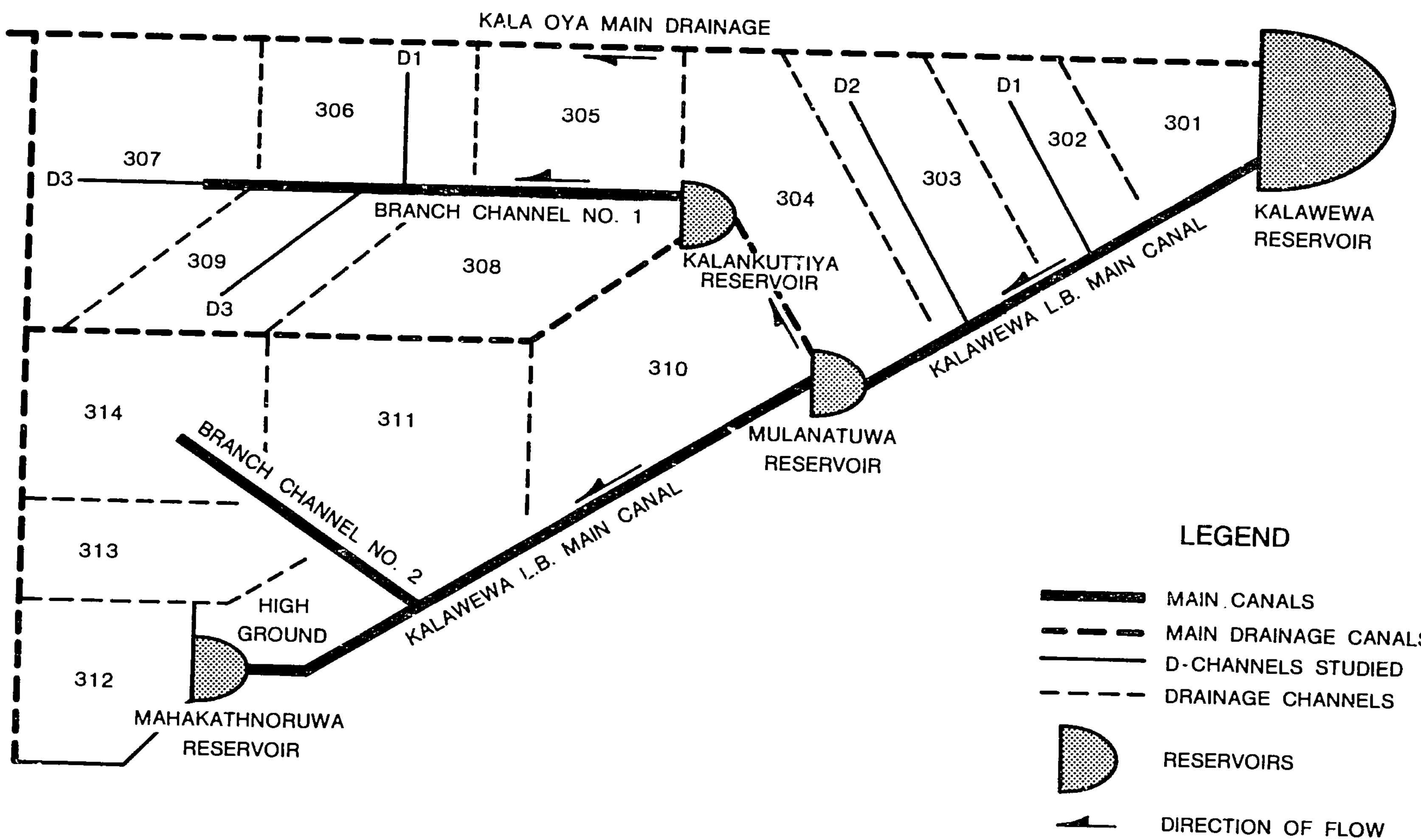


Figure 2. Schematic of Kalawewa Left Bank Irrigation Scheme

Table 1. Study Sites Used in the 1983 Diagnostic Analysis of Farm Irrigation Systems Workshop

Team	Block	D-Channel	Turnout
No. 1 Uda Walawe	302	D-1	7 14
No. 3 Tambuttegama	303	D-2	4 14
No. 4 Galnewa	306	D-1	1 5
No. 2 Nochchiyagama	307	D-3	0 15
No. 5 System B and G	309	D-3	2 6

B. Climate, Soils, and Topography

The climate in the Mahaweli project area is tropical with a mean annual rainfall of approximately 1,422 mm. Nearly 70% of this annual rainfall occurs during the Maha season from October to mid-January. The rest of the annual rainfall is mainly from mid-March to mid-May. The uneven and unpredictable rainfall in this area necessitates the use of supplementary irrigation in Maha and almost full irrigation in Yala. The average annual temperature is approximately 26 C (80 F), with minimum temperatures between 20 and 28 C and maximum temperatures between 27 and 34 C.

Two types of soil are predominant in System H. The highly permeable reddish brown earth (RBE) of which total approximately 60% and the poorly drained low humic gley (LHG) soils. Generally, the RBE soils are located at the rim or top of the soil catina and the LHG soils at the bottom of the basin. Because of their susceptability to waterlogging, it is difficult to grow upland crops in LHG soils.

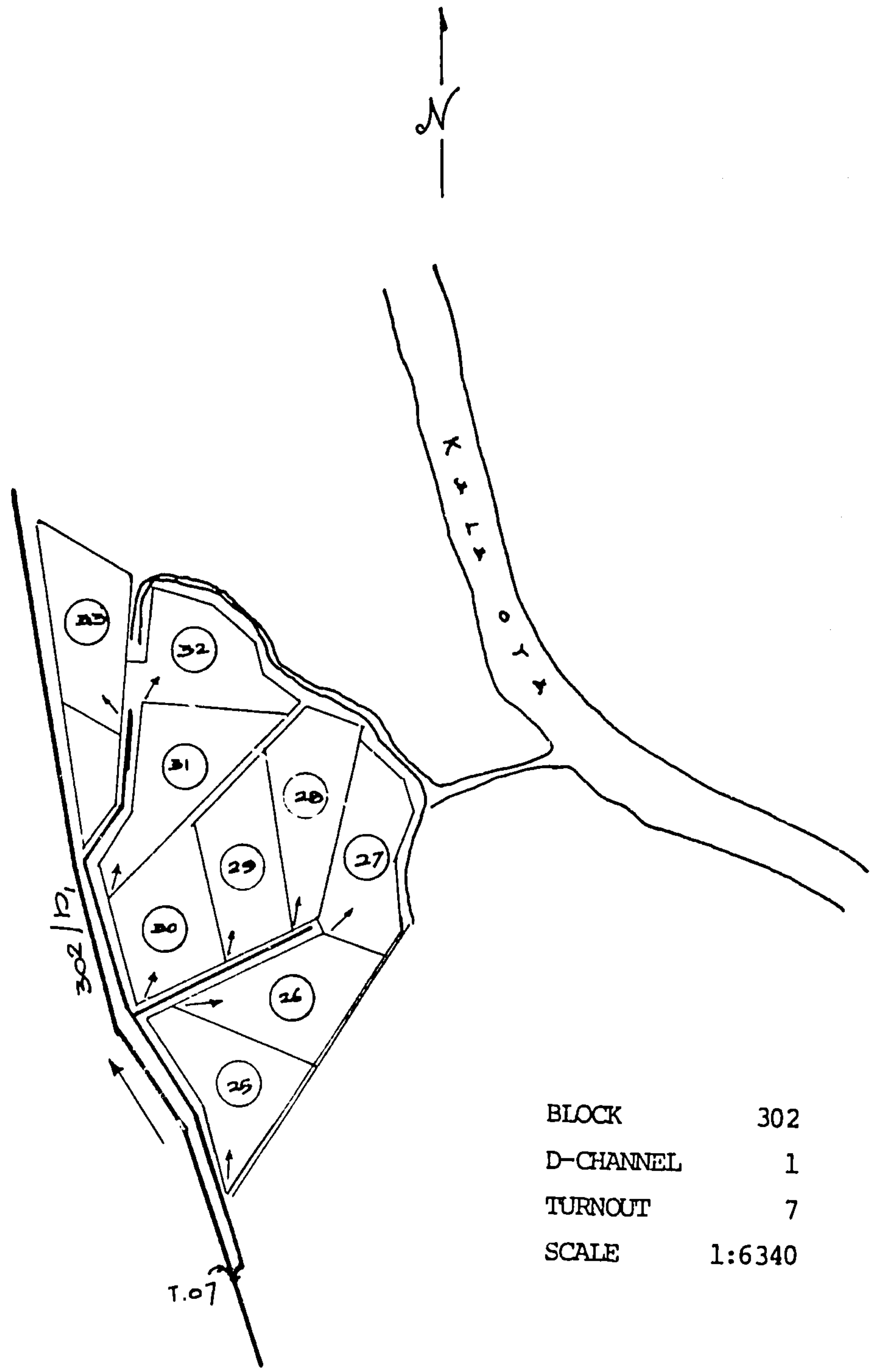


Figure 3. Map of Block 302/D.1/T.7

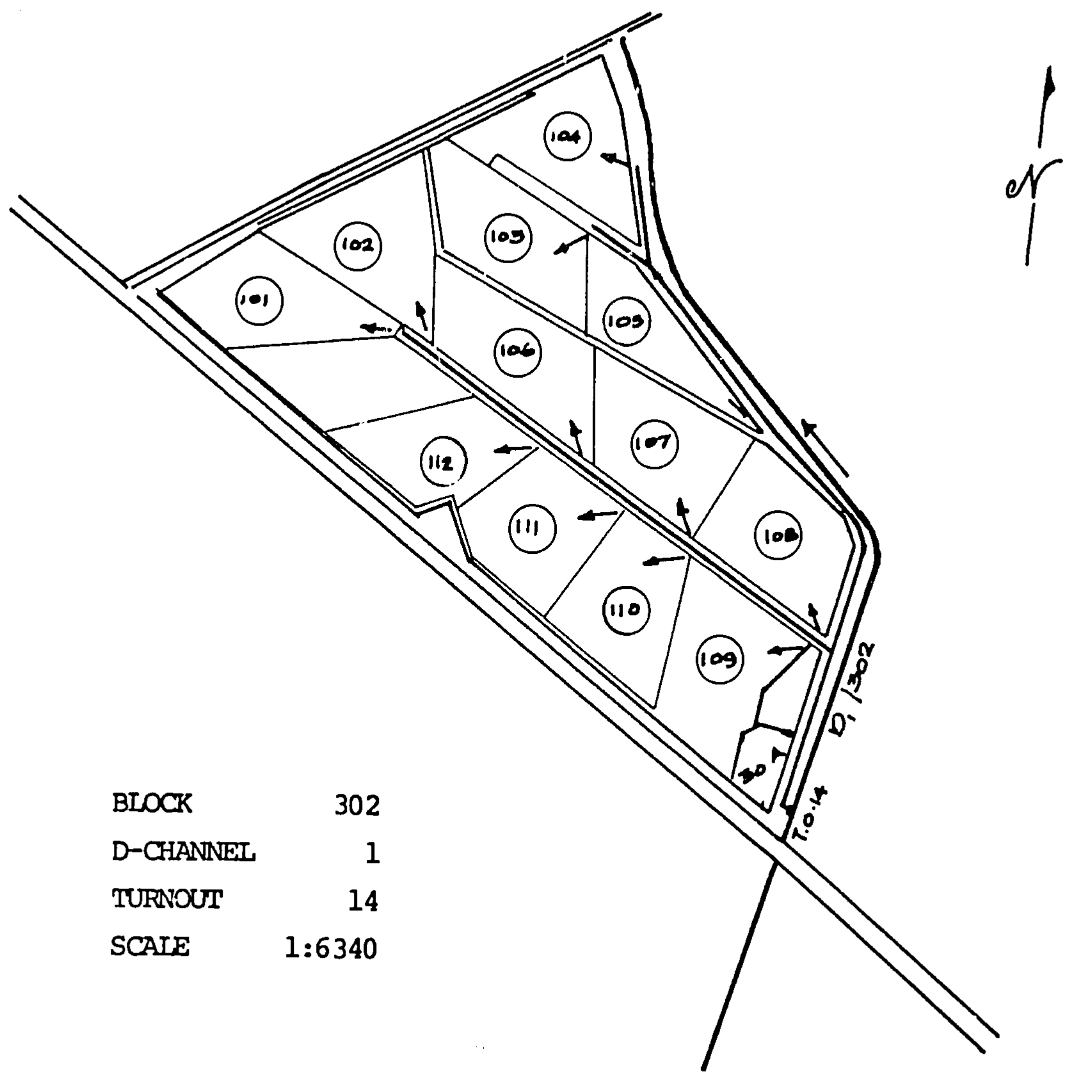


Figure 4. Map of Block 302/D.1/T.14

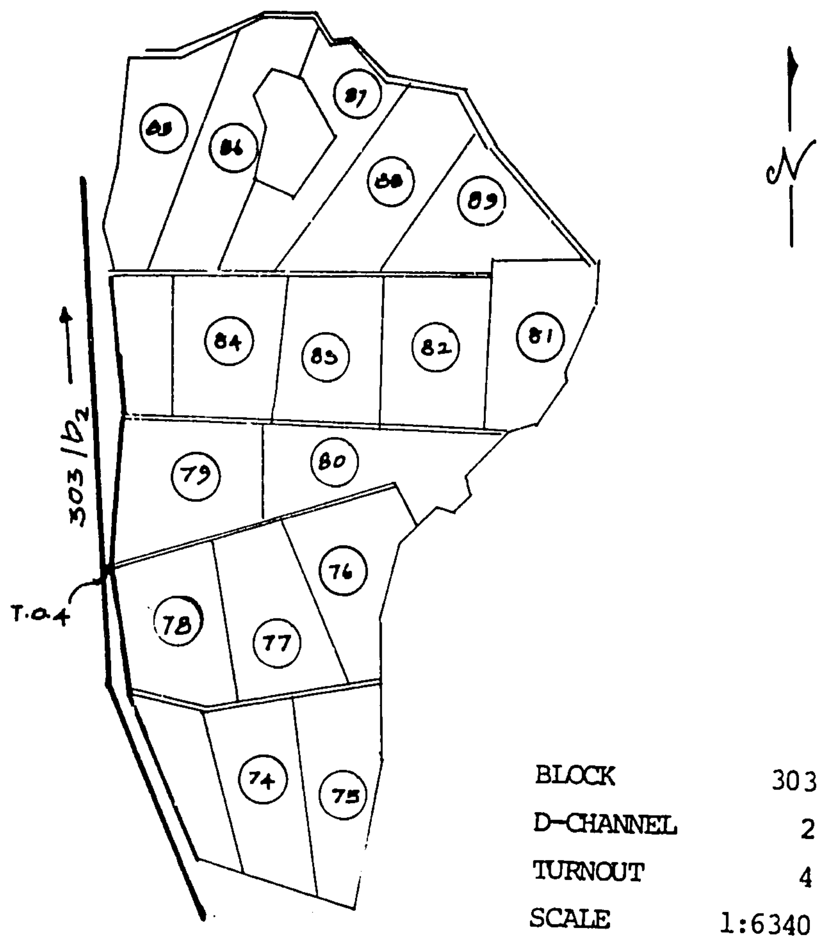


Figure 5. Map of Block 303/D.2/T.4

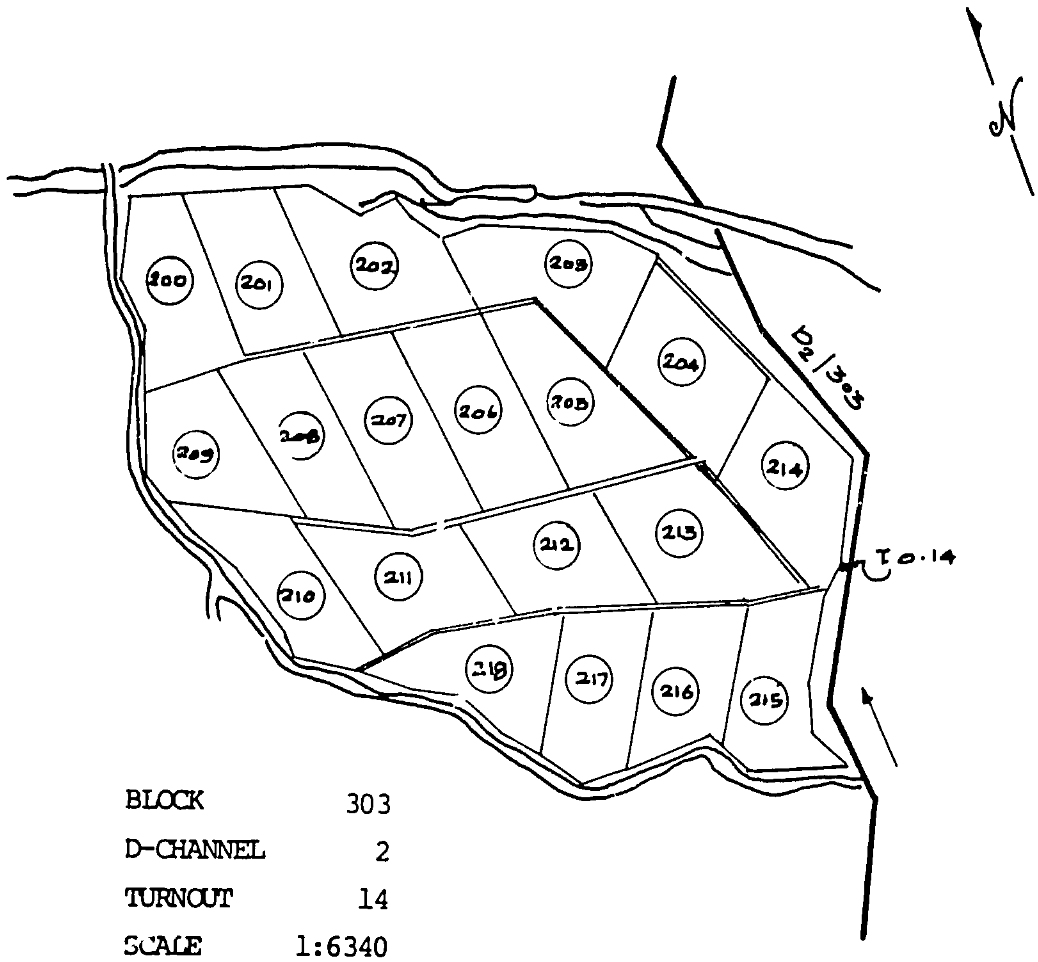


Figure 6. Map of Block 303/D.2/T.14

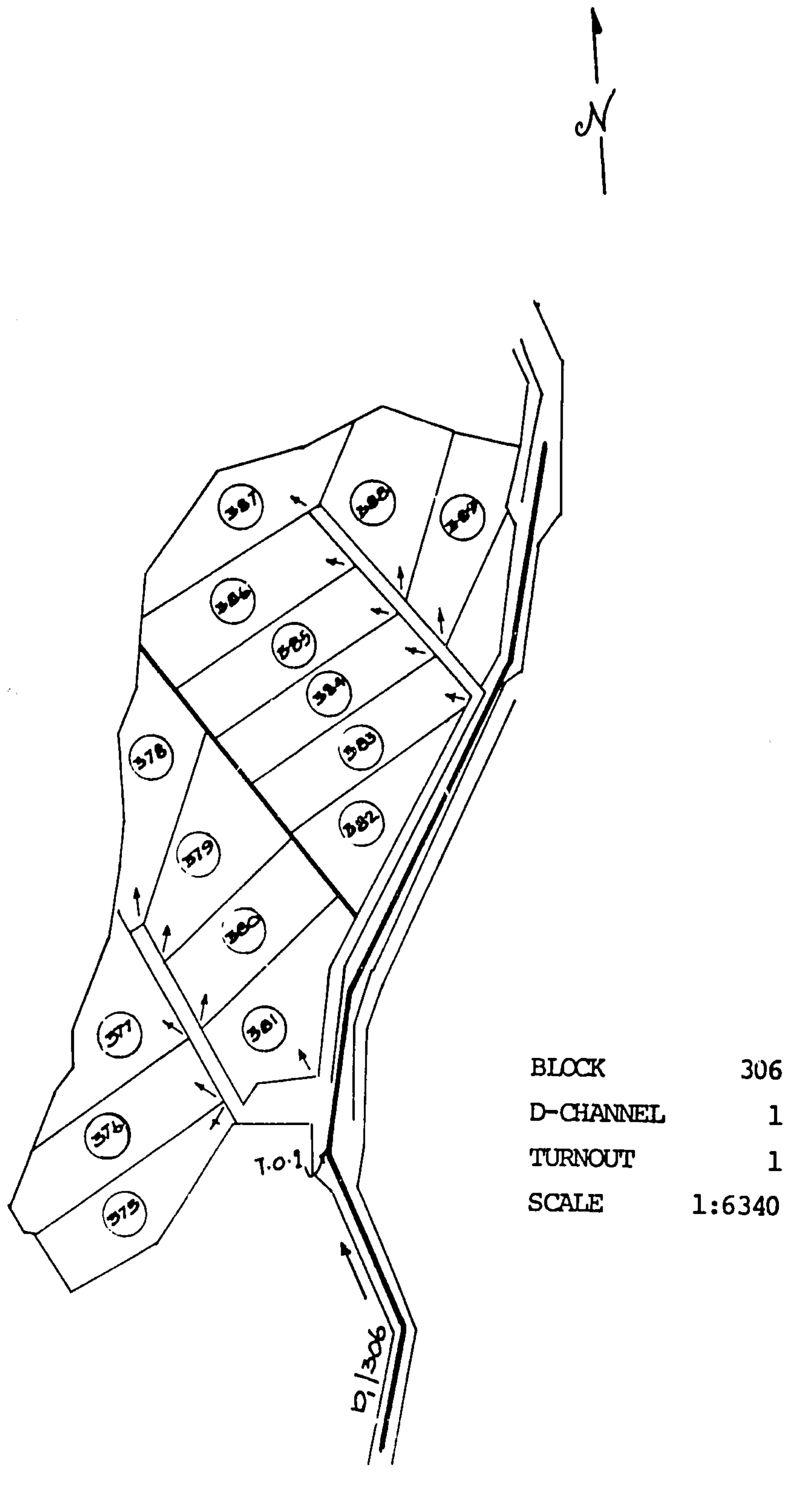


Figure 7. Map of Block 306/D.1/T.1

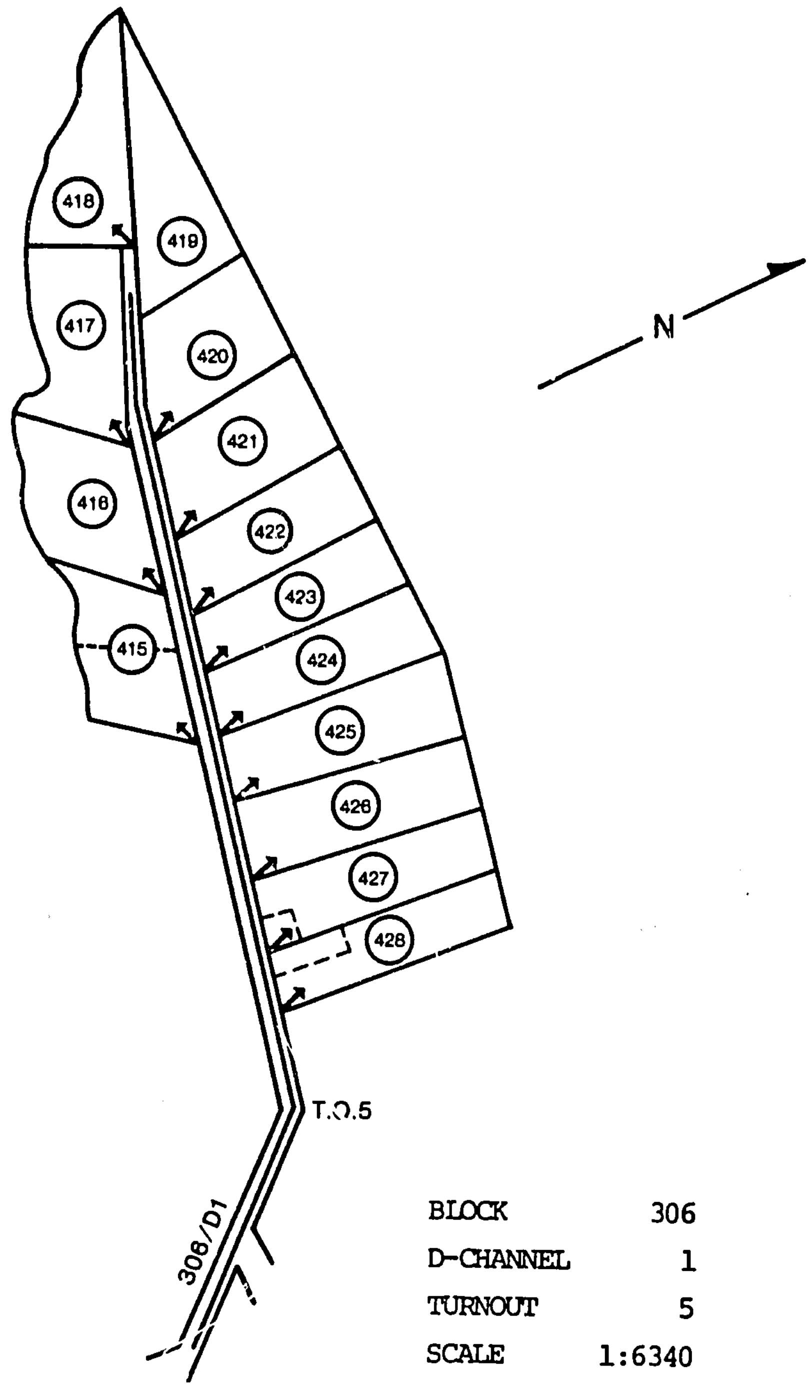
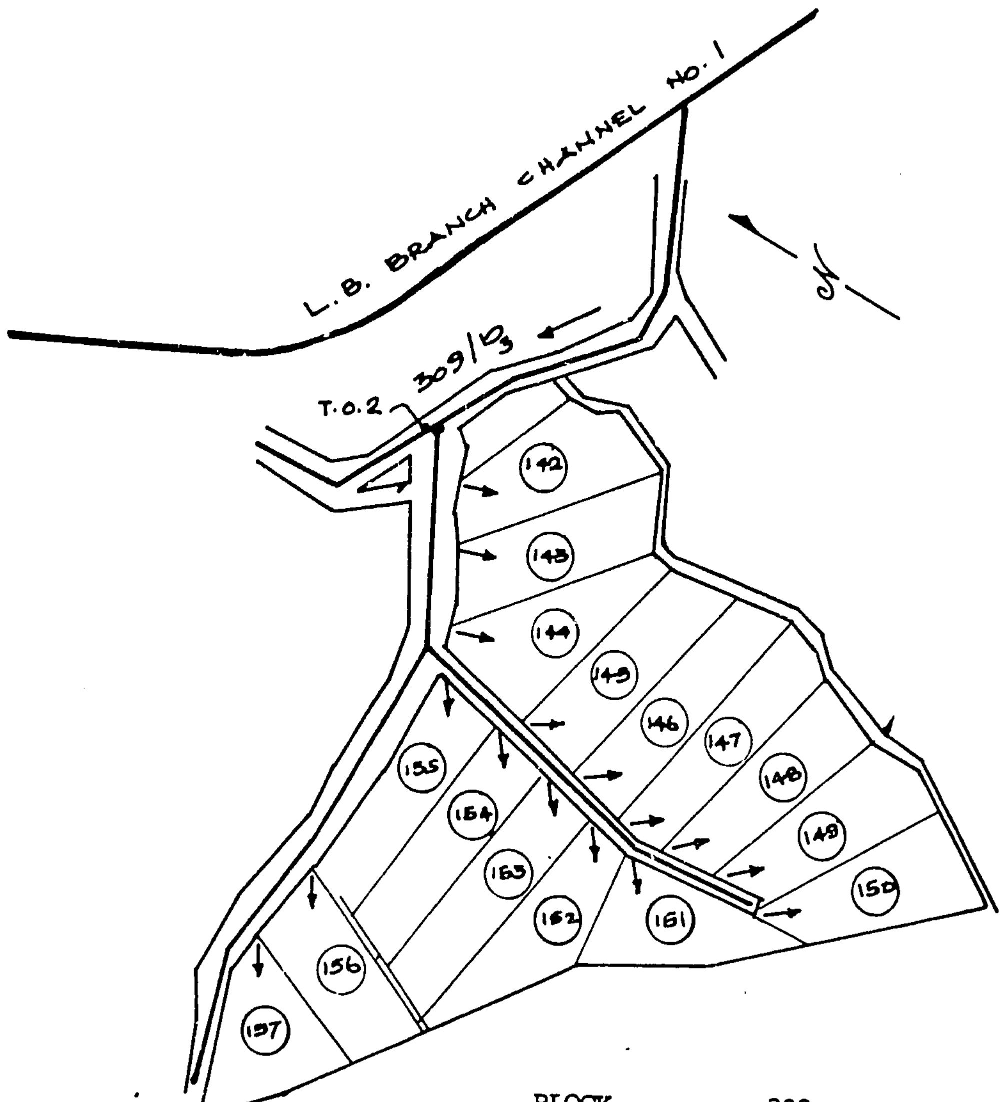


Figure 8. Map of Block 306/D.1/T.5



BLOCK	309
D-CHANNEL	3
TURNOUT	2
SCALE	1:6340

Figure 9. Map of Block 309/D.3/T.2

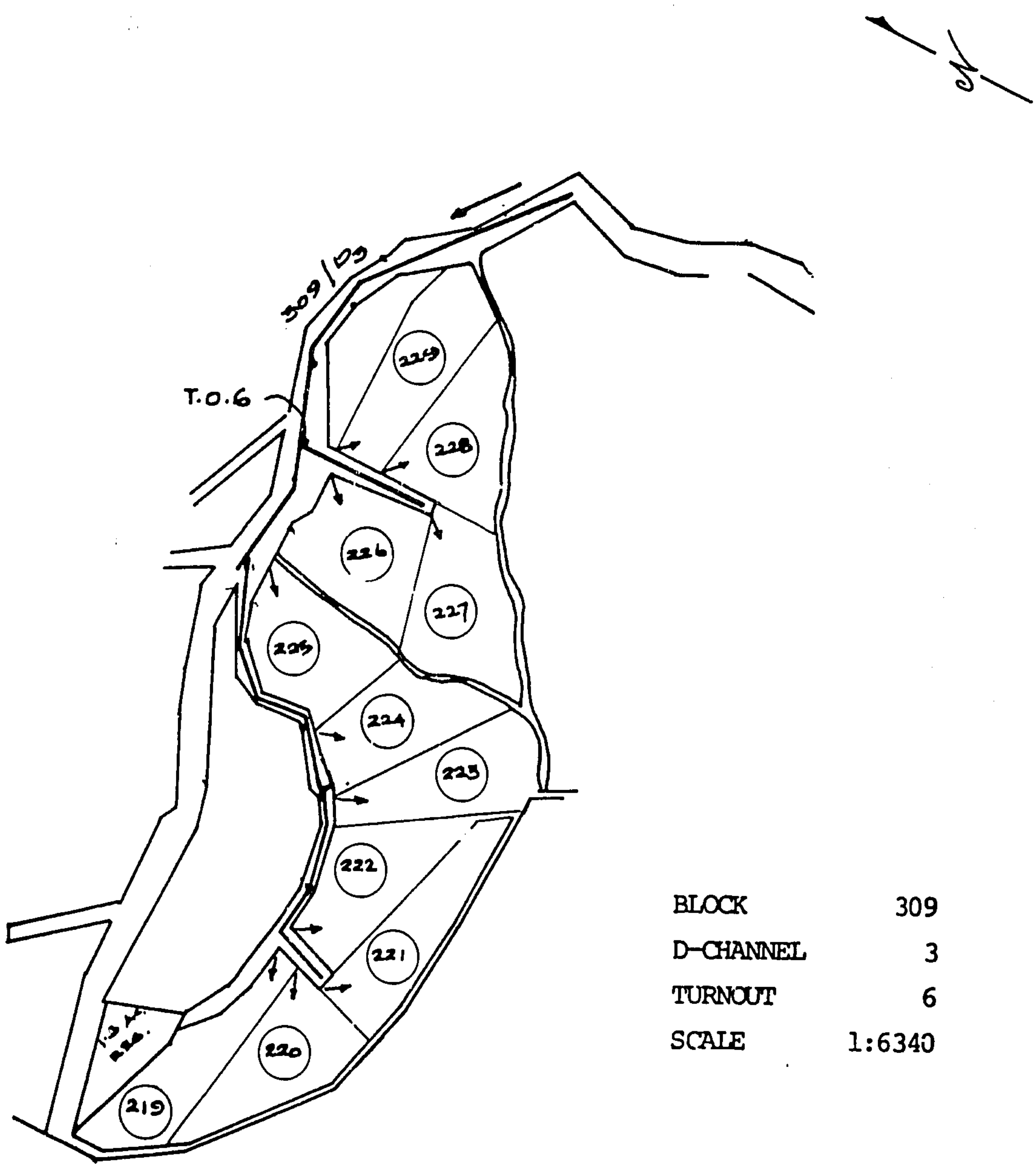


Figure 10. Map of Block 309/D.3/T.6

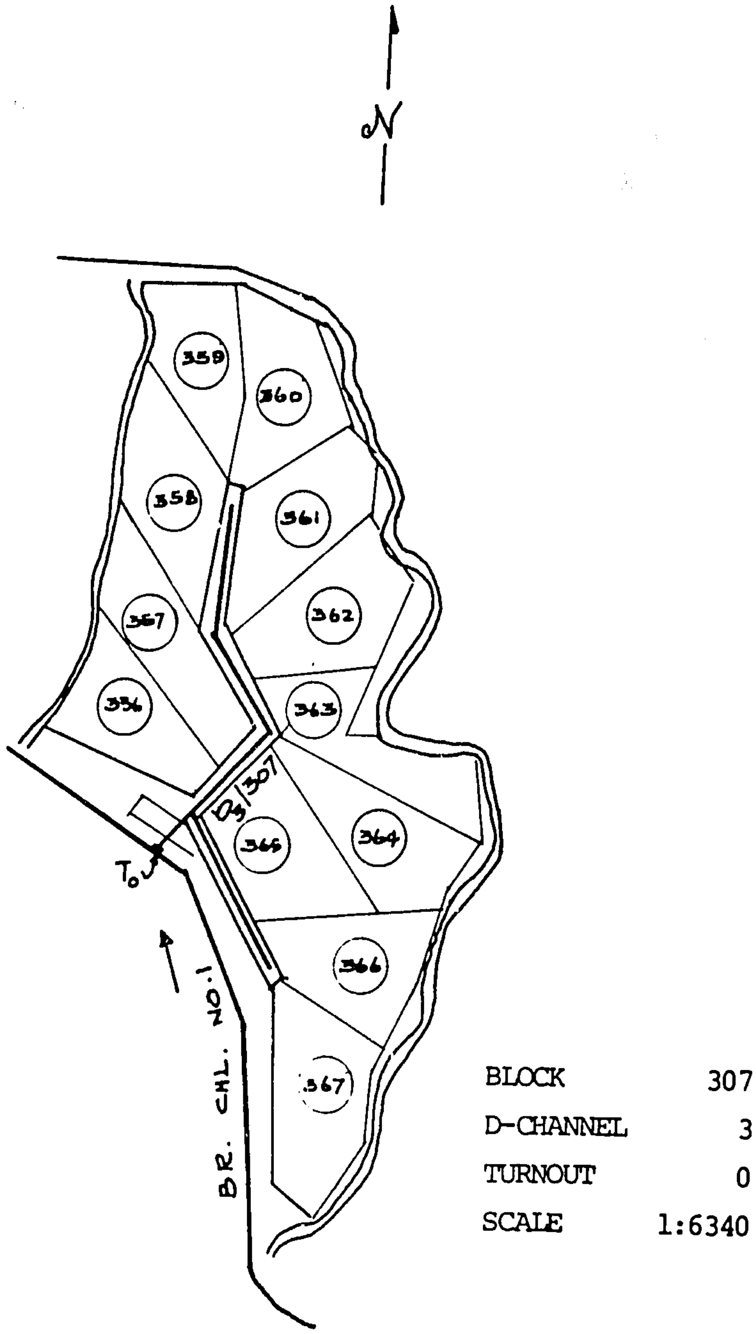


Figure 11. Map of Block 307/D.3/T.0

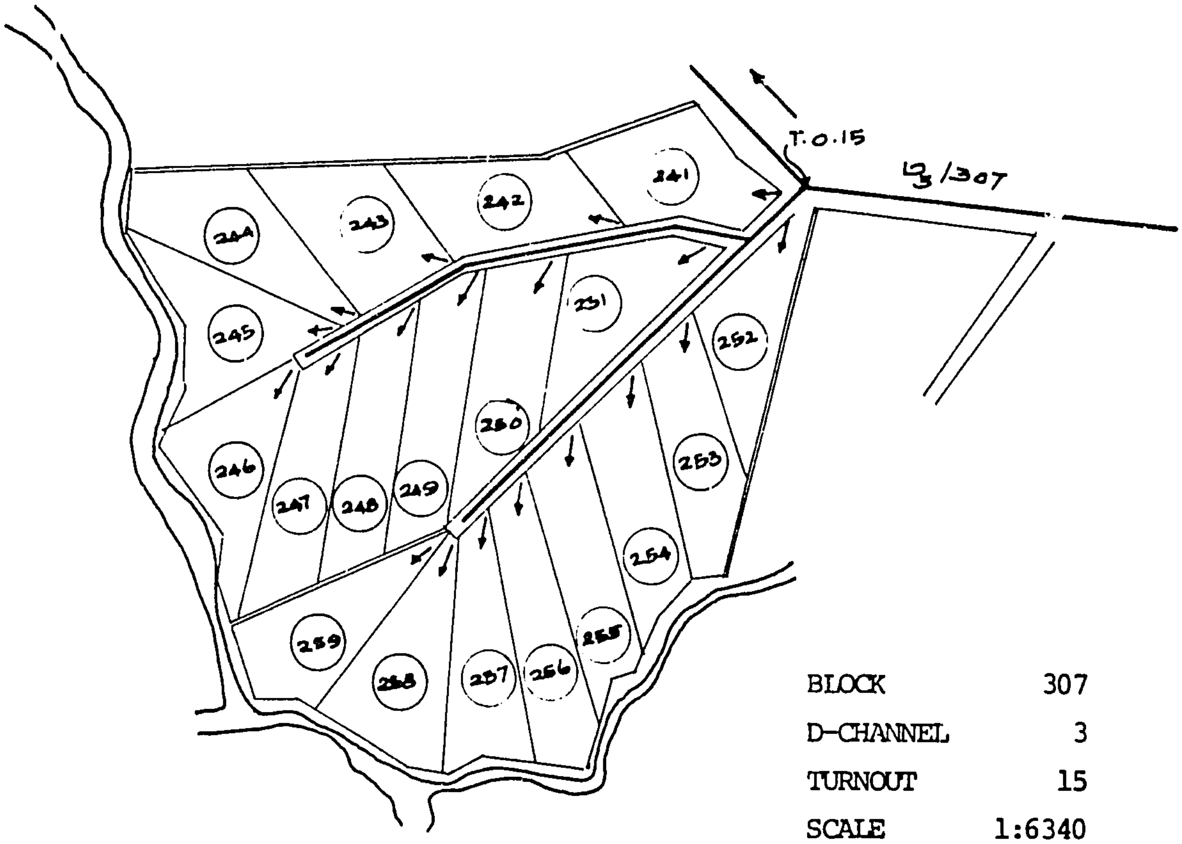


Figure 12. Map of Block 307/D.3/T.15

The topography of the area is characterized by a gently undulating land with slopes ranging from 0 to 8 percent. Prior to development, almost 80 percent of the project area was under forest. This land was terraced into small basins in the conversion to farmland.

C. Operational Plan of the Irrigation System

The Kalawewa left bank canal feeds an area of 6,073 hectares, through its channel network consisting of two branch canals, thirty distributory canals, and four regulating reservoirs (Figure 2). Water distribution up to the field channel is controlled with gated turnout structures. Water distribution within a field channel, which feeds a turnout area of 15 to 20 irrigable lots was designed to be based on rotations through the ungated farm turnouts.

The irrigable area of 6,073 hectares is subdivided into three administrative blocks, each consisting of approximately 2,500 farmer families. The Galnewa block consists of 4 irrigation blocks (301 to 304) and is fed directly from the main canal (Figure 13). The Kalankuttiya block consists of 5 irrigation blocks (305 - 309) with the Kalankuttiya regulating tank at the head (Figure 14). The Meegalewa block consists of 5 irrigation blocks (310 to 314) with the Mulannatuwa regulating tank at the head. The Mahakathnoruwa tank at the tail end of the main canal regulates the water supply to block 312. Each administrative block which has a reservoir at the head has the advantage of predictability concerning the availability of water to some extent, an ideal situation in an irrigation network.

In the selection of study sites the main consideration was to select three representative D-channels from the head, middle, and tail of the main canal as variations may be expected with respect to adequacy, reliability, and equity. As the Galnewa block is fed directly from the main canal, which also carries water to the other blocks, water availability is assured. On the other hand, there is a certain amount of uncertainty with regard to the availability of water to the blocks further down the channel.

D. Cropping Patterns

Traditionally, paddy has been cultivated in all irrigable areas of the old settlement schemes. In System H however, every effort is being made to increase the cultivation of other field crops in Yala. This has become necessary due to the limitations of water availability during this season. The subsidiary field crops that are grown successfully are chili, soybean, cowpea, bombay onion and sesame. Chili is the most popular crop due to its high profitability. For the first time, green chilies cultivated in a pilot project in Yala 1983 were exported to the Middle East. Paddy is cultivated in over 95% of the area in the Maha season.

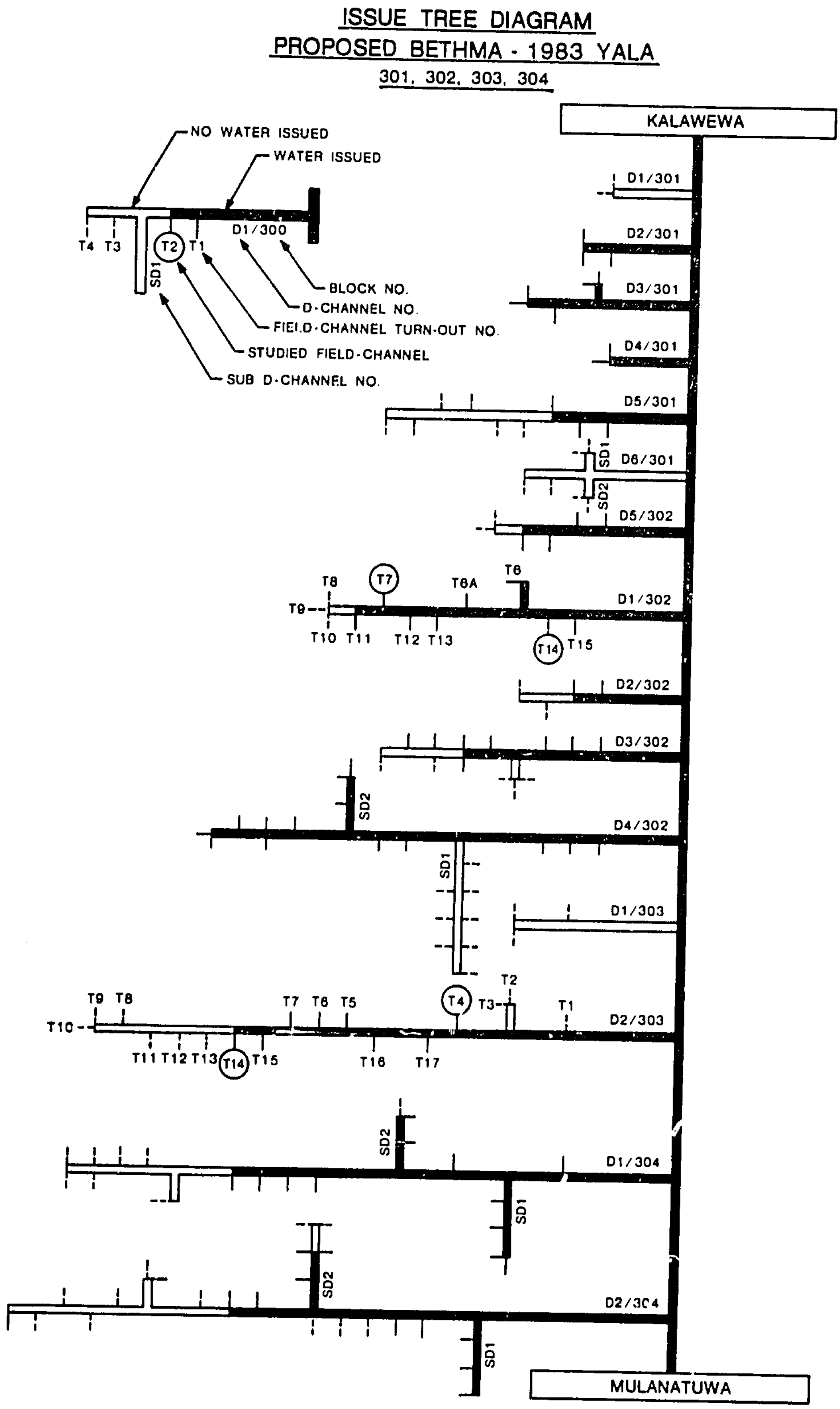


Figure 13. Water Issue in Galnewa Block, 1983 *Yala*

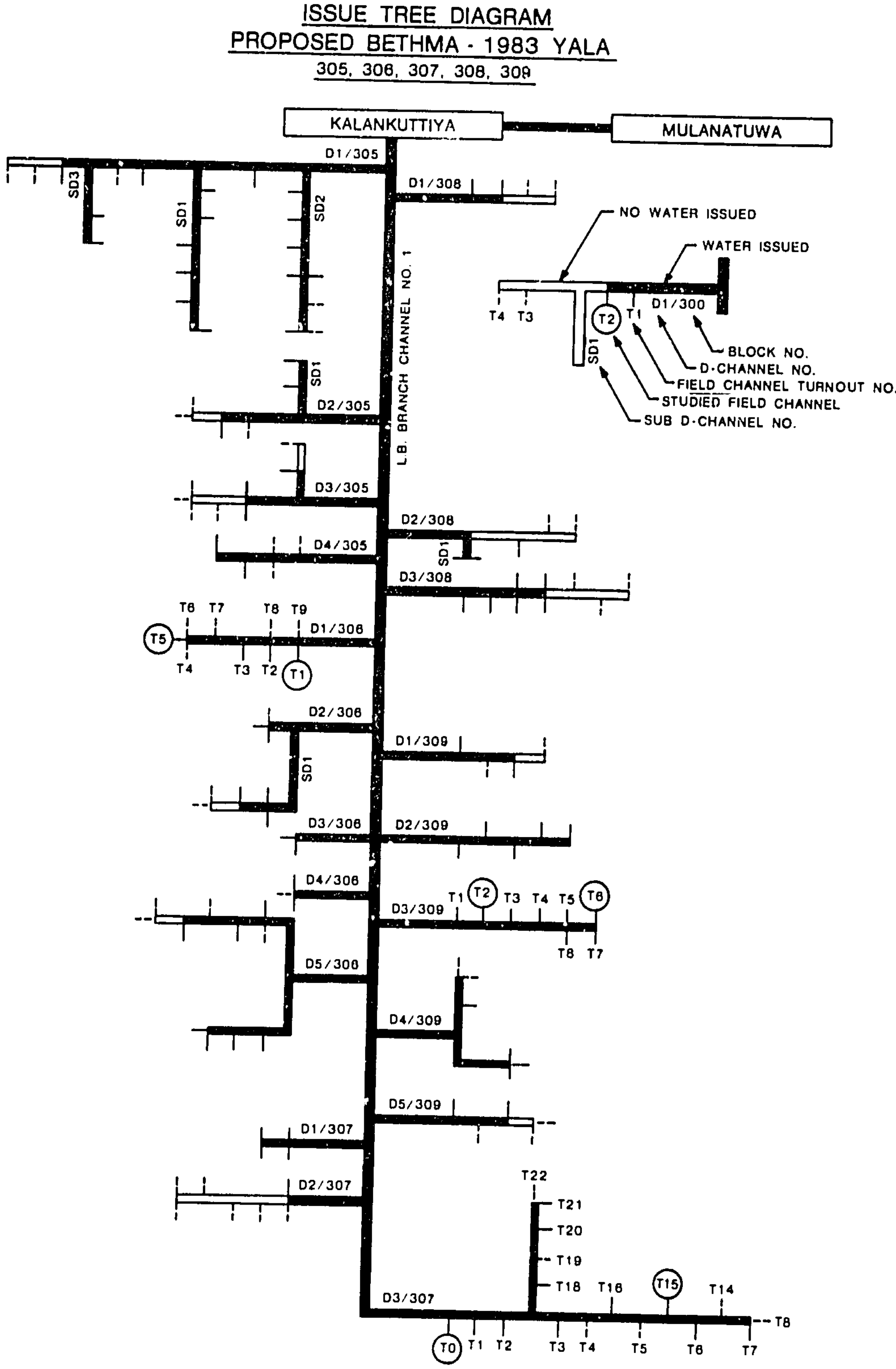


Figure 14. Water Issue in Kalankuttiya Block, 1983 *Yala*

Coconut, jackfruit, banana, mango and varieties of citrus are grown on the highlands. During *Maha*, vegetables are also cultivated on the homesteads but during *Yala* supplementary vegetables are mainly grown around the periphery of the irrigated fields. Detaled maps of cropping patterns during this study are loated in Appendix A of the report.

E. Socio-economic Conditions

Prior to the development of the project area for settlement the study location was in scrub jungle interspersed with traditional (*purana*) villages. The inhabitants of these villages, most of whom have been resettled in the same area, were on a subsistence level existence. They cultivated rainfed paddy and other field crops on the highlands during the *Maha* season where failure of the monsoon rains meant crop failure for the entire year.

