1980 YEARBOOK FOR SRI LANKA WATER MANAGEMENT RESEARCH

INITIAL ANALYSIS OF PRE-REHABILITATION SITUATION IN LEFT BANK GAL OYA

JUNE 1982

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Sri Lanka

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RESEARCH STUDY No 48

JUNE 1982

Agrarian Research and Training Institute,
Colombo, Sri Lanka
and
Rural Development Committee Center for
International Studies, Cornell University,
Ithaca, New York

Prepared for the Water Management Project of the
Government of Sri Lanka and the U.S. Agency for
International Development

FOREWORD

Sri Lanka had a tradition of irrigated agriculture for over two thousand years. It had been the ambition of most of the Sinhala kings to build maximum number of tanks and reservoirs during their kingship. As a result, the entire country was covered with tanks of various sizes for the purpose of irrigating agriculture, particularly, paddy. Historical evidence shows that there was an efficient system of management of these irrigation schemes. The rules and regulations governing the use of water in particular tanks were very often inscribed on a stone and installed at the site for the information of all. Unfortunately these management systems were lost to us during the dark ages that Ceylon passed through immediately before and during the foreign invasions. A revival of the irrigation system was seen towards the end of 19th century and in addition to the rehabilitation of old systems,new irrigation schemes were also undertaken since Independence.

With increasing investments in the irrigation sector, water management has become a key element in the irrigation policy of the government. There is also a realisation that co-operation of water users is imperative to have an efficient system of water management. Hence,all the new investment projects in irrigation had a condition that the authorities concerned should evolve suitable methods to get the co-operation and participation of farmers for water management. As such, when the USAID supported Gal Oya Rehabilitation Project was commissioned,the Agrarian Research & Training Institute was requested by the donor agency and the Government of Sri Lanka to recommend the most efficient farmer organisation for water management in the Gal Oya scheme. This assignment necessitated conducting of socio-economic surveys. It includes the formation of water user organisation, the study of ways and means of farmer participation at various levels in the process of water delivery and methods of communication between the users and controllers of water, etc.

Although the ARTI undertook this task, it had no prior experience in action-research of this nature. However, in preparing the plans for this research programme it had the benefit of advice from the Rural Development Committee of Cornell University in USA as a Consultancy. Professors Uphoff, Levine, Barker and Coward as short-term consultants were constantly in touch with the Irrigation and Water Management Group of the ARTI in preparing the design and conducting this research programme. In addition, there were also the long-term consultants such as Ed Vander Velde and Mark Swendson to work with the ARTI research team continuously.

Research on water management will be a continuing process at the ARTI for several more years to come. As and when certain research results are available, they will be disseminated through research documents and occasional publications as is the normal practice at the ARTI. In addition, it is felt useful to publish an Year Book on water management research as an annual publication incorporating all relevant materials which are not sufficient to be published as individual publications but will make a useful document when put together. This first Year Book presents the results of the base-line socio-economic survey done at Gal Oya under the water management project by the ARTI. It is intended that the Year Book will not confine to the dissemination of research done by the ARTI alone. It is open to other researchers as well and I hope that in future other individuals and institutions interested in the field of water management will contribute research results to the future issues of the Year Book.

I wish to thank all those at the ARTI and Cornell University for their contributions in making this Year Book a reality. Messrs C.M. Wijayaratna (Co-ordinator), H.A. Ranbanda and Lakshman Wickremasinghe - Research & Training Officers of this Institute were responsible for planning and conducting the base-line study. Professor Norman Uphoff of Cornell University and M/s Lakshman Wickremasinghe and C.M. Wijayaratna were responsible for the preparation of this Year Book for 1980.

T.B. Subasinghe
DIRECTOR

INTRODUCTION

This first yearbook on water management research in Sri Lanka presents the results of socio-economic research done by ARTI in support of the Water Management Project at Gal Oya, from October 1979 to September 1980. The Water Management Project is implemented by the Ministry of Land and Land Development and the Irrigation Department, with financial assistance from USAID. The Irrigation Department is assisted in its effort by Engineering Consultants Inc., (ECI). The Project envisages the fulfillment of a series of major water management objectives based upon the rehabilitation and modernization of the left bank sub-system of the Gal Oya irrigation scheme.

Under the Project, provision was made for conducting socio-economic research on the Gal Oya Project area, including detailed record-keeping of irrigation, agricultural and socio-economic data on farms in a sample of the area, and a baseline study during the first year. These activities will provide a basis for assessing the impact of the project over its four-year life-of-project and also for suggesting ways of increasing implementation effectiveness during that time. Such knowledge is intended also to provide a basis for improving water management elsewhere in Sri Lanka.