III. METHODOLOGY

A. Reconnaissance and Work Plans for the Field Study

The workshop started with an introduction and orientation to the process of Diagnostic Analysis. The interdisciplinary approach to be employed in identifying irrigation problems was outlined to the participants.

At the end of the first week, the participants were split up into five teams. The teams consisted of an irrigation engineer, on-farm engineer, agronomist, economist, sociologist, and a women in development member. These teams represented each of the Mahaweli project areas. The choice of participants was so designed that after the workshop, each project area would have an interdisciplinary team trained in Diagnostic Analysis and able to work together in that area.

At the end of the first week the teams were sent out to the study area to perform a one-day reconnaissance survey. Each team made observations of the farming system under a pre-selected D-channel. The next day each team wrote a brief summary of observations on the reconnaissance and the leader presented this to the whole group highlighting what seemed to be the major problems, and where further investigation and study was necessary. Since the duration of the reconnaissance study was only one day, it was not exhaustive but did give the teams an idea of the system and its field operation.

Work plans for the detailed field study to be carried out over the next two weeks, were then formulated. These plans were based on the initial observations made during the reconnaissance survey and were designed to obtain data which would enable the participants to better understand the problems investigated.

Detailed methodologies were then designed by each disciplinary group. These methodologies and strategies which are recorded on a disciplinary basis, follow in this report. The data collected during the subsequent field study was collated and studied in greater detail by a selected group of participants, with the assistance of the trainers. These findings and recommendations are presented as appendices in the last section of this report.

B. Detailed Methodologies

1. Agronomy

The reconnaissance survey of System H suggested that low levels of production were associated with inequitable distribution of water, over irrigation of upland crops, low input levels, poor land preparation and weed control, and the development of salinity problems in the lower reaches of turnouts. Detailed agronomic studies attempted to examine these problems in more detail. On the first day of the nine-day detailed study, the agronomist of each team walked through his assigned turnouts. Observations included: the crops growing within each allotment, differences in growth stages, the general condition of the crops, and areas of poor growth associated with either management or soil problems. These observations provided basic information about cropping patterns, cropping intensity, and management related problems and served as a basis for selecting allotments for detailed study. Three allotments, located in the upper, middle and lower reaches of each turnout, were selected for detailed study. Specific data on the soils and crops were collected using methods described in Lowdermilk et al., 1981. A summary of the types and methods of data collected in each selected allotment follows:

a. Soils

Soil samples from depths of 0 to 15, 15 to 30, 30 to 60, and 60 to 90 cm were collected from the selected allotments. As the samples were collected, soil texture and pH were determined using the touch and feel method for soil texture (Thein, 1979) and a colorimetric method for pH. In addition, attempts were made to characterize the soil by depth increments. The remaining soil from each soil depth increment was retained for subsequent salinity analysis.

Areas with problem soils were assessed visually and from conversations with the farmer. Visual assessments were based on accumulation of salt deposits and/or areas with depressed plant populations. Soil samples were collected from the problem areas for subsequent laboratory analysis.

Soil samples brought to the training center were air-dried and sieved through a 2 mm screen. Each sample was analyzed for pH and electrical conductivity using the saturated paste method of soil salinity analysis (Richards, ed., 1969). In addition, the agronomists attempted to analyze the soil samples for available nitrogen (N), phosphoros (P) and potassium (K) using a portable soil test kit. However colorimeter readings of available N, P, and K were not reasonable and this activity was terminated. At the end of the workshop, four soil samples from blocks 302 and 307 were brought to the Colorado State University Soil Testing Facility. These samples were analyzed for available ammonium-nitrogen (NH_4-N), nitrate-nitrogen (NO_3-N), phosphorus (P), potassium (K), zinc (ZN), iron (Fe), manganese (Mn), and copper (Cu).

Auger holes developed from soil sampling served as observation wells for water table measurements. At least three observation wells, located in the upper, middle, and lower reaches of each turnout, were used to assess water table depths. Water samples from the observation holes, drainge channels and field channels were brought to the training center and analyzed for salinity (Richards, ed., 1969).

b. Crops

Within the selected allotments of each turnout, basins were selected at random for chilies and/or paddy. Information pertaining to varieties was obtained from the farmers. The other observations which were made included the mothod of establishment, spacing, stage of growth, approximate time of planting, visual and chemical (tissue tests) assessments of nutrient status. Visual assessment of the incidence of weeds, diseases, and pest infestations were also made.

The average number of tillers per-m^2 was determined from tiller counts made in nine randomly selected areas of each paddy field. A 900 cm^2 frame was used for the tiller counts. The average number of grains per-panicle was determined from grain counts of ten randomly selected panicles in paddy fields at or near maturity. The average number of grains per-panicle, tillers per-m^2, and an average weight of 1,000 grains were used to calculate potential yields of paddy.

Average weed infestations in paddy were estimated from weed counts made in nine randomly selected areas of the field. Weed counts were made using a 900 cm^2 frame.

Rooting depths of chili plants from areas with unusually high water tables were compared with rooting depths of chili plants from areas with normal water tables. The rooting depth was estimated by measuring the root length of several chili plants.

2. Engineering

During the reconnaissance survey, field observations were made by the participants to identify the key constraints and benefits of the water conveyance and distribution, water application and drainage systems in the five study areas. A natural sequence for selecting methodologies to be used in the detailed study would be to progress from the observations made to methods used as follows:

(1) summarize field observations,

(2) make specific assumptions based on the observations,

(3) determine required information to validate the assumptions, and

(4) select suitable methodologies to provide the needed information.

The following sections employ these four steps for the water conveyance and distribution, application, and drainage systems to select proper methodologies for collecting the required information in order to verify the specific assumptions made, based on the field observations.

a. Water Conveyance and Distribution System

Observations--The field observations from the reconnaissance survey for the system can be summarized as follows:

(1) Lack of D-channel maintenance, excessive vegetative growth;

(2) Poor maintenance of D-channel structures, many structures were damaged;

(3) Excessive erosion and sedimentation along D-channel bottoms and banks;

(4) Field turnouts damaged at some points

- water leaking through gated openings,

- measurement structures non-existent or faulty in many cases,

- some turnout areas receiving continuous water issue through ungated outlets;

(5) Farmers complained of excess soil water in some upland areas, visible seepage along channel banks at some points;

(6) Farmers complained of unreliable and inadequate supplies of water from field turnouts; and

(7) Obstructions made in D-channels by farmers at certain points.

Assumptions Made--The following assumptions were made based on the field observations above:

(1) Maintenance plan not properly implemented by the project irrigation personnel or simply ineffective;

(2) D-channel profiles (longitudinal and cross-sections) are different from the original designs;

(3) Excessive water losses due to vegetative growth, poor maintenance of the channels and erosion and sedimentation along the channel bottoms and banks;

(4) Water issues to the F-channel are not monitored and vary from one to the next; and

(5) Lack of communications exist among the operational staff as well as between staff and farmers.

Information Required--The following list was established to show all the information needed to verify the specific assumptions made in the previous section:

(1) Original and actual maintenance plans,

(2) Original and actual maintenance procedures,

(3) Original design specification and actual profiles of D-channels,

(4) Discharge measurements for a number of D-channel and field turnouts, and

(5) Staff and farmer inputs concerning evaluation of communication channels.

Methods Used--The following methods were selected and used by the participants to obtain the required information:

(1) Interviews were held with operational staff and farmers to obtain information on operational procedures, maintenance plan, and communication capabilities among staff and between staff and farmers.

(2) Differential leveling was conducted along D-channels to gather data on longitudinal and cross-sectional profiles. Plotting of the profiles was mostly done by a pocket size computer and it was operated by the workshop participants.

(3) Inflow-outflow method was selected to determine water losses in D-channels. Current meters were used by the participants to measure water velocity at different sections along the channels. Discharge rates were calculated by multiplying the velocity with its corresponding cross-sectional area. A pocket size computer was used to speed up this particular task.

(4) Cutthroat flumes were used for measuring the discharge rates at the head of all field channels branched from a field turnout to determine the total discharge at the turnout.

b. Water Application System

For this study, the water application system was divided in two parts, F-channels and farm areas. Therefore, the following discussion in this section will be separated according to the division of these two parts.

Observations--Six major observations were made for the F-channels in the study areas, as follows:

(1) Poor maintenance of F-channels, excessive vegetative growth;

(2) Many damaged or collapsed structures;

(3) Many illegal farm turnouts;

(4) Farmers receiving water continuously and simultaneously along F-channels;

(5) A few farmers complained of excess soil water in some upland crop areas: paddy was observed being grown in these areas; and

(6) F-channel reservations being cultivated by farmers.

For the farm areas, the following observations were made by the workshop participants:

(1) Farm layout in upland crop areas is not conducive for furrow irrigation of upland crops, mainly chilies, during Yala season; all set up for paddy cultivation under check flooding during Maha season.

(2) Basins do not appear to be properly leveled.

(3) Basins are not of uniform size.

(4) Some allotments showed signs of salinity problems.

(5) Some farmers have drainage channels between their allotments and those above them.

(6) Shallow wells on some farms show high water tables.

Assumptions Made--According to the F-channel observations, the following four assumptions were made:

(1) Excessive conveyance losses along F-channels.

(2) Control structures do not function at all along the F-channels.

(3) F-channel profiles are different from the original designs.

(4) No effective farm organization exists to facilitate channel maintenance or water allocations.

For the farm areas, four assumptions were made by the participants and are presented as follows:

(1) Farm layout is different from original design in upland crop areas.

(2) Upland crops are overirrigated by farmers.

(3) High water tables exist in all study areas.

(4) Unleveled basins, especially upland crop areas.

Information Required--The information requirements presented in this section were determined by the participants so that the assumptions made earlier could be validated. For F-channels, the information requirements are:

(1) Inflow and outflow measurements for sections of the F-channels.

(2) Present condition of all the structures along the F-channels.

(3) Original design specifications and actual profiles of F-channels.

(4) Project irrigation staff and farmer inputs concerning evaluation of communication channels.

For farm areas, the following information from the turnout areas is needed:

(1) Original design specifications and actual farm layout.

(2) Six to nine point elevations within selected basins.

(3) Actual depths of irrigation applied by the farmers, required depths and recommended depths of irrigation by the project irrigation staff.

(4) Actual water table depths over the turnout areas before, during and after irrigation.

Methods Used--The following methods were selected and used to provide the required information described in the previous section.

The methods used to obtain the information for F-channels were:

(1) Inflow-outflow method was used to determine water losses in F-channels. Two cutthroat flumes were set up at a fixed interval and readings were taken over a period of 6 hours by the participants. Discharges were obtained directly from a standard cutthroat flume table based on the readings recorded in the field.

(2) An evaluation was conducted by each participant on the condition of the structures along F-channels.

(3) Differential leveling was carried out along F-channels to gather data on longitudinal profiles.

(4) Interviews were held with project irrigation staff and farmers to gather information on F-channel operational procedures, maintenance plan, and communication capabilities among staff and between staff and farmers.

For farm areas, the following methods were used to collect the required information indicated earlier:

(1) Point leveling was conducted within some selected basins to determine the general levelness of farmer's fields. The farm layout of a few allotments in upland crop areas were drawn based on the leveling data.

(2) A cylinder infiltrometer was used to measure the infiltration rate in each of the selected basins.

(3) The gravimetric method was used to measure soil moisture. Soil samples were taken from depths of six inches to two feet in some selected basins before, during and after irrigation. Based on these samples, the soil moisture deficiency was determined for each of the selected basins.

(4) Water table measurements were made by using an auger to dig holes in upper, middle, and lower locations within the turnout areas and measurements of water depth were made before the irrigation, on the date of irrigation, and one,

three, and five days after irrigation. Point leveling was conducted as well, to obtain the elevations of the auger holes within the turnout area.

(5) Irrigation evaluation was carried out by a number of the participants to determine irrigation efficiency in farmer's field. Parshall flumes, cutthroat flumes, standard 90-degree V-notch weirs, and/or orifice plates were used to measure the inflow and outflow rates of a few selected chili fields. With the flow rates, the time of application, and the field area; the depth of water applied to a field was determined. The application efficiency was computed as the amount of water stored in the soil or the soil moisture deficiency based on the results provided by the gravimetric method, divided by the amount of water applied to the field. The water delivery efficiency was calculated by taking the ratio of flow at the second flume to the flow at the first. Finally, the irrigation efficiency was determined as the product of the delivery efficiency and the application efficiency; it is a measure of the effectiveness of the water used that is available at the field inlet.

c. Drainage System

Observations--The following observations were made during the reconnaissance survey for the drainage system:

(1) Drainage channels did not appear to be deep enough to provide adequate drainage,

(2) Some farmers blocked drainage channels to reuse drainage water, and

(3) Lack of drainage channel maintenance and excessive vegetative growth.

Assumptions--Based on the above observations, the following assumptions were made by the workshop participants:

(1) Drainage profiles deviate from the original designs, and

(2) Maintenance plan not properly implemented or simply ineffective.

Information Required--To validate the assumptions, the following information requirements were identified:

(1) Elevations of drainage channel bottom with respect to the farm areas served, and

(2) Original and actual maintenance plan and procedures.

Methods Used--To provide the required information, the following methods were used:

(1) Point leveling was conducted along the drainage channels to measure elevations in respect to the farm areas served, and

(2) Interviews were held with project irrigation personnel and farmers to obtain information on maintenance plans and procedures for the drainage channels.

3. Economics

a. Questionnaire Design

The questionnaire used by the team economists was designed to collect farm input/output data for the major crop enterprises of the 1982/83 Maha and Yala seasons. The questionnaire therefore focused on paddy and other field crop cultivation. In order to ensure a smooth flow of dialogue, the questions were arranged in the natural sequence of cultivation practices for paddy and other field crops.

The questionnaire was developed in consideration of the agro-economic situation existing in the study area. The existing agro-economic conditions were partially assessed by interviewing farmers in several areas and gathering information from earlier surveys conducted in the region. In addition, the questionnaire was modified after carrying out a one-day reconnaissance survey and it was pre-tested by interviewing ten farmers in the study area at the end of the first week. The revised draft of the questionnaire was then studied carefully and discussed by all of the economists who participated in the Diagnostic Analysis workshop, before the actual field survey was conducted.

b. Selecting the Sample

The main criteria for selecting D-channel turnouts and allotments, were the availability of water to the area and the soil types present. The major soil types identified in the turnout areas were well drained soils in the upland areas, imperfectly drained soils through the middle sections, and poorly drained soils in the lowland areas. In addition, there is some evidence that the availability of water decreases towards the tail of distributary channels as well as the field channels. Stratified sampling was used in order to represent head, middle, and tail trends among distributary channels as well as individual allotments.

Twenty representative allotments chosen from two turnout areas along designated D-channels were to be considered by each of the team economists. These twenty allotments were to represent the head, middle, and tail portions of each field turnout. In some cases twenty farmers could not be contacted for interviews, as some economists faced time and scheduling constraints within the limited nine-day field study period. However, a total of 96 farmers were interviewed during the field study period. These 96 farmers were all the original allotees associated with the land parcel. No bethma partners were interviewed.

c. Data collection

The main source of data for the agro-economic part of the field study was a one-time questionnaire survey of 96 farmers. Data were collected through single visit personal interviews. For the farmer's convenience, and to obtain more accurate data, the social and economic aspect data were gathered through separate questionnaires during the same visit by two members from the same team: one sociologist and one economist.

At the time of the survey (July 1983 Yala season), paddy cultivators were not occupied with major cultivation activities. On the other hand, most of the farmers who cultivated other field crops (chili) were engaged in the time and labor intensive tasks of weeding, pest and disease control, etc. Most of the other field crops cultivators were, therefore, interviewed at their farm units while others were interviewed at their homesteads. Homesteads were often located at some distance from the irrigated allotments, and it became necessary for team members to spend time commuting between interview sites.

The data collected covered the following main areas:

1) Cropping pattern and intensity
2) Agricultural production inputs and activities.
3) Production levels, marketing and credit.

As most of the farmers do not maintain systematic farm records, the information gathered was usually recalled from memory. For this reason, the data obtained may differ from the actual figures. This is partly resolved by constructing a representative farm unit (representative of head, middle, and tail of each field channel) using the simple arithmetic means of the various data gathered.

Due to the difficulty in gathering information about small extent cultivations such as vegetables, onions, etc., the data gathered focuses on major crop enterprises. Supplemental crops are used primarily for home consumption and some minimal marketing throughout the cropping season.

4. Sociology

The central data gathering strategy employed by the sociologists emphasized balance between qualitative and quantitative techniques. Open-ended informal interviews of key informants combined with observations recorded as field notes comprised the qualitative component. The quantitative data was gathered by structured questionnaires prepared by the sociologists for administration to sample farmers. The questionnaire was developed utilizing many items previously used in Diagnostic Analysis workshops in Sri Lanka and Bangladesh, reflecting input from all the disciplinary teams. The original questionnaires were modified based upon collaboration with the sociology team. This followed three days of field reconnaissance involving informal, exploratory interviews with a cross-section of study area farmers, villagers, and local irrigation officials. The questionnaires contained both open and closed ended questions designed to obtain information on the following aspects of attitudes and behavior which influence irrigation activity:

(1) The availability and utility of institutional services,

(2) The perceived problems of farmers,

(3) The farmers irrigation knowledge,

(4) The effectiveness of the bethma system and pattern of land tenure,

(5) The farmers involvement in the maintenance of the irrigation system, and

(6) The farmers perceptions of community life after resettlement.

A reconnaissance survey of the farm sites involving informal unstructured interviews of representative farmers was conducted prior to the development of the questionnaire. This survey was useful in clarifying important areas of research investigation and refining specific items included on the survey instrument. The questionnaires were initially written in English and translated into Sinhala by consensus of the participants regarding the use of language which was most familiar to the respondent population. The farmer questionnaire was pre-tested in a hamlet which was typical of the study area which led to subsequent refinement.

Both supervised practice interviews and careful instructions on proper survey techniques were used in interviewer training. In addition, interviewers were instructed to maintain field notes to record significant qualitative observations relevant to farmer irrigation behavior. All the interviewers had previous experience in administering survey questionnaires in field settings.

Judgemental sampling procedures were used to select farmers representing the head, middle, and tail of the main channel, D-channels and turnouts. The administration of the questionnaire to the 92 sample farmers was conducted in the field at either the hamlet homestead or irrigable allotment. In addition, 10 turnout group leaders, 4 Unit Managers, 5 Field Assistants (irrigation), 5 Field Assistants (agriculture), and 5 Patrol Laborers were interviewed as key informants. These individuals interact closely with farmers on irrigation and agricultural activities and constitute a valuable source of important qualitative information on water management practices.

The analysis of the qualitative data and the reduction and analysis of the quantitative data for summary and inclusion in the project report comprised the final stage of study activity. The management of the quantitative data was facilitated by the use of the Apple III microcomputer.

5. Women's Roles in Irrigated Agriculture

The addition of the women's survey team to the Diagnostic Analysis Workshop necessitated a broad, general approach as this was the initial inclusion of such a team in an interdisciplinary program. The interaction between women and an irrigated agricultural production system had not previously been included in the 1982 Sri Lanka Diagnostic Analysis Workshop. The role of women in on-farm and off-farm water management may have important effects as to the success, efficiency, and production of the agricultural system. Furthermore, the differential effects of irrigation on women, the contribution of women to the system, and the benefits women derive from the system are important concepts in understanding the operation of the irrigation system.

Five women were selected by the Mahaweli Authority to participate in the Diagnostic Analysis Workshop. These women were all officers of local Community Development Centers and a Home Development Center of the Mahaweli Authority of Sri Lanka, and are involved with training farm women in a wide range of topics including: national traditions and customs, home economics, health and sanitation, upland crops, cattle rearing, needlework and handicrafts, and community leadership. All of the women selected have used questionnaires to carry out field level surveys, and were familiar with interviewing techniques.

A group discussion was held in order to make use of the wide range of knowledge and experience of the women's team in the design of the questionnaire. Consultation with team leaders from the 1982 Sri Lanka Diagnostic Analysis Workshop also provided background information for the questionnaire design.

After discussion, the following objectives were defined by the women's team:

(1) To identify the activities and assess the participation of women in both the irrigated agricultural production system and the household system.

(2) To identify the decision making process involved in the irrigated agricultural production system and the household system.

(3) To identify the training needs and requests of women in relation to the irrigated system and the household system.

(4) To survey the availability of institutional extension services as well as other channels of knowledge to women.

(5) To survey the perceived problems within the irrigated system.

(6) To survey the sources of household income and expenditure patterns.

(7) To identify participation of women in various organizations and informal groups.

(8) To survey the personal stresses and satisfactions, both physical and emotional, of women in a resettlement scheme.

In order to increase the objectivity of the questionnaire many of the questions were open-ended, allowing a wide range of responses. Other questions involved the selection of more specific coded responses in order to eliminate confusion and improve interviewing efficiency.

Although the questionnaire was constructed in English, it was translated into Sinhala for use by the survey team. A discussion concerning interviewing techniques was held and the team members practiced administering the questionnaire among themselves. An important concept discussed was the adoption of a conversational style to develop rapport with the farm woman being interviewed, as some of the questions were of a personal nature. The team members also agreed to stress the confidentiality of the interview and responses.

Reconnaissance and testing of the interview was conducted in a nearby area, adjacent to the location chosen for later study. Seven farm women were interviewed by the survey team. After a group discussion reviewing the recorded responses, a few modifications were made to the questionnaire. Based on the reconnaissance it was decided that it was very important when interviewing the farm woman that her husband should not be present, as it was noticed during reconnaissance that he might dominate the conversation.

The study locations were previously selected by the Mahaweli Authority in consultation with the workshop coordinator. The actual sample selection was done by each interdisciplinary team. At the turnout level, samples were selected which best represented the water management characteristics of the head, middle, and tail of that particular turnout. Although the selection of farm women at this level was originally designed to be random, the difficulties imposed by drought, the operation of the <u>bethma</u> system, and harvesting schedules resulted in sampling based partially upon availability. The final sample consisted of ninety-nine interviews; thirty-one from the head, thirty-three from the middle, and thirty-five from the tail of the respective turnouts.

The final questionnaire was constructed with the following format:

I. Demographic Information
II. Irrigated System
   A. Activities Performed
   B. Decision-making Processes
   C. Training and Information
   D. Perception of Problems Related to the Irrigation System
III. Household System
   A. Activities Performed
   B. Decision-making Processes
   C. Training and Information
   D. Income and Expenditure Patterns
IV. Organizational Participation
V. Stress and Satisfaction Index

Information was gathered by visiting farm women in their homesteads, and involved approximately 45 minutes to 1 hour to complete an interview. Since many of the women were involved in harvesting, interviews were arranged to avoid their field work hours. In addition to the questionnaire, all of the women's team members kept a field notebook for recording impressions and observations relevant to each interview.

Each women's member of an interdisciplinary team tabulated her data and wrote a discipline report. Interdisciplinary reports were written after discussions among the team, with all six members contributing to the report. These reports were orally presented by one team member at the close of the Diagnostic Analysis Workshop.

More extensive analysis was done by an Apple III microcomputer at the Water Management Synthesis Project at Colorado State University. Frequency tables were generated with non-adjusted and adjusted absolute and relative frequencies. Based on these analyses, the final detailed discipline and interdisciplinary reports were written.

IV. RESULTS AND DISCUSSION

A. Water Control and Delivery

1. Irrigation System

The design and operational plan of the irrigation system is to provide for the equitable, adequate, and reliable delivery of water to farms in a specific area. This ensures that all farmers receive an appropriate supply of water, at the required times, for the cultivation of their crops. The amount and scheduling of this water is usually decided at the beginning of each cropping season.

Before the 1983 *Yala* season, the Water Management Panel made a decision to cultivate only 50 percent of the lands under the Kalawewa Reservoir. This decision was made due to the projected shortage of water for a full-season *Yala* cultivation. As the first date of water issue approached, the prolonged water shortage forced a revision of the initial decision. The Water Management Panel concluded that only 50 percent of the land on the left bank main canal of Kalawewa Reservior would be cultivated employing a *bethma* scheme. Although a *bethma* is a traditional practice used in times of water shortage, this was the first attempt by the Mahaweli Authority to incorporate this scheme into the operation of the irrigation system. The objectives of using a *bethma* were to:

(1) Provide better control over the available water supply, and

(2) Provide a more equitable delivery of water to the majority of farmers, by a sharing arrangement.

Practicality would suggest that lands under D-channels closest to the Kalawewa Reservior would be the easiest to irrigate, leaving the lands furthest from the reservior fallow. However, in order to decrease the travel distance for farmers involved, it was decided to use the *bethma* scheme on an administrative block basis. This meant that some D-channels in each block would be completely closed, and the tail of some of the longer D-channels would also be closed. Farmers from closed D-channels were to share land, equally, with other farmers from D-channels receiving water. Seventy percent of the relocated farmers were able to find suitable field plots with either relatives or friends. The remaining farmers were assisted by the Unit Manager to find land to cultivate. The extent to which the *bethma* was organized by the Mahaweli Authority demonstrates the sincere efforts made to ensure that the majority of farmers would have an opportunity to cultivate a crop during the 1983 *Yala* season, regardless of the difficult operating conditions imposed by the water shortage.

Control of water from the main canal to the D-channels was evaluated. It was found that off-take structures from the main canal were capable of delivering the water as designed to the D-channels. However, measured water issues varied at the head of the channels studied from -21 to +84 percent of the intended operational capacity. Acceptable variations would be approximately ± 5 percent. This suggests that although water control is possible at this level, it is not currently being realized.

A detailed examination of control structures was made along one D-channel. Of thirteen water control structures (regulators and turnouts) inspected, two were in very poor condition. The remaining eleven structures were fairly well maintained. Nevertheless, the majority of farmers and turnout group leaders surveyed reported that the quality of these structures was poor. Irrigation field assistants and patrol laborers also stated that there are many instances of damage to existing measuring devices. Observations of other channels indicated structures in a similar condition. Although the majority of structures were in good condition, the few in poor condition could greatly reduce the capacity for effective water control.

Measurements made with portable flumes at the head of four F-channels revealed that under-issues to turnouts ranged from 18 to 20 percent. These under-issues were seen with no distinction between the head and tail of these D-channels. Because all issues were below what they were intended to be, the problem at this level appears to be more than just poor water control practices. However, these same findings were not observed during the 1982 Diagnostic Analysis Workshop, as issues measured were both greater and less than the designed rates. Therefore, the problem this year may be the result of the scheduled under-issues to D-channels associated with the bethma system used. These under-issues might have resulted in reduced flow depths. It was observed, in fact, that actual flow depths were less than originally designed. If this is the case, the F-channel turnouts are operated under less hydraulic head than required to produce the intended discharges.

Conveyance loss measurements made in eleven different D-channel sections indicated losses from 0.1 to 2.0 percent per 100 meters, averaging approximately 1 percent. The original design provides for a loss of 15 percent from the head of the D-channel to the farm gate. Assuming a loss of 10 percent in the F-channel and the average length of a D-channel to be 2 kilometers, the losses calculated from the D-channels would appear to be moderately high for earthen channels.

In the study of one F-channel it was found that only two of the fourteen farm turnouts were in good condition. The majority of farm turnouts were either willfully damaged or not properly maintained. None of the regulators in the F-channels were functioning satisfactorily. This was because the planks that should have closed the farm turnouts and regulators in F-channels had not been provided. Due to the acceleration of the construction program certain deadlines were imposed. This, combined with a shortage of supervisory resources meant that some aspects of construction, particularly at the F-channel level, went unchecked. Therefore, at the farm turnout level the expected control capability was not attainable.

Poor maintenance of the F-channels was noted such as erosion, excessive weed growth, deliberate cutting of channel banks, and damage to structures. Serious erosion was noted in the F-channels. Some channels were lower than the turnout, and in some instances the channel was actually lower than the field to be irrigated. Past observations indicated that poor maintenance of F-channels was also a problem. This problem may have been further aggrevated by the fact that 50 percent of the farmers were bethma cultivators from a different location. These farmers, together with leasees, were less concerned about maintenance of the channels. Interviews with farmers owning the irrigated allotments confirmed these observations.

Measurements of conveyance losses along six sections of three different F-channels revealed that losses ranged from 3.5 to 30 percent per 100 meters. Assuming an overall loss of 10% along a 1 kilometer long F-channel, the measured losses were on the average considered to be high.

When interviewed, thirty percent of the sampled farmers indicated that the water supply was inadequate and unreliable due to poor water distribution and channel maintenance. Interviews of the farm women also corraborated these findings. Significant variation of opinion from the head to the tail of the irrigation system was also observed. Twenty-eight percent of the women from the head of the system, compared to 68 percent of the women from the tail of the system contended that water supply was among the most serious of their problems.

Nearly half of the interviewed farmers reported that as a result of poor water delivery and inequitable delivery, illegal practices were used. Illegal practices included taking water out of turn without authority, blocking F-channels, and damaging structures. Irrigation officials who were interviewed confirmed that farmers were using such methods. The reason for such damage may be hypothesized from the farmer's own response. Farmers resorted to illegal measures in order to gain some measure of water control. This type of action may be very rational from the farmer's point of view but only leads to further water shortages and makes water distribution more difficult from the authorities' point of view. Cultivation of reservations along the F-channels was also commonly observed. This leads to weakening of the channel banks, and increased seepage losses.

Where water is a key input to production, the uncertainty of water delivery will not encourage optimal crop management practices.

The uncertainty or perceived risk may force the farmer to minimize any potential financial failures. Capital and labor are complementary inputs to water, not substitutes. Therefore, inputs such as labor, hybrid seed, and agrochemicals are invested relative to the risk factor involved with water delivery. If water delivery is a problem in an irrigation system, those farmers most directly affected by unreliable water supply will tend to reduce their level of crop management. This discrepancy in management practices will further aggrevate income differentials.

For example, in block 307/D.3/T.15, agronomic observations indicated poor crop stands, high weed infestations, low predicted yields, and plant nutrient stress. Informal conversations by the agronomists with the farmers suggested that water delivery problems occurred soon after sowing. Due to a lack of water during this stage, weed control was difficult for the farmers. Consequently, when severe weed infestations occurred, farmers became discouraged and ceased to invest further labor and materials in their crop for 1983 Yala season.

It can be concluded from the previous discussion that water control and delivery, in the 1983 Yala season, were affected by a number of factors. Water shortages, poor water control practices (particularly at the field turnout level), poor maintenance of channels and control structures, and illegal practices all affect the ability of the Mahaweli Authority to control and deliver an adequate, equitable, and reliable supply of water to the farmer for crop cultivation.

Based on the limitations of this study the observations and measurements collected suggest the need for rehabilitation of certain sections of the irrigation system, as well as the need to educate farmers (both women and men) and also the irrigation officials in better water management practices. Methods to improve the on-farm water control by the farmer should also be identified. The formation of a strong farmer organization at the turnout level for cooperation and problem solving should also be considered.

2. Household System

a. Domestic Water Supply

The original design of the Mahaweli scheme provided for the construction of a large well for twenty families. It was later decided to construct smaller wells, to be used by only six families, thereby decreasing the travel distance requ[illegible] The quality of water in some wells was not suitable for consumpt[illegible] due to leaching from newly installed concrete linings. Over time this would improve but the water currently in the wells should be emptied. However, many of the farm families have constructed wells on their homestead for a more convenient source of water. A survey revealed that over 80 percent of the homesteads were exclusively using water from these wells. Households located in close proximity to channels were using this source in addition to well water.

During Maha, water in the homestead wells is adequate, however, during Yala, wells were unreliable (especially in the tail of the system). The water supply of many wells located near irrigation channels fluctuated, depending on seepage from the channel. When well water was not adequate, farm women were required to walk up to one-half mile to obtain drinking water, involving a considerable investment of time and energy for farm women.

b. Home Garden Water Supply

The extent of home gardening varied considerably depending on the homestead location in the irrigation system. Ninety-eight percent of the women from the head of the system were actively gardening on the homestead allotment, compared to 78 percent from the tail of the system. On homesteads at the head of the system all of the women interviewed had home gardens producing both fruit and vegetables. At the tail of the system women were much more dependent upon the established fruit trees, as only 50 percent of the gardens were able to grow supplementary vegetables. This difference becomes even more distinct when income from the home garden is considered. Forty-one percent of the households from the head of the system were receiving an income from the home garden, compared to 17 percent from the tail of the system.

One obvious reason for the success of vegetable gardening on homesteads at the head of the system was the observation that 100 percent of the women were actually watering their home gardens in block 302. By comparison, only 8 percent of the women from the tail of the system were able to water home gardens. These variations were due to the proximity of the homestead to an irrigation channel.

The adequacy, equity, and reliability of a water supply to the household system is necessary for personal, family, and community well being. Although a separate delivery system for domestic water was not originally designed, this possibility should be considered for future settlements. In this area, it is suggested that a more quantitative investigation of the household water supply be intiated in a search for solutions. In addition, more quantitative information is needed to determine the contribution of the home garden to overall family income.

B. Water Application and Drainage

This section examines the water application practices used by farmers in crop cultivation. Discussion also includes the detrimental effects resulting from the mismanagement of water, with respect to land and crops. Consideration in this section is also given to the drainage of surplus water from fields.

The method of irrigation employed by farmers in this area can be generally described as level basin irrigation. Fields are specifically laid out to facilitate the cultivation of paddy during Maha. Only slight modifications to this design are made for the cultivation of upland crops during Yala. The average size of basins was 16 m x 10 m, regardless of soil type. Initially, a basin 30 m x 30 m was recommended, but later modified to 10 m x 10 m based on research conducted at the Maha-Illupallama Research Center. The currently used basin size falls between these recommended sizes.

The irrigation of paddy was accomplished by flooding the uppermost basin until a depth of about 4 cm was established over the entire surface. Water was then allowed to flow through a check in the basin bund to the next lower basin. This process was repeated until all basins had been irrigated and had a standing water depth of about 4 cm. For this type of practice to be effective, the basins must be level and the soil infiltration rates should be low.

It was found that about 70 percent of the sampled paddy basins were either good or acceptable in terms of levelness (within ± 2 cm). Paddy was cultivated primarily in poorly drained lowland areas. However, a few farmers were cultivating paddy in well-drained upland areas. In either case, if the basin is not level or the soil is well drained, excessive application of water may occur. Furthermore, maintenance of the soil moisture content in well drained soils is difficult, and will drop below levels tolerable by paddy between irrigations resulting in stress to the crop.

The farmers perceptions of proper irrigation, as far as upland crops, is that if the high spots in the basin are wetted then sufficient moisture to satisfy crop needs has been applied. Most farmers do not seem to know how much water they are actually applying, let alone how much they need to apply. Indeed, over half of the farmers surveyed reported that they would only stop irrigating when water covered all of the high spots in the field.

The irrigation of upland crops is carried out in much the same manner as paddy. The main exception is that standing water is not maintained once a basin is covered. To assist in this irrigation practice, small field ditches should be used. These allow for water to be conveyed to lower basins without having to maintain standing water in upper basins. However, these small field ditches were not always observed to be present.

The recommended form of land preparation for upland crops was raised narrow beds. This form of land preparation would allow for sufficient water to be applied in furrows between beds without covering the entire basin. But since farmers perceptions were different (perhaps due to lack of knowledge), most farmers cultivated upland crops on wide slightly raised beds, which could be totally flooded.

It was observed on several occasions at different sites that farmers, after flooding a basin to cover all but the highest spots, would splash water with their hands onto the remaining dry spots. This observation suggests the degree of unlevelness of basins where upland crops were cultivated. In fact, nearly 70 percent of sampled upland crop basins were found to be unacceptable with regard to leveling.

When basins are not properly leveled, unequal distribution of water within a basin can result. Soil moisture content measurements made in one upland crop basin showed a high moisture content at the perimeter of the basin, while a low moisture content remained in the middle of the basin.

Based upon the observed irrigation practices mentioned, over irrigation may be occurring. Sufficient field studies were not conducted to verify this directly, but the monitoring of the water table strongly suggested that over irrigation occurs. The water table in most areas was observed to be high, particularly in allotments closest to D-channels and where paddy was being cultivated. At most locations the observed depth of the water table was within 30 cm of the surface for at least 3 to 4 days after irrigation.

High water tables, aside from over irrigation, which may be due in part to the farmers' lack of knowledge concerning water management, can also result from:

(1) Excessive seepage from D-channels,

(2) Excessive seepage and leakage from F-channels, and/or

(3) Inadequate drainage.

The detrimental effects of a high water table were also noted in the field survey. The root depth of chilies was only 6 to 13 cm in areas where a high water table existed, whereas in a healthy plant it should be approximately 60 to 90 cm. This condition is likely to result in reduced yields of chilies. Some farmers also reported plant losses due to waterlogging. Another problem associated with high water tables is that of salinity in soils. Some farmers left allotments or portions of allotments uncultivated due to a build-up of salinity in the soil. Soil samples were analyzed from these problem areas. These analysis showed that salinity levels were indeed above those tolerated by crops.

Field observations showed that most farmers do not have drainage ditches on their allotments. The tertiary drainage channel depths were not maintained adequately by the farmers to remove excess water from turnout areas. It was also noted that some of the drainage channels were blocked by farmers to divert water for irrigation back to allotments at the tail of the system. As a result, high water tables and waterlogging may be expected.

C. Resources

The objectives and goals of System H of the Accelerated Mahaweli Program are to assist in national development and to improve the quality of life by providing certain natural resources along with social and institutional services to farm families settled there. The farm families themselves must provide the vital resources of labor, capital, and management needed to transform the other resources into marketable products. In this section the availability, allocation, and conservation of the resources needed and used by farm families will be discussed. Detailed discussion of the social and institutional services provided by the Mahaweli Authority and the government of Sri Lanka will follow in Section F. Institutional Development.

1. Availability

The basic resource of land is provided by the Mahaweli Authority. Each settler family is alloted one hectare (2.5 acres) of farm land and 0.2 hectares (0.5 acres) for a homestead. In addition, the irrigation water needed for the cultivation of this farm land is provided by the Mahaweli Authority from the main irrigation grid system. Initially, a large well for domestic use was constructed for each 20 families in the hamlets, but later, smaller wells for every six families were provided. Each new settler family was given Rs 1,000 cash, dry rations, seed paddy, and basic agricultural implements at the time of settlement. Various support services are also provided by the Mahaweli Authority, usually through the Unit Manager, to farm families. Some of these services include:

(1) The availability of seed, agrochemicals, agricultural implements, and farm power;

(2) An extension service which provided two Agricultural Field Assistants (in irrigation and agriculture) for every 250 farmers;

(3) Community Development Centers for education and training; and

(4) the Marketing Division of the Mahaweli Authority which: arranges buyers; establishes a guaranteed, fair price; sets up crop quality standards; establishes collection centers, and transportation from the farm gate; issues a Goods Received Note (GRN) voucher to the farmer and bank; and assists with credit recommendation and repayment of loans.

It must be noted at this point that a "service" such as any of those mentioned in the above discussion, has no "inherent" value. The value-in-use should be the means to evaluate the worth of any of these services.

2. Allocation

a. Water and Land

During the 1983 *Yala* season, in the System H area, the distribution of basic land and water resources was modified by the previously described *bethma* system. Within this framework, the irrigated area that was cultivable was cropped in the following pattern for 1983 *Yala*: 65 percent in paddy, 22 percent in other field crops, and the balance of the area was left fallow. Field observations indicated that based on the soil classification and topography, the cultivation of crops in certain areas was inappropriate. In some cases, paddy was cultivated in well-drained upland soils, resulting in excessive water application which created problems for farmers growing other field crops nearby. Over irrigation may have aggravated the high water table in some areas, adversely affecting root growth of upland crops. For example, measurements of chili root depth ranged from 5 to 13 cm, compared to a normal depth of approximately 60 to 90 cm.

In addition, these type of poor water management practices may increase any existing salinity problems. If land becomes saline the cultivable land may be reduced or even lost to the farmer. For example, one allotment in block 306 was abandoned by the farmer after two successive crop failures. Salinity measurements of 15 mmhos/cm indicated extremely saline conditions and crop production in this allotment would be nearly impossible.

A separate surface delivery system for household water was not designed by the Mahaweli Authority in System H. Households depend primarily upon wells dug on their own homestead allotments. The reliability of water supply to the household is dependent upon these wells, many of which commonly go dry during the *Yala* season. Aside from general health and sanitation aspects, the reliability of homestead wells is important for other reasons. The appropriation of much of the 0.2 hectares (0.5 acres) of the homestead for home gardening and nursery establishment is common. These activities require both an adequate and reliable source of water. In addition to providing products for home consumption and/or supplemental income from the home garden, the condition of the nursery may have a substantial impact on actual crop yields realized.

b. Labor

Comparative figures for shortages and surpluses of labor throughout the calendar year are not available However, when family labor is compared to hired labor some conclusions concerning labor distribution can be made. Data obtained for the 1983 *Yala* season found that hired labor was used in approximately the same proportion as family labor, regardless of the crop cultivated. Although the labor distribution was relatively similar for production of both paddy and chili, the total labor requirements for chili cultivation were approximately five times greater than for paddy. The extent of paddy production in *Yala*, combined with the modified practices used by farmers, significantly decrease the labor requirements for paddy in *Yala*, compared to *Maha*. For example, in *Maha* almost 100 percent of the area is cropped in paddy, whereas during *Yala* this area was greatly reduced. In addition, the labor-intensive transplanting method is more common in *Maha*, compared to broadcast seeding in *Yala*. Family labor also appears to respond elastically to these periods of labor shortages. Increased participation by women in field activities occurred when labor was needed, and decreased when labor was less of a problem.

The most labor intensive activities associated with chili cultivation were land preparation and weed control. For paddy, land preparation, harvesting, and processing required the greatest labor inputs. Since it is apparent that land preparation is an activity requiring a large allocation of labor, methods which reduce the effort and time spent on land preparation are important. This becomes particularly critical when land preparation must be accomplished under the time constraints associated with the dates of first water issue.

The Mahaweli Authority has recognized this problem and offers the purchase of two-wheel tractors to farmers by a graduated payment program. These two-wheel tractors have been purchased by many farmers, under this program. In fact, 65 percent of farmers cultivating paddy were using two-wheel tractors for land preparation. However, in chili cultivation, the majority of farmers used manpower for land preparation. This may be one of the major factors which limit the extent of chili and upland crop cultivation. Indeed, if the recommendations for land preparation associated with chili cultivation were actually followed, an even greater amount of manpower would be required.

A survey of farm women indicated that the majority of women (93 percent) assist in activities associated with crop production as part of the family labor. In *Yala* paddy production, the major activities performed by women included harvesting, weeding, and transplanting. Chili cultivation involved women primarily in those same activities. Women were involved in chili cultivation to a greater degree than paddy, primarily because of the overall increased labor requirements of chili cultivation. One important task, which was mainly the responsibility of the farm woman, involved growing supplementary vegetables either around the perimeter of the irrigated field, or as small plots within the field. Women mentioned that they had increased field work after resettlement. Competition between necessary activities associated with the household may decrease the amount of labor women are able to contribute toward field work. Therefore, any improvement or reduction of time-consuming activities on the household would enable women to increase participation in field work.

c. Capital

Due to the limited scope of data collection, actual income figures are unavailable. However, based on information obtained, the average net income (returns to family labor, land, and management) per hectare for dry chili was expected to be Rs 22,272. The expected net income for paddy averaged Rs 3,700 per hectare. Average cost figures used for this calculation did not include interest payments. The calculated expected net income also gives no indication of cash flow. The timing of cash receipts and expenditures is critical for a farming operation.

The investment of capital in crop production is a decision that may be based on a number of factors. For example, 92 percent of the farmers surveyed used own-source seed in Yala. When comparisons based on present practices are made, it was found that own-source seed was costing the farmer Rs 402 per hectare compared to Rs 408 per hectare for government issued seed. These cost figures are not significantly different, but the hidden costs of transportation, personal time/labor, and cash flow have not been assessed. Aside from purely logical reasons for this behavior, the farmer's concept of cost may be different for available, own-source seed and purchased seed. When yield potential is considered, the hybrid government seed may be superior, but due to the uncertainty associated with seasonal water supply the investment of capital may be limited. This decrease of crop production inputs to minimize loss of capital may also include cash spent for fertilizers and pesticides.

Even though farmers may reduce the amount of capital allocated to crop production inputs in uncertain, or high-risk situations, a family survey indicated that compared to all other family expenditures, crop production inputs were ranked as a fairly high priority. Only expenses related to food for the household were ranked higher. Clothing and miscellaneous household items were ranked in the moderate to low priority, and savings and loan repayment were rated as lowest in priority.

d. Management

One of the most important resources for the farmer is the knowledge and understanding of good crop production practices as well as business decisions. The way in which a farmer manages all of the resources available is largely a function of knowledge.

The decision to cultivate paddy on well-drained soils may indicate a poor management of land, water, labor, and other investments. The lack of fertilizer use in paddy production was evident by observed nitrogen and phosphorus deficiencies. The use of herbicides and other weed control methods in paddy were poor and ineffective. For example, weed population of all surveyed fields averaged 350 weeds per square meter.

Chili cultivation requires a greater degreee of management than paddy production. From agronomic observations it appeared that farmers were generally applying better practices in chili cultivation with respect to fertilizers, weed controls and pest management.

The particular area of crop production involving water management was most relevant to this study. Compared to all other practices, the farmer appeared to be least effective concerning the appropriate management of water. The effects of over irrigation were previously discussed. In addition, for effective water management, a rotational system was originally designed. Interviews with farmers revealed that most farmers did not follow a rotational method for sharing water, but instead resorted to illegal methods in order to gain some measure of water control.

Because cash flow is extremely important to a farming operation, the management of the sale of the crop and associated cash receipts may determine success or failure for the farm family. In this study it was revealed that the majority of farmers requiring loans borrowed from private traders rather than from institutions. The various reasons for this decision are discussed in detail in Appendix C of this report. It may be that when farmers borrowed from private lenders the end result was a greater final cost, affecting the net income, and capital cash flow.

One manner in which the farmer may control cash flow is through successive sales of portions of the crop yield. It is common for most farmers to sell the major portion of the crop yield immediately after harvest due to lack of storage facilities, required loan repayments, and the arrival of private traders at the farm gate. However, some farmers are able to withhold part of their crop from the market until prices rise and/or additional income is needed.

3. Conservation

The proper and appropriate allocation of resources will naturally result in conservation of those resources. The conservation of finite resources is obviously critical to the continuation of any system. However, the conservation of renewable resources is sometimes viewed with less urgency. Resources such as soil, point to the fact that renewability is not always an accurate concept from a practical viewpoint.

a. Natural Resources

This study revealed that a great degree of water waste was due to losses in conveyance and poor distribution, particularly at the farm level. These losses could be minimized by a better channel maintenance program and increased participation of farmers in water distribution and channel maintenance. The use of the bethma system in 1983 Yala was an attempt by the Mahaweli Authority to effectively use available water. While it appears that efficient use of the limited water supply was accomplished, the introduction of farmers from outside areas may have affected the maintenance of channels to some degree. It was reported by landed farmers that the bethma cultivators did not maintain the F-channels because they didn't consider themselves to be a part of the community and lacked any incentives to maintain channels.

If the water table remains elevated, or increases, the total cultivable area may be reduced. This reduction could be due to either the direct affect of waterlogging on plants, or indirectly due to increases in soil salinity. Since the rise in the water table may be largely due to over irrigation and channel seepage, better distribution and channel maintenance may assist in alleviating problems associated with a high water table. Field observations suggested that a relatively shallow layer of bedrock may severely restrict the downward movement of water in most soils of System H. If this is true, then the management of these soils under irrigation will be more complex than is implied by the current land use classes. More detailed soil surveys which focus on soil depths and drainage characteristics, would better define the use limitations of these soils.

One very important natural resource for farm families is timber for firewood. Farm women interviewed related that the supply of available fuelwood was decreasing in the area. Many of the women mentioned that the distance required to fetch firewood was too great for them to travel. In this situation, the husband was assuming the responsibility for firewood collection when returning home from other activities. In fact, some families had resorted to purchasing firewood due to decreased availability. This additional cost may further strain the limited finances of the farm family.

The Mahaweli Authority has recognized this serious problem and newer settlement areas are provided with tracts of land specifically for fuelwood and timber plantation establishment. System H, however, had very little area left as reservation so reforestation plantings are limited to small areas and avenue planting.

The land resource categorized as reservation area should also be protected from misuse. Many farmers were using these channel banks and borders for crop cultivation, which may weaken channel banks leading to erosion and seepage. Eighty-eight percent of the women interviewed were gathering food items such as fresh green leaves from these areas for home consumption. The cultivation of chena areas during both Maha and Yala was also cited as an important source of family income. The use of these areas may be important to farm families and information concerning both the benefits and detrimental results should be carefully evaluated.

b. Human Resource and Institutional Services

The single most valuable resource in a farming operation is undoubtedly the farm family itself. It becomes difficult to discuss the conservation of this resource, compared to a more finite, natural resource such as land or water. In order to understand the division of family labor into the various tasks and activities a more quantitative study is required.

Management decisions concerning both crop production and business transactions are dependent upon the experience, knowledge, and understanding of the farm family. Increased knowledge, coupled with technological advances, would maximize the use of family resources.

The various institutional services provided by the Mahaweli Authority are designed to increase the efficiency and preservation of both natural and human resources. These support services may be of great value to the farm family only if they are perceptive and responsive to the needs of the farm family.

D. Farmer Involvement

Ultimately, it must be the farmer who makes crop management decisions and resolves specific problems. The Mahaweli Authority has formed a number of organizations and societies to be used by farmers for these purposes. Their success or failure, however, depends solely upon the farmers' acceptance and use of these organizations.

The turnout group was designed by the project management to provide the farmer with a mechanism to control water issues at the farm level. Through this system, farmers would be able to cooperate with each other by using water on a rotational basis. The turnout group was also designed to provide a means for mutual communication between project management and the farmers.

In reality, farmers considered turnout groups to be an organization used by project management to communicate with farmers, rather than an organization used by farmers to solve their problems as participants. Since the farmers may not perceive the turnout group as a way to solve problems, they may resort to illegal and destructive methods as an attempt to solve problems such as water delivery. The lack of farmer participation in turnout groups may also be responsible for the lack of cooperation regarding irrigation rotations and channel maintenance. For example, nearly 50 percent of the farmers interviewed reported that taking water out of turn without permission occurred either "sometimes" or "often." This practice was more frequent at the middle or tail of the system, than at head locations.

The Mahaweli Authority has also recently founded Community Development Societies. This organization was designed to assist and instruct farmers with irrigation, agriculture, marketing, and credit.

Unfortunately, almost one-half of the farmers surveyed were not aware of the existence of this association, and of those who were, less than one-half regarded the organization as even "somewhat" effective.

One of the most important areas of farmer involvement involves the cleaning and maintenance of F-channels. This responsibility rests with the farmers. Without proper maintenance, the water delivery system is ineffective, in addition, water losses may also increase. During this workshop it was suggested that the extent of farmer participation in maintenance activities was largely a function of land ownership and cultivation category. The farmers surveyed who were cultivating their own land appeared to participate in channel cleaning more often than either a leasee, or a bethma partner. The fully landed farmer may have an investment to protect, compared to a temporary occupant of the land. Although there was generally agreement among all categories of farmers that F-channels should be cleaned at least twice in a season, the majority only performed this activity once a season, if at all. Despite the less than optimal cleaning participation, farmers surveyed expressed a fairly high level of satisfaction concerning channel maintenance.

When women were surveyed concerning their participation in such organizations as turnout groups, Community Development Societies, and attendance at kanna meetings. It was found that 99 percent of the women relied upon their husband to attend and participate in these associations. Even when women-headed households were surveyed, these women reported that they were too busy managing their farm work, in conjunction with performing hired labor, to attend meetings or training activities. In this case they mentioned they would talk with other farmers later to obtain information or dates of water issue. If the turnout groups were actually performing as a problem solving mechanism and responding to farmers involvement, the non-involvement of women may result in reduced benefits for the entire farm family.

E. Institutional Development

The organizational structure of the Mahaweli Authority for the management of the project area is based on three separate levels: the project level, block level, and unit level. The unit level is most directly associated with the farmer and is administered by a Unit Manager. This official is responsible for many development activities; is consequently over worked, and may find it difficult to meet the diversity of demands placed upon him by both the institution and the farmer.

The Unit Manager supervises two Field Assistants (agriculture and irrigation). These assistants act as extension agents, providing technical expertise to the farmers. These officials, although aware of illegal practices and damage done by farmers, felt that they did not have legal support to penalize errant farmers. Although most of the male farmers surveyed were satisfied with the effectiveness and information provided to them; women working in virtually the same field activities responded that they received no information in this manner. If extension is provided only to men, the productivity and efficiency of field work performed by women would be reduced.

The formation of turnout groups has already been mentioned to some extent. The majority of farmers surveyed reported that in most instances there was no proper turnout organization functioning. In addition, the farmers did not perceive the turnout group to be a mechanism for action-oriented problem solving, nor for decision-making by farmer participation.

The newly established Community Development facilities were not well known among farmers as indicated in section D. Farmer involvement. Again, the association appears to be functioning as the last link in a one-way communication process, rather than responding to farmer input. Many of the women surveyed expressed a great interest in attending instructional programs offered by the Community Development section of the project management. The women stated that although they were very interested, it was doubtful that they would be able to attend programs due to time and travel constraints.

Cultivation (kanna) meetings held prior to each season were reported by farmers to be a good source of irrigation news and information. Women surveyed indicated that they do not attend these meetings; but either rely upon their husband for this information, or talk with other farmers.

Another support service offered to the farmer by the Mahaweli Authority is the Marketing Division. This organization assists farmers by arranging buyers; establishing quality standards; setting a guaranteed, fair price; setting up collection centers and transporting from the farm gate; issuing a Goods Received Note (GRN) voucher to the farmer and bank; and assisting with obtaining credit and loan repayment. However, the government marketing services are not widely used by the farmer, as private markets offer particular advantages.

Figures for 1983 Yala were not yet available but 1982-83 Maha figures indicated that 83 percent of the farmers responding had sold their paddy harvest to private traders. There may be hidden costs to government sponsored marketing programs. Higher guaranteed prices may be offset by higher transportation, processing, and personal costs. Unless these government sponsored programs are appropriate for the farmers in this area, and are responsive to farmer participation, their use is limited.

Perhaps a useful role for government marketing programs might be in grain storage. As prices fluctuate throughout the season most farmers are unable to take advantage of price rises. Due to lack of storage facilities, the majority of farmers sell their crop immediately after harvest when prices are lowest. The withholding of a portion of the harvest could not only bring a higher price to the farmer, but may decrease the price fluctuations thus stabilizing prices.

The pilot project involving the private contract marketing of green chilies for export is promising, but no data was yet available. This contracting arrangement may minimize the risk involved with locating a buyer and estimating pricing, while the export aspect could enhance the cash-crop attribute of chili cultivation.

The institutional loan organizations operating from government banks in the area are assisted by the Mahaweli Authority in providing credit to farmers. Inexpensive loan opportunities are available to farmers through goverment loans. However, most farmers surveyed did not take advantage of this program. Through informal conversation with farmers it was evident that when loans were required money was borrowed from relatives, friends, or private traders. However, farmers were reluctant to disclose the actual amounts or interest rates charged. It is not easy to conclude why a farmer might pay as high as 20 to 35 percent in interest to a private trader when government loans were available for 9 percent. However, it is known that due to crop failure farmers have defaulted on previous government loans; making them ineligible for additional loans until repayment in cash is made. This may be the major reason that farmers are unable to obtain government sponsored loans. Among farmers interviewed, 11 percent had obtained loans from institutional sources for chili production, compared to only 3 percent for paddy production. In fact, calculations indicated that a capital outlay for chili cultivation was double that required for paddy.

The high percentage (55 percent) of farmers interviewed who had defaulted on government loans may also be the reason for the sale of crops to private traders rather than government sponsored marketing agencies. If the farmer sells to a private trader he receives cash, compared to the GRN voucher issued by the Mahaweli Authority. If a farmer has outstanding payments on an institutional loan, the GRN voucher is also sent to the bank where payments are automatically deducted and the balance remitted to the farmer. This may be regarded as a hidden cost, both for using government marketing agencies, and for obtaining institutional loans.

V. SUMMARY OF FINDINGS AND RECOMMENDATIONS

The Diagnostic Analysis Workshop conducted in June-July of 1983 followed two consecutive years of drought in the study area. In the past, institutional policies have been criticized for lacking flexibility in responding to uncertainties of water supply. However, it must be noted that the Mahaweli Authorities made several decisions in order to ensure that the majority of farmers would be able to cultivate a crop for the 1983 Yala season. One such decision led to the implementation of the traditional bethma system of cultivation, as discussed earlier. While this provided a unique opportunity to evaluate the operation of the irrigation and agricultural systems, it may have increased the difficulties normally encountered in a Diagnostic Analysis Workshop. Provided the limitations imposed, the major findings, conclusions and recommendations follow.

A. Conclusions

Measurements and observations indicated that some sections of both D-channels and F-channels were sloping in excess of design specifications, implying problems with the original construction of these channels. Most channels were generally in poor condition due to vegetative growth, sedimentation, and deterioration. Most control structures observed in D-channels were judged to be in satisfactory condition, while most structures located in F-channels were either in poor condition or totally non-functional. At the D-channel level, the system appeared capable of the designed operation, but the variability of measured discharges indicated that this potential was not currently realized. At the farm level, the consistent under-issues measured may have been due to the lack of necessary hydraulic head within the D-channels. These reduced D-channel flows were associated with the bethma system.

As a result of the previously mentioned conditions, the delivery of water to the farmers was subject to problems of inadequacy and unreliability. Men and women interviewed, perceived water problems to be a constraint to crop production. Agronomic observations suggested that unreliable water supply led to heavy weed infestations in paddy, and possibly curtailed further agronomic inputs by farmers. Interviews with farmers and officials indicated that willful damage to control structures and illegal methods to obtain water may be an attempt by farmers to gain some perceived measure of water control. While the maintenance and problems of D-channels are the responsibility of the Mahaweli Authority, and may be dependent upon allocation of funds, the maintenance of the F-channel has been designated the responsibility of the farmers. A previous workshop noted the lack of regular F-channel maintenance by the farmer, but the bethma system may have aggrevated this problem for the 1983 Yala season. Based on interviews with farmers, it was concluded that the betma partners' lack of long-term commitment decreased the already inadequate channel maintenance.

Measurements of farm fields revealed that although paddy fields were within acceptable ranges levelness, most upland crop fields were found to be poorly leveled. This discrepancy was likely due to the differences in land preparation practices for the two crops, including the seasonal labor scarcity at this time. When farmers were interviewed concerning water management practices, the majority of responses suggested that over-irrigation of upland crops may be occurring due to unlevel fields. In addition, the lack of detailed soils information for the study area made specific cropping recommendations tenuous. It was observed that previous soil classification was based on limited information while oversimplified drainage characteristics of these soils. During the Yala season, non-paddy crops were recommended for soils in the upper reaches of the irrigation system. In actuality, many of these soils were poorly drained and require special management practices. The combination of over-irrigation, seepage from D-channels, and inadequate drainage resulted in widespread elevation of water tables in the study area. The effect of poor drainage was evident when rooting depths of chilies were examined. Poor drainage may also have led to the salinity problems observed in the lower reaches of the irrigation system, where some allotments had been abandoned.

The problem of equitable and reliable water supply not only includes the irrigated crop production system but must be considered for the domestic water supply if the total well-being of the farm family is intended. Observations and interviews indicated that although community wells were provided by the Mahaweli Authority, most families had constructed wells on their own homestead. This was not only for convenience, but for water quality, as many of the community wells contained leachate from concrete linings. Women interviewed reported that the unreliability of their homestead wells during Yala was a problem, and affected the productivity of home gardens. The intensity of the problem was directly correlated to the relative position of the homestead within the irrigation system. Women from the head of the irrigation system reported fewer domestic water problems, and greater productivity of home gardens, than women located at the tail of the irrigation system.

While the physical resources such as land and water are provided by the Mahaweli Authority, the farm family is the necessary catalyst needed to transform these resources into marketable products. The contribution of labor, knowledge, capital, and management skills of the farm family largely determine the success or failure of the development project. Farm interviews revealed seasonal labor shortages, especially in the cultivation of upland crops such as chilies, which require much greater labor investment than paddy. The use of broadcast seeding for paddy during Yala season, over the transplanting method, was further evidence of a response to labor shortages. Surveys of farm women indicated that the majority assisted in major activities associated with all stages of crop production, with increased field work resulting from resettlement.

Capital and credit are essential inputs for farmers, especially chili cultivators. Surveys indicated that many farmers had defaulted on past government loans, primarily due to crop failure because of drought, making them ineligible for continued low interest institutional loans. Through informal discussions it was learned that many farmers borrowed considerable amounts from relatives, friends, or private traders.

When surveyed, many farmers reported that they preferred to use private marketing mechanisms rather than deal with government sponsored programs. A number of factors may influence the farmer in this decision including a variety of hidden costs. A contract marketing pilot project for green chilies was implemented by the Mahaweli Authority for the 1983 Yala season. Although information concerning its success was not yet available it appeared to be a promising venture. At the time of the workshop, a limited number of excellent soybean fields were observed. The Mahaweli Authority is encouraging the cultivation of soybeans, and was in the last construction stages of a soybean seed cake processing plant adjacent to the study area. Efforts such as these should stimulate crop diversification and provide new economic opportunities for farmers.

The knowledge and management skills of the farmers were evaluated both through observations and interviews. While most of the male farmers expressed satisfaction with the extension services, women involved in agricultural activities reported virtually no contact with field assistants. Women did, however, express great interest in learning about water management and agricultural production. Although male farmers perceived the extension service to be satisfactory, observations suggested that many of the cultural practices recommended by the Mahaweli Authority were not adopted by farmers. Through discussions it was revealed that many farmers relied upon private traders for agricultural and market information.

The Mahaweli Authority has established a variety of organizations to train, inform, and assist farm families. When surveyed, many farmers were unaware of organizations and programs such as the Community Development Centers. Many women expressed interest in these programs, but reported that it was doubtful they would participate due to travel and time constraints. Although turnout groups were evident, the lack of effective farmer participation was obvious. Poor F-channel maintenance, the absence of a rotation schedule for irrigation, and the illegal and destructive methods used for obtaining water indicated that the turnout groups were not functioning as intended. When interviewed, farmers expressed the opinion that turnout groups were used by project management to communicate to farmers, rather than as a participatory, problem solving organization.

As a resettlement area, it would be anticipated that a great deal of stress and anxiety would accompany the early stages of settlement development. However, with time, farm families would be expected to become more stable, and stress and anxiety should decrease. Most of the settlers in the study area had been cultivating their allotments for approximately ten to twelve seasons. Both men and women were interviewed concerning community satisfaction after resettlement and visualization of future well-being. Overall, most men and women expressed a generally high level of satisfaction with the community and the resettlement experience. Various reasons, specifically land ownership, were cited for satisfaction. Among women, significant differences in satisfaction existed between women from different locations within the irrigation system. The majority of both men and women also appeared to be optimistic concerning their future in the resettlement study area.

B. Recommendations

Based on the limited field study, conducted as part of the training workshop, a number of recommendations were made. While a few recommendations are specific, the majority are general with more detailed investigation needed. It must be realized, however, that no single recommendation is a solution, but must be considered in the context of other recommendations. Especially important is the need to inter-relate physical improvements in the irrigation system with social organizations that increase farmer participation.

1. Physical Rehabilitation

(1) Repair or replace structures in D- and F-channels that have been damaged or destroyed.

(2) Construct additional structures and measuring devices at critical points to establish the designed longitudinal slopes and improve water control.

(3) Reconstruct portions of channels that have deteriorated to unacceptable levels.

(4) Return drainage channels to design specifications.

2. Organizational and Extension Needs

(1) Establish functional farmer groups based on water user location at the F-channel level, with the following responsibilities:

(a) to improve the physical condition of channels,

(b) to implement a continued, regular schedule of maintenance,

(c) to establish and adhere to a rotational system of farm irrigation,

(d) to develop some type of incentive and penalty system for the enforcement of the above responsibilities,

(e) to involve women working in agricultural activities, and

(f) to communicate problems to irrigation officials and work with officials in solving problems.

(2) Provide additional extension information to farmers regarding the relationships between irrigation and watertable elevation.

(3) Increase the number of women field assistants to specifically provide extension to women involved in agricultural activities.

(4) Develop a mobile demonstration unit to bring Community Development Center Programs to families with time and travel constraints.

3. Research Considerations

(1) More detailed soil surveys are needed to determine the physical and chemical limitations of soils; such as drainage characteristics, subsurface materials, and salinity.

(2) Farmer managed research trials may provide a mechanism for testing new management practices and disseminating information regarding water management and agricultural practices.

(3) Further, more detailed evaluation of the domestic water system for reliability and adequacy is necessary.

(4) Development of methods to ease seasonal labor constraints, by increasing labor productivity, are needed.

(5) The development of a system of farm record keeping in order to identify: specific on-farm inputs and expenses, sources of supplementary family income, and income distributions.

(6) Further efforts and support are required to stimulate crop diversity; such as the green chili pilot project, and the construction of a soybean processing plant.

(7) A more detailed investigation of the real value of capital and credit in the production process is necessary if institutional programs are to be relevant to farmer needs.

VI. APPENDICES

A. Agronomy

1. Introduction

System H of the Mahaweli Project is located in the low country dry zone approximately 125 m above sea level. Rainfall in this region is quite variable with an average yearly rainfall ranging from 500-1,800 mm. Approximately two-thirds of the annual rainfall occurs during the monsoon months of September through December. The major paddy cultivation season of the dry zone, *Maha*, coincides with this high rainfall period. The monsoon rains are followed by a period of low rainfall beginning in January and extending through early March. A second rainy period from mid-March through early May coincides with the start of *Yala* cropping season. The major dry season of the year occurs during *Yala*, beginning in late May and extending into early September. *Yala* season crops include paddy, chili, soybean, cowpea, bombay onion and sesame.

The Kalawewa Reservoir and its four regulating reservoirs were designed to provide supplemental irrigation during *Maha* season and full-season irrigation during *Yala*. With the exception of a severe drought in 1981-82, the Mahaweli Authority has been relatively successful in its efforts to provide supplemental irrigation to the project area during the *Maha* season. The provision of full-season irrigation during the *Yala* season, however, has been less than satisfactory.

A number of factors affect the ability of these major reservoirs to meet irrigation demands during *Yala*. The first involves the actual storage capacity of the reservoirs. The storage capacities of these reservoirs are well below the amount of water needed for *Yala* irrigations. Therefore, they are dependent upon continuous, successive diversions from the Mahaweli Ganga. These scheduled diversions have been neither uniform nor easy to predict due to climatic factors in the watershed area. The fluctuations in flow of the Mahaweli Ganga are not possible to regulate at this time, as structures for this purpose are lacking. However, a regulating reservoir (Kotmale) is presently under construction and should provide a more predictable, consistent supply of water for the System H area.

Another factor responsible for the inadequate irrigation supply during *Yala* relates to the actual amount of water issued from the reservoirs. According to operational plans, a total of 1.4 ha-m was designated to be issued during *Yala*. In actuality, the total amount of water issued for *Yala* often exceeds 1.8 ha-m. Past studies (Alwis, et al., 1983) suggest that this amount of water is in excess of actual irrigation requirements, and much of the surplus is lost through poor on-farm water management practices. Basically, as a result of these problems, the Mahaweli Authority has been unable to meet full-season irrigation requirements during *Yala* for the System H area.

In past *Yala* seasons, the above mentioned problems were intensified by poor management decisions regarding area to be cropped, cropping patterns, and date of first water issue. For example, in some *Yala* seasons, cropping areas were not reduced, unsuitable cropping patterns were recommended, and first water issue schedules were not decided and implemented on a timely basis. As a result of these management decisions, farmers experienced crop losses and lower yields resulting in financial hardships. Consequently, these farmers may have lost confidence in the ability of the Mahaweli Authority to supply equitable, reliable, and adequate water to meet their needs during *Yala*. Studies conducted during the 1982 *Yala* season suggested that when farmers perceived a high risk situation, inputs such as agrochemicals, fertilizer, and labor were reduced.

The climatic data presented in Table A-1 was collected from the Maha Illuppalama Research Station, which is located approximately 8 km from the study site. Rainfall during the 1982-83 *Maha* was above normal in the System H area and although rainfall was unusually low in the catchment areas, sufficient water was available to provide supplemental irrigation throughout the cropping season. Consequently, farmers in System H produced record paddy yields. Average *Maha* paddy yields in the System H area were reported to be above 4,900 kg per ha.

The abnormally dry weather in the catchment areas of the Mahaweli Project persisted throughout the 1983 *Yala*. The effects of this drought on diversions to the Kalawewa reservoir were accurately predicted by the Water Management Panel. Decisions regarding area to be cultivated, cropping patterns and the first water issues were made by this panel. These decisions included: restricting the area commanded by the irrigation system to the left bank canal, only providing irrigation water to certain D-channels or portions of D-channels, and requesting farmers to confine paddy cultivation to the middle and lower reaches of turnouts. In addition, the Mahaweli Authority imposed a traditional *bethma*, as described earlier in this report, on the areas commanded by the irrigation system. It appeared from observations and informal conversations with farmers that these management decisions were successful in alleviating many of the problems associated with past *Yala* seasons.

Table A-1. Meteorological Data From the Maha-Illupallama Research Station for the 1982-1983 Cropping Seasons

Year	Month	Rainfall (mm)	Temperature C Max	Temperature C Min	Total Monthly Evaporation (mm)	Average Daily Evaporation (mm)
Maha 1982	Jan	0.1	30.5	19.7	128.6	4.1
	Feb	0.0	33.2	19.2	164.2	6.1
Yala 1982	Mar	97.4	35.0	22.0	170.9	5.9
	Apr	114.8	34.5	24.2	158.8	5.3
	May	162.9	33.1	24.0	149.7	4.8
	Jun	17.3	31.5	24.8	129.4	4.3
	Jul	1.4	33.0	24.6	171.7	5.5
	Aug	4.7	34.0	24.6	88.9	5.6
Maha 1982/83	Sep	42.0	34.3	24.7	185.3	6.0
	Oct	265.5	32.3	23.1	143.4	4.6
	Nov	243.3	30.1	22.8	102.4	3.1
	Dec	145.9	28.4	21.6	74.9	2.6
	Jan	5.7	30.1	20.4	109.5	3.5
	Feb	0.0	34.0	21.0	139.5	5.0
Yala 1983	Mar	0.0	36.7	22.3	195.5	6.3
	Apr	74.3	37.3	24.8	176.0	5.9
	May	219.4	34.0	23.1	185.2	6.0
	Jun	21.0	33.6	25.3	168.8	5.6
	Jul	27.0	32.5	24.8	193.7	6.2
	Aug	--	--	--	--	--

2. Soils

Two major soil types, the reddish brown earths (RBE) and low humic gleys (LHG), have been described in the System H area. The reddish brown earths are the most common soils occupying approximately 60 percent of the project area. These soils were largely formed in place and are predominantly found on the knolls and upper to middle slopes of the rolling topography. The reddish brown earths are good agricultural soils except in steep topography. Water erosion and soil moisture shortage due to inadequate rainfall are the main problems.

The low humic gleys occupy approximately 35 percent of the project area. These soils are primarily alluvial and are found in the lower slopes and valleys. The low humic gleys are good agricultural soils, but they are susceptible to waterlogging and salinity due to their topographical location.

Before the Mahaweli Project was established an attempt was made to define a set of land use classes which would be relevant to irrigated crop production. Two relatively simple classes of land use, primarily based on drainage characteristics, were defined and cropping patterns for each class were established. The two classes of land use and their recommended cropping pattern were:

(1) Well drained reddish brown earths located on the upper and middle slopes to be planted with irrigated upland crops such as chili, soybean, and vegetables during Yala and upland paddy during Maha; and

(2) Poorly drained low humic gleys of the lower slopes and valleys to be planted with lowland paddy during Yala and Maha.

However, when the irrigation system became operational, water tables rose throughout System H. The high water tables were particularly devastating to irrigated upland crops located in the middle slopes of the command areas. This problem was resolved by dividing the reddish brown earth soils into two land use classes. The first land use class remained essentially the same. Only soils of the middle slopes were excluded from the first land use class. These soils were redefined in the newer land use class as imperfectly drained reddish brown earths. Cropping patterns recommended for this class were other field crops in Yala and paddy in Maha.

Although land use classes are of general use, there is a tendency for project officers to regard them as inclusive. There are, however, a number of site specific factors which have a pronounced affect on crop selection, irrigation, and other management practices used to obtain maximum crop yields. Some of these factors were identified during detailed studies and are described in subsequent sections dealing with soil physical properties, soil chemical properties, water tables and water quality.

a. Soil Physical Properties

Soil physical properties which affect irrigated cropping systems include soil tilth, depth, and soil texture. Ideally, all of these characteristics should be measured for a complete understanding of soil physical properties. However, due to the limited scope of this study, simplified measurements and visual observations were used to assess soil physical properties.

Visual assessment of the quality of land preparation provided an indirect appraisal of soil tilth. In general, land preparation for irrigated upland crops was much better in the lighter textured soils than in the heavier textured soils. Irrigated upland crops were usually planted in basins. Later raised beds which were constructed by hand with the aid of a mammoty, were built around the plants. Apparently, farmers have little difficulty with the preparation of raised beds in the weakly structured lighter textured soils. However, the higher clay content soils (primarily low humic gleys) in the lower slopes and valleys of the irrigation system are extremely difficult to work. This limitation severely restricts the type of crops which can be grown successfully in the lower reaches of turnouts.

Although direct measurements of soil depth were not included in this study, soil samples to a depth of 90 cm were collected from selected allotments within each turnout. These samples, observations of hand wells, and the general topographical features of the turnouts indicated that for most of the area soil depth is sufficient for most crops. However, rock outcrops were observed in several turnouts. Although soil depths were not measured, soils near these outcrops were obviously shallow.

Observations of soil texture are summarized in Table A-2. In general, the reddish brown earths of the upper and middle slopes were lighter in texture than the low humic gleys of the lower slopes. However, variations in soil texture were quite common, particularly in the middle and lower slopes of the turnouts. More importantly, some turnouts, such as T.2 and T.5 of block 309, have lighter textured soils throughout the turnout. Field officers should be aware of these differences when recommending cropping patterns to farmers.

b. Soil Chemical Properties

Soil chemical properties measured during this study were restricted to pH and electrical conductivity (salt content). Table A-3 summarizes the range of soil pH values obtained from soil samples collected in the upper, middle, and lower reaches of 10 turnouts in System H. Soil pH values ranged from 6.2 to 8.4 in the upper and middle reaches of the turnouts. Similar values ranged from 7.0 to 8.2 in the lower reaches of turnouts. This range of pH values suggests that these soils are favorable for the production of most field crops.

Table A-2. Variations in Soil Texture* with Depth for Allotments Located in the Upper, Middle, and Lower Reaches of Ten Turnouts of System H

Allotment Location	Depth (cm)	3[illegible].1		303/D.2		306/D.1		309/D.3		307/D.3	
		T.7	T.14	T.4	T.14	T.1	T.5	T.2	T.5	T.0	T.15
Upper Allotment	0-15	CL	L	L	CL	SL	SL	SCL	SL	LS	LS
	15-30	CL	L	CL	CL	SCL	SL	SL	SL	SL	LS
	30-60	SC	SC	CL	SL	SC	C	SC	SC	SCL	SCL
	60-90	SC	SC	C	SL	SC	C	SC	SC	SCL	SCL
Middle Allotment	0-15	CL	CL	L	C	SL	C	CL	SC	SL	LS
	15-30	SC	L	C	C	SCL	C	CL	SC	SL	SL
	30-60	SC	L	SC	SC	SC	C	SC	SL	SC	SCL
	60-90	SC	L	C	SC	SC	C	SC	SL	SC	SC
Lower Allotment	0-15	SC	C	SC	C	SCL	C	SL	SL	SC	SL
	15-30	SC	C	SC	SC	SC	C	SL	SC	SCL	SC
	30-60	L	SC	C	SC	SC	C	SCL	SL	SC	SCL
	60-90	L	SC	C	C	SC	C	CL	SC	SC	SC

* Soil Texture:
C = clay
L = loam
CL = clay loam
SC = sandy clay
SL = sandy loam
SCL = sandy clay loam

Table A-3. The Range of Soil pH Values Observed in Upper, Middle, and Lower Reaches of Ten Turnouts in System H

Soil Depth (cm)	Soil pH Range		
	Upper	Middle	Lower
0 - 15	6.2 - 7.6	6.6 - 8.2	7.1 - 8.0
15 - 30	6.4 - 8.0	6.2 - 8.2	7.2 - 8.2
30 - 60	7.0 - 7.6	6.8 - 8.2	7.3 - 8.2
60 - 90	7.0 - 7.9	7.0 - 8.4	7.0 - 8.2

The electrical conductivity of soils from selected allotments located in the upper, middle, and lower reaches of ten turnouts in System H are shown in Table A-4. Electrical conductivity of these soils ranged from 0.5 to 2.0 mmhos/cm, which suggest that the major portion of turnout commands do not have salinity problems.

However, soil samples were also collected from five allotments in which soil related problems were either observed or suggested by the farmer. All of these allotments were located in the lower reaches of the turnouts. One allotment (306/D1/T.1 378) was abandoned by the farmer after two successive crop failures. Electrical conductivity measurement of soil samples from this allotment and two other allotments located in blocks 306 and 307 were greater than 10 mmhos/cm (Table A-5). Economical production of field crops would be nearly impossible with the levels of salinity indicated by these measurements.

Electrical conductivity measurements of samples obtained from two other allotments located in blocks 302 and 303 were within acceptable limits (Table A-5). However, the poor performance of paddy in these two allotments may have resulted from higher salinity levels during the early vegetative period.

c. Water Table

A detailed description of water tables is presented in Appendix B of this report. Therefore, this section will only deal with the implications of high water tables on the current land use classes. In a later section of this report these implications will be expanded to include current cropping practices.

Soils located on the upper reaches of most turnouts are currently identified as well drained reddish brown earths. Due to the introduction of irrigation and other factors, water tables in the area have risen, and the well drained reddish brown earth land use class is no longer applicable.

Visual observations suggested that subsurface drainage in the reddish brown earths may be severely restricted by a relatively shallow layer of bedrock. If this is the case, then management of these soils under irrigation will be much more complex than is implied by the current land use classes. Therefore, detailed soil surveys including soil drainage characteristics should be implemented throughout System H.

Table A-4. Electrical Conductivity Values Obtained From Soil Samples Collected From Allotments Located in the Upper, Middle, and Lower Reaches of Ten Turnouts in System H

Study Site	Upper		Middle		Lower	
	Allot. Number	EC mmhos/cm	Allot. Number	EC mmhos/cm	Allot. Number	EC mmhos/cm
302/D.1/T.7	25	0.6	29	0.8	32	1.0
302/D.1/T.14	108	0.7	106	1.1	104	1.3
303/D.2/T.4	18	0.9	83	0.6	81	1.1
303/D.2/T.14	215	1.0	206	0.3	209	1.2
306/D.1/T.1	375	0.9	376	0.6	377	0.4
306/D.1/T.5	426	0.9	424	1.5	415	2.0
309/D.3/T.2	142	1.2	145	1.0	150	1.2
309/D.3/T.15	220	0.8	224	1.6	229	2.0
307/D.3/T.0	356	0.5	361	0.7	360	0.9
307/D.3.T.15	251	0.5	250	0.6	246	1.3

Table A-5. Electrical Conductivity Values Obtained From Soil Samples Collected From Allotments with Obvious Soil Problems on System H

Allotment Location	EC mmhos/cm
302/D.1/T.14 102	2.0
303/D.2/T.14 209	1.8
306/D.1/T.1 378*	15.0
306/D.1/T.1 387	14.8
307/D.3/T.15 258	>10.0

* Field abandoned

d. Water Quality

The results of water quality measurements are summarized in Table A-6. Electrical conductivity measurements of irrigation water, which ranged from 300 to 480 umhos/cm, were well within the limits set for low-salinity hazard water. Similar measurements of drainage water ranged from 510 to 900 umhos (Table A-6). The salinity hazard of drainage water was slightly higher than of irrigation water. However, illegal use of drainage water by a few farmers in the lowest reaches of some turnouts probably has little long-term affects.

Salinity measurements of groundwater in the lowest reaches of turnouts ranged from 430 to 1,450 umhos/cm (Table A-6). Groundwater samples from five of the turnouts were indicative of soil salinity problems discussed earlier.

3. Crops

Crop recommendations for *Yala* are based on the previously discussed land use classes. These recommendations restrict irrigated upland crops to the upper reaches of most turnouts and paddy to the middle and lower reaches of most turnouts. Recommended *Yala* irrigated upland crops include chili, soybean, gram, cowpeas, and vegetables.

Table A-6. Electrical Conductivity Values for Irrigation Water, Drainage Water, and Groundwater Samples Obtained From Ten Turnouts of System H

Location		Electrical Conductivity umhos/cm		
		Irrigation Water	Drainage Water	Groundwater
302/D.1	T.1	420	475	630
	T.14	480	625	1,100
303/D.2	T.4	375	510	1,450
	T.14	377	825	750
306/D.1	T.1	-	-	-
	T.5	-	-	-
309/D.3	T.2	-	900	860
	T.5			
307/D.3	T.0	425	530	925
	T.15	300	558	430

a. Cropping Patterns

Actual cropping patterns observed in the 10 turnouts are shown in Figures A-1 through A-10. Although the heaviest concentration of irrigated upland crops occurred in the upper reaches of most turnouts, these crops were also observed in the middle and lower reaches of most turnouts. Similarly, paddy was primarily cultivated in the middle and lower reaches of most turnouts with varying areas in the upper reaches planted with paddy. Interestingly, three turnouts were almost exclusively planted with paddy (Figures 6, 9, and 10). The observed cropping patterns indicated that farmers in System H did not follow the recommended Yala cropping patterns.

The cultivable area, area planted with specific crops, area left fallow, and the cropping intensities of each of the 10 turnouts are summarized in Table A-7. The total cultivable area of the 10 turnouts was approximately 141 ha. The overall cropping intensity for this area averaged approximately 88 percent; ranging from a low of approximately 54 percent in T.2 of block 309, to a high of 100 percent in T.14 of block 303. Low cropping intensities in block 309 were due to deficiencies in the field channels. Allotments or portions of allotments were left fallow in other turnouts primarily because of salinity problems and early season crop failures.

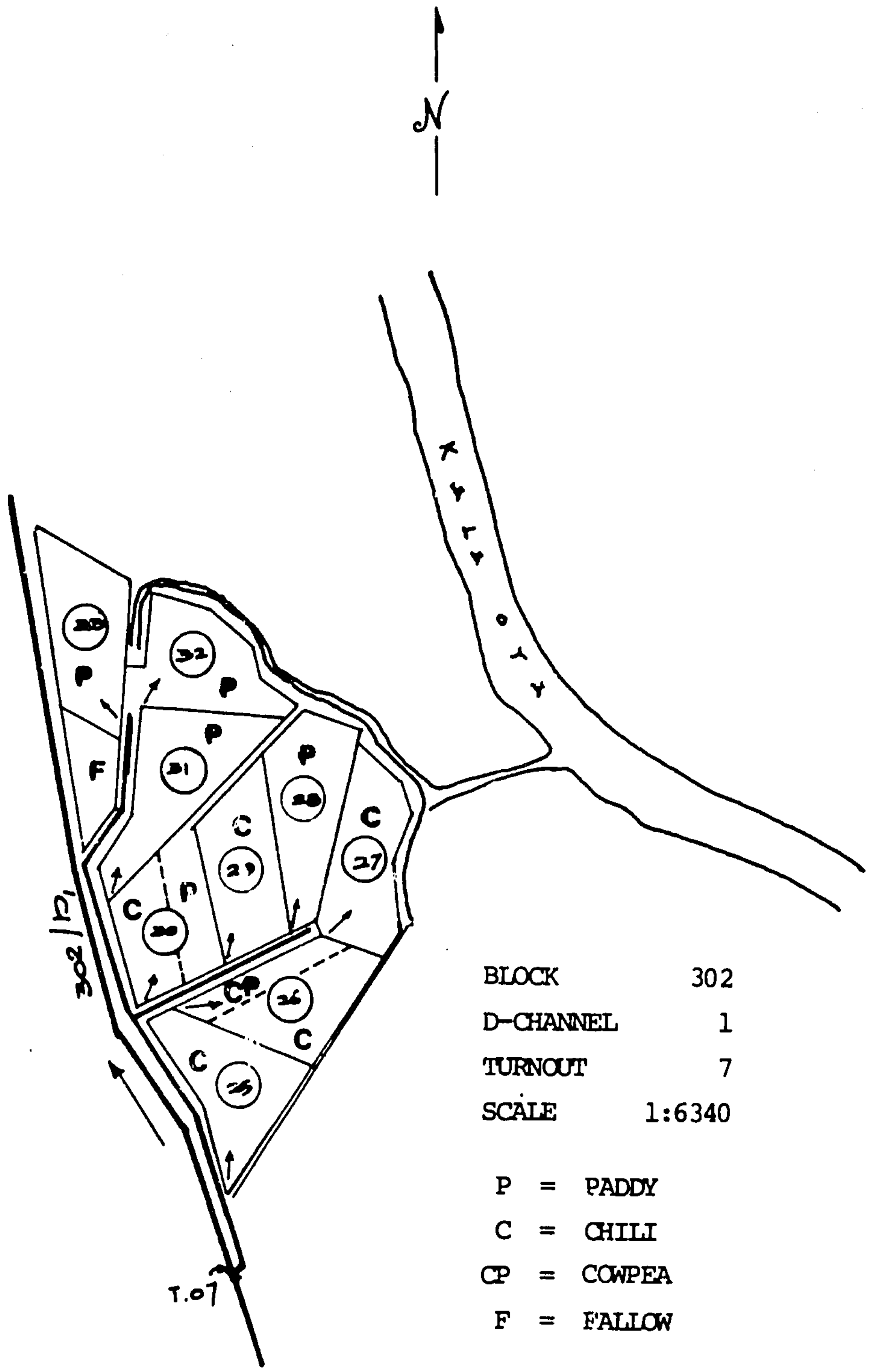


Figure A-1. 1983 Yala Cropping Patterns in Block 302/D.1/T.7

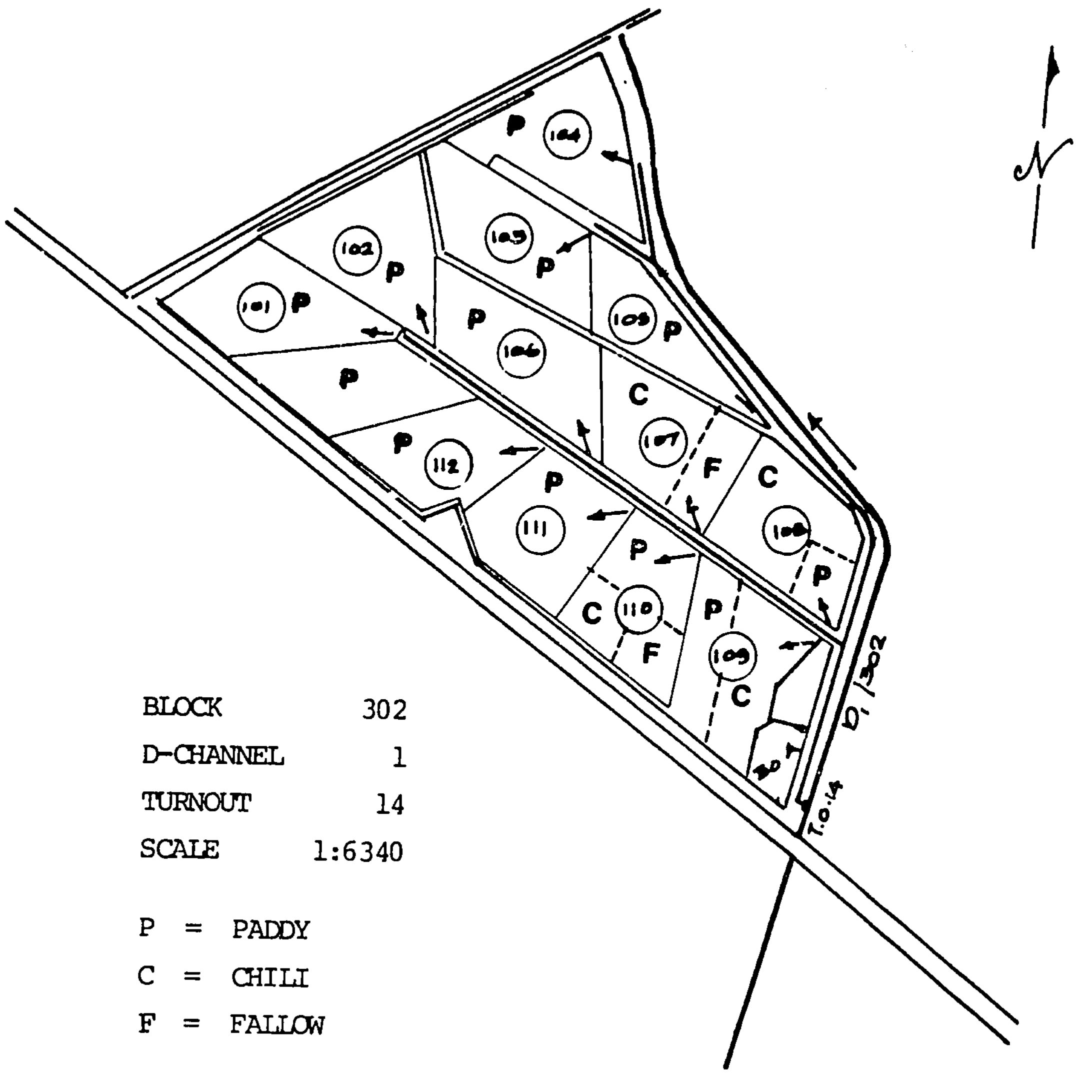


Figure A-2. 1983 <u>Yala</u> Cropping Patterns in Block 302/D.1/T.14

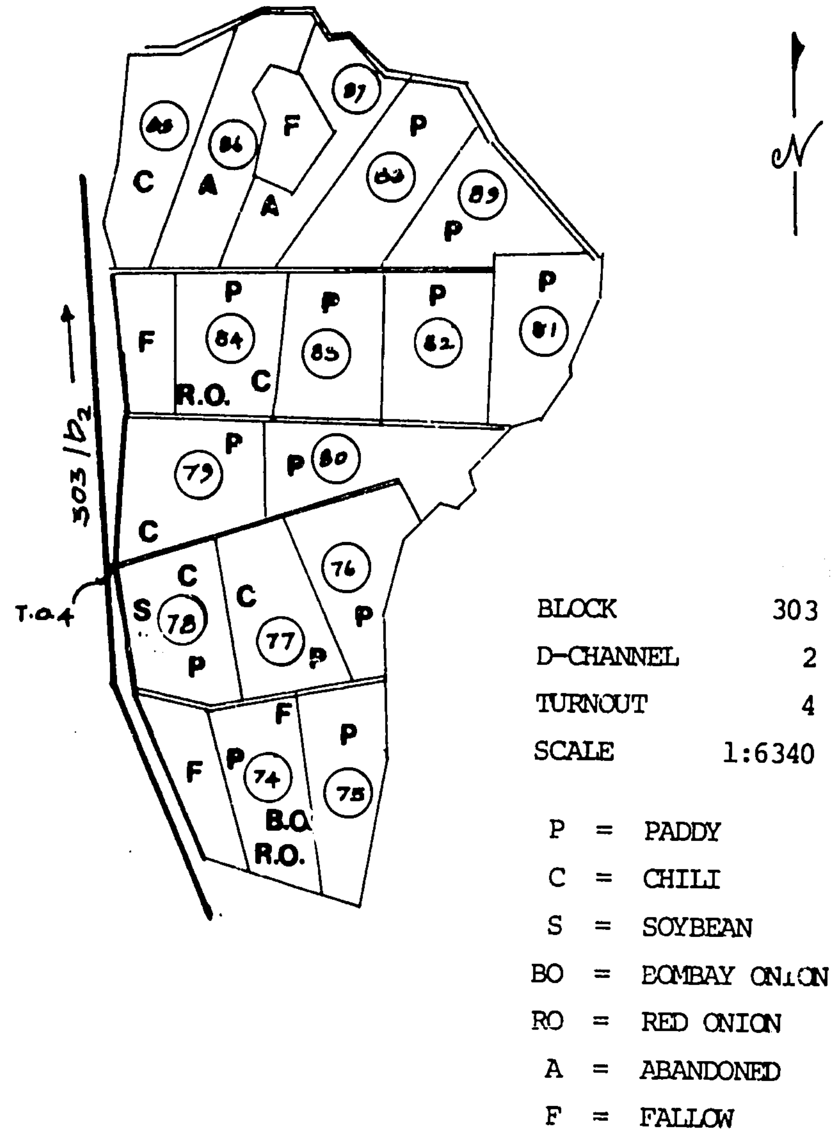
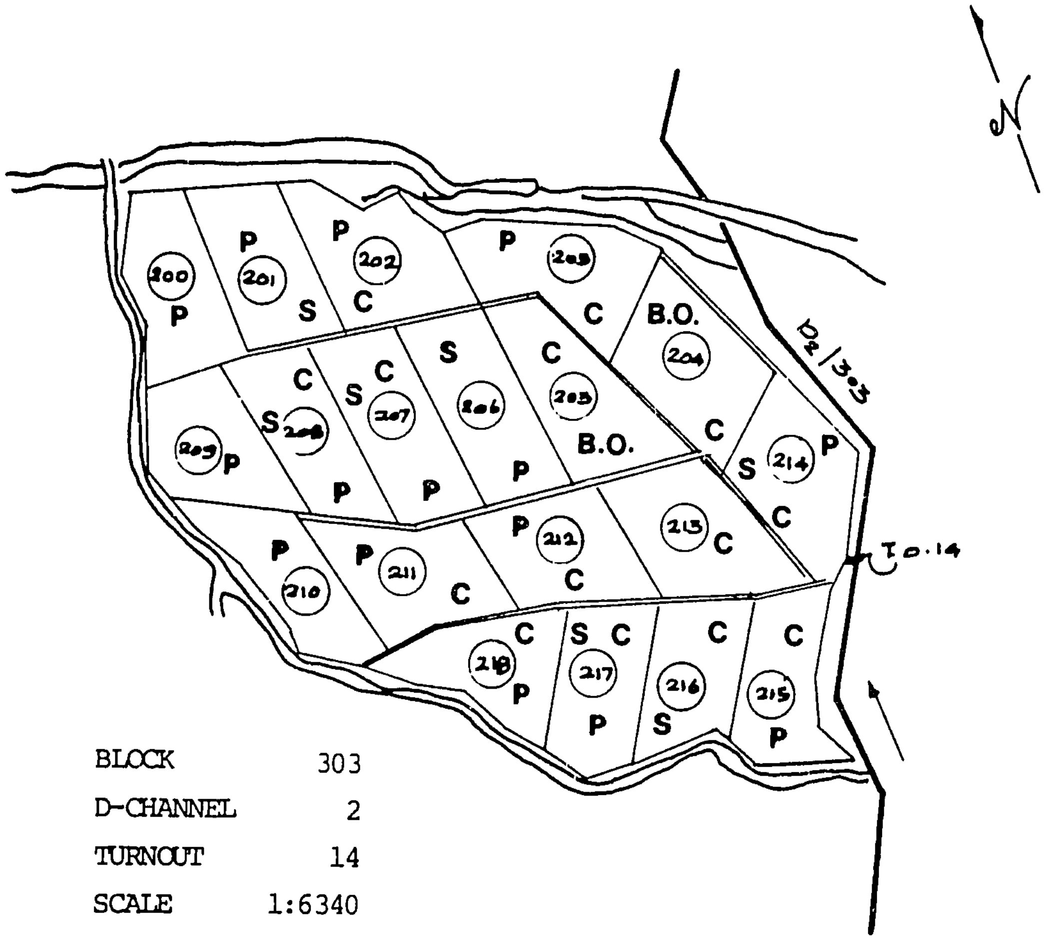