One major component of socio-economic research not implemented during the first year was work on institutional organization of farmers to assist in irrigation rehabilitation and management, as provided for in the project design and accepted in ARTI's socio-economic research plan. During the first year, ARTI in cooperation with Cornell University, undertook various analyses relative to this area of work and initiated plans for an action research programme for institutional development at the farm and field channel level. This is one of the major focuses of ARTI effort during the second year and will be reviewed in a separate research paper.

Under a cooperative agreement which USAID has with Cornell University's Committee (which has had cooperating relationships with ARTI since 1973), a number of consultants, and a long-term consultant have been working with the Water Management Research Group of ARTI on implementation of the socio-economic aspects of the Water Management Project. Working with the WMRG as short-term consultants have been Professors Randy Barker (Agricultural Economics), Walter Coward (Rural Sociology), Gilbert Levine (Agricultural Engineering), Norman Uphoff (Political Science) and Dr. David Korten (Public Administration). Also, Mr. Benjamin Bagadion, Assistant Administrator and Mr. Carlos Isles, Chief Community Organizer, of the National

Irrigation Administration of the Philippines have worked with ARTI under the Cornell Cooperative Agreement. Prof. Edward Vander Velde (Geography) has been the resident consultant since June 1980, and Mr. Hammond Murray-Rust (Agricultural Engineering) has also worked with the WMRG, conducting research on the structures and operations of water distribution in Gal Oya.

The record keeping exercise was launched in October 1979 in eighteen colony (settlement) units on the Left Bank and six colony units of the Right Bank and River Division of the Gal Oya irrigation scheme. Twenty-four trained investigators were resident in the respective colony units for the duration of this exercise.

A baseline survey was undertaken in March 1980, in the same record-keeping colony units of the Left Bank and in an extended area in the Right Bank and River Division. All together, 780 farmers were interviewed for the baseline study, 480 from the Left Bank and 300 from the other two areas.

This first report focuses on some of the principal initial findings pertaining to the Left Bank area from analsyis of the data generated in the aforementioned exercise.

The Water Management Research Group wishes to thank the following persons for their assistance and support during various stages of the study. Dr. Randy Cummings, USAID, Colombo for helping us to resolve some thorny issues with regard to the selection of the sample for the baseline study in the Right Bank and River Division areas of the Gal Oya scheme and his intellectual companionship during the field surveys; Professor Randy Barker for able advice and guidance in analyzing the agro-economic data; Mr. Doug Merrey, Institutional Adviser, ECI for his insightful comments on an earlier draft; and Mr. Gunawardena, Investigator, ARTI, for his able assistance in making administrative and supervisory tasks of the WMRG in Gal Oya lighter.

We especially wish to thank Professor Norman T. Uphoff for his invaluable advice and guidance in analyzing social and attitudinal data, in editing this report and his genuine and abiding interest in water management studies in Sri Lanka.

C.M. Wijayaratne
Lakshman Wickramasinghe
H.A. Ranbanda (on study leave)
Water Management Research Group, ARTI