Figure A-3. 1983 *Yala* Cropping Patterns in Block 303/D.2/T.4



BLOCK	303
D-CHANNEL	2
TURNOUT	14
SCALE	1:6340

P = PADDY

C = CHILI

S = SOYBEAN

BO = BOMBAY ONION

Figure A-4. 1983 Yala Cropping Patterns in Block 303/D.2/T.14

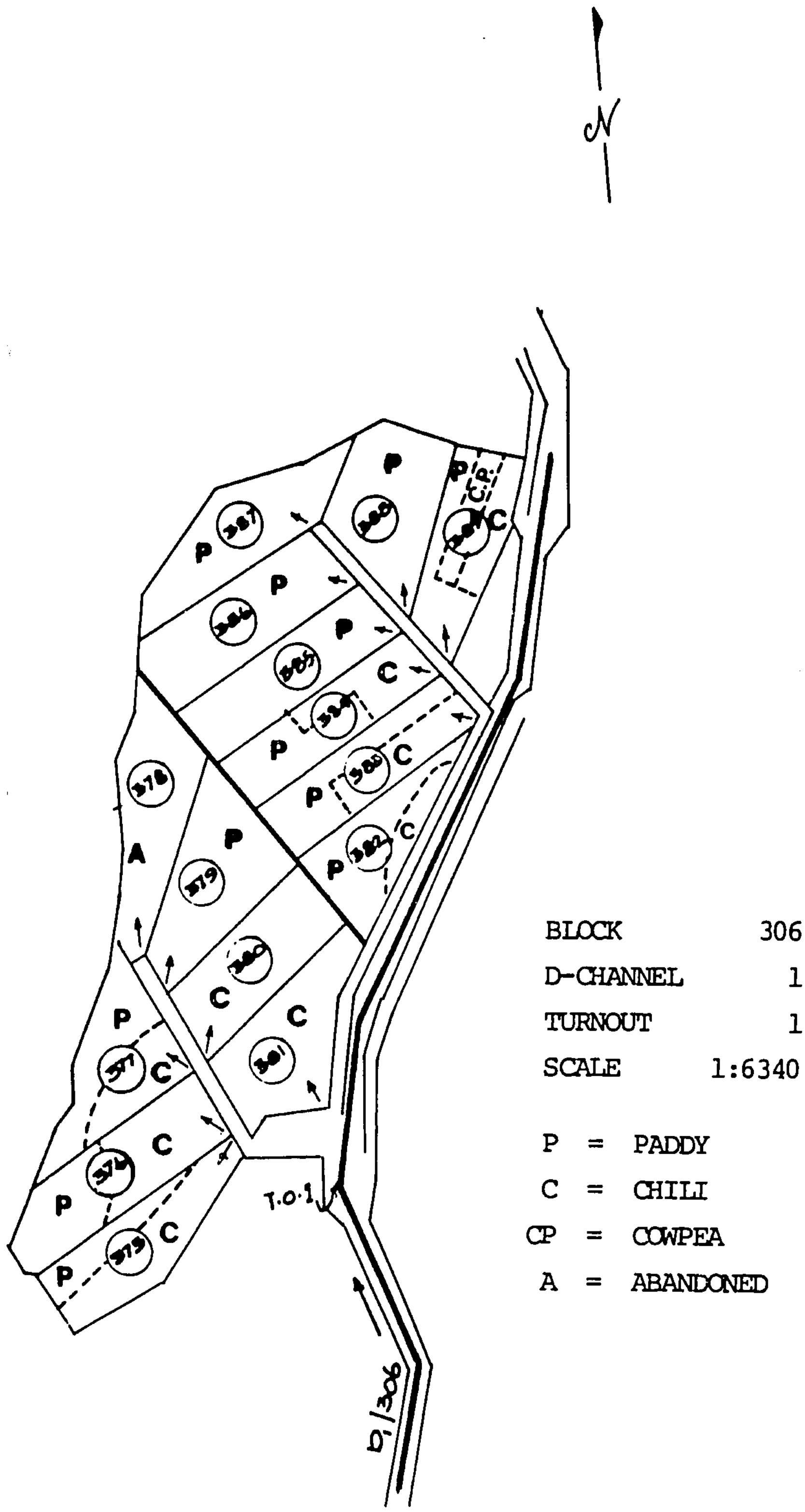


Figure A-5. 1983 Yala Cropping Patterns in Block 306/D.1/T.1

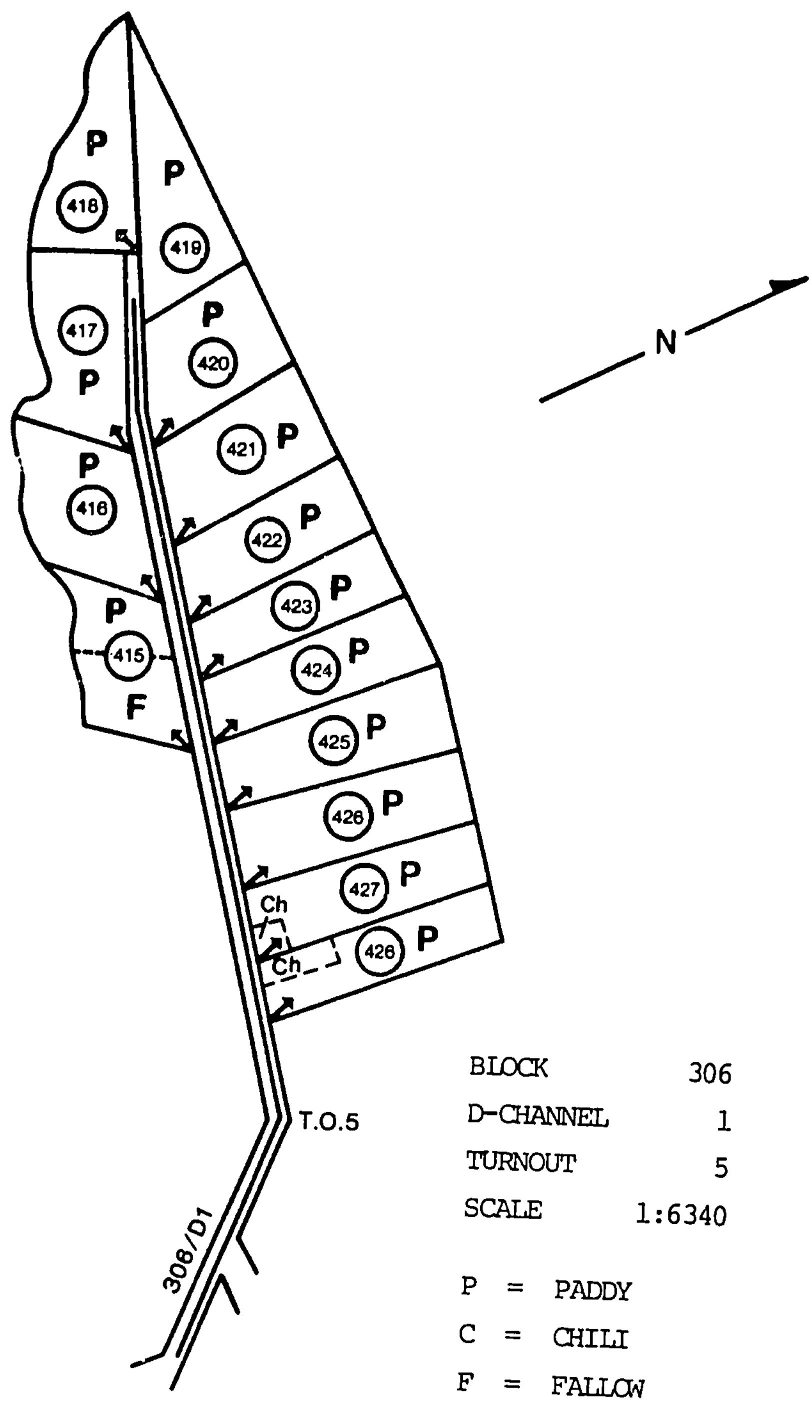


Figure A-6. 1983 Yala Cropping Patterns in Block 306/D.1/T.5

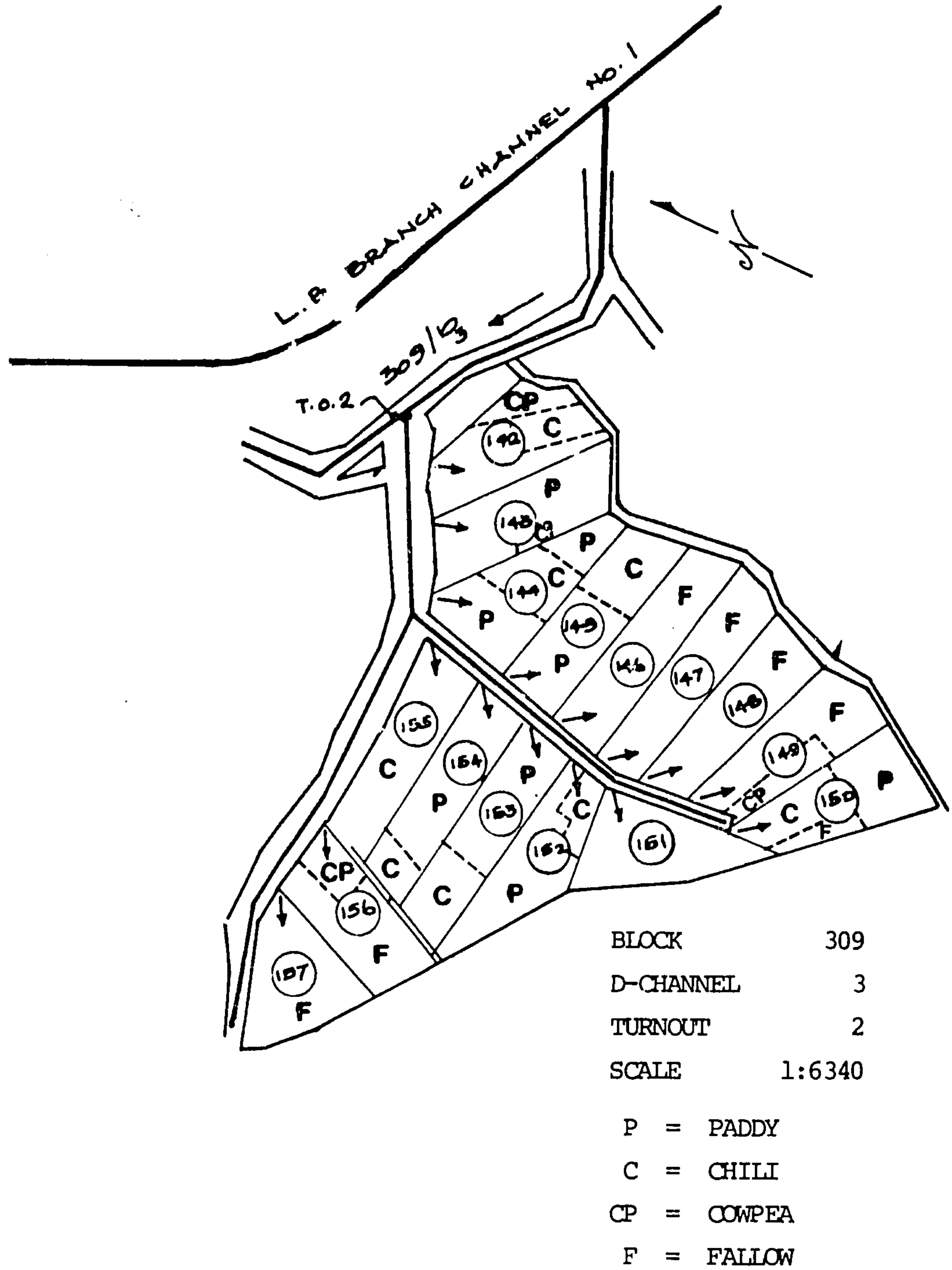


Figure A-7. 1983 <u>Yala</u> Cropping Patterns in Block 309/D.3/T.2

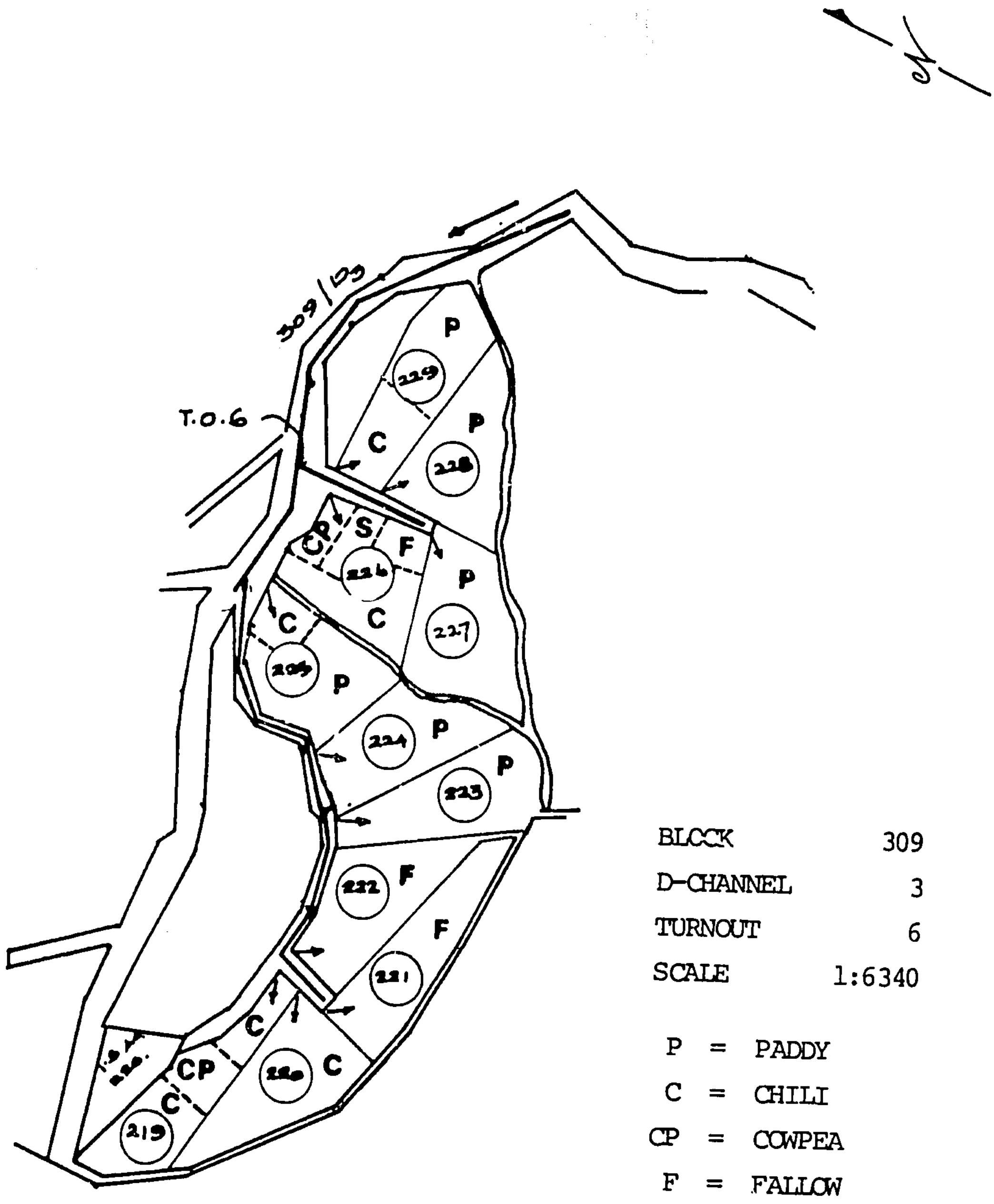


Figure A-8. 1983 *Yala* Cropping Patterns in Block 309/D.3/T.6

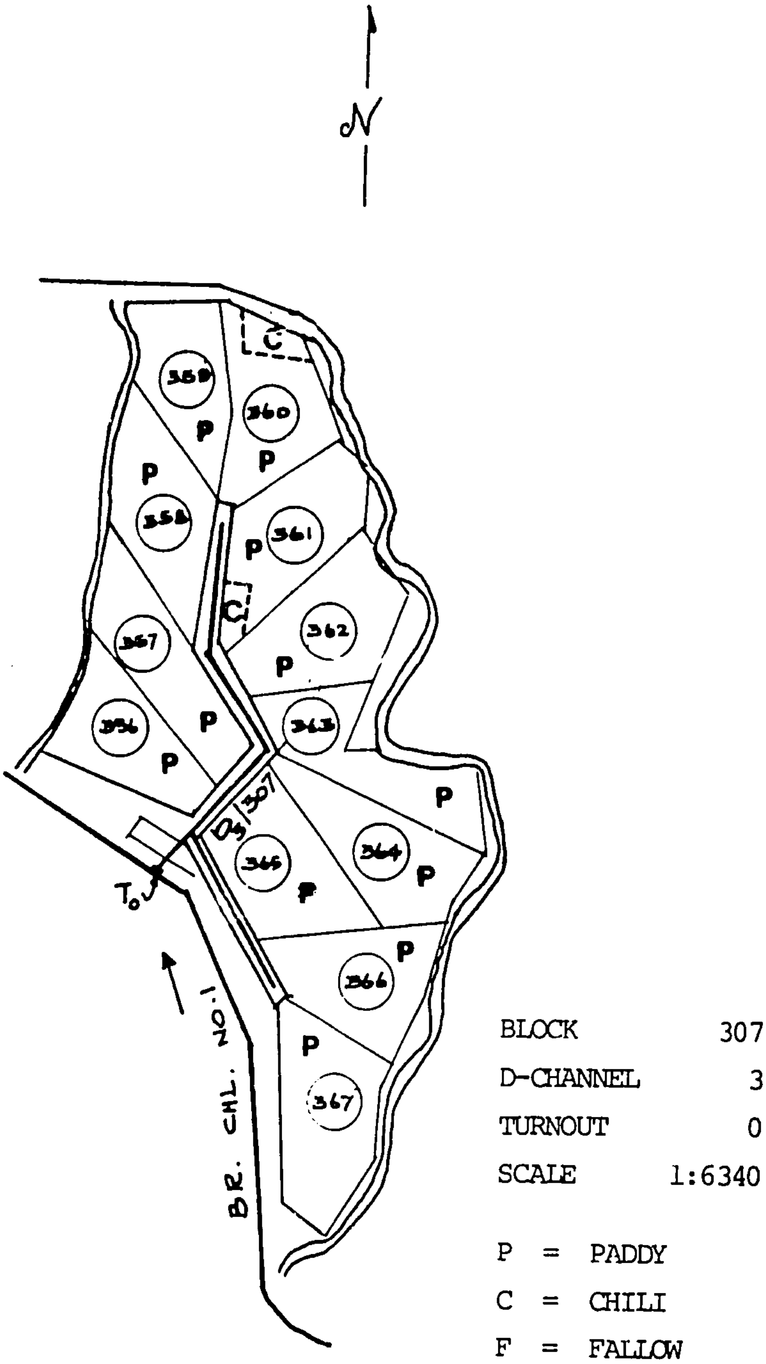


Figure A-9. 1983 Yala Cropping Patterns in Block 307/D.3/T.0

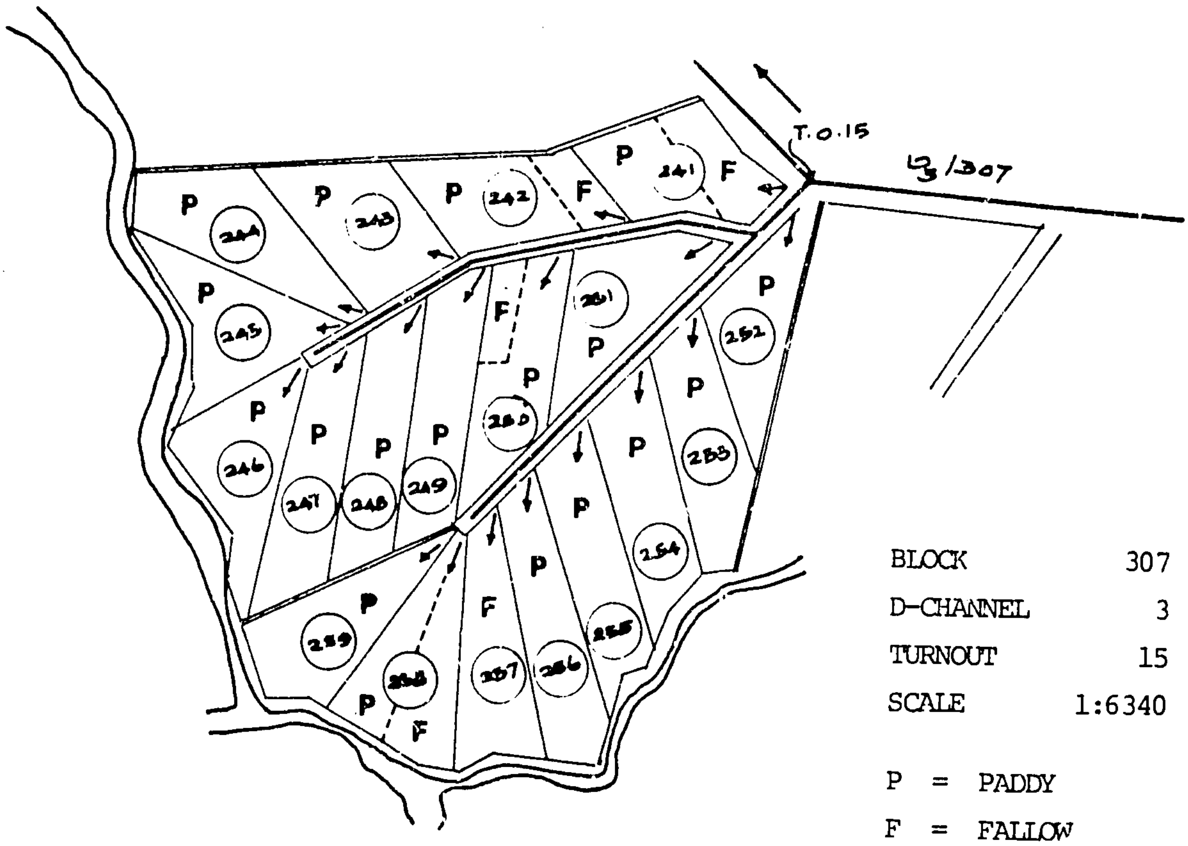


Figure A-10. 1983 Yala Cropping Patterns in Block 307/D.3/T.15

Table A-7. Cultivable Area, Area Cultivated with Different Crops, Area Left Fallow, and the Cropping Intensities of Ten Turnouts in System H

Turnout Location	Total Cultivated Area (ha)	Area Cultivated (ha)						Cropping Intensity Percentage
		Paddy	Chilies	Cowpea	Soybean	Vegetables	Fallow	
302/D1/T7	9	4	4.7	0.04	--	--	0.26	97.1%
302/D1/T14	12	8.97	2.08	--	--	--	0.50	92.1%
303/D2/T4	14	11.61	1.31	--	0.10	0.20	0.78	94.4%
303/D2/T14	19	8.09	8.4	--	2.12	0.60	--	100 %
306/D1/T1	15	7.38	4.7	--	0.40	0.20	2.47	84.5%
306/D1/T5	14	13.51	0.14	--	--	--	0.50	97.5%
309/D3/T2	16	5.72	2.51	0.35	--	--	7.59	53.6%
309/D3/T6	11	5.51	2.42	0.10	--	0.10	2.98	73.9%
307/D3/T0	12	11.07	0.60	--	--	--	0.33	97.2%
307/D3/T15	19	16.59	--	--	--	--	2.41	87.3%
Total	141	92.45	26.86	.49	2.6	1.1	17.82	--
Percent of the total cultivable area	100%	65.6	19.0	<.1	1.8	0.8	12.6	87.8%

Irrigated crops observed in the 10 turnouts included paddy, chili, soybean, cowpea, and vegetables. Of these, paddy occupied approximately 66 percent of the cultivable area of the 10 turnouts. Within turnouts the area planted in paddy ranged from 44 to 100 percent. The next most abundant crop was chili. Chili was cultivated on approximately 19 percent of the total area of the 10 turnouts and ranged from 0 to 52 percent of the cultivable area within turnouts. Other crops such as cowpea, soybean and vegetables occupied less than 3 percent of the total command areas of the 10 turnouts.

b. Crop Management

Observations of the farmer management practices were limited by the brevity of the study period. Consequently, these investigations were primarily based on qualitative observations of crop performance. However, two management practices of the farmer, weed control in paddy and water management practices in chili, were identified as major problems during the reconnaissance survey and studied in greater detail during the workshop.

Because paddy is primarily broadcast sown during Yala, few farmers practice hand weeding. Instead they usually rely on standing water and/or the application of herbicides. Weed control in paddy, however, was highly ineffective in all of the turnouts studied. Paddy weed populations in sampled turnouts ranged from 67 to more than 1,000 weeds per square meter and averaged over 350 weeds per square meter for all of the fields surveyed.

The control of weeds with standing water is an effective practice provided there is sufficient water, and seepage and deep percolation losses are low. Field observations and conversations with farmers suggest that these conditions do not exist in System H. This was most apparent in block 307 (Table A-8)) where farmers claimed that excessive weed infestations were caused by inadequate irrigation water during the early vegetative period. However paddy weed infestations in other turnouts with more dependable water supplies were nearly as serious as those observed in 307 (Table A-8). In any event, proper weed control should be possible with the herbicides available to the farmer. The fact that farmers are unable to control weeds with the available herbicides suggests a lack of knowledge. To determine this, however, would require a longer investigative period than was permitted in the workshop format.

Other less quantifiable observations of paddy fields included land preparation, seed source and fertility levels. Field observations suggested that most fields received adequate land preparation prior to broadcasting paddy. However, it was difficult to evaluate land preparation in fields nearly ready for harvest.

Table A-8. Average Tillers/m^2, and Weeds/m^2 in Paddy Fields Located in the Upper Reaches (302/D1) and Lower Reaches (307/D3) of the Irrigation System in System H

Average Values	Allotment Location									
	T.7		T.14		T.0			T.15		
	25	32	16	104	356	361	360	251	250	246
Tillers/m^2	220	281	260	256	367	366	160	350	468	351
Weeds/m^2	330	242	220	183	412	212	415	314	286	578

Almost all of the fields surveyed were planted with high yielding rice varieties (B6-34-8 and B6-276-S). However, plant height variations and other morphologic characteristics suggested that many farmers rely on their own seed rather than purchasing new seed from the Mahaweli Authority.

Fertility levels of paddy were difficult to determine as most paddy fields were at or near maturity. However, nitrogen deficiency symptoms were observed in most fields. Nitrogen deficiency symptoms were most apparent in block 307. Farmers in this block held back further fertilizer applications after the previously discussed weed infestations developed.

Pest and disease infestations were minimal. Apparently insect infestations are usually low during Yala and most disease problems have been minimized with the use of improved high yielding rice varieties.

Potential paddy yields for the 1983 Yala season were much lower than the average paddy yields obtained during the previous Maha. Estimates of potential paddy yields in ten allotments in blocks 302 and 303 ranged from 1100 kg per ha to 4700 kg/ha and averaged 3300 kg/ha. The low potential yields of paddy were indicative of lower levels of management. Although conclusive data is lacking, it appears that farmers decreased inputs to rice because of unreliable water supplies and/or the fear of unreliable water.

Chili is one of the most profitable Yala crops grown in System H. Net incomes from chili are often 10 to 15 times those obtained from Yala paddy. However, the area suitable for chili cultivation is limited by elevated water tables. In addition chili cultivation may be further limited by labor and capital investment cost, which are 4 to 5 times those of Yala paddy. Because of the above limitations, only 19 percent of the cultivable area of the 10 turnouts was planted with chili.

Agronomic observations indicated that farmers were more willing to invest capital and labor resources in chili than paddy during Yala. Indeed, limited observations in some turnouts suggested that farmers tended to invest more energy and capital on insect control than really necessary.

Because of the greater emphasis on crop management, chili crops were generally observed to be free of serious weed and pest infestations. In addition, fertility levels appeared to be sufficient in most chili plots. However, concern was expressed about the application of fertilizers at appropriate growth stages.

Although the above management practices were near optimal, most farmers appeared to be unaware of the problems associated with the irrigation of chilies in soils with inherently poor internal drainage characteristics. This lack of understanding was quite apparent when plant height, rooting depth and water table depth were compared in chili plots located in the upper, middle and lower reaches of 306/D.1/T.1 (Table A-9). Minimum depth to water tables measured in two allotments located in the upper reaches of T.1 were 35.6 and 28.3 cm, respectively. Similar measurements in two allotments located in the middle and one allotment located in the lower reaches of this turnout showed minimum depth to water tables of 51, 26 and 8 cm, respectively. The water table measurements were made over a 9 day period. The minimum depth to water tables shown in Table A-9 occurred during the period of water issue. Water tables only receded after water issues were completed. As a result, water tables were at or near the measured level for a period of approximately three days. Maximum depths to the water table in the upper, middle and lower reaches of the turnout, recorded before the next water issue, were approximately 100, 80 and 26 cm, respectively.

The expected rooting depth of chili is 60 to 90 cm. However, chili roots are extremely sensitive to prolonged periods of saturation. Measurements of rooting depth in T.1 suggested that chili plants had been exposed to water tables much more elevated than those measured during this study (Table A-9). Shallow rooting depths such as these severely limit the ability of the chili plant to exploit the soil for water and mineral nutrients. The ultimate effect, as shown in Table A-9, is stunted growth and decreased pod formation.

Table A-9. The Effect of Shallow Water Tables on Rooting Depth and Plant Height of Chili Plots Planted in the Upper, Middle and Lower Reaches of 306/D.1/T.1

	Allotment Location				
	Upper Reaches		Middle Reaches		Lower Reaches
	375	376	375	383	37
Minimum water table depth (cm)	35	28	51	26	8
Rooting depth (cm)	11	10	13	5	5
Average plant height, cm	48	30	52	16	13
Average number of pods per plant	36	57	42	9	4
Age of chili crop (days)	75	76	73	69-73	71

Related studies by the team engineers indicated that elevated water tables were created by excessive seepage losses from D-channels and F-channels, poor drainage, and over-irrigation. The distribution of paddy fields throughout the command areas of turnouts during _Yala_ is also a factor contributing to high water tables.

There are, however, a number of irrigation practices already recommended by the Mahaweli Authority which would improve the soil-plant- water relationships of chili cultivation. These practices include the planting of irrigated upland crops (such as chili) on single row or double row raised beds, increasing the period between irrigation applications from 7 days to 14 days, and only planting irrigated upland crops in the upper reaches of most turnouts. With the exception of a few farmers, who increased the interval between irrigation applications, there was little evidence of farmers following the irrigation recommendations of the Mahaweli Authority. However, since the detrimental effects of elevated water tables on chili plants are readily observed, it should be relatively easy to convince farmers to increase intervals between irrigation and plant chilies in raised beds.

4. Summary and Conclusions

Agronomic investigations were performed on 10 turnouts located in blocks 302, 303, 306, 307 and 309 of System H during the 1983 *Yala*. The results of these studies are summarized below.

Abnormally dry weather in the catchment areas of the Mahaweli Project decreased the amount of water diverted to the Kalawewa Reservior. The Mahaweli Authority minimized delivery problems by restricting the area commanded by the irrigation system to certain D-channels or portions of D-channels of the left bank canal. In addition, the Mahaweli Authority maximized the number of farmers receiving the benefit of irrigation water by imposing a traditional *bethma* system.

Field investigations indicated that most soils in the middle to lower reaches of the 10 turnouts were favorable for *Yala* rice cultivation. However, serious soil salinity problems in the lower reaches of some turnouts were evident. High soil salinity was responsible for the abandonment of certain allotments. Salinization of these lands was attributed to the poor condition and misuse of the drainage channels.

Soils in the upper reaches of the turnouts, identified as well drained reddish brown earths, were susceptible to periods of water logging from elevated water tables. Although elevated water tables were associated with inefficiencies in the irrigation system, the poor subsurface drainage characteristics of these soils aggrevated the problem. More detailed soil surveys are needed to determine the physical and chemical limitations of these soils under irrigation.

Cropping intensity in the 10 turnouts averaged approximately 88 percent, and ranged from a low of 54 percent to a high of 100 percent. Low cropping intensities resulted from poorly maintained field channels in two turnouts and abandonment of allotments or portions of allotments because of salinization.

Irrigated crops observed in the 10 turnouts included paddy, chili, soybean, cowpea and vegetables. Paddy was the most prevalent crop occupying approximately 66 percent of the cultivable area. The next most abundant crop, chili, occupied approximately 19 percent of the cultivable area.

Estimates of potential yields of paddy in 10 allotments averaged 3300 kg per ha and ranged from 1100 to 4200 kg per ha. Low potential paddy yields were attributed to heavy weed infestations and low fertilizer applications. Although conclusive data was lacking, it appeared that unreliable water supplies and/or the fear of unreliable water influenced the level of management applied to paddy.

Although irrigated chili is one of the most profitable Yala crops, the area planted to chili in System H is limited by elevated water tables and large investment costs. With the exception of irrigation, the management practices applied in most chili plots was near optimal. However, most farmers do not understand the complex relationships that exist between irrigation applications and fluctuating water tables. Consequently potential chili yields in many chili plots were limited by elevated water tables which restricted root growth to the upper 15 cm of soil. Several water management practices, which would alleviate this problem, are recommended by the Mahaweli Authority. However, these improved water management practices have not been adopted by the farmer.

B. Engineering

1. Description of the Irrigation System

System H of the Mahaweli Project consists of 43,500 ha (108,000 ac) of farm area in the Kala Oya river basin. Five major reservoirs--Kandalama, Dambulu-Oya, Kalawewa, Rajangana, and Angamuwa--provide water storage facilities for different sections of the system. Dambulu-Oya and Kandalama are in parallel and these two are in series with Kalawewa and Rajangana reservoirs. This location of reservoirs enables water to be reused within the system. Diversion of Mahaweli water to Kandalama and Dambulu-Oya reservoirs can be made independently. Kalawewa receives water through Dambulu-Oya as well as return flow from water used in H-6, H-7, H-8, and H-9 areas. In addition, Rajangana receives an ample return flow from H-1, H-2, H-3, H-4, and H-5 areas such that it does not require a direct diversion to supplement the water requirement.

The storage capacity of Kalawewa is one-third of the seasonal water requirement of the command area below it and is therefore largely dependent upon the Mahaweli diversion. Overuse of water may result in the cultivable area being reduced, particularly during Yala seasons.

The main canals were designed with large hydraulic inertia. This was to enable the canals to be used as compensating reservoirs as well as conveyance canals. In this way, the main canals can accommodate varying demands from the distributaries without delay in supply or excessive waste. The small reservoirs of Galnewa, Mulanatuwa, Kalankuttiya, and Mahakatnovuwa also were intended to provide regulatory capacity. The left bank main canal was routed through these small reservoirs. By having adequate storage in these small reservoirs, the left bank main canal can be operated independently as several separate sections for short periods.

a. Water Conveyance and Distribution System

The water conveyance and distribution system for this study was considered to consist of main canals, branch canals, and distributary channels (D-channels). Main and branch canals supply water to the D-channels and in turn the D-channels supply water to field channels (F-channels) through field turnouts. The main canals were layed out along contours so that a maximum area could be commanded. The branch canals and D-channels were layed out along ridges. To avoid deep cuts at D-channel heads, some were layed out along contours for short to intermediate distances at their upper reaches.

Original Design--The water conveyance system was designed to convey the peak daily water requirements based on the following factors:

(1) cropping pattern,
(2) conveyance and farm losses,
(3) field water requirement,
(4) irrigation pattern,
(5) effective rainfall, and
(6) method of irrigation.

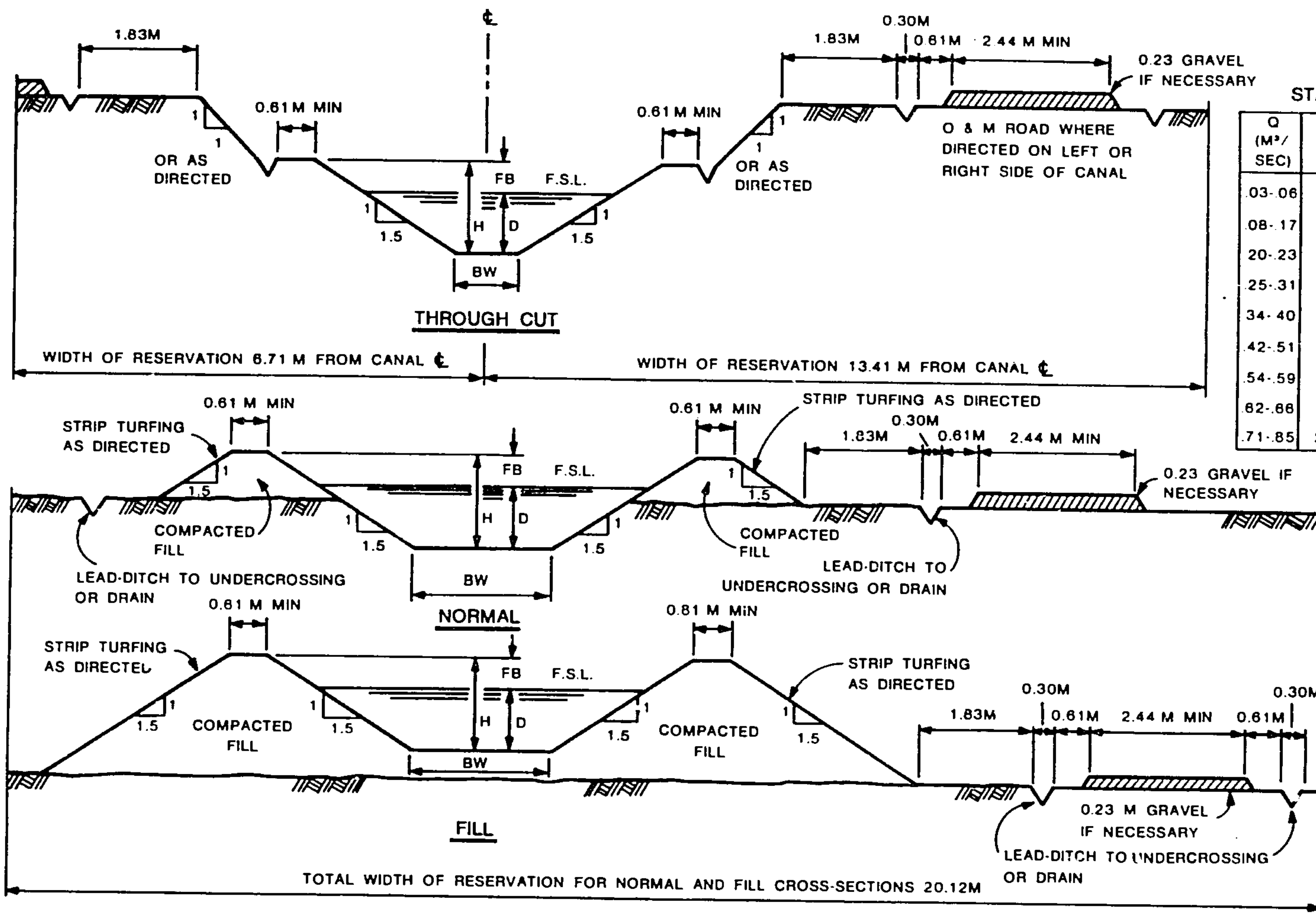
The capacities of main and branch canals were designed to satisfy the following requirements and assumptions:

(1) Peak demand of the total command area supplied,
(2) Continuous 24 hour discharge,
(3) Seven days per week issue, and
(4) Canal efficiency of 75 percent.

Canals were designed using Manning's formula. Maximum ave age velocities of 0.9 m/sec (3.0 ft/sec) and side slopes of 1V:2H for earth embankments were specified based on standard design criteria. Control devices on the main canal were to consist of sluices, off take structures, regulators, spills, road bridges, and aqueducts. Parshall flumes were to be provided at the head of the main and branch canals for daily measurement of discharges. Turnout structures were constructed to issue water from the main canal to D-channels and have capacities varying from 60 to 850 l/s (2 to 30 cfs) depending upon the commanded area. Turnouts with single 30, 45, or 60 cm (1.0, 1.5, or 2.0 ft) diameter openings were designed to handle capacities less than 340 l/s (12 cfs). For capacities of more than 340 l/s (12 cfs), turnouts were designed to have two 60 cm (2 ft) diameter openings. Cast iron slide gates were to be used to close turnout openings and were to be adjustable to any partial opening from fully closed to fully open. Each structure was to have a hump, breadth varying from 60 to 410 cm (2.0 to 13.5 ft), that could be used as a flow measuring device. The gated regulators were provided to make it possible to maintain the water level in the main canal at two-thirds of full supply depth at the furthest upstream offtake structure from the regulator, under a zero flow condition.

The D-channels were designed to supply the peak daily water requirement of all commanded field turnouts simultaneously. The design discharge of each field turnout was specified to be 28 l/s (1.0 cfs) for convenience. Therefore, a D-channel with N field turnouts was designed with a capacity of N times 28 l/s (N cfs) plus 15 percent conveyance losses. D-channels were designed to be double banked in order to avoid admittance of drainage waters from higher areas. Channel side slopes of excavation and fill were to be kept at 1V:1.5H with bed slopes of 0.0004. In designing the earthen channel cross-sections Manning's formula was used with a full supply depth of 37 to 60 cm (1.2 to 2.0 ft) and a maximum velocity of 0.9 m/sec (3.0 ft/sec). For a typical cross-section, see Figure B-1.

TYPICAL DESIGNED SECTION OF A DISTRIBUTARY CHANNEL



STANDARD SECTIONS

Q (M³/SEC)	BW (M)	D (M)	FB (M)	H (M)
.03-.06	0.30	0.34	0.58	0.92
.08-.17	0.46	0.44	0.43	0.92
20-.23	0.61	0.52	0.40	0.92
.25-.31	0.76	0.55	0.76	1.31
34-40	1.22	0.55	0.76	1.31
.42-.51	1.52	0.55	0.76	1.31
.54-.59	1.83	0.55	0.76	1.31
.62-.66	2.13	0.55	0.76	1.31
.71-.85	2.44	0.61	0.70	1.31

$S=0.0004$

$H=D+FB$

Figure B-1. Design Cross-section of Distributary Channels

Weir type regulators were provided along the D-channels such that a water depth equal to a two-thirds full supply could be maintained at the furthest upstream field turnout when flow over the regulator weir was zero. All of the field turnout structures were designed according to a standard type to supply the desired discharge of 28 l/s (1.0 cfs) when the water level in the D-channel was at two-thirds full supply depth. The discharge opening was to be a 23 cm (9 inches) diameter. Flow measurements were to be accomplished by measuring the depth over a 30 cm (1 ft) wide weir or hump. The gate and measuring weir or hump associated with each of these structures were designed to make possible the issue of a controlled partial discharge.

The following head losses were accommodated in the design of structures:

(1) From main canal bed to the highest command area level, on the average - 300 mm (1.0 ft);

(2) Regulators - 150 mm (0.5 ft);

(3) Dividers in the D-channel - 150 mm (0.5 ft);

(4) Aquaducts - 150 mm (0.5 ft); and

(5) Pipe culverts in D-channels - 75 mm (0.25 ft).

In design of the field turnout structures, F-channel bed levels at their commencement were specified to be 470 mm below the two-thirds full supply level of the D-channel.

Operational Plan--The different systems under the accelerated Mahaweli program are linked by a national grid. This grid enables the sharing of Mahaweli diversion water between the various projects. At the project level, as well as within each project, the general operational objectives are that the supply of water be adequate, reliable, and equitable. In order to accomplish these objectives an estimate must first be made of both the water that will be available as well as the required water during a season. Available water is determined from current storage levels in reservoirs and projected inflows to those reservoirs during the given season. Required water is determined based upon the types and acreages of crops to be grown and the conveyance, distribution, and application efficiencies expected.

The Water Management Secretariat under the Mahaweli Authority prepares details of water availability and proposes several water allocation options for the different systems each season. Decisions regarding the final allocations of water are made by the Water Management Panel. This panel which is chaired by the Director General of the Mahaweli Authority consists of the Secretaries of the Ministries of Mahaweli Development and of Land and Land Development, Heads of the Irrigation Department, the Mahaweli Economic Agency, and the Department of Agriculture, Additional Secretary of the Ministry of Mahaweli Development, and the government agents of the respective areas. The Water Management Secretariat is responsible for implementing the diversion policies and for making regular reviews of the diversion program during the course of the cultivation season. In the event of actual water availability deviating substantially from projected forecasts, authority to revise the program is obtained from the Water Management Panel. The Panel is considered the premier high level institution which establishes the criteria for the selection of cropping patterns as well as making allocations of water to each project.

Project personnel call cultivation meetings, according to the provisions of the irrigation ordinance, at least two weeks before the first issue of water. The Water Management Panel's recommendations of cropping patterns and the cultivation calendar proposed by them are then presented to the farmers at these meetings. Farmers have a certain degree of liberty to deviate from the recommendations, but are expected to work within the established water allocation schedules.

At the commencement of any cultivation season, the project irrigation personnel prepare a rotation schedule of water issues for the land preparation period. A rotation schedule for the vegetative period is prepared as the cultivation progresses to suit the actual cropping pattern. The following data is used for the preparation of these schedules:

(1) The cropping pattern including acreage:

- As decided at cultivation meeting for land preparation period, and

- As actually practiced for vegetative period,

(2) Land preparation period as decided at cultivation meetings, and

(3) Conveyance losses in the distribution system from reservoir to farm turnouts is assumed to be 25 percent, with 15 percent occurring from the head of D-channels to farm turnouts.

(4) Irrigation requirement:

- An irrigation of 40 mm (1.5 inches) for land preparation for upland crops,

- A total of 180 mm (7 inches) for land preparation for paddy, (this includes 120 mm (5 inches) for initial land preparation and a subsequent 50 mm (2 inches) after 10 to 12 days for puddling operations),

- During the vegetative period 64 mm (2.5 inches) will be applied every 7 days, and

- Evapotranspiration demands require irrigation starting from the first flooding through the season until 15 days before harvest for paddy.

The different levels of the conveyance and distribution system are managed by the project irrigation personnel. The organizational chart for the project irrigation personnel is shown in Figure B-2. The division of responsibility is as follows:

(1) Reservoir head works are under the control of the Deputy Resident Project Manager (Water Management) who is also responsible for the overall irrigation system.

(2) Main canal and branch canals are managed by an Irrigation Engineer in each block. This management involves the monitoring, regulating, and issuing of water to each D-channel according to the rotation schedule. These duties are delegated to a separate Engineering Assistant. The main canal is operated continuously 7 days per week while branch canals are operated 7 days per week during land preparation periods and 6 days per week thereafter.

(3) D-channels can be operated continuously, but intermittent issues of 3 to 4 days per week is preferred. Operation of a D-channel to ensure an adequate, reliable, and equitable supply of water at each field turnout is the responsibility of a Unit Manager. A Field Assistant (Water Management) assists the Unit Manager in carrying out these duties. The Unit Manager also consults with the Engineering Assistant with regard to technical matters such as water monitoring, preparation of operation schedules, and adjustment necessary during periods of rain.

Interaction between different levels of the project irrigation personnel is accomplished through the following communication arrangements:

(1) Deputy Resident Project Manager explains to all categories of irrigation personnel and Block and Unit Managers decisions made by the Water Management Panel.

(2) The Irrigation Engineer and his Engineering Assistants prepare rotation schedules based on cultivation data furnished by the Unit Manager.

(3) Unit Managers contact the Irrigation Engineer in the event of it being necessary to deviate from the established rotation schedule.

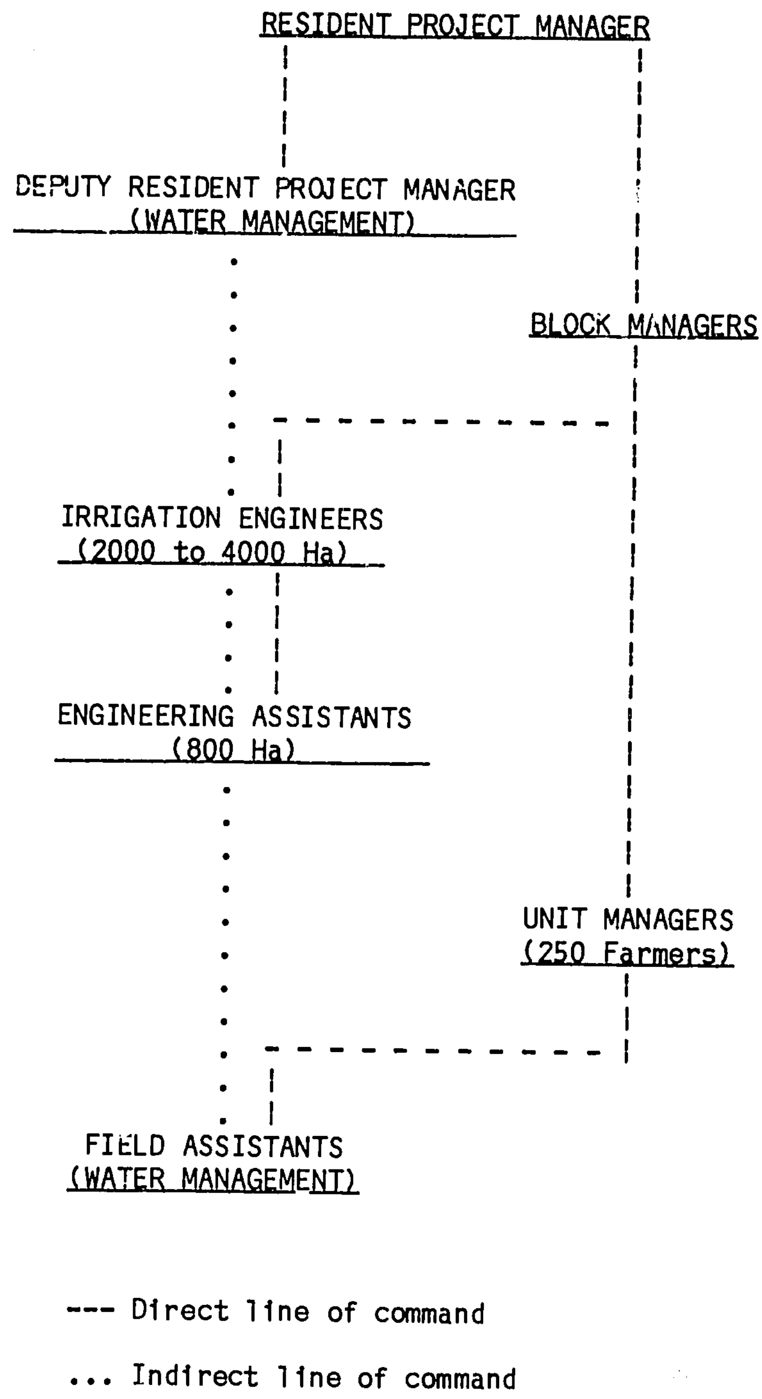


Figure B-2. Organization chart for the Project Irrigation Personnel.

(4) Each Engineering Assistant submits information regarding daily flow rates and water levels to the Irrigation Engineer and Deputy Resident Project Manager.

(5) Weekly meetings are convened by the Block Managers with the Irrigation Engineer, Engineering Assistants, Unit Managers, and Field Assistants.

Maintenance Plan--The maintenance of the water conveyance and distribution system up to field turnouts was to be the responsibility of the project irrigation personnel. It was assumed that the operational staff themselves would be capable of handling this maintenance. It was decided that canal desilting, bund formation, and maintenance of structures were to be done annually while clearing of vegetative growth on channel bunds and reservations were to be done seasonally.

b. Water Application System

The water application system was restricted to the F-channels and the farms commanded by those channels. This consideration was for convenience in separation of operational control. Water distribution in the main canal, branch canal, and D-channels, including the field turnouts, is to be controlled by the project irrigation personnel as described in the previous section. Below the field turnout distribution of water is in the hands of the farmers. Also, responsibility for maintenance of the system is divided between project irrigation personnel and farmers at the field turnouts. Each F-channel is designed to command an area of 12 to 16 ha (30 to 40 ac) and it is referred to as a "turnout area".

Original Design--F-channels were designed to carry a flow rate of 28 l/s (1.0 cfs). A typical cross-section was used as shown in Figure B-3. Regulator drop structures were to be installed along F-channels in order to maintain a bed slope of 0.0004. Farm turnouts were also to be installed along F-channels corresponding to each allotment. These turnouts were designed to have a discharge of 14 l/s (0.5 cfs). Farm turnout structures were designed to have either a 15 cm x 15 cm (6 in x 6 in) or a 15 cm (6 in) diameter opening. The opening, in either case, was to be closed using a plank in grove arrangement. The regulators were to be constructed to block the entire F-channel with a planking arrangement just downstream of each farm turnout. Where possible, one structure incorporating the regulator, drop, and two farm turnouts, each serving an allotment on opposite sides of the F-channel, was to be used.

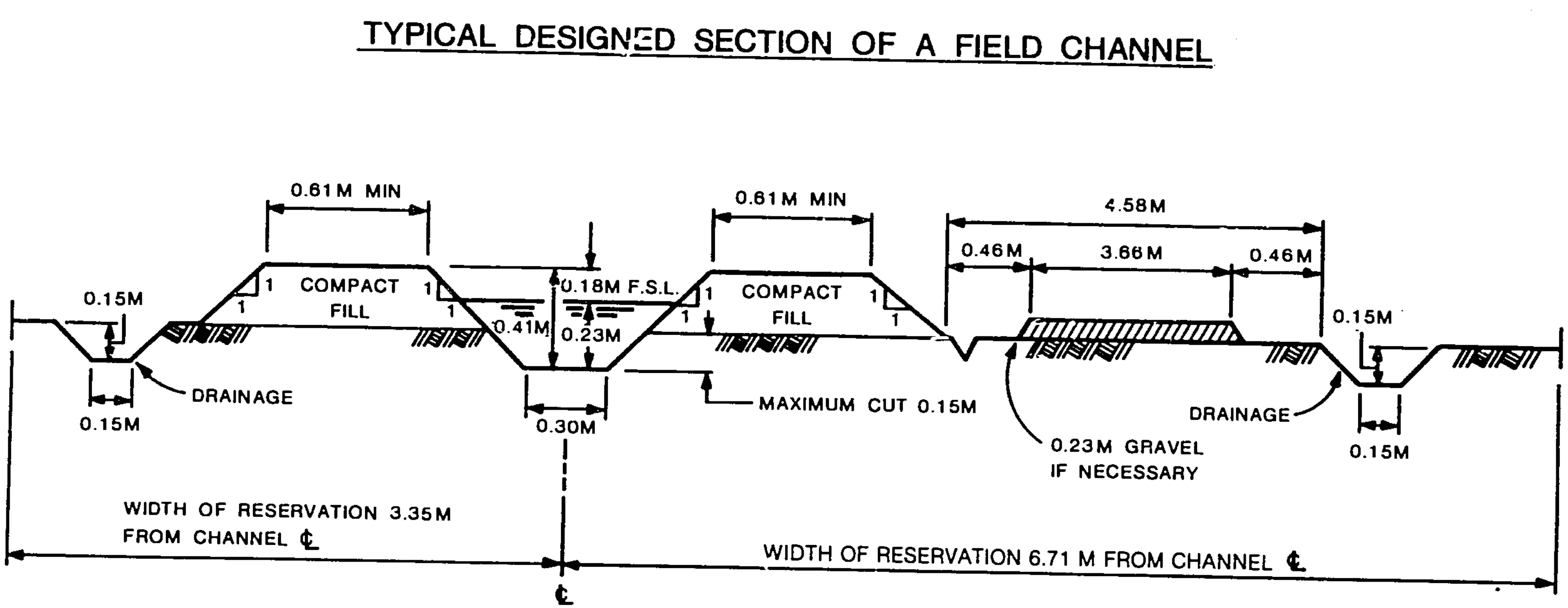


Figure B-3. Design Cross-section of Field Channels

Farms were to be laid out for either irrigation of upland crops or paddy. Farms where upland crops were to be grown were to use furrow irrigation on bench terraces with slopes of 1 percent. The width of furrows and length of the farm in the direction of irrigation were not to exceed 60 m and 180 m, respectively. Farms where paddy was to be grown were to be under basin irrigation. The maximum length of a basin was to be 30 m and other dimensions designed to suit topography. Slopes of 0.2 percent to 0.4 percent were to be allowed in the direction perpendicular to the direction of maximum ground slope.

The actual design used for construction was altered from the original design in that all farms were levelled as bench terraces and then subdivided into small basins. Even farms recommended exclusively for upland crops were levelled in the above manner because the farmers wanted to cultivate paddy during _Maha_. Contour bunds were laid out 10 m apart. This distance was reduced when the depth of cut in land levelling would exceed 15 cm.

Operational Plan--The farmers are responsible for the rotation schedule within their turnout area. The entire F-channel discharge is to be diverted to two allotments simultaneously until their water requirements are met. The F-channel discharge is then to be diverted to the next pair of allotments, and so on, until all allotments have been irrigated.

Maintenance Plan--The responsibility of maintaining the F-channel and road along it is vested with the farmers. F-channels should be desilted and their bunds reformed at regular intervals as decided at cultivation meetings. Project irrigation personnel are to be responsible for making sure that this work is properly done.

c. Drainage System

The drainage system incorporates both natural and excavated channels for the removal of surface and subsurface drainage from cultivated lands. In demarcating field turnout area boundaries, existing natural channels were incorporated into the drainage system with improvements made if necessary. Drainage channels were excavated in the absence of natural channels. This system consists of primary, secondary, and tertiary channels. The tertiary channels collect water directly from allotments within adjacent turnout areas. The secondary channels receive the discharges of the tertiary channels from lands lying adjacent D-channels. And the primary channels receive the discharges of secondary channels and are usually natural channels discharging into either a river or a reservoir.

Original Design--The drainage system was intended to handle the following:

(1) Storm runoff from catchments,

(2) Spillage from reservoirs,

(3) Spillage from conveyance and distribution system,

(4) Removal of standing water from paddy lands,

(5) Removal of excess water from over irrigation, and

(6) Collection and removal of subsurface drainage.

The actual design was based upon the following:

(1) Peak storm runoff rates were determined using the rational method,

(2) Channel capacities to handle the 5-year storm, and

(3) Structure (culverts and minor bridges) capacities to handle the 20-year storm.

Based upon the above criteria, the maximum discharges used for the design of channels and structures within turnout areas were 1,400 l/s (50 cfs) and 2,800 l/s (100 cfs), respectively. These capacities were decreased in proportion to the area drained. For drainage channels and structures outside turnout areas the design was based upon storm runoff from served catchment and the spillage from the conveyance and distribution system.

Operational Plan--The drainage system has no control structures and, therefore, requires no operational activities.

Maintenance Plan--Maintenance of primary and secondary drainage channels was intended to be the responsibility of the project irrigation personnel. Tertiary drainage channels in turnout areas were to be maintained by the farmers.

2. Evaluation of the Irrigation System

In the previous section, (Description of the Irrigation System) the original designs, operational plans, and maintenance plans of the conveyance and distribution, application, and drainage systems were discussed. In this section the observed physical conditions and actual operation of these systems will be discussed. This discussion is based upon the findings of the detailed studies conducted as part of the Diagnostic Analysis Workshop.

a. Water Conveyance and Distribution System

As explained previously, the water conveyance and distribution system was considered to consist of the main and branch canals and the D-channels. Emphasis was given to the evaluation of D-channels during the detailed studies with no direct studies made on main or branch canals. However, the five D-channels studied were chosen to represent the head, middle, and tail reaches of the main and branch canal system. Therefore, some information was obtained that could be interpreted to give limited insight into the main and branch canal operation.

Observed Physical Condition--The longitudinal profiles, as drawn from survey data for the five D-channels, showed that slopes varied considerably from the design slope of 0.0004 (See Figures B-4. B-5. B-6, B-7, and B-8). Steeper slopes contribute to higher velocities which can cause scouring. Milder slopes and negative slopes contribute to reduced velocities which can cause siltation. The result of scouring and siltation can both be noted when plotted cross-sections of D-channels are examined (See Figures B-9, B-10, B-11, and B-12). Where scouring of channel banks and/or siltation of channel bottoms has occurred the result is wide shallow water courses. As a consequence of this the operational head will be reduced and the wetted perimeter increased.

As a result of the deteriorated condition of D-channel cross-sections it was assumed that conveynce losses might be high. Measurements of conveyance losses for different reaches of the D-channels under study were made and the data are presented in Table B-1. The average length of channel reach used for these measurements was 500 m. The conveyance losses varied from 0.1 to 2.0 percent per 100 m length; the average being about 0.8 percent per 100 m. Since the average length of a typical D-channel is two kilometers, the typical conveyance efficiency would be 85 percent (conveyance efficiency = $(1.000 - 0.008)^{20} \times 100$). This 85 percent conveyance efficiency is for issuing water to the last field turnout along the D-channel. The average conveyance efficiency, taking into consideration all field turnouts, will be higher because not all turnouts are located at the end of the D-channel but are spaced all along its length. Nevertheless, in comparing this average conveyance efficiency with the assumed, 95 percent, conveyance losses would appear to be moderately high.

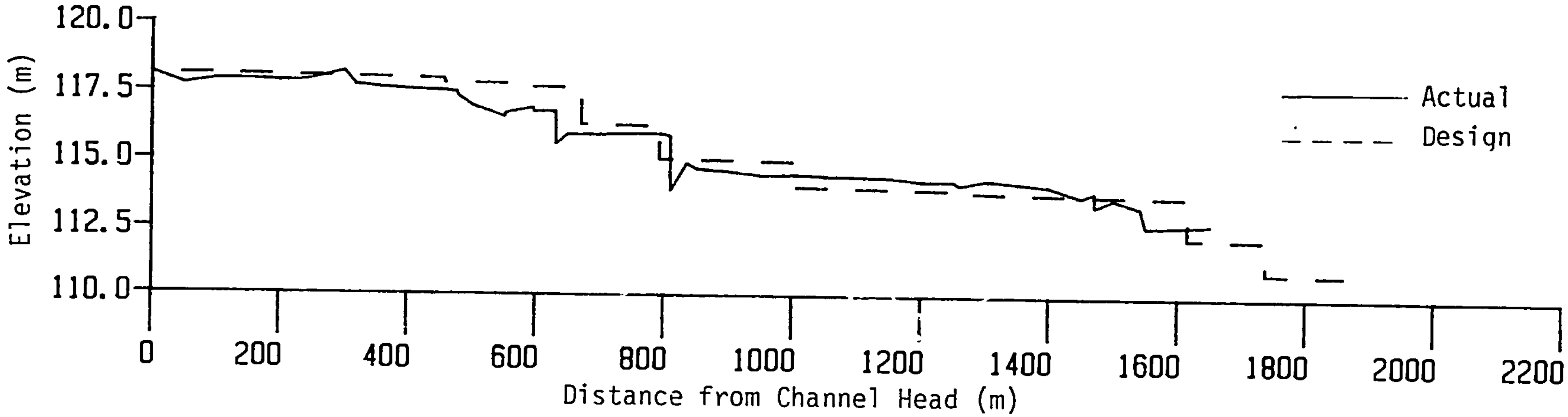


Figure B-4. Longitudinal Profile of Distributary Channel 1, Block 302

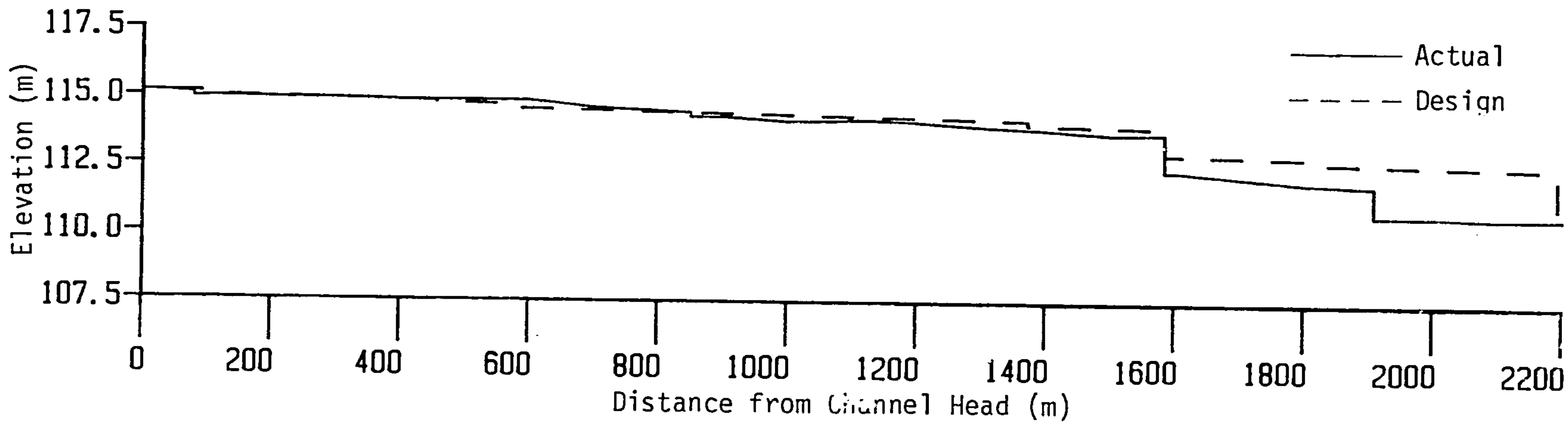


Figure B-5. Longitudinal Profile of Distributary Channel 2, Block 303

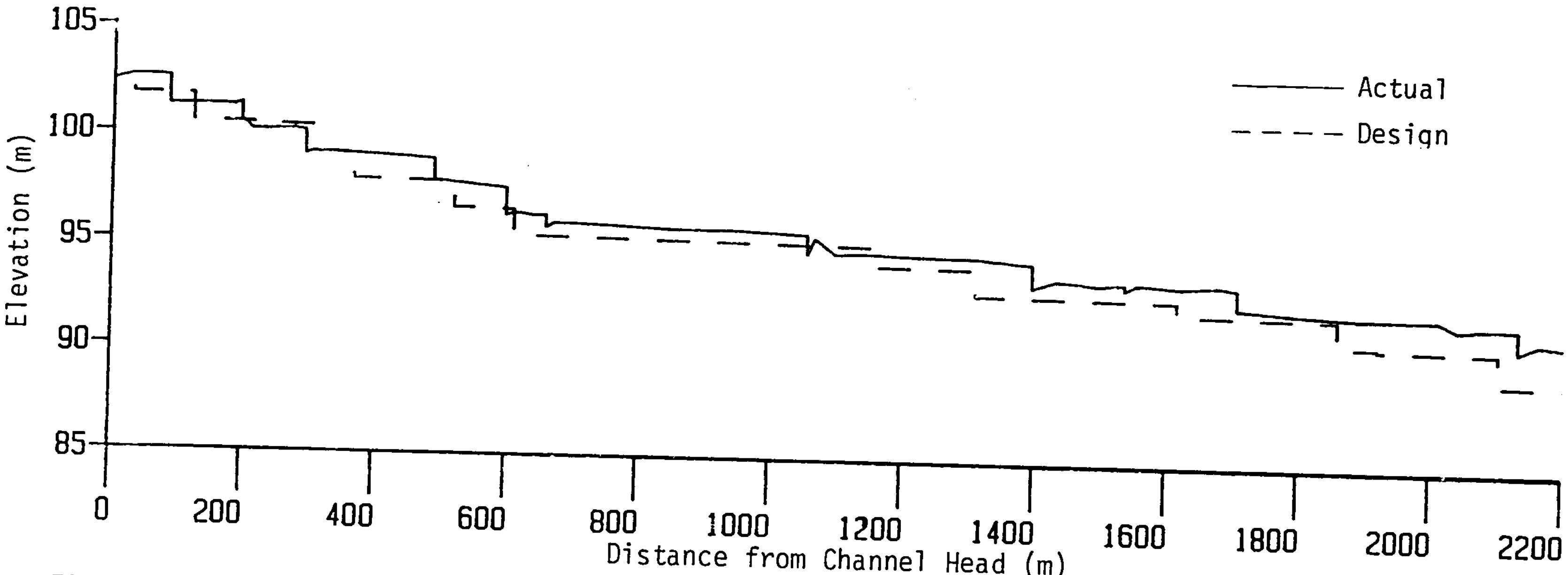


Figure B-6. Longitudinal Profile of D-Channel 1, Block 306

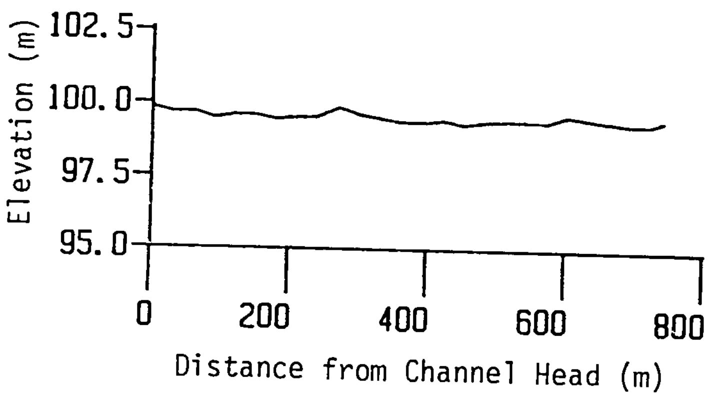


Figure B-7. Longitudinal Profile of D-Channel 3, Block 307

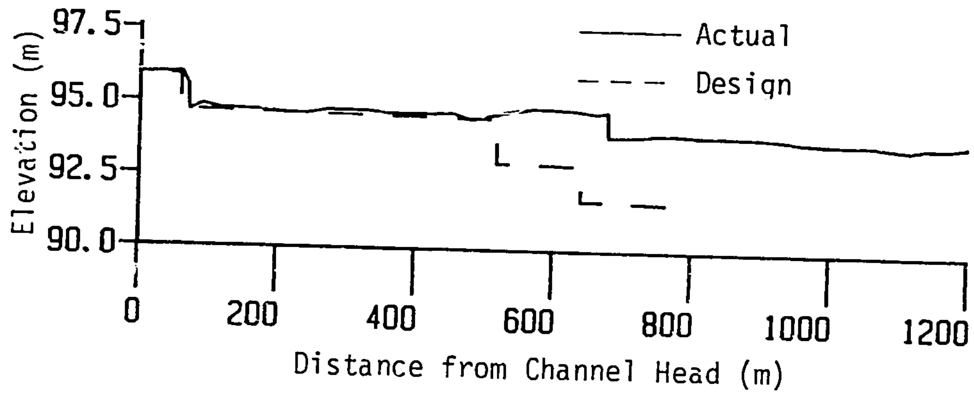


Figure B-8. Longitudinal Profile of D-Channel 3, Block 309

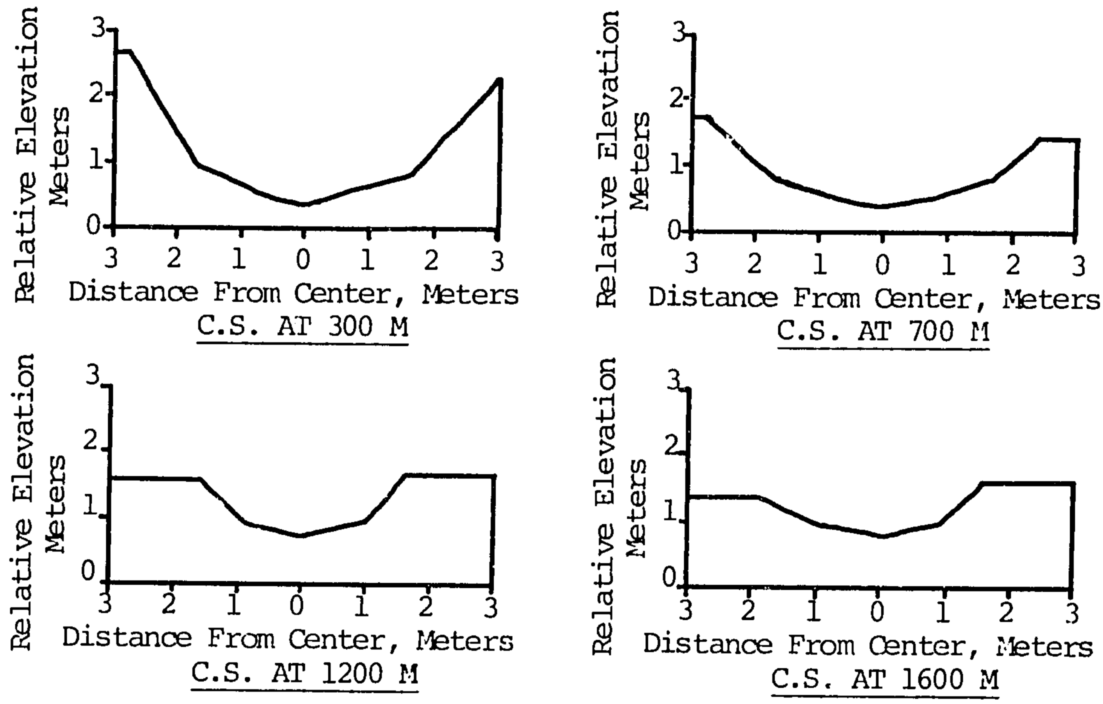


Figure B-9. Cross-sections of D-channel 1, Block 302

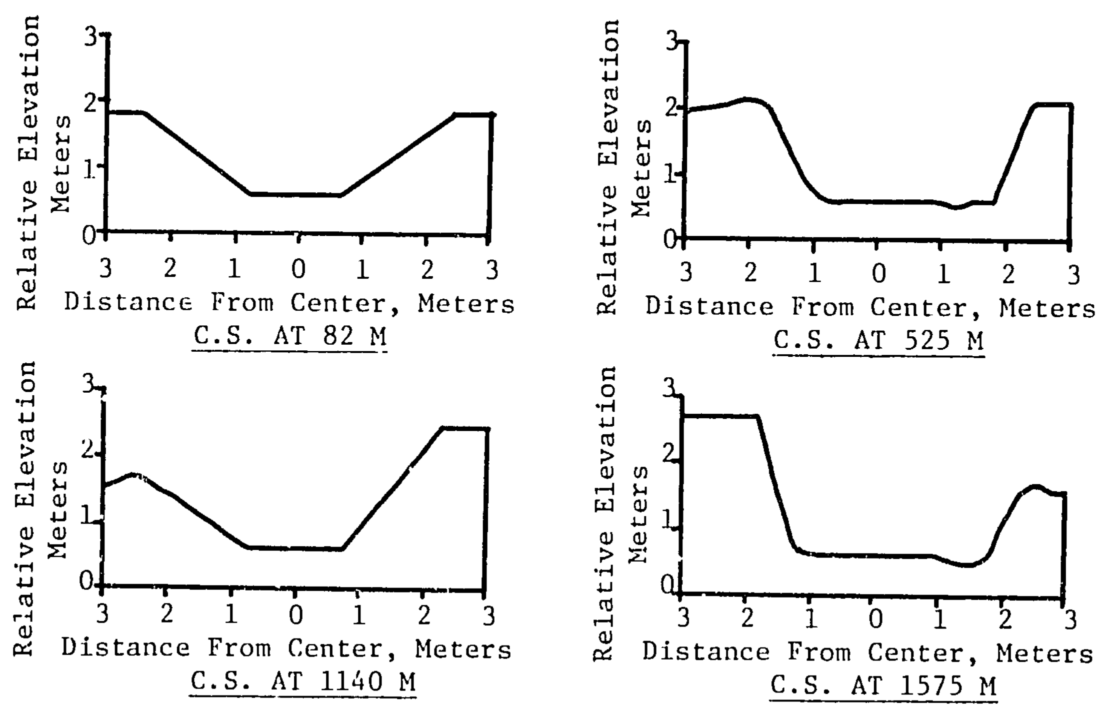


Figure B-10. Cross-sections of D-channel 2, Block 303

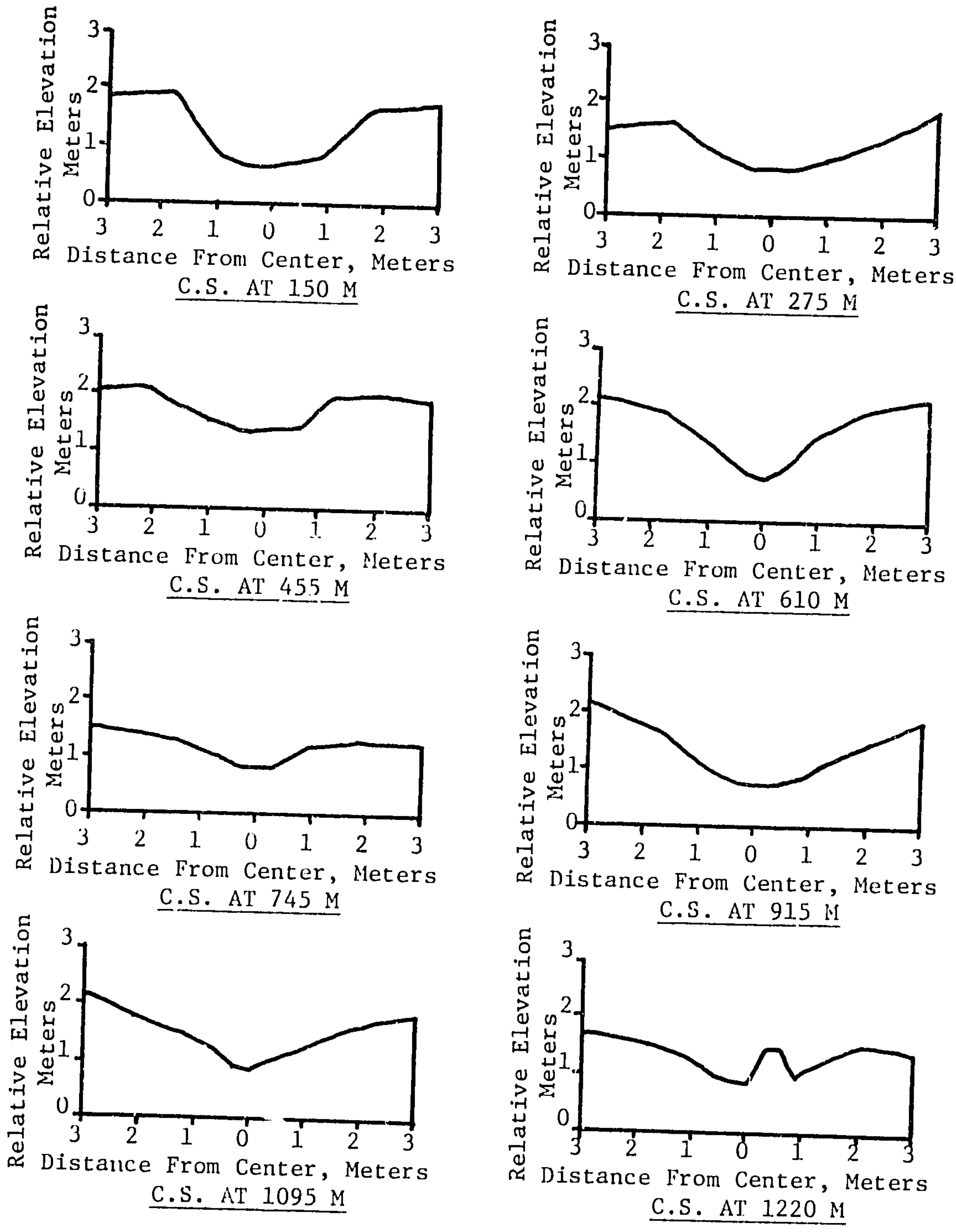


Figure B-11. Cross-sections of D-channel 1, Block 306

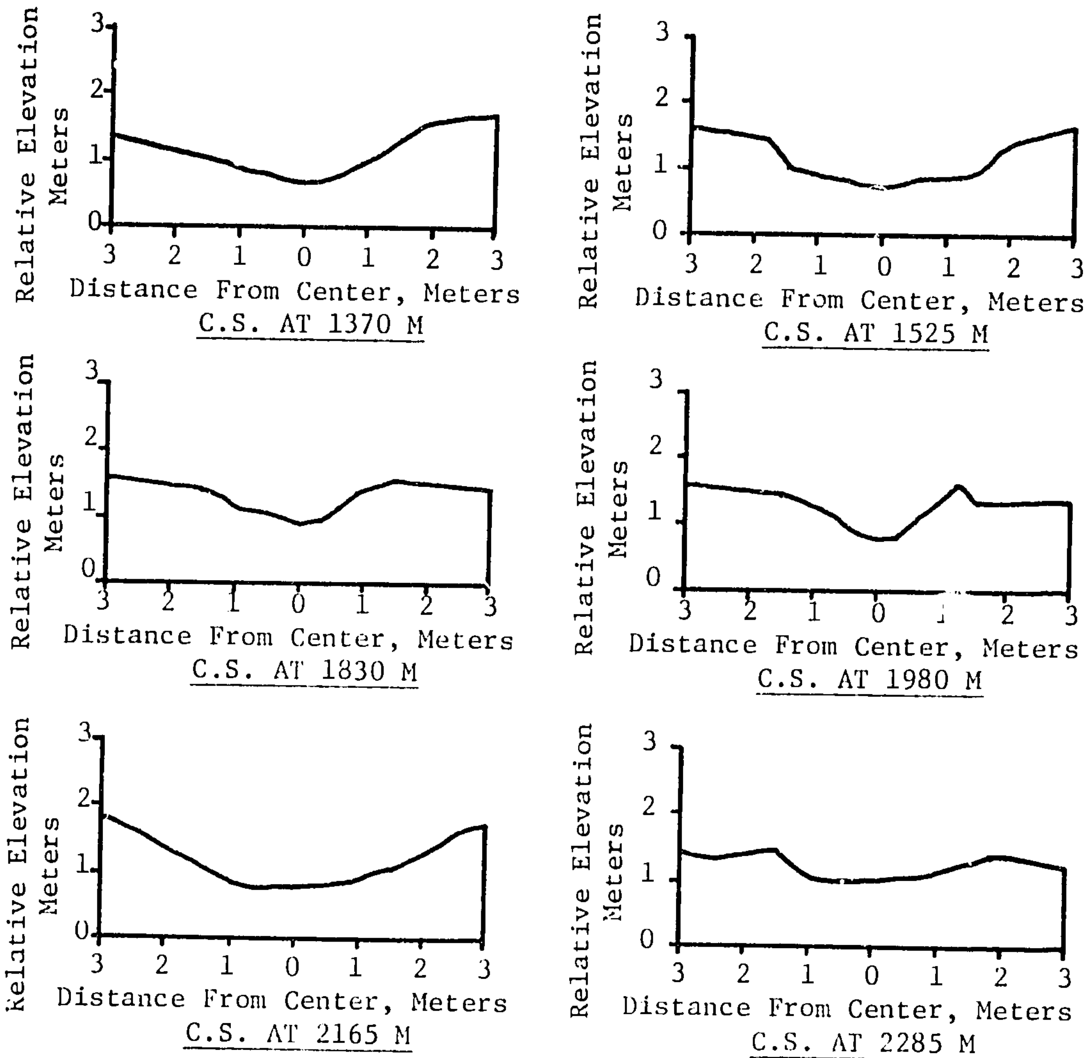


Figure B-11. (continued)

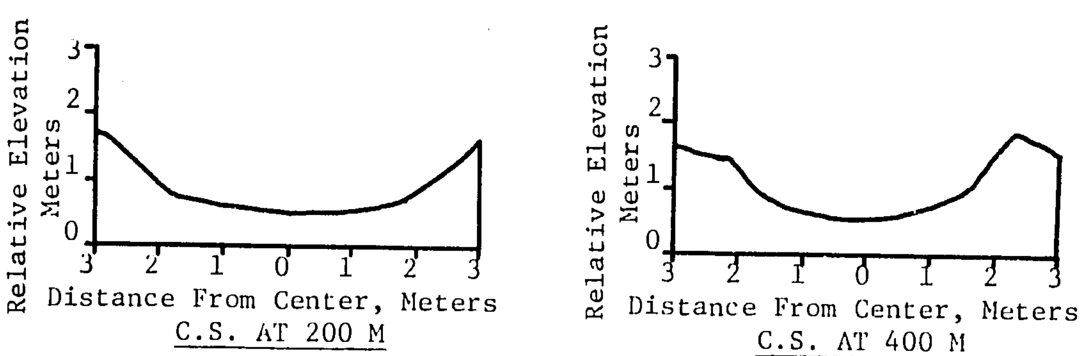


Figure B-12. Cross-sections of D-channel 3, Block 307

Table B-1. Conveyance Losses of D-channels.

D-channel	Measuring Device	U/S Station		D/S Station		Distance Between Measuring Stations	Conveyance Loss
		Distance from Turnout	Inflow (liters/sec)	Distance from Turnout	Outflow (liters/sec)		(% per 100 m)
302/D.1	Current Meter	90 m	189.6	590 m	160.7	500 m	0.11
	Current Meter	1100 m	121.8	1600 m	95.7	500 m	0.75
303/D.2	Current Meter	25 m	209.0	525 m	200.4	500 m	0.83
	Current Meter	525 m	200.4	1200 m	189.4	675 m	0.81
	Current Meter	1210 m	173.4	1530 m	167.0	320 m	1.14
306/D.1	Current Meter	15 m	127.6	476 m	126.4	461 m	0.20
	Current Meter	610 m	107.0	1036 m	97.8	426 m	2.00
	Current Meter	1112 m	60.9	1536 m	58.4	424 m	1.39
	Current Meter	1737 m	25.5	2194 m	25.0	457 m	0.43
307/D.2	Current Meter	61 m	415.4	433 m	404.3	372 m	0.71
309/D.3	Current Meter	113 m	124.3	549 m	121.2	436 m	0.57

In addition to the deteriorated condition of D-channel cross-sections the following factors might be contributing to conveyance losses:

(1) Vegetative growth on channel banks,

(2) Inadequately compacted earthen channel banks,

(3) Holes in and through channel banks as a result of burrowing animals and insects,

(4) Gravelly earth encountered in deep cuts, and/or

(5) Leakage around and through damaged control structures.

These losses may be minimized by channel rehabilitation and kept low through improved maintenance practices. A comprehensive study and economic analysis would be necessary before any decisions could be made, however.

A survey of the structures along D-channel 1 in block 306 was conducted to determine their condition. Conditions were characterized as either good or poor depending upon ability to fulfill their intended functions. The head gate was in good condition. Three out of four regulator drop structures were in good condition. Eight out of nine field turnout gates were in good condition except that none of them were constructed with measuring devices as they were supposed to be. Out of the 21 total number of structures, which also included box culverts, siphons, retaining walls, and channel lining, 18 could be considered in good condition.

Some of the defects to structures included slow leaks through turnout gates, collapsing of minor portions of the downstream sections of drop stuctures, leakage around structures, and scouring below structures. Detailed surveys were not carried out along other D-channels, but general observations supported the survey findings as typical. Although the magnitude of these damages were small and limited to only a few of the structures, these damages still constitute a potential reduction in the ability to control water.

Besides the condition of structures, the general condition of the channels themselves were observed. As already mentioned, considerable scouring and siltation has taken place along channels. In addition to this a substantial amount of vegetative growth existed on channel banks. During interviews held with the operational staff it was confirmed that necessary structural repairs and channel cleaning was done before the commencement of each irrigation season. In light of the poor overall condition of the D-channels, an additional mid-season clearning of channels may be necessary.

Actual Operation--The discharge rates into the studied D-channels from the main and branch canals were measured. These measurements were, except in one case, made only once. Therefore, no data were available to describe hourly or even daily fluctuations in these discharge rates. Lack of data restricts what can be inferred as well as the reliability of inferences made. Nevertheless, when these observed discharge rates are compared with the intended operational discharges for Yala 1983, at least limited inferences can be drawn. Table B-2 gives the maximum designed discharges, operational discharges for Yala 1983, and the measured discharges for the five D-channels. Also given are the percent variations between measured discharge and intended operational discharges for Yala 1983. The operational discharges for Yala 1983 were reduced from the maximum designed discharges because of the reduced acreage that was being cultivated. The substantially high issue to D-channel 3 in block 307 at the tail end of the system was explained by the operational staff as an attempt to overcome unpredictability of the water supply there. Supposedly, this unpredictability was due to unauthorized manipulation of the D-channel turnout gates upstream.

Variations from the operational schedule should be considered high when they exceed ± 5 percent. Even though measured discharges varied greatly from intended discharges, the fact that they were both greater and less than the intended suggests that the problem was not due to structural capacity but rather poor operational practices at the main and branch canal level.

The discharge rates into a number of F-channels from two of the studied D-channels were also measured. More such measurements were not made due to a lack of issues at the time of the detailed studies. Like with the D-channel measurements, those taken in the F-channels were not repeated, as they should have been, to provide understanding of hourly or daily fluctuations. Table B-3 gives the maximum designed discharges and the operational discharges for Yala 1983, which for the F-channels were to remain the same. Also the measured discharges and the percent variation between the intended operational and measured discharges are given.

As can be seen from Table B-3 all issues to the F-channels measured were less than what was called for in the operational plan. These under issues varied from 20 to 70 percent less than intended. This information suggests a double problem at the D-channel level. The first problem is one of physical limitations and the second is, as before, poor operational practices. Since all issues measured were less than the intended rate it would appear that the intended discharge cannot be issued. This condition may be the result of either the field turnouts not functioning as designed or insufficient operational head in the D-channels. Since measured F-channel issues were both greater and less than the design discharge during last year's Diagnostic Analysis

Table B-2. Flow Measurements at the Head of D-channels.

Channel Description		Maximum Discharge (liters/sec)	Operational Discharge (liters/sec)	Measured Discharge (liters/sec)	Deficit or Excess Discharge (%)
302/D.1	(6/7/83)	340	140	190	+36
302/D.1	(7/7/83)	340	140	223	+66
303/D.2		481	234	209	-11
306/D.1		397	163	128	-21
307/D.3		553	225	415	+84
309/D.3		260	107	124	+16

Table B-3. Flow Measurements at the Head of F-channels.

Channel Description	Maximum Discharge (liters/sec)	Operational Discharge (liters/sec)	Measured Discharge (liters/sec)	Deficit or Excess Discharge (%)
302/D.1/T.6A	28	28	23	-18
/T.7	28	28	14	-50
/T.13	28	28	22	-21
/T.14	28	28	17	-39
/T.15	28	28	8.5	-70
/T.16	28	28	19	-32
303/D.2/T.4	28	28	13	-54
/T.14	28	28	18	-36

Workshop for a non-bethma season, the problem may be tied to the scheduled under issues in the D-channels. These deliberate under issues allow for lower operational heads and thus under issues through field turnouts.

The second problem of poor operational practices is revealed in the wide range of discharges measured. The absence of measuring devices in the field turnout structures is a definite constraint to water control at the D-channel level. Issues to the field turnouts are purely based upon visual estimates and thus subject to wide variations.

During the interviews held with the operational staff it was revealed that the control of water in D-channels was made additionally difficult due to the following reasons:

(1) Unauthorized manipulation of distributary and field turnouts by upstream farmers; and

(2) The confused way in which water is distributed within turnout areas requiring more water to be issued to F-channels in order to satisfy requirements. The predictability and adequacy of water supply to D-channels towards the tail end of the main and branch canal system often could not be achieved due to the above mentioned reasons.

b. Water Application System

The water application system, as previously defined for this study, was considered to consist of the F-channels and the farms commanded by those channels. This section will discuss the observed physical condition of this system as well as its actual operation.

Observed Physical Conditions--Longitudinal profiles drawn from survey data for the ten turnout areas studied are presented in Figures B-13 through B-22. Estimated average slopes of F-channels between structures range between 0.0003 to 0.02 with an overall average of 0.008. These slopes are considerably steeper than the design slope of 0.0004. It would be assumed that these steeper slopes would produce higher than desired flow velocities and thus erosion of the channels. Observations verified this assumption, because excessive erosion has taken place in most all of the studied F-channels. The major problem caused by this condition is that channels have been eroded so deeply in some places as to render structures inoperative. There were instances where some allotments could no longer be served by the farm turnouts designated for them because of this erosion. Farmers resorted to taking water out of the F-channel further upstream and conveying it down to their allotment via secondary field ditches.

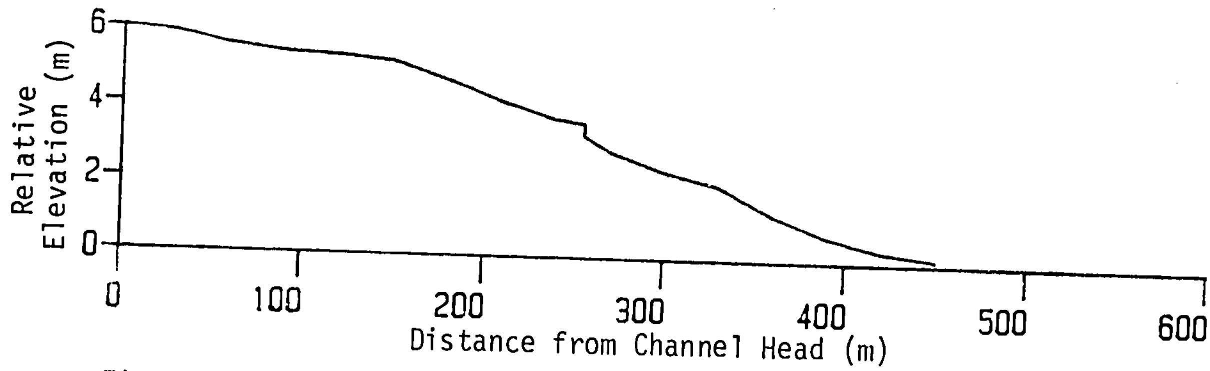


Figure B-13. Longitudinal Profile of F-Channel 7 under D-Channel 1, Block 302

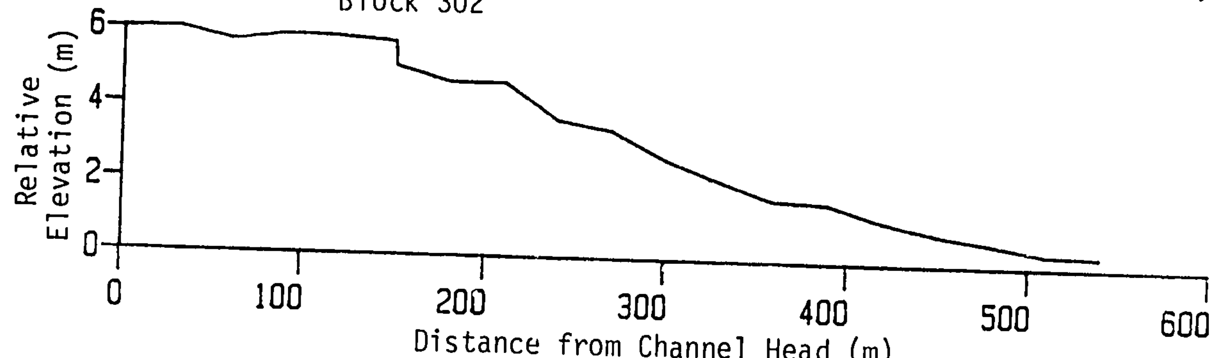


Figure B-14. Longitudinal Profile of F-Channel 14, under D-Channel 1, Block 302

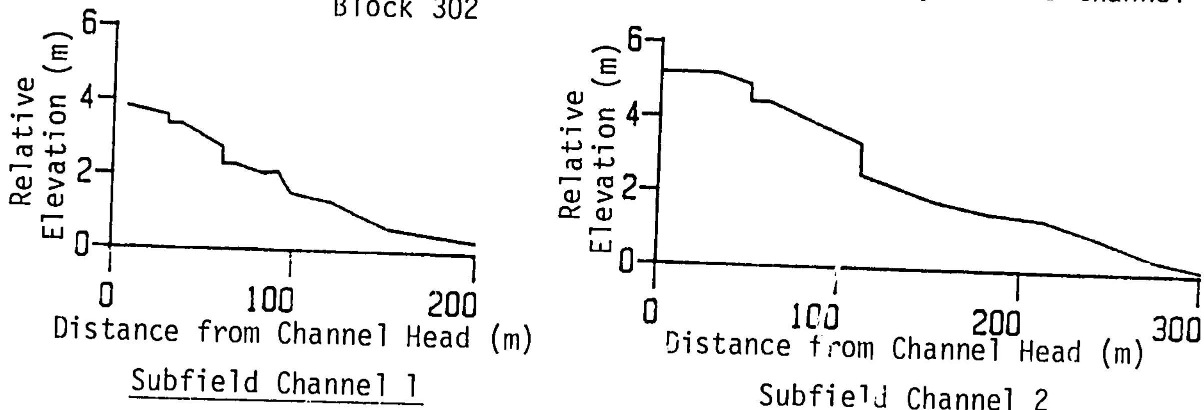


Figure B-15. Longitudinal Profile of F-Channel 4 under D-Channel 2, Block 303

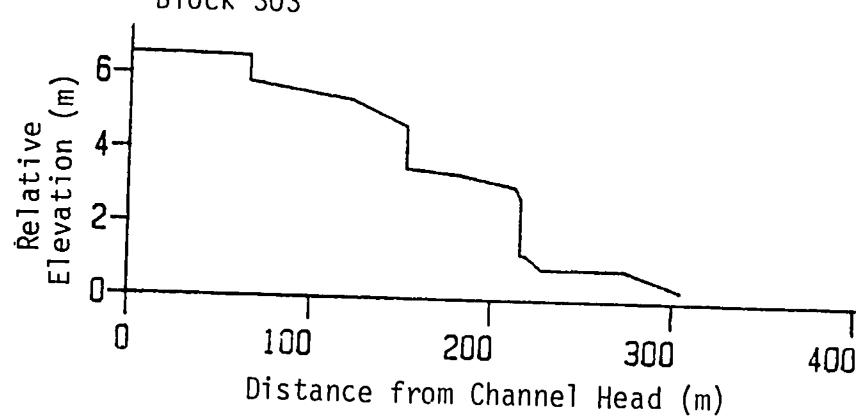


Figure B-16. Longitudinal Profile of F-Channel 14 under D-Channel 2, Block 303

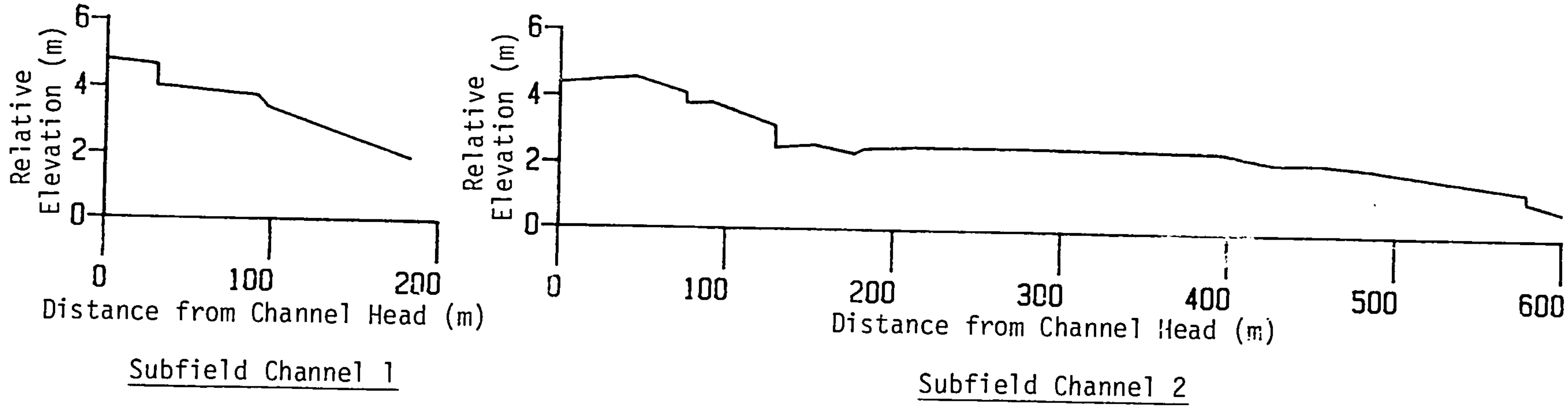


Figure B-17. Longitudinal Profile of Field Channel 1, under D-Channel 1, Block 306

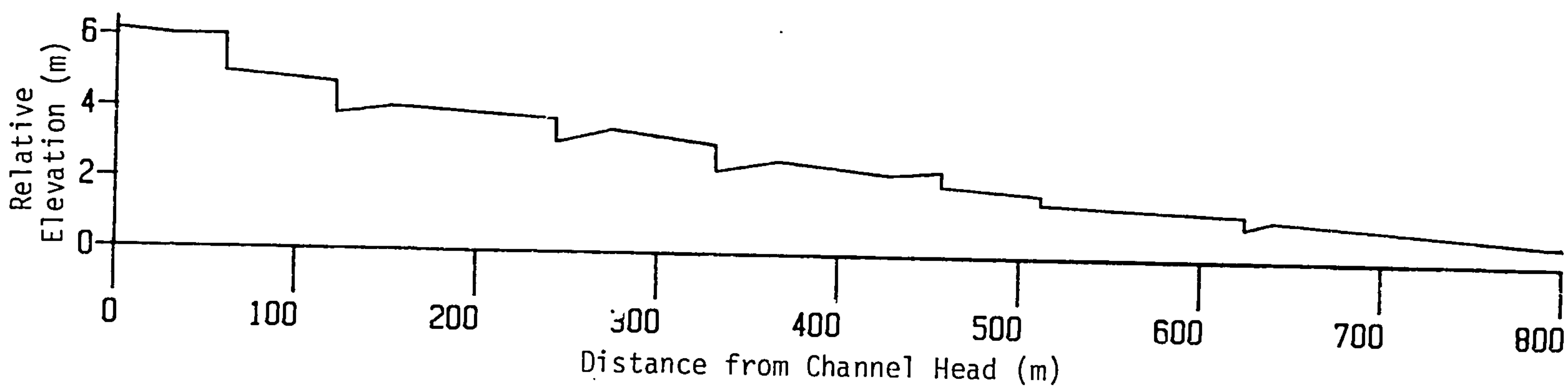


Figure B-18. Longitudinal Profile of Field Channel 5, under D-Channel 1, Block 306

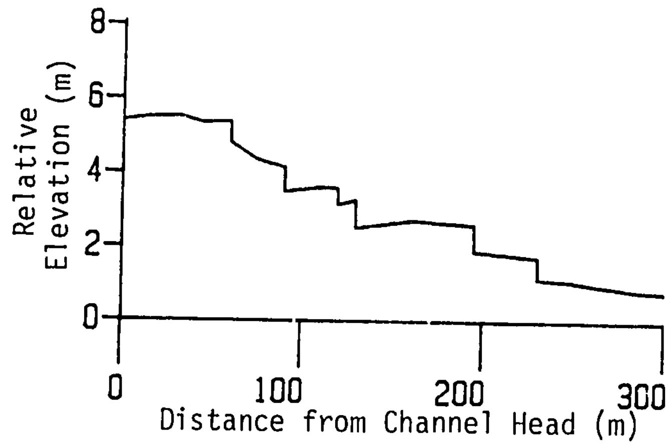


Figure B-19. Longitudinal Prof'le of F-Channel 0 under D-Channel 3, Block 307

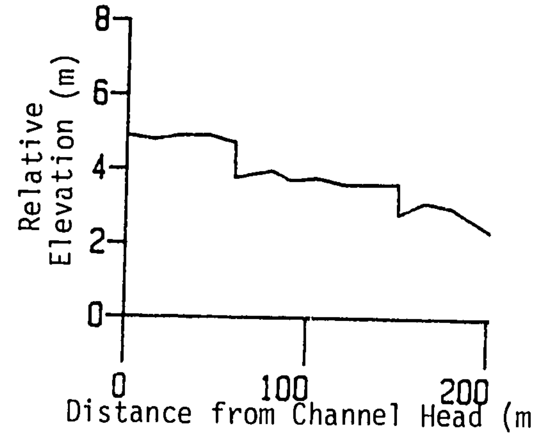
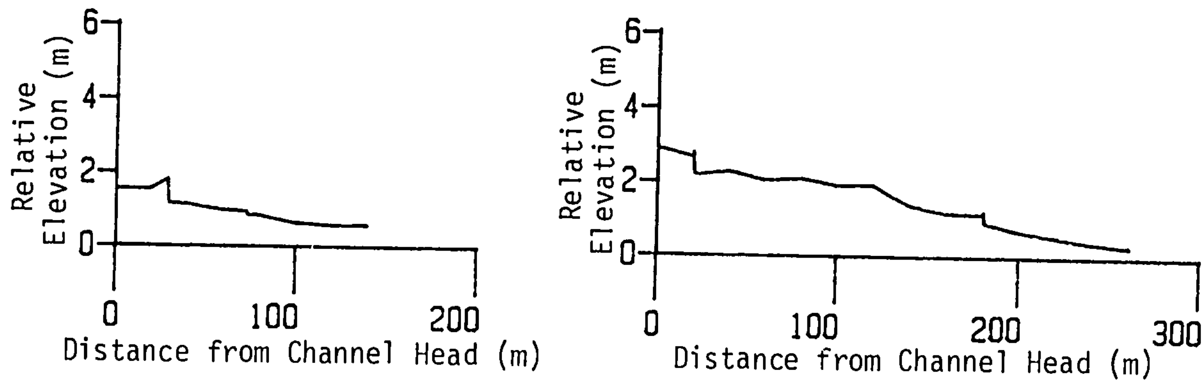


Figure B-20. Lonqitudinal Profile of F-Channel 15 under D-Channel 3, Block 307



Subfield Channel 1

Subfield Channel 2

Figure B-21. Longitudinal Profile of F-Channel 2 under D-Channel 3, Block 309

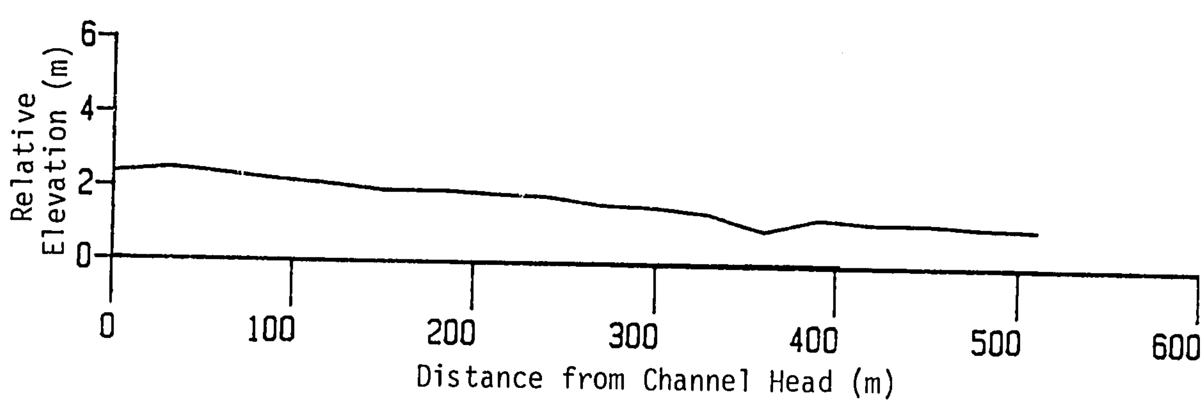


Figure B-22. Longitudinal Profile of F-Channel 6 under D-Channel 3, Block 309

A survey was conducted of the structures along F-channel 1 off D-channel 1 in block 306 to determine their condition. As for the D-channel structures, the condition of these F-channel structures was characterized as either good or bad depending upon their ability to fulfill their intended functions. The field turnout was in good condition except for the lack of its measuring device. The flow divider and four drop structures were all in good condition. As for the farm turnouts, however, only 2 out of 14 were in good condition. The majority of the farm turnouts had been willfully damaged or totally destroyed. None of the regulator or farm turnout structures had the planks for closure of the openings. The condition of a section of channel that was lined was considered poor because leaks through numerous cracks were significant.