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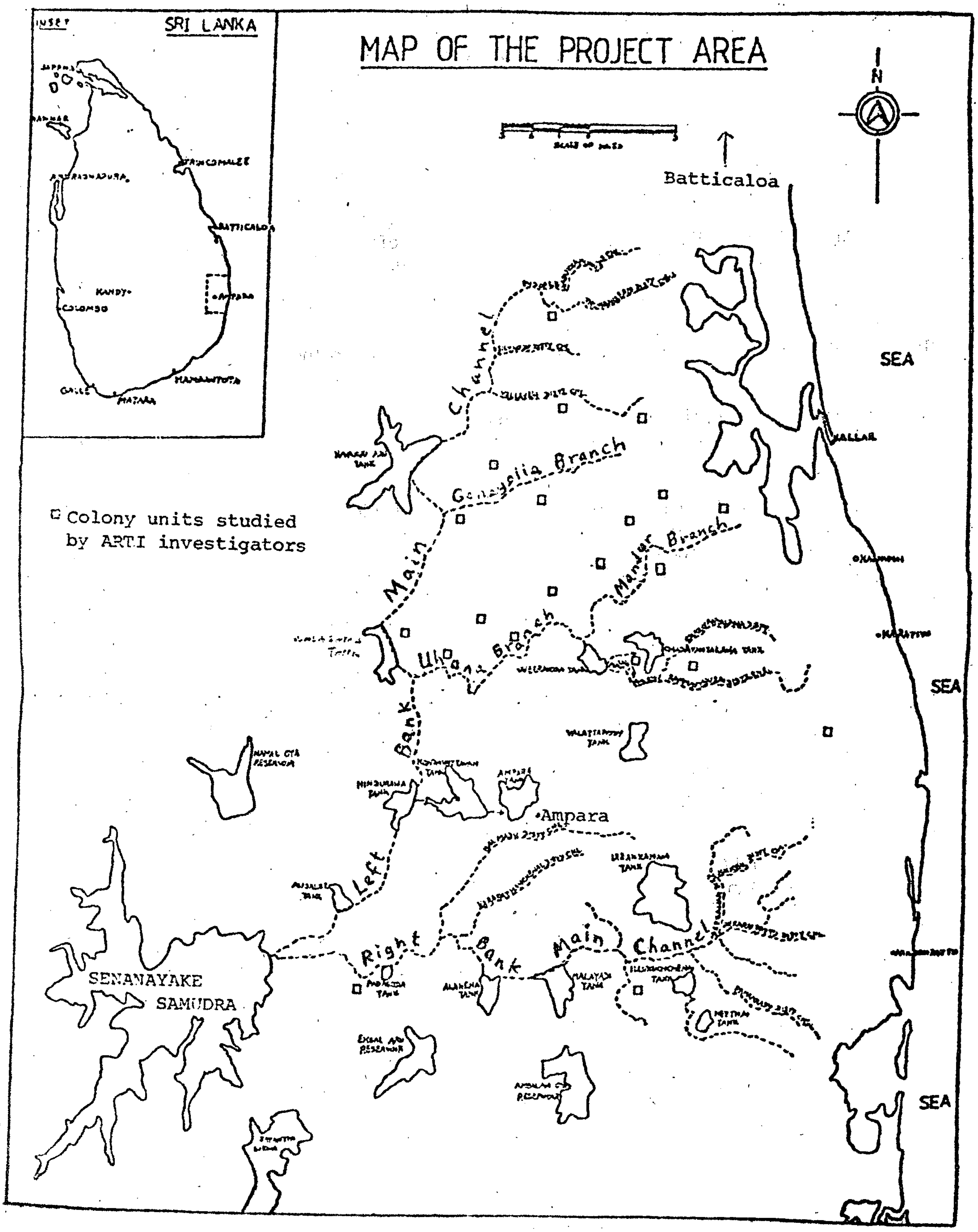


MAP OF THE PROJECT AREA
INSET
SRI LANKA
N
Batticaloa
SEA
SEA
SEA
Colony units studied by ARTI investigators
Main Channel
Gonagolla Branch
Mandur Branch
Uhana Branch
Left Bank
Ampara
Right Bank Main Channel
SENANAYAKE SAMUDRA

Chapter I

RESEARCH DESIGN AND METHODOLOGY

C.M. Wijayaratne

The specific assignments undertaken by the Agrarian Research and Training Institute in support of the Gal Oya Water Management Project during the 4½-year life-of-project are as follow.[1]

(a) To conduct a baseline survey of
   i) Socio-economic conditions of the settlers in the Project area and
   ii) Water management (WM) aspects of the Scheme;

(b) Continuing socio-economic and water management surveys to monitor and assess changes during project implementation;

(c) Conduct periodical evaluations of the project's socio-economic impact including consequences of the water management programme for farmers;

(d) Conduct socio-economic research to design "organizational structures" for water management, which has been translated into institutional organization of farmers; and

(e) Conduct additional research studies pertaining to water management.

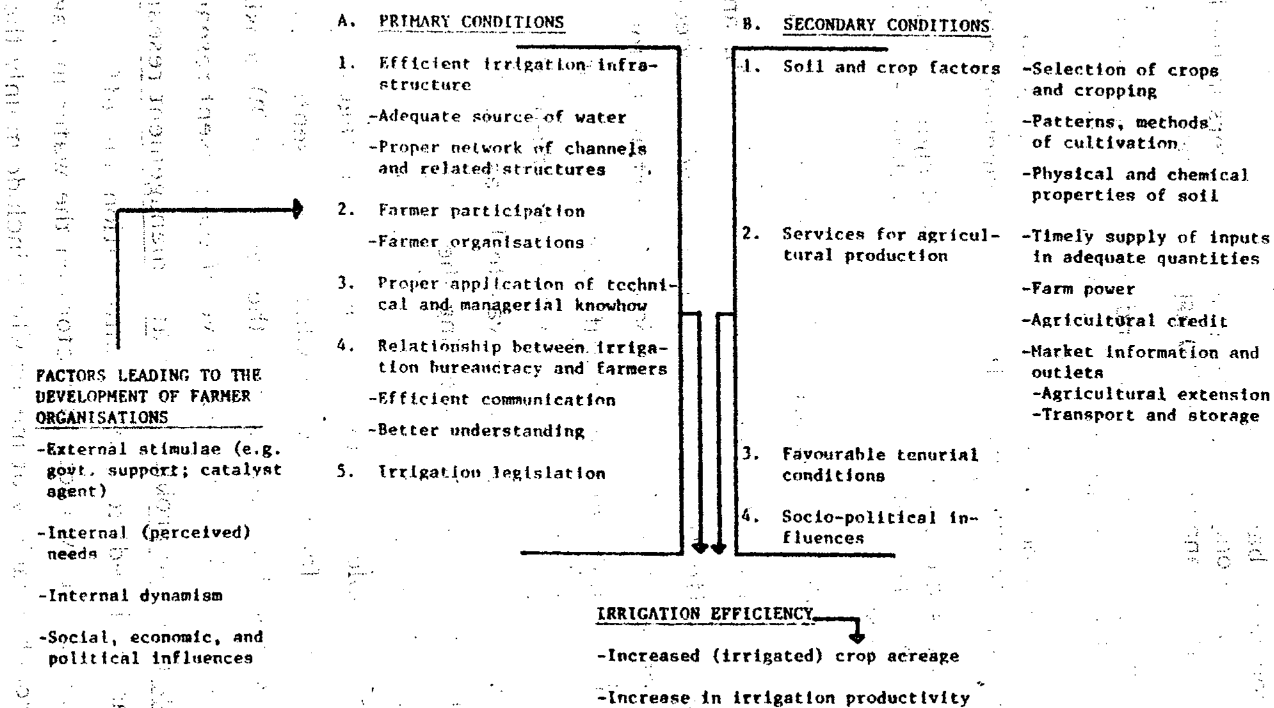
In the initial phase of planning the project research, an attempt was made to identify the factors affecting water management and to proceed to study the influence of such factors on water management. Some important factors are listed in the Chart I. This was useful not only to identify the priority areas of water management research, but also to decide on areas in which the pre-project situation with regard to water management in the project area was to be assessed. In addition, it was deemed necessary to analyze the factors affecting the utilization of irrigation water so as to construct a set of indicators which could be used in monitoring and evaluating project benefits both in the implementation and post-project stages.

The first set of factors (A) in Chart I represents those which are essentially agronomic and technical in nature, while the second set (B) consists of the institutional-organizational factors. Since the objective of the present research project is to employ an integrated approach to problems of water management research, the data collection programme was designed to gather information on effects and consequences of interaction of the above two sets of factors on the water management practices in the project area through a variety of means which include mainly the following techniques:

[1] A short description of the project (its area and history, and its objectives) can be found at the end of this chapter.

Chart 1-1:

Factors Influencing Irrigation Efficiency



1. A continuous record keeping/monitoring exercise on a selected sample of farms in the project area using trained investigators;
2. A supplementary baseline (questionnaire) survey;
3. Periodic surveys designed mainly for evaluation purposes;
4. Review of available literature;
5. Field observations by researchers;
6. Information collection through a programme of special water management (research) studies; and
7. Expert consultation.

The record keeping/monitoring programme was used as the major source of information mainly for the following reasons:

1. Data pertaining to water use, especially in relation to reliability and adequacy of water supply at various levels, cannot be ascertained adequately and in a reliable manner without continuing and close observation;
2. Because of "recall" lapse among farmers, the details of farm operations carried out by farmers throughout a cultivation season, including costs and returns, cannot be ascertained accurately through a "one-shot" questionnaire survey.
3. Qualitative types of information on cooperation and conflict, group dynamics and patterns of leadership, quality of self-reliance, etc. could only be gathered through some participant-observer activities which ARTI investigators living in the communities could do.

The plan of work and the ways and means by which the information gathered through the above methods would be used to accomplish the tasks assigned to the Agrarian Research and Training Institute are illustrated in Chart 2.

Data Sought

The type of data collected through the above-mentioned programmes can be classified as follows:

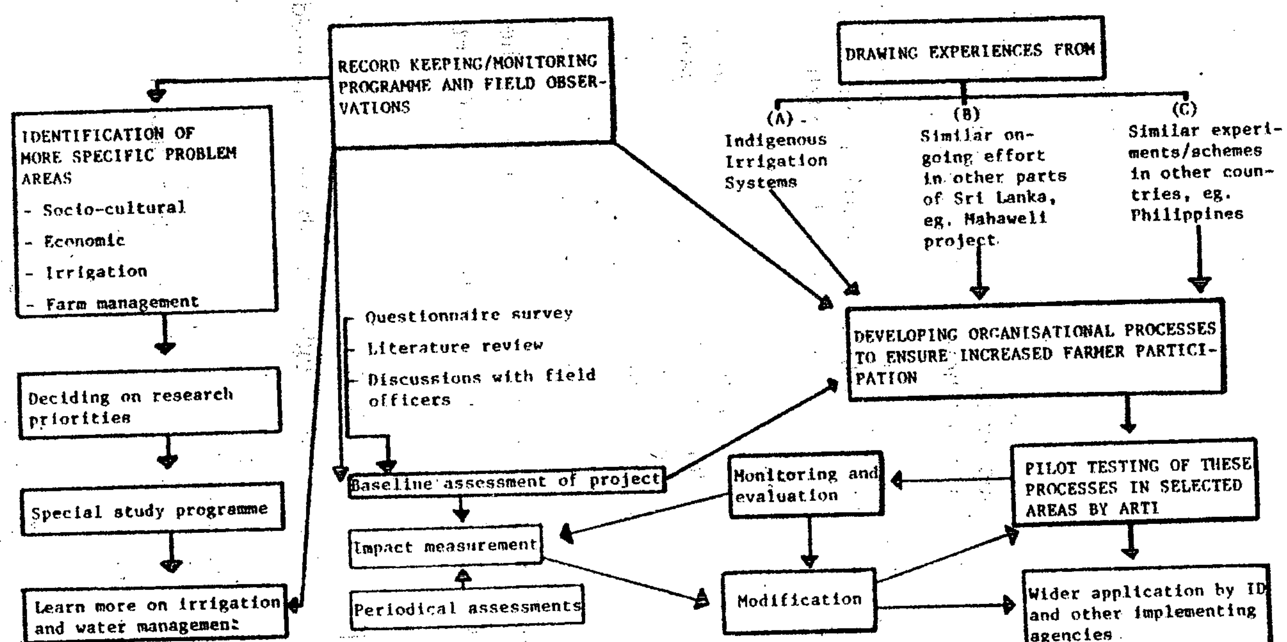
A. Specific information related to water use.
B. Information related to farm and household economy.
C. Social and community aspects.

A. Specific Information Related to Water Use.

I. Water distribution:

a) Pre-scheduling and regularity of channel flow (quantity and reliability); information on mechanisms through which pre-scheduling is arranged; bureaucratic decision-making as against cooperative decision-making; deviations from schedules, etc.;

Chart 1-2:
Research Design and Plan of Work



b) Equitability in distribution of water in respect to head vs. tail, large vs. small, regular vs. encroached holdings.

II. Farmer involvement:

a) Farmer participation in decision-making on water management at various levels (main, branch, distributary, and field channel levels and in the turn-out area);

b) Farmer participation in maintenance of channels, distribution of water and handling disputes;

c) Farmers knowledge and perception on optimizing the use of irrigation water; attitudes to water management, levels of knowledge of efficient use of water, knowledge of benefits to self and community, etc.;

d) Communication between farmers and controllers -- frequency of contact, uni-directional vs. bi-directional; disparities in exposure; authoritarian vs. democratic; effectiveness and responsiveness, etc.;

e) Types of formal and informal organizations as well as individuals influencing water management; mechanisms of their operation, etc.

III. Cultivation:

a) Farmers adherence to cultivation schedules decided at cultivation meetings;

b) Degree of staggering of paddy cultivation and its impact on water use, rotations, etc.;

c) Intensification of land use;

d) Increase in irrigated crop acreages as a result of better water management.

IV. Domestic use of water -- sources, pattern of use, problems associated with domestic water.

V. Other aspects of operation and maintenance of the system.

VI. Water losses and wastage, adoption of water-saving agricultural practices and technology.

B. <u>Information Related to Farm and Household Economy.</u>

I. Farm households:

a) Size of households; population growth rates;
b) Age, sex, marital status, etc. of members of the household;
c) Educational status;
d) Occupations

II. Farm holdings:

a) Size of holdings (owned, rented, encroached, or worked by labourers);

b) Status of holdings (owned, rented, encroached, etc.);

c) Area cultivated and cropping pattern and seasonal variations;

d) Distribution of holdings, fragmentation, etc.;

e) Intensity of cultivation.

III. Farm operations:

a) Use of modern inputs (fertilizer, plant protection chemicals, etc.);

b) Farm equipment and availability and use of farm power;

c) Cultivation practices in irrigated land and highland;

d) Harvesting and threshing operations;

e) Farm productivity and yield levels.

IV. Employment:

a) Employment and availability of labor for agriculture, labor use characteristic of households;

b) Off-farm employment.

V. Credit, marketing, input supply and other aspects of production:

a) Availability and dependability of sources of credit;

b) Delivery of inputs in time;

c) Agricltural advisory services.

d) Availability of marketing outlets, processing facilities and their efficiency;

e) Market information;

f) Net returns to different factors of production;

g) Profitability of farming;

h) Household expenditure pattern;

i) Levels, structure and distribution of incomes from farming and non-farming activities.