Detailed surveys were not carried out along other F-channels, but general observations supported the survey findings as being typical. These generally poor conditions of F-channel structures should, therefore, be considered a major constraint to systematic water control at the F-channel level.

Along with the condition of structures, the general conditions of the F-channel themselves were noted. Besides the obvious erosion problems along channel bottoms, the overall condition of F-channels was considered poor. Cleaning of channels had not been done for some time. The flow of water could not even be seen along some reaches of F-channels because of the vegetative growth in the channels. Bund reformation and desilting have also been neglected.

In light of the generally poor condition of F-channels it was assured that conveyance losses might be high. Measurements of conveyance losses were, therefore, made in six of the ten studied F-channels. The summary of these measurements along with the calculated conveyance losses in percent per 100 m are provided in Table B-4. These conveyance losses varied from 3.5 to 30 percent per 100 m for the six sections measured. The average conveyance loss was 12.6 percent per 100 m. Since an average F-channel length is one kilometer, it is obvious that conveyance losses were indeed high for F-channels. These conveyance losses may be greatly reduced if maintenance practices were improved.

Another general observation was made concerning conveyance losses in F-channels. Conveyance losses tended to be the highest when the flow rate was the smallest. It would, therefore, seem logical that when a reduced supply of water is to be delivered, that the period of issue be shortened as opposed to reducing the discharge rate.

All of the farm allotments were subdivided into small level basins. In evaluating the physical condition of the farms the levelness and the size of their individual basins was considered along with crop bedding practices and cumulative intake rates.

Table B-4. Conveyance Losses of F-channels.

F-channel	Measuring Device	U/S Station Inflow (liters/sec)	D/S Station Outflow (liters/sec)	Distance Between Measuring Stations	Conveyance Loss (% per 100 m)
302/D.1/T.7	Cutthroat Flume	14.30	11.33	70 m	29.7
/T.14	Cutthroat Flume	6.23	5.24	100 m	15.9
303/D.2/T.4	V - notch	3.89	3.51	100 m	9.6
/T.14	Cutthroat Flume	18.69	16.99	100 m	9.1
309/D.3/T.1	Cutthroat Flume	26.61	25.48	122 m	3.5
/T.2	Cutthroat Flume	36.81	33.98	100 m	7.7

The use of level basin irrigation can be very efficient and effective if certain conditions are satisfied. One of the most important conditions is that the basins be truely level. For the purpose of evaluation, differences in bed elevations of less than ± 2 cm is considered level. Spot elevations were taken in a number of basins within each of the study areas; Table B-5 presents a summary of the data gathered. In order to make a relative comparison of the levelness of these basins the criteria given in Table B-6 was established. A code of 1 is associated with a basin that is considered level based upon measured elevations having a standard deviation of less than 2 cm and a maximum range of less than 4 cm. Codes of 2, 3, and 4 are used to identify progressively less level basins according to the criteria. Table B-7 presents a summary of the levelness of surveyed basins using the above described codes. This analysis was first done according to block and crop and then according to only crop for all surveyed basins. For basins in which chilies were cultivated, 16 out of 24 surveyed, or nearly 70 percent, were found to be poorly leveled. For basins in which paddy was cultivated, 15 out of 22 surveyed, or nearly 70 percent, were found to be satisfactorily leveled.

It was expected that paddy basins would be, on the average, more level than basins where chilies were cultivated simply due to the differences in land preparation practices for the two crops. Nevertheless, the general lack of levelness of surveyed basins and particularly that of basins in which chilies are cultivated suggests the probable inefficient use of water during irrigation.

Measurements of basin sizes were also taken. The summary of these measurements are presented in Table B-8. The size of basins does not significantly vary from the head to the tail of the system. The average size is about 16 m x 10 m.

Original plans specified basin sizes of 30 m x 30 m. Recent research conducted at the Maha Illuppallama Research Institute suggests that basin sizes of 10 m x 10 m be used, however. Larger basins would facilitate mechanization of cultivation practices, but smaller ones would allow more for precise leveling. The actual size of basins used would seem to be an acceptable compromise.

Basins in which paddy was cultivated had the typical flat beds. A few of these basins also had shallow furrows fanning out from the inflow point to better facilitate the spreading of water during the flooding stage of each irrigation. Narrow raised beds separated by furrows was the intended crop bedding practice to be used for upland crops. What was actually found were wide slightly raised beds separated by furrows. These upland cropping beds were found to be as large as 5 m x 5 m.

Table B-5. Summary of Basin Levelness Data

Block	Dist. Channel	Field Channel	Allotment Number	Crop	Field Size			Number of Measured Elevations	Maximum Ranges (cm)	Standard Deviations (cm)
					Length (m)	Width (m)	Area (ha)			
302	1	1	25	Chillies	10.8	8.2	0.0088	6	7.0	2.6
			25	Chillies	11.1	7.2	0.0080	6	6.0	2.3
			25	Chillies	14.3	6.7	0.0096	6	4.0	1.4
			29	Chillies	13.8	13.1	0.0181	6	8.0	3.3
			29	Chillies	11.6	10.4	0.0121	6	9.0	3.3
			29	Chillies	15.6	11.6	0.0181	6	7.0	2.8
			29	Chillies	15.2	10.8	0.0164	6	11.0	5.1
			31	Chillies	10.4	7.3	0.0076	6	14.0	5.3
			31	Chillies	17.0	14.6	0.0248	6	39.0	14.5
			31	Chillies	20.4	7.9	0.0161	6	3.0	1.3
			31	Chillies	16.2	12.2	0.0198	6	7.0	2.4
		14	102	Paddy	22.0	7.3	0.0161	6	3.0	1.2
			102	Paddy	18.5	12.5	0.0231	6	3.0	1.2
			102	Paddy				6	4.0	1.3
			102	Paddy	12.0	15.8	0.0190	6	5.0	1.7
			108	Chillies	17.4	17.4	0.0303	6	5.0	2.2
			108	Chillies	18.9	14.5	0.0274	6	7.0	2.7
			108	Chillies	17.0	15.4	0.0262	6	4.0	1.4
			108	Chillies	18.9	16.3	0.0308	6	7.0	2.7
			111	Paddy	11.6	10.7	0.0124	6	4.0	1.7
			111	Paddy				6	3.0	1.0
			111	Paddy				6	5.0	1.8
			111	Paddy				6	4.0	1.9
303	2	14	215	Chillies	12.2	9.1	0.0111	13	17.0	4.7
			217	Chillies				10	28.0	8.9
			210	Paddy	20.2	10.0	0.0202	23	3.2	0.9
		4	78	Chillies	9.8	4.9	0.0048	9	13.0	3.9
			74	Paddy	8.5	6.1	0.0052	9	4.0	1.3
			79	Chillies	15.2	6.1	0.0093	9	9.0	2.8
			83	Paddy	12.2	6.1	0.0074	9	4.0	1.3
306	1	1	383	Chillies	17.3	12.8	0.0221	16	6.0	1.8
		5		Paddy	18.0	11.3	0.0203	5	3.0	1.6
				Paddy	23.5	13.4	0.0315	5	6.0	2.7
				Paddy	11.3	10.0	0.0113	4	3.0	1.3
				Paddy	11.8	7.6	0.0090	5	8.0	2.9
307	3	0	361	Chillies	14.0	5.2	0.0073	9	6.0	2.2
			358	Paddy	15.0	13.0	0.0195	9	6.0	1.7
			367	Chillies	16.0	7.0	0.0112	9	4.0	1.5
			357	Chillies	33.0	8.0	0.0264	9	6.0	2.0
		15	251	Paddy	21.0	9.0	0.0189	9	9.0	2.8
			250	Paddy	13.0	7.0	0.0091	9	4.0	1.2
			246	Paddy	15.0	7.0	0.0105	9	7.0	2.0
309	3	2	141					11	94.0	32.0
			145					11	60.0	23.0
		6	224					9	1.0	0.5
			219					9	2.0	0.7

Table B-6. Codes for Evaluation of Basin Levelness.

Criteria	Condition	Code
STD <= 2 cm & Range <= 4 cm	Good	1
STD <= 2 cm & Range > 4 cm	Satisfactory	2
STD > 2 cm & Range <= 4 cm	Not Satisfactory	3
STD > 2 cm & Range > 4 cm	Poor	4

Table B-7. Basin Levelness - Analysis Based on Blocks and Crops.

Block	Crop	No. of Basins	Code			
			1	2	3	4
302	Chili	15	3	2	0	10
	Paddy	8	5	1	1	1
303	Chili	4	0	0	0	4
	Paddy	3	0	3	0	0
306	Chili	1	0	0	0	1
	Paddy	4	2	0	0	2
307	Chili	3	1	1	0	1
	Paddy	4	1	2	0	1
309	Chili	1	1	0	0	0
	Paddy	3	1	0	0	2
Overall	Chili	24	5	3	0	16
	Paddy	22	9	6	1	6

Table B-8. Average Farm Basin Sizes.

Block	Location	No. of Samples	Ave. Length (m)	Ave. Width (m)	Ave. Area (sq. m)
302	Head	6	15.42	8.98	138.49
	Middle	8	16.06	13.68	219.57
	Tail	5	15.11	10.54	159.25
303	Head	3	12.40	6.69	82.98
	Middle	2	10.37	6.10	63.23
	Tail	1	20.20	10.00	202.00
306	Head	1	17.30	12.80	221.44
	Tail	4	16.15	10.58	170.79
307	Head	3	23.33	8.00	186.67
	Middle	3	13.33	8.50	113.33
	Tail	1	15.00	7.00	105.00
Overall	Head	13	16.70	8.52	143.00
	Middle	13	14.55	11.31	171.00
	Tail	11	15.90	10.20	162.00
	Average	37	15.70	9.97	158.00

Cumulative intake rates of different soils in the study area were measured; Figures B-23, B-24, and B-25 present the data gathered. This data is extremely limited, not only because of the few number of tests conducted, but also because of the lack of supportive information collected. The supportive information necessary to make direct comparisons possible includes water table depths and soil moisture contents at the time of testing. In spite of these limitations one observation can be made from these test results. It could take from 10 to 120 minutes to apply a depth of 6.4 cm, the design depth of irrigation, according to the cumulative intake measurements made. This observation strongly suggests that broad generalization might not be appropriate when assuming required irrigation durations.

Actual Operation--F-channels were to be operated on a rotational basis by the farmers. In the majority of the turnout areas, however, no rotational scheme was being used. The head end farmers tended to take all of the water they wanted for as long as they wished while tail end farmers got whatever was left. Since farm turnout structures were in such poor condition, farmers often cut openings in the F-channel banks to obtain water. This practice tended to contribute to the overall poor condition of the channels and increased conveyance losses. This lack of cooperation among farmers was the most obvious manifestation of the non-existance of an effective farmer organization at the turnout level.

The irrigation of paddy is accomplished by flooding the upper most basin until a depth of about 4 cm is established. Water is then allowed to flow through an opening in the dike of the basin down to the next lower basin. This process is repeated until all basins have been flooded and a depth of about 4 cm maintained in each. The openings in the dikes between basins are then closed starting from the most downstream basin and working back to the upper most basin.

Although upland crops, particularly chilies, were to be irrigated using furrows between narrow raised beds, they too are being irrigated by flooding the entire basins. The process used is similar to that used for paddy with a few modifications. One change is, as described previously, to use ditches within the basin. A ditch usually borders the entire basin and then additional ditches criss-cross or longitudinally divide the basin into wide slightly raised beds. As with paddy, each basin is flooded starting at the highest and moving down to the lowest. Another modification is that each basin is flooded until all of the high spots are covered and then it is allowed to completely drain out. Once a basin has been irrigated the ditches allow for the drainage of water to avoid standing water after irrigation. As an irrigation progresses, the ditches of upper basins are used to convey water to lower ones.

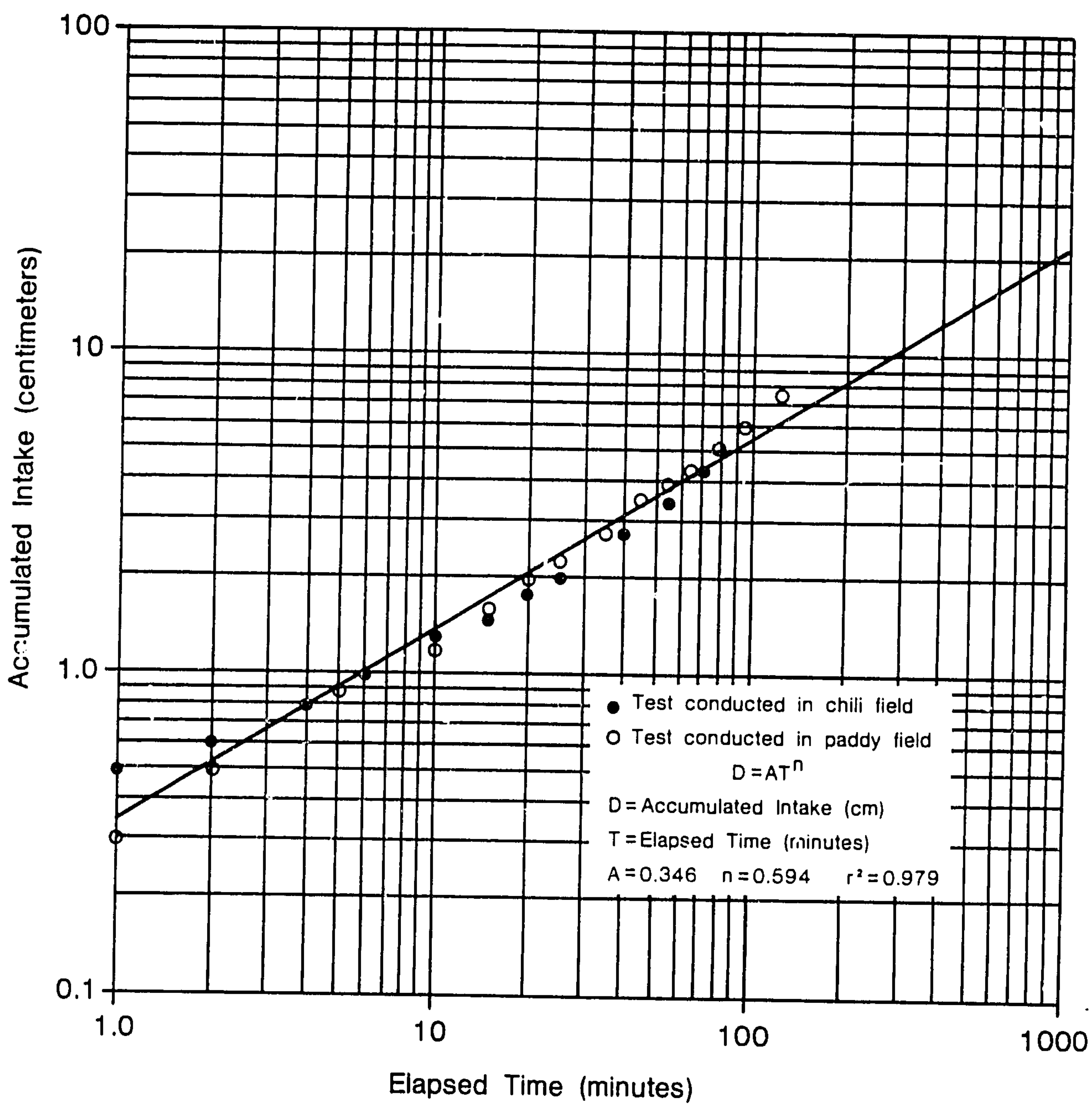


Figure B-23. Cumulative Infiltration Measured at Two Locations in Block 306 Served by D-channel 1.

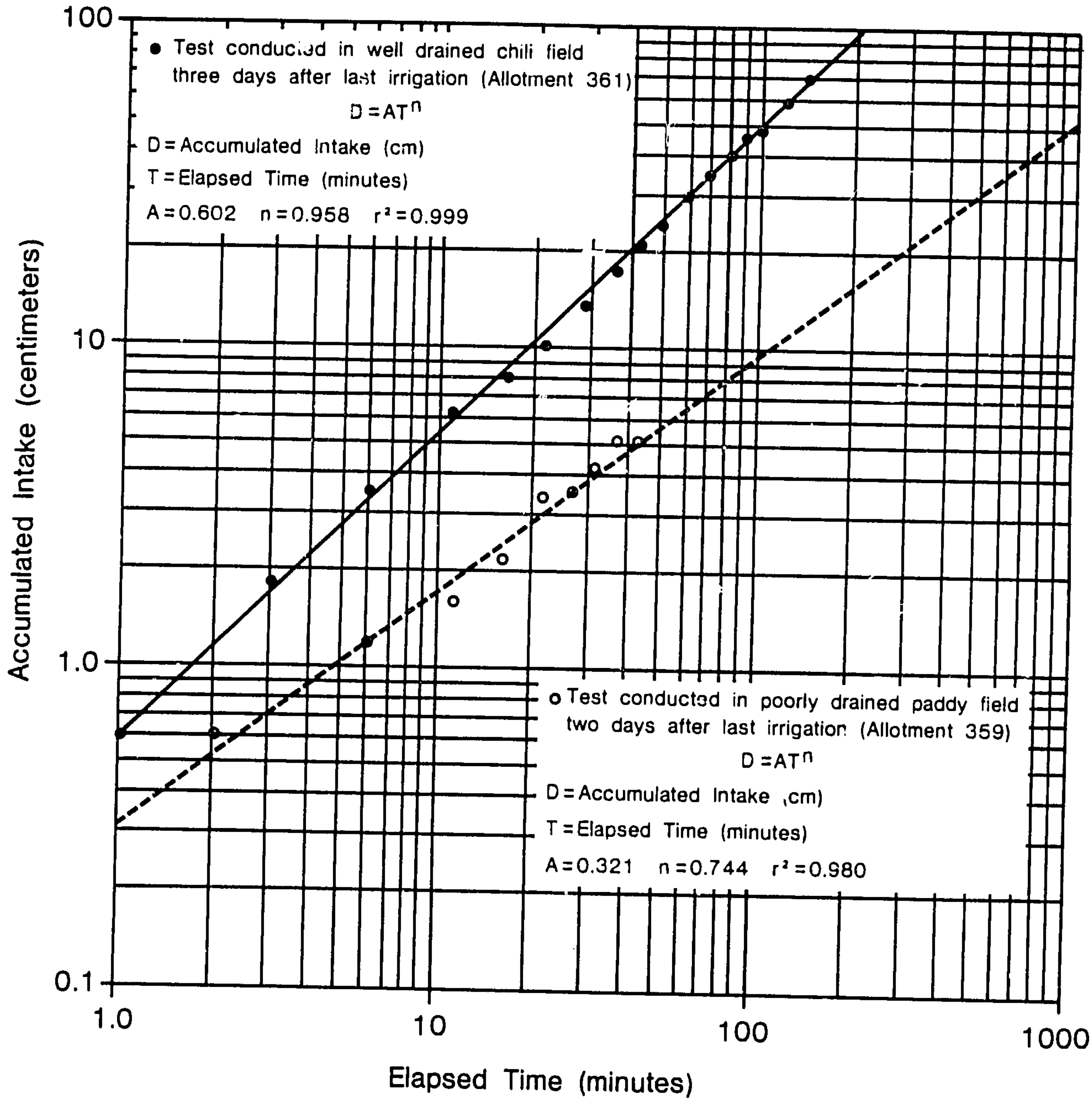


Figure B-24. Cumulative Infiltration Measured at Two Locations in Turnout 0, Block 307, D-channel 3

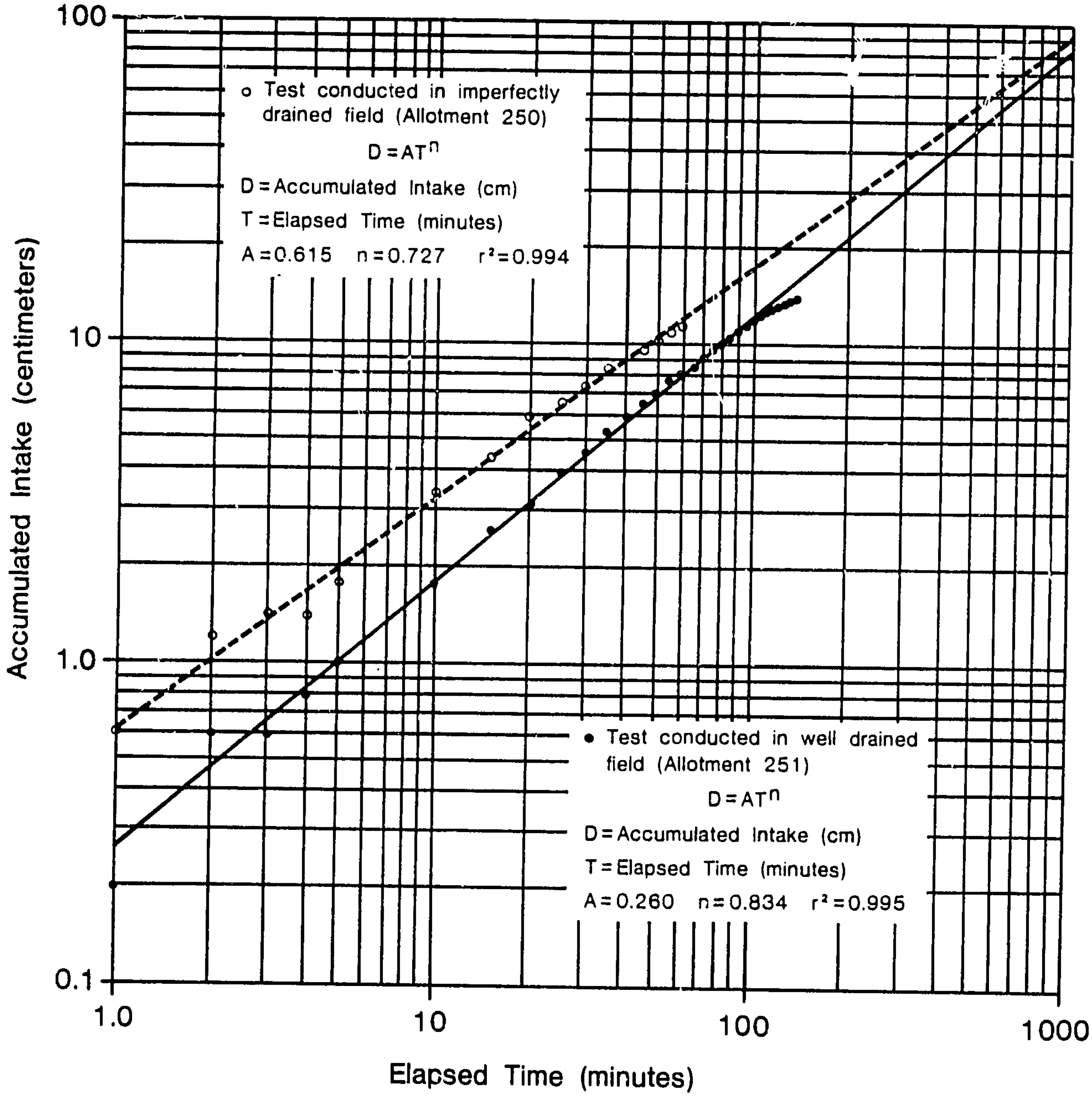


Figure B-25. Cumulative Infiltration Measured at Two Locations in Turnout 15, Block 307, D-channel 3

Because of the above observed irrigation practices it was assumed that irrigation efficiencies would generally be low. Irrigation evaluations were, therefore, planned to verify this assumption. As a result of cut-backs in issues at the time of the detailed studies, however, sufficient evaluations were not carried out for conclusions. The limited data that were collected are given in Table B-9. Although this suggests that farmers were applying the correct amounts of water, it would be necessary to make observations throughout an entire irrigation season, and at many more locations before conclusive statements could be made concerning the efficiency and effectiveness of irrigation practices. Also, the application efficiencies given in Table B-9 were calculated assuming uniform distribution of water. Again, because of the irrigation practices used this assumption was undoubtedly in error, and soil moisture measurements taken in one basin confirmed this. This soil moisture data is presented in Table B-10. Additional measurements should be made to determine distribution uniformity to compliment application efficiency determinations in order to have a complete evaluation of irrigation practices.

Although the irrigation evaluations conducted did not suggest that over irrigation was occurring, measurements of water table elevations and fluctuations, presented in Table B-11, suggests this to be a strong possibility. It should be noted from the data that the water table would rise considerably, immediately after irrigation in upper and middle slopes. This rise would occur in lower slopes following a lag time and then continue to rise for 2 to 3 days after the end of the irrigation. The water table in upper and middle slopes ranged from 25 to 40 cm depth for 3 to 4 days after an irrigation. Since the root zone depth for chilies is about 60 cm, these high water tables will have a detrimental effect on plant growth.

These high water tables strongly suggest that over irrigation is indeed occurring. There are other causes, however, that may also be contributing to the high water tables. Although no irrigations were carried out in block 307, rises in the water table can be seen that coincided with issues to the D-channel during the ninth and tenth of July.

c. Drainage System

The design farm layout includes a drainage ditch along the down slope edge of every allotment leading to the turnout drain. This would provide a way to drain away excess water that would otherwise cause a problem for the next allotment. These farm drains were not seen to be used, however. Some farmers had excavated drains along the up slope edges of their allotment, though, in order to prevent the intrusion of seepage water from adjacent allotments.

Table B-9. Water Application Efficiencies in Three Turnout Areas

Turnout Area	Allotment No.	Position of Slope	1	2	3	4	5	6	7	8	9
			Moisture at Field Capacity (%)	Moisture Prior to Irrigation 0-30 cm (%)	Moisture Prior to Irrigation 30-60 cm (%)	Bulk Density (g/cu. cm)	Water Stored 0-30 cm (cm)	Water Stored 30-60 cm (cm)	Water Deficit in Root Zone (cm)	Water Applied (cm)	Application Efficiency (%)
302/D.1/T.7	27 (Chili)	Upper	20	15.0	18.0	1.50	2.25	0.90	3.15	5.07	62.1
302/D.1/T.7	27 (Chili)	Lower	--	--	--	--	--	--	--	6.90	--
303/D.2/T.4	78 (Paddy)	Upper	--	--	--	--	--	--	--	7.00	--
306/D.1/T.1	383 (Chili)	Upper	22	15.8	12.9	1.58	2.95	4.31	7.26	6.60	100.0

-- Data not available

Table B-10. Soil Moisture Content Data from a Basin in which Chilies were being Cultivated.

Depth (cm)	Percent Moisture Content One Day Before Irrigation*		Percent Moisture Content Three Days after Irrigation**	
	At the Center of the Basin	At the Edge of the Basin	At the Center of the Basin	At the Edge of the Basin
15	12.74	19.97	--	--
30	14.23	16.17	16.70	19.30
45	11.90	15.80	--	--
60	10.40	13.80	--	--

* Depth of water table one day before irrigation was 100 cm.
** Depth of water table three days after Irrigation was 56 cm.
-- No data available.

Table B-11. Water Table Fluctuations

Turnout Area		Depth of Water Table from the Surface (cm)									
		July									
		6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
302/D.1/T.7	Upper Slope		25*	25*	26*	30	36	45	62	30	25*
	Middle Slope		15	18	18	20	25	26	26	20	15
	Lower Slope		0	0	0	0	5	5	7	7.5	--
302/D.1/T.14	Upper Slope		20*	18*	19*	25	30	34	48	35	26*
	Middle Slope		10	8	10	16	20	22	24	10	8
	Lower Slope		0	0	0	1.5	3	4.5	6	3.5	0
303/D.2/T.4	Upper Slope	40**	32**	32**			56**	72**	74**	70**	33**
	Middle Slope		- 4	- 1			5	8	15	20	18
	Lower Slope		100	65			8	12	14	17	19
303/D.2/T.14	Upper Slope		68**	11**I			59**	94**	100**	78**	85**
	Middle Slope		50	52			69	78	83	90	80
	Lower Slope		- 31	- 3			- 2	- 2	6	44	40
306/D.1/T.1	Upper Slope		103	100	33	43	56	64	36	38	39
	Middle Slope		80	60	46	46	41	40	44	46	49
	Lower Slope			19	14	10	8	24	26	22	20
306/D.1/T.5	Upper Slope				40	- 2	- 1	0	4	11	15
	Middle Slope				28	-12	- 9	- 7	- 4	- 2	- 1
	Lower Slope				60	-10	- 8	- 6	- 1	9	12
307/D.3/T.0	Upper Slope	77*	60*	40**			34	56	72.5	71	77
	Middle Slope	100	75	81**			69	74	85	94	> 100
	Lower Slope	115	108	109**			96	96.5	94	96	> 115
307/D.3/T.15	Upper Slope		118	105			84	104	114	118	> 118
	Middle Slope		118	100			94	102	112	118	> 118
	Lower Slope		106	95			86	85	85	116	> 118
309/D.3/T.2	Upper Slope			112			69	74	79	94	
	Middle Slope			71			25	38	41	51	
	Upper Slope			71			46	55	56	61	
309/D.3/T.6	Upper Slope			89			25	46	51	56	
	Middle Slope			51			15	20	31	41	
	Lower Slope			76			46	56	81	94	

* Water in D-Channel ** Water Issued to Field Turnout I Land Irrigated

The turnout drains were in very bad condition. The available drains were shallow and overgrown with vegetation. Farmers did not seem to care whether drains were maintained or not. It was also noted that some drains were being blocked and the water collected to supplement irrigation water for tail end allotments. The condition of drainage channels suggest that they are unable to serve the purpose for which they are intended. The existence of high water tables and salinity problems in the lower slopes support this conclusion.

C. Economics

1. Introduction

The purpose of an interdisciplinary diagnostic analysis is to gain a thorough understanding of how an irrigation system operates. The primary role of economics in this analysis is:

(1) To identify land use and cropping patterns, current input and production levels, and income characteristics for the area;

(2) To identify the technical, institutional, infrastructural, and economic constraints to farm productivity and income optimization; and

(3) Based on the above, to suggest measures which could be implemented to improve the productivity and standard of living in the area.

2. The Data

The data gathered by the team economists were restricted to the major crop enterprises of the 1982/83 Maha and Yala seasons. In Maha it is common practice for all of the irrigable command area to be planted in paddy, and the cultivation practices do not vary significantly from year to year. However, during the Yala season, the cropping pattern and production information is very important, as different crops are grown according to the soil types and water availability in the region. With this in mind, even though data were gathered for both seasons, only the Yala season data were analyzed by microcomputer for this report. Wherever appropriate, however, general observations, and 1981/82 Maha season observations, have been taken into consideration to describe the prevailing economic situation of the region.

3. Water Management - Bethma

The expected amount of rainfall was not received in the catchment areas of the Mahaweli River basin prior to the 1983 Yala cultivation. As a result, the volume of water stored in the main reservoir was not sufficient to irrigate, for cultivation, the entire command area. After discussing with the farmers the possible management strategies, the Mahaweli Project Management took measures to issue water for only half of the field turnouts. Under this system, two farmers--the original owner of the allotment and a partner farmer from another turnout--share one allotment.

This system is known as the bethma cultivation system and was officially implemented for the first time during the 1982/83 Yala season in the study area. Preliminary observations indicate that the bethma system may be an economically viable solution to water scarcity for the region. (Before more definite conclusions can be reached it will be necessary to do a more complete study of the economic effects of the system.)

4. Cropping Patterns

Maha and Yala are the two cropping seasons in Sri Lanka. Maha, the rainy season, begins in October and ends in April-May, and Yala, the dry season, begins in June and ends in September. Maha is the main cropping season for the region surveyed, and during this season farmers do not face severe problems of water scarcity as they receive rainfall as well as supplemental irrigation water. Due to the seasonal water constraints and the existing soil characteristics, one expects to see paddy cultivation in all areas of every turnout in the study area for Maha. In Yala, on the other hand, other field crops (mostly chilies) are grown at the head of field turnouts where soils tend to be well drained and imperfectly drained, and paddy is grown at the tail of field turnouts where poorly drained soils predominate.

The cropping pattern trend described above was observed for the 1982/83 Maha and 1983 Yala seasons in the study area. The extent of chili cultivation in Yala decreased from the head to tail of field turnouts. Conversely, the area under paddy increased towards the tail. The figures in Table C-1 illustrate this trend. There were, however, exceptions observed where, for instance, only paddy would be grown at the head of a field turnout.

Table C-1. Head to Tail Cropping Pattern Within Field Turnout Areas - Yala.

Relative Position	Average Area (hectares) in Chilies	Average Area (hectares) in Paddy	Average Area (hectares) Cropped
Head	0.25	0.31	0.56
Middle	0.15	0.42	0.57
Tail	0.15	0.35	0.50

5. Land Preparation

Land preparation for paddy may involve tractor power, draft power, human labor or any combination thereof. Farmers commonly begin the land preparation process when the first irrigation water for the season is issued, and the usual preparation sequence is plowing, puddling, and then levelling.

In the case of other field crops, land preparation primarily involves the use of tractor power and/or human labor. The clearing and plowing involves either animal or machine power, while flatbeds or ridges and furrows are formed manually to make the land ready for planting.

In the case of other field crops, if a two-wheel or four-wheel tractor was used for plowing, the average cost was Rs 1,235 per hectare. For paddy cultivation, an additional expenditure of Rs 618 per hectare was required for puddling and levelling. On the other hand, only Rs 1,235 per hectare was required to complete the entire land preparation process using draft power provided by water buffalo. The animal draft method does, however, require a greater time and labor commitment than the two- or four-wheel tractor.

For Yala 1983, most paddy farmers (65%) used two-wheel tractors for land preparation. The percentages of farmers who have used animal draft, four-wheel tractors or manual labor are 13 percent, 10 percent, and 2 percent, respectively. The remaining 10 percent of the farmers have used a combination of the above mentioned methods.

The primary reasons identified by the farmers interviewed for using two-wheel tractors were as follows:

(1) The two-wheel tractor is the most available resource.

(2) It takes less time to complete land preparation with a two-wheel tractor than with any other method. (For a two-week land preparation period, irrigation water is issued continuously. Thereafter, a rotation schedule is maintained. Therefore, it is important to complete land preparation as quickly as possible.)

(3) The two-wheel tractor has a minimum labor requirement. If a two-wheel tractor is hired, the farmer has only to inspect the work and he need not hire additional labor. On the other hand, animal draft power requires nine to twelve labor units per hectare for guiding the animals.

Four-wheel tractors have time and labor advantages for land preparation similar to those of the two-wheel tractors, but they were not popular. The lack of popularity is due to an availability constraint and the difficulties involved in their operation on small allotments of 1 hectare.

In considering chili cultivators, the greatest percentage (43%) used only manpower (using *mammoties*). Thirty-seven percent used only two-wheel tractors, 10 percent used four-wheel tractors, and 8 percent used animal draft power. The remaining 2 percent used a combination of these methods.

The higher percentage of manpower use observed among chili cultivators appears to result from the more limited extent of the cultivation. This limit is due, in part, to the *bethma* system. The *bethma* system may affect the economic choice between available technologies for the land preparation phase of the production process.

6. Crop Establishment

Transplanting and broadcasting are the most commonly adopted methods of crop establishment for paddy cultivators during both *Yala* and *Maha*. If transplanting is done, a nursery must be established and good management practices applied. In *Yala* 1983, only 7 percent of the paddy farmers interviewed practiced the traditional method of transplanting. These farmers planted their own nurseries at an average cash cost of Rs 75.

Transplanting has several advantages over broadcasting as a crop establishment method. When transplanting is adopted, a fine surface texture is not as critical, weeds are controlled more successfully and higher yields are often obtained. However, farmers are reluctant to use this method in *Yala* due to the high labor requirement and the inconvenience. Transplanting is the most labor intensive operation for paddy cultivation; on the average, 45 man-days per hectare are required. Broadcasting is a more convenient, less labor intensive method; only 1-2 man-days per hectare are required. As a result, most farmers adopted broadcasting as the establishment method for paddy in the *Yala* season.

In contrast, for chili cultivation, transplanting is the only method adopted. Almost all of the chili cultivators interviewed established their own nurseries to provide seedlings for cultivation, as there is no other source of young plants. In the study area, interviewers found farmers to be experienced in maintaining nurseries, and thus, using good management practices. On the average 36 man-days per hectare were required for transplanting, and on the average, the cash cost for a chili seedling nursery was Rs 70 for *Yala* 1983. The transplanting was usually done on flat beds--very few farmers adopted ridge and furrows.

7. Weed Control

Among paddy cultivators, weed control was primarily achieved through the use of herbicides. Of the paddy farmers interviewed during *Yala* 1983, 85 percent used herbicides for weed control, and the other 15 percent used the standing water method of control, due to the high cost of the chemicals. However, the standing water method of control could only be used at the tail of the field turnouts, as the soils of the head locations were too well drained to employ this method. During the study period, the average cost for herbicides and sprayer was Rs 301 per hectare for paddy weed control in 1983 Yala. If a farmer had used the recommended dosage, his cost for chemicals and sprayer would actually have been RS 1,111 per hectare. The low average cost observed, shows clearly that few farmers are using the recommended dosages.* This may be due in part to a lack of knowledge, but the high cost of herbicides is primarily to blame. This practice resulted in poor weed control.

Though poor weed control was often a problem among the paddy farmers interviewed, the average amount spent for herbicides by farmers at the tail locations is somewhat higher than the amount spent by those at the head ends (within field turnouts)--Rs 346 per hectare versus Rs 272 per hectare. Among field turnouts however, the head-tail comparison of herbicide application was not consistent as illustrated by Table C-2.

Table C-2. Cost of Herbicides and Sprayer per Hectare - Paddy

Block/ D-channel	302 / D.1		303 / D.2		306 / D.1		309 / D.3		307 / D.3	
Turnout	T.14	T.7	T.4	T.14	T.1	T.5	T.2	T.6	T.0	T.15
Head/Tail	H	T	H	T	H	T	H	T	H	T
Rs per hectare	264	208	368	175	225	284	146	494	338	437

All of the chili cultivators interviewed practiced weed control, but it was primarily done manually, as appropriate herbicides are not available. The number of weedings varied from four to six per season. For chili cultivators weed control is the most serious and costly problem of cultivation. At the time of the survey, most farmers had not completed the weed control process. However, on the average, 34 man-days (family labor and hired labor) had already been devoted to the practice. Labor costs, including payment in kind, had reached an average of Rs 1,531 per hectare.

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* The recommended dosage per hectare is: 34 DPA - 7.4 to 9.9 litres
60% MCPA - 1.2 litres

8. Pest and Disease Control

Approximately one half of the paddy cultivators and 85 percent of the chili cultivators interviewed reported that they employed disease and pest control practices, and both groups used chemicals. The average cost per hectare of the pesticides used was Rs 99 for paddy, and Rs 1,428 for chili. For the *Yala* season, a significant difference in pesticide use was observed among field turnouts, as well as within field turnouts, for chili crops. Within field turnouts, the average expenditure per hectare for pesticides in the head locations was Rs 1,482 while at the tail locations the figure was Rs 1,111. Among field turnouts, in every D-channel observed, except block 303/D.2, the head locations reported greater expenditures for pesticides (See Table C-3).

Table C-3. Cost Per Hectare (Rs) of Pesticide and Sprayer for Chili

	307/D.1	303/D.2	306/D.2	309/D.3	307/D.3
Head	1156	642	1677	1388	1403
Tail	531	2515	931	790	--

No significant difference in pesticide use was observed among turnouts, or within field turnout areas, for *Yala* paddy cultivation.

9. Seed

All of the paddy and chili cultivators interviewed reported the use of newly improved high yielding varieties. In addition, paddy cultivators commonly used long-maturing varieties (3 1/2 to 4 1/2 months) in *Maha* and quickly-maturing varieties (3 to 3 1/2 months) in *Yala*. This is due to the varying availability of water. In *Maha* farmers generally receive constant and sufficient water over a longer period, while in *Yala*, farmers may receive less water over a shorter period. When appropriate, the longer-maturing varieties generally show higher yields.

In considering the source of seed paddy, 92 percent of the farmers used own-source seed in *Yala*, and 4 percent used seeds obtained from various other sources: private dealers, Unit Managers, and the Agrarian Services Center (ASC).

Although the use of high yielding seed was reported, farmers were not receiving the expected yields from the hybrid varieties. The continuous use of own-source seed (seed saved from the previous harvest season) is assumed to be diluting the hybrid yield qualities of the seed. This may be a contributing factor to lower yields, although the lower yields may be further explained by other crop management practices. Reasons for the continued use of own-source seed were identified as follows:

(1) The price of seed paddy issued by the Agriculture Department of Sri Lanka is considered by the farmer to be expensive (Rs 4 per kilogram), and many farmers do not intend to spend the necessary funds for seed materials, especially during _Yala_ when yields are traditionally lower and the risk/uncertainty factor is greater.

(2) There is not a sufficient supply of the hybrid seeds available to meet the seed requirements of all cultivators. This shortage is a result of Sri Lanka's current inability to produce the required quantity of the newly improved high yielding seed paddy.

The average quantity of seed paddy used in _Yala_ was found to be 140 kilograms per hectare. This figure is somewhat higher than the Department of Agriculture's recommendation--102 kilograms per hectare for broadcasting. Using more than the recommended amount of seed was a common practice in the study area, as farmers believed they could ensure increased yields in this manner.

A distribution of chili cultivaters according to their use of different seed sources is given in Table C-4 below.

Table C-4. Seed Source for Chili Cultivators

Source of Seed	No. of Farmers	% of Farmers
1. A.S.C.	02	04
2. Unit Manager	23	47
3. Dept. of Agriculture	11	22
4. Private trader	05	10
5. Own	08	17
TOTALS	49	100

There should be no quality difference in the seed from the first three sources, as they are all produced by the Department of Agriculture, and only 17 percent used own-source seed. The average cost of chili seed was Rs 104 per kilogram. The average reported amount of seed used per hectare was 1.5 kilograms, which is very similar to the Department of Agriculture's recommendations.*

10. Income

At the time of data collection, chili cultivators had spent an average of Rs. 9,080 per hectare on the production process (land preparation, weed and pest control, planting, labor etc.), and it was estimated that an additional Rs 3,100 per hectare would be required to complete the cultivation process, bringing the total average expenditures to Rs 12,180 per hectare. Considering an expected average yield of 1,567 kilograms per hectare (Agriculture Department report - 1981 *Yala* chili yields), and the average market price of Rs 22 per kilo, the expected average net income (returns to family labor, land and management) per hectare for dry chili is Rs 22,272. Income realized may vary from head to tail within field turnout areas according to crop management and irrigation practices as well as the inherent soil conditions.

For paddy production, at the time of the survey, an average of Rs 3,856 per hectare had been spent, and it was estimated that an additional Rs 1,544 per hectare would be expended to complete cultivation. Using an estimated average yield figure of 3,170 kilograms per hectare for paddy (Agricultural Department report - 1981 *Yala* paddy yields), and an expected market price of Rs 2.87 per kilogram, an average net income per hectare of Rs 3,700 can be calculated. Again, net income may vary according to location, when different cropping conditions exist, and different crop management practices are employed.

It should be noted that these average cost figures do not include interest payments, which can range from 9 percent per annum to 35 percent per month depending on the source of the loan. Also, the net income figures give no indication of what the farmers actual cash flow may be. For a farming operation the timing for cash investment is critical, and an income per hectare figure gives no insight to the timing of cash receipts.

11. Credit

Credit is an essential input for farmers in the study area; especially for chili cultivators as they require a larger capital outlay than do paddy farmers (The capital outlay required for chili is nearly twice that required for paddy). However, as many farmers (55%) had

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* The Department of Agriculture recommends 1.2 kilograms per hectare.

previously defaulted on a government sponsored loan, they were unable to obtain low interest institutional loans. (The annual interest rate is 9 percent for institutional loans obtained for agricultural purposes.)

The most common reasons for not obtaining institutional loans, and the percentage of farmers interviewed who cited those reasons, are presented in Table C-5.

Only about 3 percent of the paddy cultivators interviewed obtained institutional loans for the 1983 Yala season, and on the average, the loans came to Rs 1,625 per farmer. Eleven percent of the chili cultivators interviewed obtained institutional loans, and those loans averaged Rs 3,241 per farmer.

Table C-5. Farmer Response to Why Institutional Loans Were Not Obtained

Reasons	Percentage of Farmers Citing Reason
Previous default	55%
Credit not needed	25%
Not the original landowner	17%
Difficult loan application procedure	3%

The standard loans offered by institutional sources for paddy and chili are Rs 4,015 and Rs 9,822 per hectare, respectively. However, the total amount of the loan is not given to the farmer as a lump sum. The loan is released to the farmer in several installments which should correspond in time and value to the capital needs of each stage of cultivation. This procedure has been designed to prevent the misuse of loan funds. These loans must be repaid in cash, and when government marketing services are used by the farmer, repayment becomes automatic as the debt is subtracted from his crop receipts.

Through informal discussions, it was learned that many of the defaulters, as well as other farmers in the area, borrowed considerable sums from relations, friends and/or private traders. Farmers were, however, reluctant to disclose the actual amounts they had borrowed from these sources or the interest rate they were charged on these loans. The most significant borrowing was from private traders, who are known to charge exhorbitant rates of interest--often 20 to 35 percent per month. Farmers must repay such loans in cash or kind. The inadequacy of existing finance and credit mechanisms is another obstacle to farmers who are striving to maximize the returns to production.

12. Production Levels

The study region is well known for chili cultivation, as chili yields obtained in the area tend to be satisfactory. Chili is primarily grown during the *Yala* season, and at the time of the survey, chili cultivations were 7-12 weeks old. It was observed by the Diagnostic Analysis teams that in general, chili farmers seemed to employ good crop management practices. On the other hand, many paddy cultivators were lax in adopting good crop management practices. This may be due in part, to experiences with crop failures brought about by the water shortages faced during previous *Yala* seasons. Because this element of risk has prevailed for several *Yala* seasons, farmers generally displayed more concern for proper paddy crop management during the *Maha* season.

Farmers who cultivate both paddy and chili during *Yala*, have to devote more effort to their chili crop, as more time is consumed in crop management practices for this crop than is necessary for paddy--this is evident when labor-use figures for the two crops are considered. Farmers also know that the income received from a successful chili crop could be greater than the income earned from a comparable paddy crop. As a result of this earning differential, and the water constraint, it appeared that *Yala* paddy cultivations were often neglected.