C. Social and Community Aspects.

I. Household conditions and facilities available: type of house, water supply and sanitary facilities.

II. Health and medical facilities: hospital and clinic facilities; infant mortality and crude death rates, estimate of life expectancy at birth; health care, family planning, etc.;

III. Education: type and number of schools and staff; distance to schools from households; school drop-out rates, etc.;

IV. Transportation and communication: road structure, modes of transportation and their distribution; number of newspapers, magazines, etc. received and read by family members; awareness of information related to water use in the scheme;

V. Entertainment and recreation;

VI. Religion and culture;

VII. Insurance;

VIII. Commerce and industry: trade establishments, cottage industries, etc.;

IX. Social organizations and structure, leadership patterns and attitudes;

X. Services provided by institutions: Rural Development Societies, Cultivation Committees, Cooperative Societies, etc.

In terms of project impact assessment, it is anticipated that the specific information related to water use (category A above) would spell out in very concrete terms whether the project had the desired impact in improving/changing infrastructural, behavioural and situational factors affecting water management. The other two categories of information would be useful in assessing the social and economic consequences of the project and would help in measuring the benefits of the project to the people and the community.

Data pertaining to most of the items classified under all three categories were ascertained through the record keeping/monitoring programme supplemented by informal interviewing and participant-observation. A special record book with seven different recording schedules was used for this purpose. During the cultivation season, the researchers visited each one of the study locations frequently and supervised the progress of record keeping work undertaken by the twenty-two trained ARTI investigators who were resident in the respective colony units for the entire duration of this exercise. The sampling technique adopted for the record keeping/monitoring programme was a two-stage stratified, random sample design with "colony units" as the primary sampling units, field channels as the secondary units, and allotments along selected field channels as the tertiary sampling units.[2] Nearly 50 percent of total colony units in the Left Bank Area were selected randomly at the first stage. At the second stage of sampling along a major distributary channel (D-channel) within the colony unit area, three field channels were selected to represent the head, middle and tail portions of the distributary's command area.[3] The total number of allotments selected from the respective command areas of these field channels was 368. If the number of allotments on a selected field channel was less than 20, all were included in the study; if there were more than 20, a random sample of 20 was taken.

The total number of farmers operating on the sample of allotments selected in the sample was, on the average, 60 percent higher than the number of allotments. It is evident that this is due to changes that had occurred in the tenurial pattern since the inception of the scheme, such as:

a) dividing the original holding among the children of an original settler, and

b) illegal land transactions.

Therefore, the total number of farms/farmers included in the final sample for the record keeping/monitoring programme the Left Bank in Maha season 1979/80 was 536.

In addition, in order to observe possible non-project influences, three additional sites outside the project area (one from the River Division and two from the Right Bank) were included in the record keeping/monitoring programme. The methodology adopted in the selection of field channels, farms, etc. and the type of information gathered in these three areas were similar to those for the Left Bank.

A supplementary questionnaire survey was carried out in March 1980 which covered almost all the farms included in the record keeping/monitoring activity and on 300 additional households from the River Division (201) and the Right Bank (99) of the Gal Oya Scheme.

Lists of settled villages/units prepared for the Right Bank and River Division formed the frame for sampling at this stage. Taking into consideration the size of

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[2]The irrigable area of the scheme had been alloted to settler families brought into the scheme at different stages of settlement in holdings of three and four acres each.

[3]In the subsequent seasons a slight modification was made in the selection of field channels. That is, whenever a distributary channel cuts across colony unit boundaries, the unit boundaries were ignored and three field channels were selected to represent the "head", "middle" and "tail" portions of the distributary, regardless of unit boundaries. This was done to get more correct measures of hydrological differences within the system.

Colonisation Unit/ Village	Record Keeping/ Monitoring Programme	Supplementary Baseline Survey
Left Bank:		
2	37	30
3	39	36
7	24	22
8	34	30
10	21	20
14	19	19
17	36	29
21	49	40
22-23	53	38
24	23	19
26	24	22
30	54	49
32	24	24
35	22	21
39	20	20
Block "J"	22	21
Block "E"	18	20
Block "D"	17	20
	536	480
Right Bank		
11A	20	17
23A	22	22
22A	--	20
5A	--	20
9A	--	20
	42	99
River Division		
Sengapadai	20	20
Madugaha Ela	--	22
1	--	20
4	--	20
16	--	19
32	--	20
40	--	20
52	--	20
58	--	19
66	--	21
	20	201
TOTAL	598	780

population and extents under agricultural production, three additional villages from the Right Bank and nine additional villages from the River Division were selected on a random basis. Then the Paddy Land Registers of the selected villages were obtained from the respective Cultivation Officers and a random selection of five percent of the farms was made with a lower limit of 20 in each study location. Therefore, in the end, 598 (of which 536 were from Left Bank) and 780 farmers were included in the record keeping exercise and baseline survey, respectively.

The analysis presented in this volume does not cover all the study locations or all the categories of data collected through the research programme. Analysis of all the data will take several years, so we have concentrated on those analyses which most readily give a good initial picture of water management practices, problems and outcomes in the Left Bank where the Gal Oya Water Management Project is being implemented, as well as on associated socio-economic factors, including domestic water supply, which should be taken into account in furthering the objectives of the WMP. In some chapters, the analysis of data is limited to selected (representative) units of the Left Bank, while in other chapters it covers the entire Left Bank Area. Future volumes will contain more data and analysis on areas that are not covered by the present analysis.

The Project Area

The Gal Oya Irrigation Scheme covers a geographical area of 600 square miles. It is located in the eastern Dry Zone, mainly in the Ampara district with part lying in the southern part of Batticaloa district. The Gal Oya Project commenced with the building of the main dam across the Gal Oya River at Inginiyagala in 1948 and the Left Bank development was completed in 1960. The main tank is the Senanayake Samudraya. The Gal Oya Scheme was designed to provide irrigation for an extent of 120,000 acres of which 60,000 acres are on the Left Bank channel. The capacity of the Senanayake Samudraya at full supply is 770,000 acre-feet. The Left Bank is planted mostly in paddy, while the Right Bank is largely paddy, but with 10,000 plus acres in sugar cane. The Gal Oya Left Bank system is estimated to be composed of 32 miles of main canals, 50 miles of major distributaries, and 68 miles of minor distributaries and field channels. The latter figures may in fact be higher.

In earlier project documents, it is mentioned that the Left Bank canal serves some 40,500 acres, including 6,000 acres served in the Kalmunai division at the end of the Left Bank main channel and in the Batticaloa district. However, the ARTI's research work in the project area suggests that the Left Bank system covers at least 65,000 acres at present. This includes encroachments and private holdings as well. The Left Bank drainage is directly into the ocean and the lagoon area.

From the early Fifties, the Gal Oya Development Board commenced setting up a large number of colonization units on the Left Bank. Forty of these units consist of approximately 6,000 households. Besides these colonization lands, there are two government farms and private lands on the Left Bank with and without water rights. The process of peasant colonization continued with the expansion of the channel system and by 1965, 11,936 colonists families had been settled.

The catchment area receives an average of about 83 inches of rainfall spread over 100 days in the year of which 63 inches comes during the northeast monsoon period, October to February. However, one may observe also marked year-to-year variability in the rainfall pattern if one considers a series of annual rainfall figures. The main demand for irrigation water is from March to September, since a Yala crop is possible only on lands which are irrigated.

The Gal Oya Scheme was within the purview of Gal Oya Development Board from its inception. However, in early 1961 along with the creation of the district of Ampara, the administration of the Left Bank had been handed over to the Government Agent, Ampara.

Project Objectives

The project is intended to develop an institutional capacity in the Irrigation Department which will enable it to manage large irrigation schemes in a more efficient manner. According to the draft proposal, the project will modernize the Left Bank of the Gal Oya Irrigation Systems, develop master plans and conduct on-farm water management research, provide an improved irrigation training programme, improve the extension programme and improve farmer participation in the rebuildling, operation and maintenance of field channels.

Organizing farmers into viable 'water user' or irrigation organizations in which they can participate in the allocation of irrigation water is an integral part of this project. Initially, socio-economic research was to be conducted to develop and test several "models" of irrigation organizations. By the end of the project, a target was set to have about 19,000 farmers, working on 57,000 acres of land, organized into water user organizations. It is expected that they would cooperate to use water more efficiently and to operate and maintain field channels. The project paper also provided that a legal framework would be established whereby farmers' organizations would play a role in water management at the distributary channel and project levels.

Research Plans

Private land holdings were not sampled in the original benchmark survey or in the record keeping/monitoring programmes, because ARTI had been previously advised that the project area included only colony units. It turns out that such holdings are substantial in the project area and definitely affect water needs and distribution. Organization of farmers for improved water management must take these holdings into account. Thus, plans are being made to conduct a special study to study the private holdings and encroachments. In addition, these areas will be included in record keeping/monitoring programmes in the future.

The ARTI Socio-Economic Research Programme on Water Management and the concepts and assumptions which guide the action-research programme for developing suitable institutional forms and processes for efficient water management in the project area are described in detail in the following ARTI documents: (A) Action Plan for Introducing Farmer Organizations and Participation in Water Management in the Gal Oya Irrigation Scheme (1980); and (B) A Proposal for Socio-Economic Research in Water Management in Sri Lanka USAID/ARTI/Cornell (1979).