Due to problems of questionnaire design and administration, 1982 *Yala* yield data, and the 1983 expected yield figures collected in this 1983 survey are inadequate for strict analysis procedures. However, based on the limited number of reliable responses which were obtained, it appears that the actual 1981 yield figures for System H are reasonable indicators of the 1982 and 1983 *Yala* production situation in the study area. According to Agricultural Department reports, the average yield for paddy and chili in *Yala* 1981 was 3,170 kilograms per hectare and 1,567 kilograms per hectare, respectively. These are average yield figures for the entire area; a breakdown of average yields by location would be expected to reflect the different crop management practices adopted, as well as varying soil and water conditions.

13. Labor Utilization

Labor is a very important input for agriculture in the study area. Farmers spend a considerable portion of their available cash for hired labor. On the average, the cost of a hired man-day is Rs 25. Meals are also supplied to the laborer, bringing the total cost of a hired man-day to about Rs 33. According to the findings of the sociologists, about 85 percent of the farmers in the study area use hired labor. Of the other 15 percent, some used only their own family labor and others used family and aththam labor (exchange labor). The use of aththam labor, however, is not common in the area.

Tables C-6 and C-7 show the cumulative average labor utilization for various cultivation practices to the time of the survey.

Table C-6. Labor Utilization for Chili - Yala 1983 (Man-days per Hectare)

Cultivation Practice	Family Labor	Hired Labor	Total
Nursery	14.26	3.81	18.07
Land preparation	33.92	40.27	74.19
Crop establishment	19.75	16.27	36.02
Fertilizer application	20.27	26.5	46.77
Weed control	35.25	48.53	83.78
Pest and disease control	12.73	6.08	18.81
Totals	136.18	141.46	277.64

Table C-7. Labor Utilization for Paddy - 1983 Yala (Man-days per Hectare)

Cultivation practice	Family Labor	Hired Labor	Total
Nursery	1.11	.27	1.38
Land preparation	15.72	16.32	32.04
Crop establishment	5.02	8.55	13.57
Fertilizer application	3.07	.40	3.47
Weed control	2.03	.82	2.85
Pest and disease control	1.01	.40	1.41
Totals	27.96	27.03	54.99

14. Fertilizer Application

The three types of fertilizers used for paddy cultivation were "basal mixture", commonly known as "V-mixture", urea, and "top dressing mixture". The majority of paddy farmers use newly improved high yielding varieties of paddy which respond well to fertilizers, and most of the cultivators interviewed use urea. The response of plants to this fertilizer can be clearly seen within a relatively short time after application. Although the basal and top dressing mixtures should be used in conjunction with urea for the optimal health and growth of paddy, the response to these fertilizers is not as apparent, and as a result, farmers who lack complete knowledge of fertilizer use and benefit are often reluctant to use the basal or top dressing fertilizers (especially the "basal mixture").

The fertilizer mixture used by most chili cultivators is known as "chili-fertilizer-mixture". At the time of the survey, the chili cultivators had applied 3 to 5 top dressings to their cultivations. Chili crops are normally given 10 to 12 top dressings during the season. When this data was collected, it seemed clear that farmers at the head of field turnouts of the D-channels, except for 303/D.2/T.4, used more fertilizer than farmers at the tail of turnouts. However, overall, only 19 percent of the chili cultivators used basal fertilizer, and there was no clear differential trend of basal fertilizer use along the D-channels or within turnout areas. Only the 302/D.1/T.14, 309/D.3, and 307/D.3 farmers used basal fertilizer.

In contrast, 87 percent of the chili farmers used top dressings. Overall an average of 377 kilograms per hectare was applied for chili at the time of the survey. This was considered to be a satisfactory application rate, and if farmers continued with this rate, they may increase their expected yields.

In considering overall fertilizer usage for chili cultivation, a clearly declining trend from head to tail was observed within field turnout areas (Table C-8).

Table C-8. Fertilizer Application for Chili Cultivation - Within Turnout Areas

Average	Head	Middle*	Tail	Average
Fertilizer cost Rs/hectare	1256.7	1596.7	1058.4	1267.0
Quantity Applied kilo/hectare	417.38	529.36	356.3	422.5

*Head, middle and tail were determined by relative irrigation position; however, most middle position allotments actually have head soil conditions.

Table C-9. Fertilizer Application for Paddy Cultivation - Within Turnout Areas

	Head	Middle	Tail	Average
Fertilizer cost Rs/hectare	558.1	681.1	791.2	689.6
Quantity Applied kilo/hectare	188.3	229	270	234

15. Marketing

There is a government declared guaranteed price for paddy which is paid by all of the government sponsored marketing agents--Paddy Marketing Board, Cooperatives, and the Project Management sales points. Though this guaranteed price exists, it is evident that most farmers sell their paddy harvest to private traders at lower prices. This seemingly illogical preference can be attributed to the following factors:

(1) Some farmers are bound to sell their harvest to private traders in order to repay loans obtained from the traders.

(2) Private traders deal at the farm gate, and this eliminated transport problems and further costs for the farmer.

(3) Private traders pay farmers in cash immediately upon completion of a sale. At government outlets, vouchers are given which must be cashed at a commercial bank. At the time of cashing, the bank may withhold any amount owed in payment of a loan.

(4) Government outlets do strict quality control, and if farmers sell to these outlets, they have to process the paddy in order to minimize the moisture and empty seed percentages. Private traders do not adhere to such strict standards, and this is more convenient for the farmer.

The 1982 Diagnostic Analysis Workshop report lists these same reasons for avoidance of government marketing opportunities. This consistency indicates an enduring marketing problem.

Although these advantages to trade with private dealers do exist, it is widely speculated that in addition to paying a lower price for paddy, private traders use short weights and measures. This may offset the lower transportation and processing costs, preventing the farmer from maximizing the returns to his harvest.

One marketing practice employed by some farmers to increase the returns to their crop, is the withholding of the crop from the market at harvest time. Prices tend to be lower (for paddy as well as other crops) during harvest periods, rising as the crop year progresses. Some farmers are able to benefit from this price fluctuation by storing their crop and selling when prices are higher. Most farmers cannot adopt this practice as they need cash immediately after harvest to repay loans and begin the next seasons cultivation. There is also a reluctance among some farmers to trust the up-swing pattern in the price fluctuation cycle.

Until 1981, there was no formal government sponsored marketing mechanism or guaranteed price for chili. For the 1981 and 1982 Yala seasons, steps were taken to improve the chili marketing procedures in the study area. Mahaweli Authority officials, after discussions with Cooperative Wholesale Establishment (C.W.E.) officials, fixed a guaranteed purchase price for dry chili. That price was communicated to the farmers either prior to the growing season or in mid-season by the Unit Manager. Under this system, farmers had a guaranteed price and market for their chili crop. However, if free market prices rose during the marketing period farmers tended to sell their harvest to private buyers. This situation prevailed during the 1981 and 1982 seasons, and the C.W.E. did not receive the expected quantity of dry chili. For the 1983 Yala season the Mahaweli Authority has not made any marketing arrangements with the C.W.E.

For the 1983 Yala season a contract marketing pilot project was planned for the study area, and at the time of the Diagnostic Analysis survey this arrangement was being carried out. To set up the contract plan, Mahaweli Authority officials first met with Sri Lanka Export Development Board officials, and through the Export Development Board agreements were made with several green chili exporters. Exporters depend heavily on Mahaweli Authority involvement, as they have limited, direct contact with farmers. The price for green chili negotiated under this plan was Rs 7 per kilogram. Production expenses are covered by the farmer, but exporters go to the farm gate to collect the harvest. This year (Yala 1983) 40.5 hectares were planted with MI-1 chili along the left bank area of Kalawewa as part of the contract marketing pilot project.

At the time of the 1983 workshop, it was impossible to draw any firm conclusions about the contract system as the marketing and production results from this Yala season had not been concluded, however, it does hold some promising possibilities. If the system is successful over the long run and can be expanded in scale, chili farmers in the region may experience significant economic benefits from the higher guaranteed prices, the lower risk factor and the convenience offered. The guaranteed nature of contract marketing may also encourage farmers to be less hesitant about making the necessary capital outlays for production inputs and practices essential to increasing yields.

16. Summary

In the Diagnostic Analysis Workshop the economist's role was to identify constraints to productivity and income generation within the system studied. Constraints are, of course, ever-present in their various forms--resource, institutional, etc.--and have been discussed in the economics section of this report.

It has been hypothesized in the development literature that labor is an abundant resource in developing rural regions--often considered to have a marginal product of zero. To the contrary, however, labor in the study area was found to be scarce with a positive marginal product. Indeed, seasonal labor scarcity was cited as the reason for broadcast seeding rather than transplanting as the preferred planting technique. Weed and pest control were also more costly due to their extensve use of relatively scarce labor. The two-wheeled tractor has eased the labor constraint to some extent, but other means of making efficient use of existing labor supplies may need to be developed. The important and very difficult task, is to ease costly seasonal labor constraints without displacing labor, thereby creating unemployment problems.

Marketing structures represent another significant constraint. In light of the lack of farmer participation in government sponsored marketing programs, it would appear that these programs are less attractive to farmers than the existing private marketing mechanisms. Unless the government systems can be modified to reconcile national as well as [illegible] and farmer objectives, the private trader will continue to dominate the output market.

Closely tied to the private marketing mechanism is private credit, another constraint to be considered. It would appear that the real value of capital in the study area is much higher than the 9% rate offered by the government for agricultural loans. The decline of farmer participation in the subsidized credit program raises important questions. Further information on the role of capital in the production process would lead to a better understanding of the credit requirements.

In view of these constraints, the following suggestions for further study include:

1. Develop appropriate methods for enhancing labor productivity to ease seasonal labor scarcity.

2. Develop a system of farm record keeping that will make information pertinent to policy decisions more readily available, i.e. input use, production and price information.

3. Investigate further the role of capital and credit in the production process; the real value and the relation to the use of other inputs.

4. Examine the national, regional and farm level objectives of existing marketing systems in order to design policy and/or programs better able to reconcile the perceived needs.

D. Sociology

1. Conceptual Framework

The effective operation and maintenance of any irrigation system involves the linking of technical engineering works, and the social organization of both project administration and water users. The role of the sociologist in diagnostic analysis is to identify patterns of interactions among members of irrigation agencies and the farmers in order to better understand the ways in which elements of social organization constrain or facilitate the efficient use of the water delivery system.

The following key categories comprised the sociological framework for this study. The questions posed in each case exemplified a few of the many and varied sociological concerns in this study of irrigation and agronomic behavior. The categories are not mutually exclusive nor questions exhaustive, but rather suggest important points of articulation between the social and technical systems which have implications for effective water use.

(1) The attitudes and skills that individuals bring to farming and irrigation systems can contribute significantly to its success or failure. Importantly, the attitudes of both the farmers and irrigation system management affect system efficiency.

What are the comparative skills, resources, and knowledge of irrigation and agriculture of traditional villagers versus the formerly landless villagers in the resettlement schemes? What are the attitudes of the villagers towards the resettlement scheme and the irrigation bureaucracy?

(2) The nature of family life, including gender and age task differentiation and traditional networks of social obligation, can help or hinder project success.

Are there effective labor sharing traditions among farmers, kin, or friendship groups?

(3) Both contemporary and traditional community organizational structures are linked to the technical system.

Does the community have a stable and effective leadership structure? Are there established and expected formal and informal organizations for water management, such as users associations or turnout groups? If so, what is the nature of the relationship between the farmers groups and the irrigation authority management?

(4) The economic subsystem plays a crucial linking role to the water delivery system.

Are there sufficient credit mechanisms to cover farmer inputs in both good and bad crop years? Are there effective local markets being developed to support crop diversification policies? What is the economic contribution of handicrafts and household agricultural production of farm women?

(5) Politics and conflict resolution can be pivotal in the success or failure of irrigation projects.

What are formal and informal rules of land tenure and water rights? When conflicts arise are there institutionalized mechanisms of resolution?

In short, the objective of the sociologist is to examine the way in which the social elements described above facilitate or constrain the efficient and equitable allocation of water and the maintenance of the delivery system.

In all, seven research categories comprised the organizational framework and focus of this investigation. These included:

(1) Demographic profile of the respondent population,

(2) Patterns of land tenure and the effectiveness of the bethma system,

(3) Perceptions of community life after resettlement,

(4) Water control and perceived problems of farmers,

(5) Farmer irrigation knowledge and behavior,

(6) Farmer involvement in maintaining the irrigation system,

(7) The availability and utility of institutional services, and

(8) Summary, conclusion and recommendations.

2. Demographic Profile of the Respondent Population

a. Settler Categories

The area selected for the study lies within blocks 302 to 309 of the left bank of Kalawewa Reservoir and comes under the command area of five D-channels. Two turnouts of each D-channel constituted the sample study area. The composition of the resettlement population in the study area included _purana_ villagers, selectees, early migrants, evacuees and encroachers.

Purana villagers--The settlement of farmers in this area began in 1976/77. There were some villages prior to the Mahaweli irrigation scheme and village communities had cultivation practices suited to the environment and requirements of the people. The distribution of water to the paddy tracts below the tank was the responsibility of the community and farmers strictly adhered to a cultivation time table and penalties were given to those who deviated from accepted norms. Rainfed _chena_ cultivation (shifting cultivation) on unirrigated uplands was beneficial to farmers when there was no assured water supply in the tank to cultivate paddy or when crops failed. The peasants lived in cluster types of settlements which provided the opportunity for each farmer to interact with others in terms of labor exchange (_aththam_), trading, and borrowing of farming implements.

Many _purana_ villagers were incorporated into the new settlements. Their lands were demarcated for distribution and the villagers were resettled on land near native places such as Handungamaa, Hurigaswewa, and Makulawa in the study area. Most still have interests in the _purana_ village because of kinship ties and many still rely upon kinsmen for labor requirements.

Selectees--The selectees were mainly landless peasants from neighboring districts who were resettled in new hamlets of the expanding system.

Early migrants--Many early migrants were attracted to the area by pre-Mahaweli irrigation schemes. Others are either encroachers on government lands, or have bought lands from _purana_ villagers. In addition, some have migrated for trading activities, or services in local communities and settled down after marriages.

Evacuees--This group of settlers comprised those who were given lands in the new settlement as a compensation for their lands acquired or submerged due to the construction of reservoirs, channels, or roads in the Mahaweli irrigation scheme.

Each settler was allocated one hectare of irrigable allotment and 0.25 hectare of homestead. In addition, the settlers were provided with basic communal facilities such as schools, hospitals, cooperatives, and agricultural extension services subsequent to physical infrastructure development. The provision of such services also resulted in attracting permanent residents such as petty traders, boutique keepers, etc. Table D-1 gives the main categories of settlers in the study area and their distribution within block areas.

Table D-1. Settler Categories in the Study Area (n = 92)

Settler Category	Head				Middle		Tail				Total	
	302		303		306		307		309			
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Purana Villagers	15	(88)	4	(20)	8	(42)	--	--	7	(39)	34	(37)
Early Migrants	1	(6)	10	(50)	1	(5)	--	--	1	(5)	13	(14)
Evacuees	--	--	4	(20)	1	(5)	--	--	--	--	5	(6)
Selectees	--	--	--	--	6	(32)	14	(78)	5	(28)	25	(27)
Encroachers (others)	--	--	1	(5)	3	(16)	4	(22)	5	(28)	13	(14)
No Response	1	(6)	1	(5)	--	--	--	--	--	--	2	(2)

The importance of spatial location (head, middle, tail) has long been a central independent variable in studies of irrigation schemes. In this study, the significance of spatial location becomes most evident when contrasted with settler status as in Table D-1.

Note that *purana* villagers were concentrated at the head of the system and selectees at the tail. This would suggest that problems of adaption and adjustment to the scheme would be most acute among selectees. In contrast to *purana* villagers, selectees would have fewer social support networks for labor or implement sharing. Selectees would also be less likely to have superior cultivation skills, since many were drawn from high density wetland areas where many were craftsmen and tradesmen. These factors combined with shortages of working capital for agricultural inputs and the common difficulties of water distribution experienced by tail-enders would portend special problems for selectees. This is born out by the tendency of selectees in the study to be the most likely to be involved in the illegal leasing out activities which will be discussed in more detail in the land tenure section immediately following.

b. Age

Thirty-five percent of the sample farmers belonged to the age group of 26-35 and another 28 percent fell into the category of 36-45. Fifteen percent were over 50 years of age. The mean age of the sampled farmers was 40 years.

c. Education

Forty-three percent of the sample farmers had a primary education and 37 percent had attended secondary school but only 12 percent had completed certificate requirements.

d. Religion

All of the sample farmers were Buddhists.

e. Family Size

The average family size in the study area was 5.6. Seventy percent of the sample farmers had 4 to 7 members in a family.

f. Length of Residence

Sixty-six percent of the sample farmers were living in the hamlet for the last five years and another 18 percent still live in the _purana_ villages. The majority of farmers had experience in cultivating their irrigated allotment for the past ten to twelve seasons.

g. Income Distribution

The respondents were asked to estimate their gross annual income. As, of course, is always the case in survey research, one can never be certain of the accuracy of responses to sensitive questions. The reported income distribution of the sample farmers is presented in Table D-2.

Table D-2. Estimated Annual Income

Annual Income	No. of Families	(%)
1. Rs. 3,000-6,000	5	(5)
2. Rs. 6,001-9,000	14	(15)
3. Rs. 9,001-12,000	19	(21)
4. Rs. 12,000-15,000	23	(25)
5. More than Rs. 15,000	31	(34)

3. Patterns of Land Tenure and Effectiveness of the Bethma System of Cultivation

a. Land Tenure

The general legal principle which governs land ownership and tenure in the study area dictates that farm allotments cannot be leased out, mortgaged, or sold. However, in traditional villages, the general principles of succession and inheritance legally determine the transmission of lands and cultivation practices. Therefore, this conflict commonly leads to deviation from the legal norms in the study area. In addition to the two types of legal settlers (original allottees and legal successors), three other groups of technically "illegal" cultivators exist. These include: tenants, lessees, and mortgagees. Tenurial conditions in the study area for 1983 Yala are presented in Table D-3.

Table D-3. Patterns of Land Tenure - Yala 1983

Settler Status	Head				Middle		Tail				Total	
	302		303		306		307		309			
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Original Allottee	16	(94)	17	(85)	12	(63)	10	(56)	12	(67)	67	(73)
Legal Successor	1	(6)	1	(5)	3	(16)	2	(11)	--	--	7	(8)
Relative	--	--	--	--	2	(11)	1	(5)	2	(11)	5	(5)
Tenant	--	--	--	--	1	(5)	1	(5)	1	(5)	3	(3)
Lessee	--	--	2	(10)	--	--	2	(11)	--	--	4	(4)
Mortgagee	--	--	--	--	1	(5)	--	--	--	--	1	(1)
Other	--	--	--	--	--	--	2	(11)	3	(17)	5	(5)

The data suggest that farmers at the middle and tail of the main canal tend to lease out or mortgage their allotments only slightly more frequently than those at the head of the system. This finding is in contrast to a previous workshop, and is no doubt partly a result of the use of the bethma system for the 1983 Yala season which reduced the owner's share of the irrigable allotment by one-half. Selectees, however, are more likely to lease out their allotments than other settlers. In all, almost one-third of the selectees had leased out their allotments.

The high rate of leasing-out among selectees is a complex problem with many contributing factors as well as important implications for system management. The concentration of selectees at the tail where water problems appear most acute, no doubt plays an important role in farmer success and failure. The concentration of selectees at the tail occurred because of priorities in allotment allocation early in the resettlement plan. Purana villagers were given first choice in allotments with most choosing the more productive farmland at the head regions, often below or near ancient village tanks. The selectees were then settled on the remaining allotments.

Agriculture skills and abilities are important also. The traditional farm knowledge and practices of Purana villagers often contrasted sharply with many selectees, many of whom were formerly artisans, tradesmen, construction workers, etc. in the more urban communities of the densely populated wetlands.

Purana villagers have long established social networks based on kinship and community cooperation. This important resource of *purana* villagers is exemplified by *aththam* (shared labor) during peak labor input periods such as planting and harvesting; and *bethma*, the traditional cooperative land and water sharing practices for periods of drought. Clearly, the selectees are inevitably at a disadvantage in any resettlement scheme because of the time lag involved in nurturing a cooperative support system in a new and strange community setting. The importance of support systems extends from labor inputs to economic inputs. The ability to manage minor crises (labor in peak work periods) and major crises (crop failure) may turn on the effectiveness of the farmers social supports. The above factors in combination (and no doubt others) goes some distance in explaining the tendency to lease out. The findings of the 1982 Diagnostic Analysis in Sri Lanka supports this analysis. "Some of the main reasons for leasing out land that we were able to identify through discussion with farmers, key informants, and irrigation officials were: 1) lack of capital to invest in highland crops, such as chiles; 2) insufficient family labor, especially for highland crop cultivation; 3) financial problems and personal distress; 4) wanting to give an opportunity to landless family members to cultivate."

The potential for the evolution of an entrepenurial class in the resettlement communities, as a result of present leasing trends, deserves further and more systematic research.

Reasons mentioned by the 1982 sample farmers for leasing out are given below:

(1) Selectees often do not reside in the homesteads as they have interests and/or property in their native villages and are often engaged in non-farm activities.

(2) Some original allottees are old and there are no adults in the family to cultivate the allotment.

(3) Selectees, because of their lack of social network and connectedness to the community, are most dependent on hired labor which requires substantial capitalization and further strains on scarce resources.

Among the sample farmers, twenty percent fall into the category of illegal cultivators according to established legal norms in the resettlement area. Recent studies (Alwis, et al., 1983) observed leasing out arrangements exceeding 50 percent in some sectors of the Mahaweli scheme. "The number of settlers giving out their lands either to be cultivated on share cropping or lease, had steadily increased over the last three seasons. In *Maha*, 1978-1979, 54% of the settlers rented out their land. This number increased to 70% in *Maha* 1979-1980. A similar study (Siriwardena, 1980) indicated more than half of the allotments were not cultivated by the settlers." The lower rate of leasing (20%) found in this study may be a result of under-reporting as well as constraints imposed by two successive years of water shortage. As noted earlier, the imposition of the *bethma* system of cultivation reduced irrigable allotments by half, leaving cultivators with less land to share in leasing out arrangements.

The tendency to lease has implications for effective water management. For example, most of the farmers and some turnout group leaders suggested that cultivation of lands by tenants, lessees, mortgagees, and encroachers created problems in maintaining the system effectively.

Some farmers believed that these groups have little commitment or interest in maintaining irrigation structures and field channels and were not perceived as members of the community, as they do not reside in the location. Their interactions with permanent residents are confined only to visits to the farm sites and communication of information is not very effective with respect to water issues, and agricultural extension services.

Not surprisingly, many farmers reported that problems sometimes arose because of differing agricultural practices of original allottees, leasees, etc. This included varying standards for pesticide application leading to pest infestations. In addition, cooperation among users is crucial for system maintenance. Many original allottees felt that leasees were mainly interested in maximizing profits by minimizing what would normally be communal inputs. This would include a reluctance on the part of leasees for involvement in collective maintenance of field channels. Leasing may also affect the success of farm organizations such as turnout groups. Cooperative systems are based on trust and mutuality of interest. The random introduction of leasees from outside the local hamlets and farming groups will necessarily result in increased farmer conflicts and may decrease the effectiveness of farmer organizations involved in system distribution and maintenance.

b. Effectiveness of *Bethma* System

The practice of *bethma* cultivation has its origin in traditional cultivation practices of *purana* villagers. It is a cooperative sharing arrangement of cultivation among *purana* villagers when there is not enough water to cultivate all of the paddy tracts under the tank during *Yala*. The village community decide to cultivate selected paddy tracts (one-third or two-thirds of the upper fields) and equally shared the cultivable area among the farmers.

The sharing of the allotment with another farmer in adjoining turnouts of the same D-channel was officially recognized for 1983 *Yala* due to inadequate water supply of the Kalawewa Reservoir. The irrigation officials and agricultural extension officers directed farmers to cultivate other field crops (mainly chillies) in well drained soils and paddy in poorly drained soils. The original allottees were encouraged to select their own _bethma_ partner on an informal basis. Officials of the Mahaweli Authority assisted in selecting the _bethma_ partner when a cultivator was unable to establish a sharing arrangement.

Most of the sample farmers (91%) cultivated under _bethma_ arrangement during 1983 _Yala_. The remaining allotments were not shared due to the small extent of cultivable land. A majority of the same farmers (70%) made sharing arrangements informally with 30 percent of the original allottees, selecting their own family members and 25 percent selecting friends. While most (89%) of the sample farmers reported they were generally satisfied with the practice of the _bethma_ system a few significant points of conflict were reported.

It was the consensus of most of the sampled farmers that the _bethma_ partner was not interested in maintaining the field channels and irrigation structures because they cultivated the land only for 1983 _Yala_. An additional problem mentioned by farmers was incompatibility with _bethma_ partners because of conflicting agronomic practices. For example, coordinating pesticide application and responsibility for cleaning field channels were cited as problems.

It was quite evident that cultivation by tenant, lessee, mortgagees, as well as _bethma_ cultivators resulted in conflicting situations between legal settlers and other cultivators. Many legal settlers believed that the inefficient management of the irrigation system was mainly due to lack of participation of _bethma_ partners.

4. Perceptions of Community Life After Resettlement

The satisfaction of settlers regarding the operation and maintenance of the irrigation system, as water users, as well as the benefits acrued as receivers of physical and social infrastructure development, agricultural extension services, etc. is discussed in this section.

The process of resettlement has often been characterized by stress and strain growing out of dislocation and the trials of adjustment to new and sometimes trying circumstances. The relationship between settler adjustment and stage of community development is usually direct and positive. As new communities evolve and mature the level of stress among community members generally declines. While this study is not longitudinal, farmer responses to questions of community satisfaction suggest that the study area is probably in the mature stage of development. In the study area, the settlers have been cultivating the allotments for 10-12 seasons in spite of two successive drought years. A set of questions were asked of the sample farmers regarding:

(1) How they felt about the new community life compared to previous settlements,

(2) Their visions of future well-being, and

(3) Improvement of the standard of living.

These expectations and aspirations indicate the positive side of the successful operation of the system.

Table D-4. Perceptions of Settlers About Individual and Family Well-Being After Resettlement and in the Future

	Yes		No		No Difference	
	No.	(%)	No.	(%)	No.	(%)
Satisfied with the new settlement?	80	(88)	11	(11)	1	(1)
Happier in future?	80	(89)	11	(11)	1	(1)
Financially better off than before resettlement?	72	(79)	19	(20)	1	(1)

The data suggest that the majority of farmers are satisfied with the improved conditions of living after re-settlement and also envisage the financial improvement in the future. Although not displayed in the table, our data revealed that dissatisfied settlers tended to be concentrated on the tail of the system.

The majority of sample farmers (more than 80 percent) preferred this community compared to the villages where they lived before. The stress and strain factor apparently is not very significant according to this study. Many farmers mentioned the benefits of land ownership, reliable water for cultivation, and social infrastructure development.

Table D-5. Perception of Community Life After Resettlement

	No.	(%)
Prefer this community to previous community?		
a. yes	80	(87)
b. no	11	(11)
c. indifferent	1	(1)
How much stress and strain in this community?		
a. very little	42	(46)
b. moderate	12	(13)
c. a great deal	8	(8)
d. none	30	(33)
Satisfied with neighbors?		
a. very satisfactory	2	(2)
b. somewhat satisfied	34	(37)
c. satisfactory	55	(60)
d. not satisfactory	1	(1)

Settlers were provided with a package of services which included the irrigable allotment, homestead, basic community services such as easy access to commercial, health, postal, education services, and agricultural extension services in addition to physical infrastructure development. These factors seem to have considerable importance to farmers and no doubt contribute much to the general high level of satisfaction expressed by settlers.

5. Water Control Situation and Perceived Problems of Farmers

This survey was carried out during 1983 Yala when inadequate water was the major constraint to cultivation. In addition, farmers also faced innumerable problems in crop production. The following table (D-6) illustrates the most significant problems reported by farmers.

Among the factors perceived as problematic by farmers, 36 percent identified water as the major problem for paddy, while 42 percent listed water as the major problem for other field crops. The next most important farming problem was draft power for paddy, and pesticides for other field crops.

Table D-6. Most Important Problems Perceived by Farmers

Problem	Paddy No.	Paddy (%)	Type: Supply (%)	Type: Working Capital (%)	Type: Other (%)	Other Field Crops No.	Other Field Crops (%)	Type: Supply (%)	Type: Working Capital (%)	Type: Other (%)
Credit	6	6.5	44	44	12	1	2	100	-	-
Water	34	36	96	-	4	25	42	100	-	-
Fertilizer	3	3	25	75	-	1	2	-	100	-
Draft Power	21	22	78	22	-	3	5	75	12	13
Land	3	3	100	-	-	3	5	100	-	-
Seed	6	6.5	92	8	-	-	-	-	-	-
Pesticides	5	5.5	-	55	45	17	29	7	46	47
Marketing	1	1	-	-	100	3	5	-	-	100
Labor	7	7.5	100	-	-	1	2	100	-	-
Other	8	9	-	-	100	5	8	13	-	97

a. Water as a Major Problem

The distribution of water problems for paddy and other field crops in 1982/83 Maha and 1983 Yala at the head, middle, and tail of the system illustrates the significance of spatial location on the irrigation system.

While there is considerable variation in farmer assessment of the magnitude of water problems both inadequate and unreliable water were noted at the tail of the main canal. While this pattern is neither unusual nor surprising, it no doubt contributes to the adaption problems of selectees, who were predominantly tailenders.

Table D-7. Distribution of Water Problems for Paddy and Other Field Crops in Maha and Yala by Head, Middle, and Tail of the Main Canal

Water Problem	Maha					Yala				
	Paddy No.	O.F.C. No.	Magnitude (%)* 1	2	3	Paddy No.	O.F.C. No.	Magnitude (%) 1	2	3
1. Inadequate Water (Total)	34	3	3	36	61	29	12	6	65	29
a. Head (302,303)	9	2	50	50	-	10	5	-	40	60
b. Middle (306)	6	-	-	33	67	6	2	25	25	50
c. Tail (307,309)	19	1	-	25	75	13	5	-	78	22
2. Unreliable Water (Total)	22	-	5	82	13	6	4	14	14	72
a. Head (302,303)	6	-	16	50	34	3	2	-	33	67
b. Middle (306)	5	-	-	67	33	3	2	33	-	67
c. Tail (307,309)	11	-	-	100	-	-	-	-	-	-
3. No Water (Total)	1	-	100	-	-	3	8	18	27	55
a. Head (302,303)	-	-	-	-	-	-	-	-	-	-
b. Middle (306)	-	-	-	-	-	-	-	-	-	-
c. Tail (307,309)	1	-	-	100	-	2	8	20	20	60

*Relative order of magnitude with 1 = highest priority.

The sample farmers were asked the major reasons contributing to the problem of inadequate and unreliable supply of water. Table D-8 below summarizes reasons stated by farmers who perceived water as a major problem for paddy in Maha, and paddy and other field crops during Yala.

Farmer responses indicate that the maintenance and management of the system could be improved. They believed that the Mahaweli Authority should perform these functions since this is their responsibility to the level of the field channel.

Water control is administered by the field irrigation officials at the D-channel head gate and turnout gates. The field assistant (irrigation) and patrol laborer are mainly responsible for reading head and tail gauges of D-channel and transmitting this information to the irrigation engineer at the block level. The field officials stated that readings are taken daily and records of discharge maintained. In block 309, discharge measurements are not read daily because of a damaged measuring device.

Table D-8. Most Important Reasons Stated by Farmers Who Perceive Water as a Major Problem

Reason	Maha	Yala	
	Paddy	Paddy	OFC
	--------------	%	--------------
Poor Channel Maintenance	27	24	12
Damaged Control Structures	26	23	35
Poor Canal Management	25	17	14
Canal Alignment	16	13	17
Stealing Water	6	23	22

Many sampled farmers (64%) said that D-channels were operated on 4 days on/3 days off while 20 percent reported 3 days on/4 days off. Only 16 percent stated 5 days on/2 days off as a typical rotation. Two turnout group leaders stated that poor maintenance was the major problem in relation to the water supply situation, and six reported inadequate water as a major problem. One turnout group leader in block 306 suggested that the location of turnout gates resulted in inadequate water delivered to the tail. Another turnout group leader (block 309) suggested that poor cultivation practices of tenants and _bethma_ partners were mainly responsible for inadequate water at some farm sites.

Turnout group leaders were asked two specific questions regarding the special problems of head and tail farmers, and possible solutions. The turnout group leader at the head of the system stated that farmers at the head of the field channel require more water due to soil type. One turnout group leader in block 303 reported that the location of farm sites is problematic for water control and distribution. A turnout group leader in block 309 reported an absence of regulation at the D-channel level. Leveling of farm sites and repairs to structures were suggested as solutions to these problems.

Inadequate water at the D-channel level and the field channel level, and damages to structures appear to be special problems for farmers at the tail of the system. The provision of more water to D- and F-channels, strict rotation schedules (particularly at important stages of cultivation), and repairs and maintenance to gates and structures were proposed.

6. Farmer Irrigation Behavior and Knowledge

a. Irrigation Behavior

The *kanna* meeting has its origin in the ancient cultivation systems of Sri Lanka. These cultivation meetings preceded each cultivation season and were an integral part of the traditional community management of water and land in irrigated agriculture. The management of the Mahaweli Authority has formalized and institutionalized the *kanna* meeting.

Irrigation practices dictate that farmers should attend the *kanna* meeting (pre-cultivation meeting), follow the prescribed procedure of selecting new crop varieties, adhere to a cultivation time table, be aware of the rotation schedule, properly maintain irrigation structures and F-channels, and also obey the general rules and regulations of the Mahaweli Authority. However, this study revealed that farmers occasionally deviated from expected irrigation practices. This resulted in verbal confrontation between farmers and field officials which inhibited amicable settlements of disputes. In addition, such situations may create problems in system management since both groups play important roles in maintaining the irrigation scheme. The following table (D-9) reports the frequency of deviant irrigation practices by sampled farmers in the study area.

The data suggest that deviant irrigation practices do not always occur frequently, but nearly 50 percent report two practices which occur "sometimes" and "often". These practices include taking water out of turn and illegal blockage of field channels. Although not displayed in this table, other data indicate that such practices appear to be concentrated primarily at the middle and tail of the main canal.

The field officials in the study area (4 unit managers, 5 field assistants (irrigation), 5 field assistants (agriculture), and 5 patrol laborers) were interviewed, and reported that some farmers used the following illegal methods to obtain water. Both the sample farmers and irrigation officials concurred that taking water out of turn and blockage of channels were significant problems.

Table D-9. Frequency of Occurrence of Deviant Irrigation Practices as Reported by Sampled Farmers (n = 92)

Behavior	Often		Sometimes		Never	
	No.	(%)	No.	(%)	No.	(%)
Taking Water Out of Turn Without Permission	11	(12)	32	(35)	49	(53)
Farmer Opening Gates	2	(2)	7	(8)	83	(90)
Illegal Outlets to Field or Cutting Bunds	2	(2)	15	(16)	75	(82)
Illegal Blockage of Field Channels	4	(4)	36	(39)	52	(57)
Damages to Turnout Gates and Irrigation Structures	1	(1)	11	(12)	80	(87)
Use of Influential Farmers to Get Water	--	--	8	(9)	84	(91)
Threatening Other Farmers for Water	6	(7)	11	(12)	75	(81)
Use of Excessive Water	8	(8)	14	(15)	70	(76)
Threatening Officers for Water	--	--	1	(1)	91	(99)

Table D-10. Illegal Methods Used by Farmers to Get More Water (N = 19)

Method	Often		Sometimes		Never	
	No.	(%)	No.	(%)	No.	(%)
Opening Gates at Night	6	(32)	8	(42)	5	(26)
Opening Gates by Day	--	--	12	(63)	7	(37)
Stealing Water from D-channel	4	(21)	8	(42)	7	(37)
Taking Water Beyond Allotted Time	7	(37)	9	(47)	3	(16)
Placing Obstruction in Order to Steal Water	3	(16)	13	(68)	3	(16)
Excessive Use of Water	3	(16)	9	(47)	7	(37)
Using influential Persons	--	--	7	(37)	12	(63)

Turnout group leaders and field officials were asked what type of action they had taken, or could be taken to prevent these illegal practices. Unit managers stated that they often warned the farmers who opened gates or took water without permission. When structures were damaged farmers were asked to do repairs themselves. If the damage was substantial, authorities estimated the cost and asked the farmers to pay (if witnesses were available). Many officials also reported that certain farmers sometimes obstructed F-channels or D-channels. The normal practice is to scold farmers, warn them in writing, and give priority in issuing more water to farmers who could not get adequate water because of such actions. Field officials and turnout group leaders said that they have no legal backing for the enforcement of agency rules and regulations. In the absence of effective, or binding legal actions it would be expected that deviant irrigation practices of farmers will continue with the resulting negative impact on control, maintenance and efficiency of the water delivery system.

The clear policy implications of the above findings is that irrigation management should study ways in which rewards can be structured to encourage farmers and lower level irrigation officials to conform to established agency rules and regulations. Discipline in the form of small fines, for example, also might prove effective. It is important, of course, to consider the potential impact of disciplinary techniques on farmer attitudes versus the value of returns to the authority of better water efficiency.

b. Irrigation Knowledge

The Mahaweli Authority has taken several steps to encourage suitable cultivation practices, and adherence to rotation schedules in an effort to increase crop production and prevent excessive use of water. Farmers are given formal training at farmer training classes and the formation of turnout groups is encouraged to enhance the adoption of suitable crop varieties, and cultivation practices. Two specific questions were asked from sample farmers to assess their knowledge about two selected irrigation practices:

(1) How do farmers decide when to start irrigating a crop of paddy, chili, and other field crops?

(2) How do they decide when to stop irrigating paddy and other field crops?

Table D-11 indicates sample farmer criteria used to start irrigating paddy, chilies, and other field crops.

Table D-11. Criteria Used to Begin Irrigation of Paddy, Chilies, and Other Field Crops

Criteria	Paddy		Chilies		O.F.C.	
	No.	(%)	No.	(%)	No.	(%)
Remember Last Date of Irrigation	9	(10)	2	(3)	1	(2)
By Appearance of Soil Surface	26	(30)	10	(13)	3	(6)
By Appearance of Plants	--	--	6	(8)	3	(6)
By Stage of Plant Growth	10	(11)	3	(4)	17	(36)
By Examining Subsurface Soil	1	(1)	36	(48)	8	(17)
When Water Comes	24	(28)	10	(13)	9	(19)
Do Not Know	--	--	--	--	6	(13)
Other	15	(18)	7	(9)	--	--

Among the sample farmers, 30 percent determined when to irrigate by observing the appearance of the soil surface. Forty-eight percent of the farmers decided to irrigate chilies by examining subsurface soil. The irrigation of other field crops was decided by stage of plant growth. There appears to be a degree of inconsistancy concerning the responses by the farmers. Although some responses suggest a reasonable knowledge, the decision to irrigate may be strongly based on water availability.

The farmers were also asked how they decided to stop irrigating paddy and other crops.

Table D-12. Criteria Used to Decide When to Stop Irrigating Paddy and Other Field Crops

Criteria	Paddy		OFC	
	(No.)	(%)	(No.)	(%)
When Water Reaches Border at the End of Field	1	(1)	15	(19)
Before Water Reaches Border at End of the Field	2	(2)	--	--
When Water Covers All High Spots in the Field	33	(38)	43	(54)
When Water Reaches a Certain Height	49	(56)	22	(27)
Do Not Know	1	(1)	--	--
Other	1	(1)	--	--

Fifty-six percent of the farmers said that they stop irrigating when water reaches a certain depth in the field for paddy while fifty-four percent cease irrigating when water covers all high spots in the field. While the former practice is technically correct for paddy the latter is probably incorrect for other field crops, especially chilies, for example which are subject to "wet feet".

7. Farmer Involvement in Maintaining the Irrigation System

The maintenance of D-channels and repairs to irrigation structures are mainly the responsibility of the Mahaweli Authority but field channel cleaning is delegated to farmers. Each farmer is expected to clean the length of the field channel apportioned to him. Most of the farmers also believe that field channels should be cleaned twice a season in order to increase the flow of water to the farm sites.

Seventy-six percent of the sample farmers stated that each farmer cleaned his section individually, while 24 percent cleaned collectively. Only 15 percent of the farmers were dissatisfied with the quality and frequency of cleaning. *Bethma* cultivators, tenants, or lessees did not show a great deal of interest in cleaning the field channel, as reported by the farmers who were dissatisfied with maintenance work.

Farmers were also asked about the following·

(1) satisfaction with maintenance of the irrigation system in terms of cleaning D-channels and F-channels,

(2) Distribution of water along D-channels and F-channels,

(3) Quality of structures at F-channels,

(4) Requests and complaints to field officers, and

(5) Number and timing of irrigations provided to farmers.

In almost every instance there was a fairly high level of satisfaction. The exception was in the case of the quality of structures in field channels. Fifty-four percent of the sample farmers reported that the quality of structures was very poor. With regard to channel cleaning, 47 percent said that they cleaned individual sections once for 1983 *Yala* and another 34 percent cleaned once for *Maha*. Fifty percent cleaned field channels two times during *Yala*, whereas 47 percent cleaned two times; and only 15 percent cleaned three times for *Yala* 1983.

Turnout group leaders were also asked about their satisfaction related to the above mentioned items. Fifty percent of turnout group leaders reported that generally the distribution of water and maintenance activities of D-channels was satisfactory. However, 7 turnout group leaders stated that the quality of structures was very poor. Fifty percent were also dissatisfied with the actions taken by the irrigation officials for requests and complaints. Generally turnout group leaders at the tail of the main canal also reported problems related to timing of irrigation given and distribution of water along D-channels.

The majority of turnout group leaders also suggested that if the individual farmer was allowed to clean his portion individually, a penalty should be given to those who do not clean their channels. Otherwise, the field channel should be cleaned collectively under the direction of turnout group leader. The D-channel is cleaned by the Mahaweli Authority and it was suggested that the contractor should also be closely supervised.

Field officials said that farmers generally cleaned F-channels only one time per season which is not adequate to deal with weed growth. They also observed that damages to field channel banks and turnout gates often occurs over a period of one year. Most officials suggested that these damages were largely due to illegal cultivation of reservation at the head of the field channels and inadequate leveling of fields.

8. Availability and Utility of Institutional Services

Management functions in the Mahaweli Authority operate at 3 levels; the project, block, and unit. The Unit Manager is responsible for servicing 200 to 250 farm families, which generally covers a D-channel area consisting of 10 to 15 turnouts. He is assisted by a Field Assistant (irrigation), a Field Assistant (agriculture), and a Patrol Laborer.

These three field officials directly interact with farmers regarding the distribution of water, cleaning and maintenance of field channels, and agricultural extension services. Farmer participation in relation to these activities begins at the turnout level. The elected turnout group leader is supposed to play an important role in communicating decisions on water management from the level of unit manager.

a. Functions of Field Officials

The 4 Unit Managers in the study area interviewed stated that their main responsibility is to provide necessary services for farmers in five functional areas including water management, agriculture, community development, marketing, credit, and land matters. He is directly responsible to the Block Manager, supervises the other field officers, and investigates requests and complaints made by farmers. Three Unit Managers expressed their problems regarding the functions of the office, local politics, and farmers. In the effort to coordinate five areas of activities, he faces the following problems:

(1) Heavy work-load,

(2) Land matters related to local politics,

(3) Use of influential persons or politicians to get more water or cultivate reservations,

(4) No legal support to take action against those who damage structures or open gates, and

(5) Irrigation structures are not constructed properly and requests from farmers to repair some structures could not be done due to financial constraints.

The Unit Manager is under great pressure due to his responsibility to perform diverse functions without sufficient financial or institutional support to solve the urgent problems of the system. The relationship between the Unit Manager and farmers inevitably is weakened due to the above mentioned problems.

The field assistants and the patrol laborers are mainly responsible for implementing decisions made at higher levels and communicating such decisions to farmers. Theoretically, it is assumed that field officials should provide the required services for cultivation to farm families. Two specific questions were asked of the farmers in order to ascertain the type of relationship between field officials and farmers, as indicated in Table D-13.

Table D-13. Farmer Contact with Field Officials and Relative Helpfulness

	Unit Manager		Field Staff: Field Assistant (Irr.)		Field Staff: Field Assistant (Agr.)		Patrol Laborers	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Knows well								
a. yes	90	(98)	87	(95)	87	(95)	89	(97)
b. no	2	(2)	5	(5)	5	(5)	3	(3)
Helpfulness								
a. very helpful	61	(66)	58	(63)	58	(63)	51	(55)
b. helpful	19	(21)	21	(23)	22	(24)	31	(34)
c. not helpful	12	(13)	13	(14)	12	(13)	10	(11)

Farmer responses to questions regarding the helpfulness of field staff are strongly positive and correspond to generally similar patterns found in the 1982 Sri Lanka Diagnostic Analysis Workshop.

Only 11 to 14 percent of the sample farmers feel that the field staff are not helpful. It is also important to note that in spite of problems in the maintenance of the irrigation system and inadequate water during Yala, farmers keep close contact with field officials.

These findings, no doubt, reflect in part the maturity and quality of a well-established agricultural resettlement scheme in its eighth year of development. The findings of farmer community satisfaction are also very favorable in part because of the many positive benefits the scheme is seen to have brought to the hamlets. Many farmers spoke very highly of the benefits of infrastructure development such as schools, dispensaries, and the community fairs. Others emphasized the importance of land ownership and reliable and equitable supplies of water compared to the pre-Mahaweli period.

b. Communication of Irrigation and Agricultural Information

The main sources available to farmers for obtaining irrigation information are presented in Table D-14.

Table D-14. Main Sources of Information Received on Irrigation Matters and Their Adequacy

	Field Staff										Adequacy*					
	Kanna Meeting		U.M.		F.A. (Irri)		Farmers		T.O.G.L.		1		2		3	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
First water issue for land preparation	63	74	3	4	2	2	6	7	11	13	84	91	8	9	-	-
Advice for on-farm water use practices	18	21	7	8	33		7	8	21	24	69	75	21	23	2	2
Rotation schedule	30	34	6	7	21	24	10	11	21	24	72	78	18	20	2	2
Changes in water issue schedule	—	—	16	18	17	20	23	26	31	36	58	63	27	29	7	8

* 1 = usually adequate
2 = somewhat adequate
3 = not adequate

This table shows that diffusion of information to farmers from the field officials is thought to be effective and fairly adequate. Twenty-seven percent of the sampled farmers stated that information about changes in water issue schedule were "somewhat adequate".

Field officials were asked how they communicated major decisions with respect of water management. It was reported that pre-seasonal cultivation (kanna) meetings were attended by the field officials and farmers, where major decisions of the cultivation calendar were disseminated. Historically, kanna meetings were held before the commencement of cultivation, and necessary repairs and maintenance were conducted before the cultivation and procurement of seeds. However, certain changes made in water issue schedules, opening and closure of gates, etc. are communicated by field officials to the farmers mainly through notices fixed at the Unit Managers office and by turnout group leaders, field assistants, and patrol laborers who visit the farm sites regularly. Farmers have rarely made complaints to higher officers regarding water management activities except in a situation of severe shortage of water.

Information regarding agricultural extension services was obtained from the agricultural field assistant (i.e. particularly agricultural inputs, new crop varieties, fertilizer use, etc.). However, 70 percent of the farmers obtained information on market prices from private traders.

There were two organizations established with the assistance of the Mahaweli Authority to organize farmers for water management and agricultural activities at the hamlet level: the Community Development Society and the turnout group. The Community Development Society was perceived as not very effective at the time of conducting the survey. Nearly 46 percent of the sample farmers were not aware of the existence of the Community Development Society, and only 40 percent of them said it was "somewhat effective". By contrast, turnout groups were recently organized and 70 percent or sample farmers saw them as effective, with 12 percent reporting they are ineffective. The field officials were asked to describe the functions of the turnout group:

(1) To assist field officials in distribution of water and agricultural extension work,

(2) To inform the field officials about damage to structures and farmer problems.

(3) To send messages relating to irrigation and agriculture to farmers, and

(4) To advise and supervise cleaning of field channels by farmers.

Although, field officials considered turnout groups as an organization which communicated information from field officials to farmers and vice versa. This may not coincide with farmers' perceptions of turnout groups. They also want to use the turnout group to obtain information required for better control of deviant irrigation practices. Some also observed that farmers organize in other informal groups on some occasions.

9. Summary of Findings and Conclusions

The central goal of this study was to identify important social factors which constrained or facilitated efficient operation of the irrigation system of the study area.

(1) Nearly half of the sample farmers perceived water as a problem in crop production, and one-third of them identified water as a specific problem in terms of inadequacy and unreliability. They also reported water has been more critical in Yala for paddy and other field crops. About one-fourth of the sample farmers identified draft power as a major problem in cultivating paddy. Labor was listed as the third most important problem.

(2) Twenty percent of the sample farmers had leased out their allotments during 1983 Yala, and farmers at the middle and tail of the main canal tended to lease out somewhat more frequently than those at the head of the irrigation system. Selectees were found to be more likely to lease out their allotments in part due to their inability to sustain successive seasons of crop failure due to capital constraints, insufficient agronomic skills, and the absence of adequate support networks.

(3) The practice of bethma cultivation during 1983 Yala reduced the irrigable allotment by half. This appears to have discouraged leasing out, but bethma cultivators were often reluctant to cooperate in cleaning field channels and other maintenance tasks.

(4) The majority of sampled farmers stated that the quality of structures in field channels is poor and adversely affects the water delivery system. The engineering findings confirmed that the present state of the structures is poor. Nearly half of the sample farmers cleaned the length of the field channel beyond turnouts one time, and the quality of cleaning was regarded as unsatisfactory. Some farmers used illegal methods such as taking water out-of-turn, blockage of field channels, and opening turnout gates. These practices inevitably compromised the efficient, reliable, and equitable distribution of water.

(5) Farmer responses indicate a generally high level of satisfaction with the community and the resettlement experience, Similarly, the majority of sampled farmers were satisfied with the institutional services provided with regard to water management and agricultural extension services. However, turnout groups were mainly considered by the farmer as an organization to communicate with farmers rather than a farmer organization to solve farmers problem, through

participation. Field officials also reported frustration in interactions at the farm level because of the absence of effective enforcement leverage to reduce deviant irrigation practices. Similarly, field officials reported the lack of financial support to repair damaged irrigation structures.

Based on the above sociology findings, two specific policy recommendations emerge:

(1) Further detailed studies are needed which can more thoroughly document the socio-economic consequences of allotment leasing. Special attention should focus on identifying and addressing adaption constraints of those farm families selected for resettlement from outside the area.

(2) Poor quality and damaged field structures, poor cooperation in maintenance of F-channels, and illegal methods which circumvent administrative rules and procedures pertaining to water delivery are all problems which may be addressed through increasing farmer participation in water management. Stronger farmer organizations, such as those encouraged by the ARTI Gal Oya Project, could result in more efficient water management practices.

E. Women's Roles in Irrigated Agriculture

1. Introduction

The Mahaweli Development Scheme is an attempt to strengthen the agriculturally-based society of Sri Lanka. The introduction of irrigation, improved technology, and new methods aim to maximize production of the agricultural system.

The role of women in national development is being increasingly acknowledged. Women are active partners with their husbands in many agricultural activities. If such involvement is ignored, or not equally addressed, the attempts to improve the quality of life associated with national development will not be effective.

Literature specifically defining female roles in the traditional purana village community is limited, but it is generally acknowledged that the primary roles of women were those of wife and mother. In the Mahaweli Development Scheme the traditional roles of women are changing. In addition to usual activities, the shift into two cultivation seasons has created an additional burden, with an increase in agricultural participation. Women are engaging, out of necessity, in many tasks previously performed by men. Due to increased agricultural participation, women may have important impacts upon the productivity of the agricultural system. In order to insure the optimal efficiency of the entire irrigated agricultural system, the needs and desires of women must not be neglected. Many of the institutional services, particularly related to agriculture, are aimed at men rather than women. This study was an attempt to identify the many and varied interactions between women living on a resettlement scheme and the irrigated agricultural system on which they depend for their existence.

2. Demographic Information

Basic information such as: age, marital status, religion, education, occupation, family size and length of homestead residence were gathered in order to develop an understanding of the social profile of the farm women, and the factors affecting behavior.

The average age of the farm women interviewed ranged from 19 to 60 yrs, with an overall average of 34 yrs. Very little variation between the five study sites, from the head to the tail of the system, was evident. Not surprisingly, 95 percent of the farm women were married, with the remaining 5 percent either widowed, divorced, remarried or single. Only one unmarried women was found in the entire survey. She was living with her parents but had been allotted land under her own name. In the early stages of resettlement, families who occupied lands affected by resettlement activities were allowed to receive multiple allotments. In this case, one family occupied a number of adjoining allotments technically awarded to their children, who remained living at home. Regulations pertaining to resettlement have changed considerably during the seven years the scheme has been in existence in System H. A recent requirement stipulates that married couples be given priority for resettlement. The allotment is titled in the husbands name only, with women able to own land only through inheritance.

All of the farm women interviewed were Buddhist. Other religions such as Hindu, Muslim, and Christian are represented in Sri Lanka, but were not found in the area surveyed.

The survey indicated that 40 percent of the farm women interviewed had received some level of primary education; while 43 percent had attended secondary school, most of which reached the tenth grade level. Only 4 percent of the farm women had continued their education past the tenth grade. The remaining 12 percent of the farm women had received no schooling whatsoever. Slight variations throughout the study area with regard to education were observed, but considered insignificant.

The average size of a farm family was calculated to be approximately 5.5 persons. Many of the established purana families had adult children who had left the household, while many of the selectee families had a large nuclear family still residing in the household. Four families in block 307 (at the tail of the system with 85 percent selectees) consisted of 10 members each. Just slightly over one-half of the farm women interviewed had preschool aged children, with an average of 1.5 preschoolers per family.

Of the four settler categories, the majority of farm women interviewed were from purana villages (Table E-1). Most purana villagers were located in the head of the system, while selectees were dominant at the tail of the system. This occurrence can be explained by the fact that many of the purana villagers, present from the inception of the resettlement scheme, were given priority in the selection for settlement. Approximately 70 percent of the land in System H was set aside for the re-establishment of such villages. Naturally, many purana villagers chose to remain either on or near their previous farms, which were more desirable farming locations than the tail of the system.

Table E-1. Composition of Farm Women by Settler Category. (n=99)

Settler Category	Block 302	303	306	309	307	Overall Percentage
	- - - -	- - -	- % -	- - -	- - -	- - -
Purana Villagers	100	90	35	40	-	58
Early Migrants	-	10	-	-	-	2
Evacuees	-	-	-	-	-	-
Selectees	-	-	40	45	85	35
Others (Encroachers/ Purchasers)	-	-	25	15	15	5

When surveyed as to previous occupations, most of the *purana* village farm women indicated that they had farmed their own land; whereas the major occupation of selectee women was sharecropping. In either case, many of the women had some previous agricultural experience. However, one important difference between these two settler categories was found when non-agricultural, previous occupations were compared. Nearly 100 percent of the *purana* farm women had been involved in some aspect of agricultural work; whether or not they also owned businesses, or worked as hired labor in secondary occupations. The selectee farm women involved in agricultural work composed approximately 80 percent, with the remaining 20 percent involved in non-agricultural occupations. This finding becomes even more significant when linked to their location in the irrigated system. The majority of selectee women, with less overall agricultural experience, were faced with the more difficult agricultural environment found in the tail of the system.

Present occupations of the farm women surveyed indicated that 93 percent were involved primarily in farming and housekeeping activities, with only 5 percent involved in housekeeping alone. Approximately 20 percent of the farm women were also involved with secondary occupations, with the majority working outside the home as hired labor. Other supporting activities included sewing and mat weaving.

3. Irrigation System

a. Participation in Crop Production Activities

It has generally been acknowledged that women actively participate in farming. What is not well-defined is the degree to which she participates, and what specific activities are performed by women.

Every attempt was made when interviewing farm women to include all activities related to crop production; in both Maha and Yala seasons. However, the workshop participant's background was not extensive in agriculture, therefore, when interviews were conducted more emphasis may have been placed on current and obvious agricultural activities related to the particular crop presently being grown in the 1983 Yala season; rather than the 1982/1983 Maha season.

The various activities performed by women are shown in Tables E-2 and E-3. Of the many activities associated with crop production it was observed that women were participating, in varying degrees, at every stage. Overall, almost all (93 percent) of the women interviewed were involved in some aspect of field work. The participation of women ranged from an overall 81 percent, harvesting paddy; to an overall 3 percent, maintaining irrigation ditches. In addition to the activities associated with the major crop, 87 percent of the farm women were also growing supplementary vegetables (primarily for home consumption) around the perimeter of the irrigated fields. Growing these plots of vegetables was the choice and responsibility of the women, rather than her husband.

Some activities such as transplanting, weeding, and harvesting have been previously recognized as traditionally performed by women. In the survey conducted, these activities were indeed performed by a majority of women (Tables E-2 and E-3). Other activities such as land preparation, broadcast seeding, applying agrochemicals, and water management (irrigating and ditch maintenance) have been considered predominantly male activities. However, a surprisingly large number of farm women interviewed were participating in these activities. With two cropping seasons, resulting from irrigation, it has become necessary for women to assist in many phases of field work. It may be noted that overall, women from the head of the system seem to be involved to a greater degree in field work than women from the tail of the system.

Table E-2. Activities Performed by Farm Women Related to Paddy Production (n=99)

:tivity	Block 302	303	306	309	307	Overall Average
	----------		%	----------		----------
Land Preparation	47	75	5	30	40	39
Seed Procurement	58	10	5	25	100	39
Nursery Establishment/ Care	84	15	10	35	25	33
Broadcast-seeding	84	5	15	25	60	37
Transplanting	79	25	85	70	30	58
Weeding	63	85	80	70	85	77
Fertilizing	37	5	10	25	--	15
Applying Pesticides	11	5	--	10	--	5
Irrigating	11	5	10	25	45	19
Channel Maintenance	--	5	--	10	30	9
Harvesting	95	95	85	70	60	81
Threshing	68	--	--	5	--	14
Processing for Home Use	63	--	55	45	--	32
Transport to Market	5	5	--	15	5	6
Selling	26	5	5	30	5	14
Growing Supplementary Vegetables	100	90	90	70	85	87

Table E-3. Activities Performed by Farm Women Related to Other Field Crop Production (n=99)

Activity	Block 302	303	306	309	307	Overall Average
	- - - - - - - - % - - - - - - - -					
Land Preparation	89	75	5	25	15	44
Seed Procurement	74	10	5	25	35	31
Nursery Establishment/ Care	74	15	10	30	20	31
Transplanting	74	80	65	60	15	62
Weeding	74	90	60	60	10	62
Fertilizing	47	50	45	30	--	36
Applying Pesticides	16	5	--	5	--	5
Irrigating	11	5	5	20	--	9
Channel Maintenance	--	5	--	10	--	3
Harvesting	89	90	65	65	10	67
Threshing	58	--	45	5	--	22
Processing	89	85	50	60	20	64
Transport to Market	5	5	--	10	--	4
Selling	26	5	5	20	--	12
Growing Supplementary Vegetables	100	90	90	70	85	87

This discrepancy may be a result of the actual cropping intensity differences between the head and tail of the system related to water distribution. Another factor which may influence whether women participate in field activities is the degree of their agricultural experience. Women from the head of the system were primarily from purana villages and would have had more previous farming experience, compared to the women from the tail of the system who were primarily selectees.

Areas in which women were noticeably absent in participation included application of pesticides and maintenance of irrigation waterways. It may be that these activities are not performed by women due to the physical requirements involved. The commonly used knap-sack sprayer, when filled to capacity, weighs approximately 20-25 kilograms, a considerably heavy burden. On the other hand, the maintenance of channels may not require any more physical labor than land preparation, transplanting, weeding, and harvesting (themselves extremely physically demanding). The lack of participation of women in ditch maintenance may be related more to the low incidence of overall farmer input regarding this activity.

With other activities such as performing irrigations, participation varied with the crop being grown. Irrigation of paddy normally requires less intensive, lower management over a longer duration. Irrigation of other field crops, however, requires a more intensive management for shorter periods of time. Paddy irrigation provides opportunities for simultaneous work such as weeding to occur during the irrigation, whereas other field crop irrigation remains an exclusively performed activity. Therefore, during paddy irrigation a cooperative effort by both men and women usually occurs; with the irrigation of other field crops the woman would be occupied with a different unrelated activity rather than combining the two activities.

Transport of the crop to market was not performed by most women surveyed due to the distance involved (the largest central market being approximately 5 miles from some farms). Many of the farmers who sold their crop to private buyers were not involved in transportation of the crop either, as the buyer would load the bagged crop near the field.

b. Decision-making Process

When farm women were interviewed about the method by which decisions were made concerning the irrigated production system they revealed that discussion and jointly shared decision-making between husband and wife was common (Table E-4). In fact, more than 80 percent of the decisions related to crop production were made jointly between husband and wife.

Table E-4. Decision-making Process Regarding the Irrigated System*

Decision Topic	302			303			306			309			307			Overall Average		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	%																	
Land Preparation	—	84	16	5	95	—	—	90	10	5	60	35	5	85	10	3	83	14
Seed Selection	—	84	16	5	85	10	—	90	10	5	60	35	5	85	10	3	81	16
Nursery Establishment/Care	—	84	16	5	80	15	—	85	15	5	60	35	5	85	10	3	79	18
Broadcast Seeding	—	95	5	5	95	—	—	90	10	5	60	35	5	85	10	3	85	12
Transplanting	—	89	11	5	95	—	—	90	10	5	60	35	5	85	10	3	84	13
Weeding	—	89	11	5	90	5	—	90	10	5	60	35	5	85	10	3	83	14
Fertilizing	—	63	37	5	20	75	—	85	15	5	60	35	5	85	10	3	63	34
Applying Pesticides	—	21	79	5	20	75	—	75	25	5	60	35	5	85	10	3	53	44
Irrigation	—	5	95	5	—	95	—	50	50	5	60	35	5	54	40	3	34	63
Channel Maintenance	—	16	84	5	—	95	—	54	45	5	60	35	5	54	40	3	37	60
Harvesting	—	100	—	5	95	—	—	90	10	5	60	35	5	85	10	3	65	11
Threshing	—	95	5	5	60	35	—	90	10	5	60	35	5	75	20	3	76	21
Processing	—	95	5	5	65	30	—	90	10	5	60	35	5	85	10	3	78	18
Transport to Market	—	53	47	5	60	35	—	80	20	5	60	35	5	80	15	3	67	30
Selling	—	95	5	5	65	30	—	90	10	5	60	35	5	85	10	3	79	18

* 1 = mainly woman
2 = jointly
3 = mainly man

In three locations (blocks 303, 309, and 307) a divorced or widowed woman was solely responsible for decisions relating to the operation of her farm. In these cases; when decisions were made jointly with a man, he was usually the father, brother, or son of the woman. In these and other blocks an occasional household existed where all farming decisions were made by the male, but these were the exception rather than the rule.

Overall, the most noticeable male-dominated decisions occurred with subjects such as pest control and water management. These two activities were also predominantly performed by men. The orientation of extension information concerning these topics was also primarily toward men, rather than women.

c. Extension and Institutional Services

The Mahaweli Authority provides extension services through irrigation and agricultural field assistants. However, these assistants primarily focus upon male members of the family, often ignoring women working in the fields next to men. Ninety-seven percent of the women interviewed stated they do not receive information or training with regard to the irrigated production system. Furthermore, women (even those without husbands) do not attend kanna meetings or belong to turnout groups. The only identifiable source of information, with regard to farming, for the farm women was her husband. Sixty-five percent of the women revealed that they do receive information through their husbands. Unfortunately, the majority of this information usually dealt only with dates of water issues and not with agronomic or water management practices.

Approximately 73 percent of the women interviewed expressed interest in receiving information or training about irrigated crop production. The major areas of interest included water management, crop varieties, and agrochemical use. If some of these programs were directed toward women, extension-type, field demonstrations would be required rather than structured classroom programs. This flexibility is needed due to the lack of free time and inability of women, particularly those with small children, to travel to instructional centers.

d. Perception of Irrigated System Problems

Women involved in farming activities work closely with the particular crop at many stages of production. This close contact makes their perception of problems a valuable source of information regarding the successful and efficient operation of the entire system. Sixty-seven percent of the women interviewed mentioned particular problems occurring in the irrigated system. The problem mentioned most often was related to water supply. Overall, fifty-seven percent of the women interviewed indicated that water was a major problem (Table E-5). Significant variation occurred from the head to the tail of the system. Approximately 28 percent of women from the head of the system thought water supply was a problem, compared to 68 percent of the women from the tail of the system. These observations were also noted by the sociologist interviewing the farm men.

One interesting observation should be noted regarding the selection of water as a problem by the women in block 309. Women from this area included water supply as a problem to a lesser degree than women from block 307 an' 306. Water distribution to block 309 was, however, no more adequate than for block 307 and 306. The critical factor appears to be the fact that the cropping intensity in block 309 was considerably reduced over the other blocks. This meant that the available water was adequate for this reduced area, whereas the same amount of water would be inadequate for the greater areas cropped in the other

Table E-5. Perceived Problems of the Irrigation System. (n=99)

Problem	Block					Overall Average
	302	303	306	309	307	
	%					
Water Supply	21	5	70	50	40	37
Soil Condition	5	5	--	--	--	2
Land Leveling	--	10	--	5	5	4
Allotment Disputes	--	15	15	--	--	6
Water/Soil	5	5	--	--	35	9
Water/Leveling	--	20	--	--	5	5
Water/Disputes	--	15	5	--	--	4
Water/Soil/Leveling	--	--	--	--	5	1
Water/Leveling/ Disputes	--	5	--	--	--	1
Soil/Disputes	--	5	--	--	--	1
Total of Water-Related Problems	26	50	75	50	85	57

blocks. It appears that those women who were farming in block 309 responded to the question based on the actual area cropped rather than the potential farming area.

4. Household System

a. Activities Associated with the Household

The traditional, primary role of women is generally regarded as that of wife and mother. Through these roles, women are largely responsible for the welfare of the family. Furthermore, the productivity of women in this role is important for national development. The activities and tasks performed by women within the household also influence the extent of her participation in crop production and community involvement. Table E-6 presents the types of household activities performed by the interviewed women. Not unexpectedly, women were primarily responsible for the operation of the household.

An activity of particular interest is that of fetching water. This activity, performed by 98 percent of the women interviewed, is of critical importance to family health. Eighty percent of the women were using water from wells, while others in block 302 were using a combination of wells and nearby channels for water. The Mahaweli Authority has installed one concrete-lined well for every six families. However, most families have dug wells on their homestead for a more convenient water supply.

The water in most wells was reported to be adequate during Maha, but not in Yala, particularly at the tail of the system. In fact, water in many wells was only adequate when water was flowing in nearby D-channels. Newly installed wells, and wells with unreliable water supply were often considered not suitable for drinking purposes due to leaching from the concrete lining. If the well located in the homestead was a reliable water supply, fetching water was not a particularly demanding activity. However, when wells were dry, particularly in the tail of the system, women were required to travel up to 1/2 mile to procure water from either wells or canals. This would involve a considerable amount of time and energy for an already busy farm woman, especially during the Yala season.

One other aspect of the household water supply deals with the effect on the home garden. Overall, 87 percent of the women interviewed had home gardens. The extent of home gardening varied considerably, depending upon the season. During Maha home gardens were very extensive with a wide variety of vegetables. Gardens required less care and attention during Maha due to the reliability of rainfall in this season. During Yala, however, most home gardens were very limited in size and diversity. Overall, home gardens in Yala consisted mainly of fruit from established trees with a few drought-tolerant vegetables such as cowpeas.

Table E-6. Activities Performed by Women in the Household System (n=99)

Activity	Block					Overall Average
	302	303	306	309	307	
	-----------------	-----	-----	%	-----	-----------------
Cooking for Family	100	90	100	95	100	97
Cooking for Field Labor	100	100	95	90	90	95
Cooking for Feasts	100	100	95	95	90	96
Fetching Water	100	100	100	95	95	98
Fetching Firewood	84	50	55	50	75	63
Marketing	47	15	50	35	50	39
Child Care	84	70	40	85	45	65
Home Gardening	95	100	85	65	90	87
Planting	100	100	100	100	100	73
Watering	100	10	6	8	25	30
Gathering Food Items	95	95	95	60	95	88
Livestock Care	16	-0-	10	5	10	8
Tending Sick	100	100	95	95	100	98
Housecleaning	100	100	100	100	95	99
Laundry	100	100	100	90	100	98
Miscellaneous Activities	95	70	90	70	75	80

Home gardening also varied depending on the location of the homestead within System H. At the head of the system (blocks 302 and 303) 98 percent of the women interviewed were actively gardening on the homestead allotment, compared to 78 percent of the women located at the tail of the system (blocks 309 and 307). The women from the head of the system had home gardens producing both fruit and vegetables. Women from the tail of the system were much more dependent upon the established fruit trees, as only 50 percent of the gardening were able to grow supplementary vegetables on their homestead allotments.

An obvious reason for the success of vegetable gardening in the head of the system was the observation that all of the women (100 percent) in this location were actively watering their home gardens in block 302 from the nearby D-channel. By comparison, due to water accessibility, far fewer of the home gardens in the tail of the system were watered.

Overall, 88 percent of the women were gathering food items such as fresh green leaves from the bunds of irrigated allotments and the channel banks. These fresh vegetables are an important supplement to the family diet.

Many of the women interviewed (80 percent) were also involved in other activities of the household such as house maintenance and construction, weaving mats for home use, and record keeping. Of those activities, the majority of women were weaving mats, baskets, and constructing other items for household use. Over half of the women in the study area have lived on their homesteads for approximately 5 years or more. At this stage, many of the families were either planning or actually constructing a new house, or additions to the original home. Many women were involved in making and stockpiling bricks for this construction. Only a few (10 percent) of the women interviewed were keeping records of family and farm expenses and incomes.

Fetching firewood has traditionally been viewed as a woman's activity, but overall, only 63 percent of the women interviewed were engaged in this activity. When questioned, the women responded that firewood was becoming increasingly scarce in the area. Women said that they had been forced to travel further and further to find firewood as nearby supplies became depleted since resettlement. As the distance involved in collecting firewood increased, this activity became the husband's responsibility. Many women said that their husbands would now load firewood on their bicycles or two-wheel tractor wagons when returning home from other activities. In fact, a few women said that they had now resorted to purchasing firewood due to decreased availability, which puts an increased burden on family finances.

The Mahaweli Authority has recognized this serious problem and the newer Mahaweli settlement areas are being constructed with large tracts of land specifically for fuelwood and timber plantation establisment. Reforestation of depleted areas is underway in some reservation areas of other systems. System H, however, had very little land left as reservations so plantings have been relegated to small areas and avenue planting. Forest clearing in new settlement areas is also being restricted to the necessary irrigated allotments, with the clearing left to a minimum on the homestead allotments.

Marketing activities of women were also restricted due to travel distances. Only 39 percent of the women interviewed participated in this activity, leaving this task to their husbands. This lack of participation by women may effect the financial opportunities for women on a personal as well as a family level.

Livestock care was generally a responsibility of the husband or young boys, not women. Although efforts have been made by the Mahaweli Authority to introduce livestock and dairy farming, very few of the households surveyed possessed livestock.

b. Decision-making Processes

Overall, it appears that decisions with regard to the household system are made jointly by both husband and wife, as was the case with crop production decisions (Table E-7). It may also be observed that when decisions were not made jointly, the decisions of women generally were dominant compared to male decision-making. This was true for all of the decisions listed in Table E-7, with the exception of family planning. In this case, most families made decisions jointly (95 percent) but in a few cases the decision was made solely by the husband, rather than the wife. Another question, associated with the family planning question, involved the ideal number of children for a family. This response appeared to be fairly evenly divided among women. Almost equal thirds of the women interviewed chose 2, 3, and 4 children, respectively.

Decisions concerning health, sanitation, and nutrition were more often made by women than any other type of decision surveyed. This information supports the targeting of women for education and training in these areas.

Decision-making by women occurred more often in block 309. This may be due to the fact that 2 woman-headed households were included in the survey. Three of the other blocks included only one woman-headed household. This accounts for some of the increased percentage of decisions by women in block 309. But, even if the two households were not considered, a larger proportion of decisions by women occur in this block. One possibility might be the predominance of selectee families located in the tail of the system, rather than the more traditional <u>purana</u> village families.

Table E-7. Decision-Making Process Regarding the Household System*

Decision	Block 302			Block 303			Block 306			Block 309			Block 307			Overall Average		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	%																	
Food/Clothing	10	87	3	5	95	-	-	93	7	25	70	5	5	90	5	9	87	4
House Maintenance/ Construction	3	97	-	12	88	-	-	93	7	18	77	5	3	92	5	7	89	4
Savings	5	95	-	6	94	-	-	95	5	15	80	5	-	100	-	5	93	2
Children:																		
Education	-	100	-	5	95	-	-	100	-	21	68	11	5	90	5	6	91	3
Discipline	-	100	-	5	95	-	-	100	-	21	68	11	5	90	5	6	91	3
Vaccination	90	10	-	5	95	-	81	19	-	100	-	-	10	90	-	57	43	-
Boiling Water	90	10	-	5	95	-	32	68	-	100	-	-	15	75	10	48	50	2
Family Planning	-	95	5	-	100	-	-	100	-	-	100	-	-	80	20	-	95	5

* 1 = Mainly Woman
2 = Jointly
3 = Mainly Man

c. Extension and Institutional Services

The Mahaweli Authority has established Community Development Centers for the education of settlers, especially women. Training modules include: national traditions and customs, home economics, health and sanitation, upland crops, cattle rearing, needlework and handicrafts, and community leadership.

Overall, 93 percent of the women interviewed had not received information or training concerning household activities. Of the remaining 7 percent who had received instruction, needlework and handicrafts were the major subjects followed by health, sanitation and nutrition. Over 80 percent of the farm women responded with a desire to receive instruction. Areas of greatest interest included health, sanitation and nutrition, home gardening, and food processing. It appears that there was little interest in livestock rearing or care. Discussions with the women interviewed revealed that they considered livestock to be a larger investment in both time and cash than they could afford.

Many of the women interviewed, although enthusiastic about training, were doubtful about their ability to participate in any instructional programs (Table E-8). As indicated earlier, the distance to training centers and child care responsibilities prevented women from participating in many currently available programs. It appears that a

Table E-8. Ability of Women to Participate in Household Training Programs. (n=99)

Are you able to participate?	Block 302	303	306	307	309	Overall Average
	-----	-----	-----	%	-----	-----
Yes:	-	35	45	80	20	36
No:	100	65	54	20	80	64

hamlet-visitation, or demonstration, would be the most appropriate method for reaching the majority of farm women. A combination of different variables influences the ability of women to participate in such training programs. The number of young children in the family, the travel distance required, the woman's age, field work responsibilities, and her own personal incentive all are involved in whether she takes part in training opportunities.

d. Income and Expenditure Patterns

Income--Although the major source of family income is derived primarily from the irrigated field crop, other sources of income generation also exist. In fact, very few households were found that did not have some additional sources of income, no matter how small. Table E-9 presents information collected concerning sources of income other than the irrigated crop. Originally, there was some attempt to quantify the

Table E-9. Other Sources of Household Income. (n=99)

Source	Block					Overall Average
	302	303	306	309	307	
	%					
Home Garden	63	95	30	15	20	45
Off-Farm Labor	5	35	-	-	10	10
Livestock:						
Products	5	-	-	-	20	5
Power	10	5	5	10	-	6
Equipment Rentals	5	10	20	20	15	14
Handicrafts	10	-	-	-	5	3
Relatives	-	-	-	-	5	1
Others:						
Chena Cultivation	37	5	5	-	-	9
Contract Work	5	-	-	5	5	3
Sewing	5	-	-	-	5	2

amount of these incomes. However, due to the difficulties incurred, this was not accomplished.

As mentioned in an earlier section regarding household activities, the existence of a home garden varied both with season and location within the irrigation system. Consequently, the generation of income from these gardens would be expected to differ. Overall, the home garden was the most common alternative income source, followed by equipment rentals and off-farm labor. Chena cultivation during Maha may consist of a number of crops, including maize, millet, chilies, squash, and melons. During Yala however, due to rainfall limitations, sesame is practically the only chena crop cultivated.

Expenditures--The women interviewed were asked to prioritize household expenditures (Table E-10). As expected, expenditures for food received exclusive, high priority ranking. Crop production inputs (such as seed, agrochemicals, hired labor and hired draft power) were ranked as moderate in priority. Clothing and miscellaneous household items were ranked in the moderate to low priority category. Savings and repayment of loans received low priority and in may cases simply were not recognized as expenditures. In the case of repayment of loans, some families had not taken out loans at all. However, the majority of families incurring repayment of loans were unable to fulfill their obligations and defaulted. This default was blamed particularly on the serious water shortages experienced in this area for the past few growing seasons.

Table E-10. Household Expenditures by Priority.* (n=99)

Source	Block					Overall Average
	302	303	306	309	307	
	%					
Food	1	1	1	1	1	1
Crop Production Inputs	3	2	3	2	2	2
Clothing	2	3	2	3	2	2
Miscellaneous Household Items	2	3	3	3	3	3
Savings	4	3	3	3	4	3
Loan Repayment	3	2	4	3	4	3

* 1 = High priority 2 = Moderate priority 3 = Low Priority 4 = No priority

5. Organizational Participation

A settlement project such as System H brings together people from many different areas. Under these conditions the system, as designed, may not be operating at a very effective level. Through individual participation in community affairs, a higher order of social cohesion may be achieved, resulting in a more efficiently operating system. To be truly effective, women must be included as active participants in community organizations.

Involvement in community organizations by women was low (Table E-11). The most popular organizations were religious (Buddhist) with an overall 24 percent of the women interviewed participating in a local,

Table E-11. Organizational Participation by Women. (n=99)

Organization	Block 302	303	306	309	307	Overall Average
	%					
Religious Society	37	65	-	-	20	24
Death Donation Society	5	5	-	15	25	10
Political Society	-	10	20	-	10	8
Rural Dev. Society	-	-	-	-	5	1
Turnout Group	-	-	-	5	-	1

village-level association. The Death Donation Society is another village-level organization whose members contribute funds to insure appropriate funerals of deceased members. A direct question was not asked concerning participation in political groups due to possible sensitivity about revealing such information. Some of the women interviewed mentioned their political involvement voluntarily, therefore this category was included in Table E-11. Only two women from the entire surveyed sample (2%) were found who belonged to either the Rural Development Society or a turnout group. These organizations would be the only ones where information and training would be disseminated. Another function of these two organizations would be to improve farmer cooperation and involvement in addressing mutual problems.

Involvement of women in informal groups was much more common (Table E-12) than in other more formal organizations. The most popular consisted of women who went as a group to a nearby canal to bath and do their laundry. Again, the proximity to firewood and the market determined whether women participated, either singly or in groups, in these activities. The women in block 302 also mentioned that older daughters would assist with such tasks such as laundry, fetching firewood, and marketing, leaving them more time to participate in other activities such as mat weaving with their friends. Some women belonged to chit groups, a form of gambling, where money won was often used for nonessentials or savings. Other informal groups consisted of women attending the health clinic, or gathering reeds for mat weaving.

Table E-12. Informal Group Activities of Women. (n=99)

Informal Group	Block 302	Block 303	Block 306	Block 309	Block 307	Overall Average
	%					
Bathing/Laundry	21	100	95	68	35	64
Firewood Gathering	74	50	40	30	30	45
Marketing	42	15	65	20	35	35
Temple Groups	21	15	--	25	45	21
Handicraft	68	--	5	--	--	15
Chit Groups	21	10	5	5	20	12

6. Stress and Satisfaction Index

Abrupt social dislocation involved in a resettlement scheme may result in personal, family, and community difficulties. Families no longer have the traditional support system supplied by relatives. New ways of life can add mental stress to an already physically and financially difficult situation. Farm women were interviewed concerning various forms of stress and their satisfaction concerning the resettlement program (Tables E-13 and E-14).

Overall, most women interviewed were satisfied with their location, financial condition, and the services provided. Exchange of items; including household and agricultural items, money, and favors, was moderately frequent. Satisfaction with friendships was categorized as somewhat to very satisfactory. When these women were questioned about why they were generally more satisfied after resettlement than before, a number of opinions emerged. Over 70 percent of the women indicated that land ownership was their primary reason for satisfaction. Financial and neighborhood/facilities were also indicated nearly as often as land ownership. This generally confirms similar findings of the sociologist interviewing farm men.

Significant differences existed between women from different locations within the irrigation system. Women from the head of the system (mostly purana villagers) appeared to be happier (97%) after resettlement than women from the tail of the system (60%). Various reasons may account for this degree of satisfaction including: proximity to relatives, familiarity with the area, the quality of farmland, and water distribution. Only 2 percent of women from the head of the system (blocks 302 and 303) were happier before resettlement, compared to 40 percent of the women from the tail of the system (blocks 309 and 307). The women from the tail of the system were largely selectees, many of which were from another geographic location and had less farming experience than the women from the head of the system. In addition, they were located in a less favorable farming area with water distribution problems. Women from the tail of the system also expressed loneliness for their relatives, and a dislike for the hotter climate than found at their previous location. It may be that these women selectees were less content than their husbands due to losses of important and valuable kinship relationships.

Table E-13. Satisfaction Index of Women After Resettlement. (n=99)

Question	Block 302	303	306	309	307	Overall Average
	-------	-------	-------	%	-------	-------
<u>Present</u>						
a. Happier after resettlement	95	100	100	70	50	83
b. Financially better after resettlement	89	95	100	70	45	80
c. Prefer present location	89	95	40	80	100	81
d. No difference	11	--	50	--	--	12
<u>Past</u>						
a. Happier before resettlement	5	--	--	30	50	17
b. Financially better before resettlement	11	5	--	30	55	20
c. Prefer previous location	--	5	10	20	--	7
d. No difference	11	--	50	--	--	12
<u>Future</u>						
a. Happier in future	11	95	100	10	95	62
b. Financially better in future	11	95	100	15	95	63
c. Don't know	89	--	--	80	5	35
<u>Item Exchange</u>						
a. Not at all	--	5	25	5	15	10
b. Infrequently	--	10	10	25	20	13
c. Moderately frequent	100	85	35	70	65	71
d. Often exchange	--	--	30	--	--	6
<u>Friendship Satisfaction</u>						
a. Unsatisfied	--	--	--	5	--	1
b. Somewhat satisfied	5	70	55	20	100	50
c. Very satisfied	95	30	45	75	--	49

Table E-14. Stress Index of Women After Resettlement. (n=99)

Question	Block 302	303	306	309	307	Overall Average
	%					
Physical/Mental Stress After Resettlement	11	10	20	65	45	30
How Much Stress/Strain:						
a. none at all	90	90	80	35	55	70
b. very little	5	--	--	10	45	12
c. moderate amount	5	--	10	15	--	6
d. very much	--	10	10	40	--	12
More Field Work After Resettlement	74	90	70	45	80	72
More Housework After Resettlement	79	85	--	15	85	53
More Off-Farm Work After Resettlement	5	40	--	--	25	14

One problem mentioned by many of the women in the tail of the system was their financial situation. Some of the families from the tail of the system had previously owned shops or businesses before coming to the System H area. While the majority of these families were selectees, some of the other families actually purchased land from the original allotee, using money from the sale of their businesses and depleting their available capital. These women mentioned that it was very difficult to manage what little money was left for both household and farming expenses. Despite these hardships, women interviewed from all locations in the irrigation system were generally optimistic about their future, both financially and socially.

The degree of stress after resettlement was significantly different from the head to the tail of the system (Table E-14). Women from the head of the system experienced much less stress (11%) than women from the tail of the system (55%). This observation can be correlated with the earlier discussion involving proximity to relatives, familiarity of the area, quality of farmland, and water distribution.

Overall, 72 percent of the women interviewed noted that they now perform more field work than previous to resettlement, while 53 percent said their housework had also increased. With a greater amount of time devoted to field and housework, not many women were able to increase their off-farm work. Variations between women from the head and tail of the system were also noted. Women from the tail of the system did consistently less additional work than those from the head of the system. If this is the case, the stress and strain mentioned by the women in the tail of the system may be primarily social, rather than physical.

7. Summary and Conclusions

A major objective of this study was to identify the participation of women in various aspects of the farm, household, and community systems. In order to insure that each of these systems functions efficiently, a better understanding and appreciation of women's involvement is necessary. Programs to address the needs and desires of women may help determine the success and productivity of the farm, household, community, and nation.

Specific objectives related to the Diagnostic Analysis Workshop were to identify the interaction between farm women living on a resettlement scheme and the irrigated agricultural system on which they depend for their existence.

Based on the constraints inherent in the workshop, the major conclusions of this study follow:

(1) Women participated in the majority of activities involved in crop production. In addition to the traditional tasks, women were found to assist in many other activities such as land preparation, applying agrochemicals, irrigating, and sale of the crop. Women were solely responsible for growing additional vegetables, in either small plots or around the perimeter of the irrigated fields, for home consumption or supplemental income.

(2) Decisions concerning the irrigated crop system were generally made jointly, by both the husband and wife. When decisions were made by only one member of the household, they were usually made by either the husband, father, son, or brother. Male-dominated decisions were related to irrigation, channel maintenance and agrochemical use.

(3) Extension and institutional services provided to women concerning agricultural and water management topics were generally non-existent. Field assistants primarily focused on males often ignoring women who were performing the same activities. Over one-half of the women interviewed mentioned that their husband relayed information to them from kanna meetings. At this time, however, it appears that the only information obtained from these meetings relates to dates of water issues. Services oriented toward women, through Community Development Centers, did not include information and training about irrigated crop production. The women interviewed expressed great interest in topics such as water management, crop varieties, and agrochemical use. Any programs directed toward women should also consider the time and travel

restrictions of the average farm woman. It cannot be expected that women will be able to be truly efficient and productive in their field activities until these needs are met.

(4) The majority of women interviewed perceived water supply as a problem. Over half of the women from the tail of the system indicated that water supply was a major problem, compared to only about one-quarter of the women from the head of the system. These findings confirm those of the sociologist interviewing male farmers.

(5) Not unexpectedly, women were responsible for the operation of the household. Water-related activities such as fetching water and home gardening are important for the family welfare. Most families have dug wells on their homesteads for convenience, but these wells appear to be unreliable and inadequate during the Yala season. When this is the case women must travel approximately 1/2 mile to procure water. Wells located in the head of the system seem to have a more reliable water supply than wells in the tail of the system. The extent of home gardening varied, depending upon the season and proximity to a reliable water supply. Women from the head of the system were watering their gardens, whereas women from the tail of the system were dependent upon rainfall. Consequently, the home gardens receiving water were producing a variety of fruits and vegetables, home gardens located in the tail of the system consisted mainly of fruit from established trees. It is recognized that the question of a reliable, adequate, and equitable domestic water supply is of critical importance to personal, family, and community well being. Based on the limited scope of this study, specific recommendations could not be made concerning this problem. Therefore, it is suggested that further study of this problem is required in a search for solutions.

(6) Decisions concerning the household were generally made jointly by both husband and wife. When decisions were made by only one family member they were generally made by the woman. These women-dominated decisions included health, sanitation and nutrition. Only one decision appeared to be made more often by men than by women; this decision concerned family planning.

(7) Although many women expressed a strong desire to participate in the programs available through the newly established Community Development Centers, time and travel distances prevented many women from attending the centers. Training programs in home management, including some form of record keeping would increase the efficient use of time, energy, and money by women.

(8) Almost every household interviewed listed other sources of income, in addition to the irrigated crop. The home garden was the most common alternative income source. The degree to which the home garden contributes toward the household income appeared to be dependent upon the location within the irrigation system. Home gardens in the head of the system contributed to a much greater degree toward income, than

gardens in the tail of the system (used mainly for home consumption). Equipment rentals and off-farm labor (specifically from women) also were additional income sources for many households. Further study is needed in order to quantify the contributions of these various items to the overall family income.

(9) Household expenditures were priorit zed in the following order: food, crop production inputs, clothing and miscellaneous household items, savings, and repayment of loans. In some cases, families were unable to make payments and defaulted on loans. This was blamed particularly on the water shortages experienced in this area for the past few seasons.

(10) The participation of women in community organizations was very minimal. Local, village-level religious and Death Donation Societies were commonly the only organization involving women. Organizations for the dissemination of information and for addressing problems, such as the Rural Development Society and farmer turnout groups involved only two women of the 99 interviewed. Even women-headed households stated that they did not attend such meetings for information, but obtained dates of water issues, etc. from other farmers. Over one-half of the women interviewed did belong to an informal group associated with common daily tasks such as firewood gathering, bathing, and laundry.

(11) Overall, most women seemed satisfied with their life after resettlement, including financial conditions and community services. The major reason for this satisfaction was due to land ownership. Some variation from the head to the tail of the system was observed. Generally, even though most of the women from both locations stated that they had increased field and house work after resettlement, the women from the head of the system (purana villagers) indicated that they felt less stressed than those from the tail of the system (selectees).

F. List of Participants and Workshop Schedule

1. PARTICIPANTS

Team 1 (UDA WALAWE) - 302/D.1/T.7 and T.14

M. S. Manapperuma	Agronomist
K. D. Abeywardene	Economist
I. R. Amerasiri	Economist
N. P. Tittagalla	Economist
C. D. Wanigasnayake	Engineer
P. G. Kamalachandra	On-Farm Engineer
G. Amerasena	Sociologist
A. Herath	Women's Role

Team 2 (NOCHCHIYAGAMA) - 307/D.3/T.O. and T.15

D. N. H. Amarasuriya	Agronomist
P. M. J. Perera	Economist
L. C. A. Dias	Engineer
G. Munasinghe	On-Farm Engineer
D. P. Wickremasinghe	Sociologist
W. Abeysirigunawardena	Women's Role

Team 3 (TAMBUTTEGAMA) - 303/D.2/T.4 and T.14

R. B. Herath	Agronomist
S. D. Gnanatileke	Economist
A. K. Weerasinghe	Engineer
D. B. Rambodagedera	On-Farm Engineer
T. N. Tennakoon	Sociologist
N. Vijithasena	Women's Role

Team 4 (GALNEWA) - 306/D.1/T.1 and T.5

M. S. Dayaratne	Agronomist
C. Badaturuge	Economist
R. S. Gunatunge	Engineer
B. W. Somapala	On-Farm Engineer
A. Rajawasam	Sociologist
R. M. C. Kumarhamy	Women's Role

Team 5 (SYSTEMS G/B) - 309/D.3/T.2 and T.6

G. Munasinghe	Agronomist
W. M. R. W. Wijetunga	Economist
S. Perera	Engineer
S. G. M. Wickremarchchi	On-Farm Engineer
H. M. R. M. Malarachchie	Women's Role
D. N. C. Herath	Sociologist

2. WORKSHOP LEADERS

Coordinators	G. R. Chandrasiri Jayantha Jayewardene	L. Nelson
Agronomy	M. A. W. Bandaranayake M. H. Jayasurya	L. Nelson
Economics	G. R. Chandrasiri A. Ekanayake	
Irrigation Engineering and On-Farm Engineering	G. G. W. Gunatileke R. A. Nandasena G. G. W. Gunatileke Jayantha Jayewardene	T. Sheng P. Wattenburger
Sociology	L. Wickremasnghe	B, Parlin
Women's Role in Development	L. Wickremasinghe A. Ekanayake	K. Kilkelly

3. SCHEDULE

Date	Day	Time	Activity	Staff
June 26	Sun	1:00-05:00 PM	Participants arrive	
June 27	Mon	8:30-09:00 AM	Registration	All
		9:00-10:30 AM	Opening Ceremonies	All
		10:30-11:00 AM	Tea	
		11:00-12:00 PM	Diagnostic Analysis - (Video slide) - discussion	J. Alwis
		12:00-01:00 PM	Research Development Process (video) discussion	H. Gamage L. Nelson
		01:00-02:00 PM	LUNCH	
		02:00-03:00 PM	Programs for irrigation improvement in Sri Lanka	J. Alwis
		03:00-03:30 PM	Diagnostic Analysis (video)	H. Gamage L. Nelson
		03:30-04:00 PM	Tea	
		04:00-05:00 PM	Initial Evaluation	All
June 28	Tue	08:00-08:30 AM	Administration	
		08:30-09:00 AM	Report on Initial Evaluation	H. Gamage
		09:00-10:00 AM	Investments in Water Management - Pakistan (video) Egyptian Water Use Project (video)	L. Nelson
		10:00-10:15 AM	Tea	
		10:15-11:15 AM	Rice Breeding Programs in Sri Lanka	Dr. Senadheera
		11:15-12:00 PM	Plant-Soil-Water Relationships (video)	H. Gamage
		12:00-01:00 PM	Cropping Systems	Dr. Upasena
		01:00-02:00 PM	LUNCH	
		02:00-02:30 PM	Role of the Agronomist in DA	L. Nelson
		02:30-03:15 PM	Role of Engineering in DA	H. Gamage
		03:15-03:30 PM	Tea	
		03:30-04:00 PM	Role of Women in Irrigated Production Systems	K. Kilkelly
		04:00-05:00 PM	Assign Teams - What's in the bag? Who did it?	L. Nelson B. Parlin

Schedule (continued)

Date	Day	Time	Activity	Staff
June 29	Wed	08:00-08:30 AM	Administration	All
		08:30-09:15 AM	Individual Expectations	L. Wickramasinghe
		09:15-10:15 AM	On-Farm Development	H. Gamage
		10:15-10:45 AM	Role of Economics in DA	A. Ekanayake
		10:45-11:00 AM	Tea	
		11:00-12:00 PM	Gal Oya Water Management Project	S. Senthilnathan
		12:00-12:30 PM	Team Work (video)	B. Parlin
		12:30-01:00 PM	Role of Sociology in DA	B. Parlin
		01:00-02:00 PM	LUNCH	
		02:00-03:00 PM	Soils of Kalawewa	J. Alwis
		03:00-03:30 PM	Water Movement in Soils (video)	L. Nelson H. Gamage
		03:30-03:45 PM	Tea	
		03:45-04:45 PM	Management Organization O&M of System H	J. Bandaragoda G. Goonathileke
		04:45-05:00 PM	Professional Attitudes	
June 30	Thu	08:00-08:30 AM	Administration	All
		08:30-09:30 AM	Farmer Involvement	L. Wickremasinghe
		09:30-10:30 AM	Socio-Economics of Irrigated Agricultural Production in System H	A. Ekanayake
		10:30-10:45 AM	Tea	
		10:45-11:30 AM	Professional Attitudes	B. Parlin
		11:30-12:30 PM	Data Collection/Report Preparation - why?	H. Gamage
		12:30-01:00 PM	Team meeting format	L. Nelson
		01:00-02:00 PM	LUNCH	
		02:00-02:30 PM	Discussion on Reconnaissance	H. Gamage
		02:30-03:30 PM	Discipline Meeting on Reconnaissance	All
		03:30-03:45 PM	Tea	
		03:45-04:15 PM	Root Growth (video)	
		04:15-05:00 PM	Individual Expectations	

Schedule (continued)

Date	Day	Time	Activity	Staff
July 1	Fri	08:00-08:30 AM	Administration	All
		08:30-01:00 PM	Discipline Reconnaissance	All
		01:00-02:00 PM	LUNCH	
		02:00-02:30 PM	Assign D-channels to teams	
		02:30-03:30 PM	Team Planning Reconnaissance	All
		03:30-03:45 PM	Tea	
		03:45-05:00 PM	Discipline activities	All
July 2	Sat	08:00-08:30 AM	Administration	All
		08:30-01:00 PM	Reconnaissance Survey by teams	All
		01:00-02:00 PM	LUNCH	
		02:00-05:00 PM	Team Reconnaissance Report preparations	All
July 3	Sun		HOLIDAY	
July 4	Mon	08:00-08:30 AM	Administration	All
		08:30-10:00 AM	Team Presentations on Reconnaissance	All
		10:00-10:45 AM	Salt-Affected Soils (video)	L. Nelson
		10:45-11:00 AM	Tea	
		11:00-01:00 PM	Discipline Meetings	All
		01:00-02:00 PM	LUNCH	
		02:00-05:00 PM	Team preparation of work plan	All
July 5	Tue	08:00-08:30 AM	Administration	All
		08:30-01:00 PM	Field testing of instruments by discipline	All
		01:00-02:00 PM	LUNCH	
		02:00-03:30 PM	Finalization of team workplan	All
		03:30-03:45 PM	Tea	
		03:45-05:00 PM	Discipline meetings	All
July 6	Wed	08:00-08:30 AM	Administration	All
		08:30-04:00 PM	Team detailed studies	All
		04:00-05:00 PM	Team meetings - data reduction	All

Schedule (continued)

Date	Day	Time	Activity	Staff
July 7	Thu	08:00-08:30 AM	Administration	All
		08:30-04:00 PM	Team detailed studies	All
		04:00-05:00 PM	Team meeting - data reduction	All
July 8	Fri	08:00-08:30 AM	Administration	All
		08:30-04:00 PM	Team detailed studies	All
		04:00-05:00 PM	Team meeting - data reduction	All
July 9	Sat		HOLIDAY	
July 10	Sun		HOLIDAY	
July 11	Mon	08:00-08:30 AM	Administration	All
		08:30-04:00 PM	Team detailed studies	All
		04:00-05:00 PM	Team meeting - data reduction	All
July 12	Tue	08:00-08:30 AM	Administration	All
		08:30-04:00 PM	Team detailed studies	All
		04:00-05:00 PM	Team meeting - data reduction	All
July 13	Wed	08:00-08:30 AM	Administration	All
		08:30-04:00 PM	Team detailed studies	All
		04:00-05:00 PM	Team meeting - data reduction	All
July	Thu	08:00-08:30 AM	Administration	All
		08:30-04:00 PM	Team detailed studies	All
		04:00-05:00 PM	Team meeting - data reduction	All
July 15	Fri	08:00-08:30 AM	Administration	All
		08:30-04:00 PM	Team detailed studies	All
		04:00-05:00 PM	Team meeting - data reduction	All
July 16	Sat	08:00-08:30 AM	Administration	All
		08:30-04:00 PM	Team detailed studies	All
		04:00-05:00 PM	Team meeting - data reduction	All
July 17	Sun		HOLIDAY	

Schedule (continued)

Date	Day	Time	Activity	Staff
July 18	Mon	08:00-05:00 PM	Discipline report preparation	All
July 19	Tue	08:00-05:00 PM	Discipline report preparation	All
July 20	Wed	08:00-12:00 PM	Discipline report preparation	All
		12:00-05:00 PM	Team report preparation	All
July 21	Thu	08:00-05:00 PM	Team report preparation	All
July 22	Fri	08:00-09:00 AM	Final Evaluation	All
		09:00-05:00 PM	Team report preparation	All
July 23	Sat	09:00-01:00 PM	Team report presentations	All
		01:00-02:00 PM	LUNCH	
		02:00-02:30 PM	Team report presentations	All
		02:30-03:00 PM	Report on final evaluations	L. Wickremasinghe H. Gamage A. Ekanayake
		03:00-03:30 PM	Program Evaluation	
		03:30-03:45 PM	Tea	
		03:45-04:30 PM	Individual Comments	
		06:00-08:00 PM	Closing Ceremonies	J. Bandaragoda
		08:00-09:00 PM	Dinner by the WMSP	All

G. Glossary

Aththam	-	Sharing of labor
Bethma	-	Sharing of farming land which has been restricted in area for cultivation during a particular season
Chena	-	The cleared jungle-land used for shifting cultivation under rainfed conditions
G.C.E. (O.L.)	-	General Certificate of Education (Ordinary Level) A government examination at completion of grade 10
Kanna Meeting	-	A pre-seasonal cultivation meeting between farmers and irrigation officials
Maha	-	Cultivation season extending from October to February
Mammoty	-	A hoe-like implement with a broad blade and a handle; used for plowing and hand weeding
Paddy	-	Unhusked rice; generally measured in bushels, with one bushel of paddy equivalent to 18.5 kg (45 lbs.)
Purana	-	Old or traditional; referring to villages previously scattered throughout the Mahaweli development area
Yala	-	Cultivation season extending from March to September

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