Chapter II

AN ANALYSIS OF WATER DISTRIBUTION IN GAL OYA LEFT BANK: A WATER AVAILABILITY INDEX AND OTHER MEASURES

C.M. Wijayaratne

2.1 Adequacy and Reliability of Water Supply in Maha 1979/80

As seen from Chapter 1, adequacy and reliability of water supply are crucial factors affecting the behavior of farmers in Gal Oya. As a major part of ARTI's monitoring and evaluation work in the Left Bank, a record-keeping program involving some 541 farmers in the 18 sampled units was designed to gather information on water supply and agricultural performances during Maha Season 1979/80.[1] This chapter deals with two categories of data:

(a) Data pertaining to the adequacy of water inputs at the individual farm level; and

(b) Data pertaining to the adequacy and reliability of water flows in the channel system.

The adequacy of water at the farm level was evaluated by observing selected farm plots on a daily basis (between 8 and 10:30 a.m. covering an average of 30 farms per colony unit), using the investigators stationed in the respective colony units. Along a major distributary channel (D-channel) within each colony unit, field channels were selected to represent the head, middle, and tail portions of the distributary's command area within that unit. If the number of farmers on a selected field channel were less than 20, all were included in the study; if there were more than 20, a random sample of 20 was taken.

The investigators were trained in methods of assessing visually the water availability in farmers' fields, so that observation errors could be reduced as far as possible. Five conditions of water availability were specified, and daily observations were made for each farm covered by the record-keeping program. Within each farm, observations were made for two selected liyaddas[2] from the date of planting to the date of harvest, the liyaddas having been selected so that one was near to and the other far from the pipe inlet supplying the farm allotment with irrigation water.

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[1]The Maha season is the "main" season in Sri Lanka, extending roughly from October when the first monsoon rains from the northeast sweep across the island, to about March when harvesting is completed.

[2]A liyadda is an individually bunded plot. The number of liyaddas per acre varies from 8 to 50.

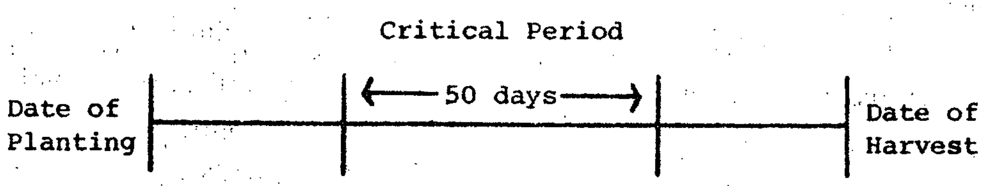
Investigators recorded for each liyadda each day the water status of that plot, whether it had:

(a) severe shortage of water (soil cracking)
(b) moderate shortage (soil dry)
(c) saturated condition (soil wet)
(d) standing water
(e) flooding, or flowing water.

On the basis of the conditions observed, a "water availability index" (WAI) was computed for each farm, using a simple system of weighting to indicate the degree to which a farm's crop had more or less water available throughout the growing period. Two indices were computed for each farm.

(a) WAI for the entire duration of the crop growth; and
(b) WAI for the 50-day period considered to be the critical period between 20 and 70 days before harvest, with the water-sensitive reproductive phase of the rice plant.

For this report, only the latter index is considered, as it is a more sensitive measure of the adequacy of water supply in the field.



To calculate the index, the number of days in the first category (a: Severe shortage) were added to the number of days in the second category (b: moderate shortage), which were weighted double plus the number of days in the third category (c: saturation) weighted triple; and the last two categories of abundant water supply (d: standing water and e: flooding) weighted as quadruple.[3]

Once the WAI was calculated for each farm, an average WAI could be calculated for those farms along the field channel at the head of the D-Channel within the unit, for those along the middle field channel, and for those along the tail field

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[3]This can be expressed as follows:
WAI = (a x1) + (b x 2) + (c x 3) + (d x 4) + (e x 4), where
No. of days of severe shortage within critical period = a
No. of days of moderate shortage within critical period = b
No. of days of saturation within critical period = c
No. of days of standing water within critical period = d
No. of days of flooding within critical period = e
(d) and (e) were weighted the same since water supplied to the plant is essentially the same; differences in aeration cannot be so readily quantified.

channel. WAI could also be calculated for all farms sampled within the unit. This permitted comparisons within units (head vs. middle vs. tail) and between units (unit averages).

The relationship between water availability and yield for different units, and for different locations within units could then be tested by using linear regression analysis:

$$y = \underline{a} + \underline{b}x$$

where y = yield, and x = Water Availability Index. The standardized coefficient b indicated the rate of increase in yield in response to changes in WAI. Standard deviations of the x and y values were calculated to test for the significance of the statistical relations thus identified.

The data were analysed to assess any significant variations in yield attributable to the WAI:

(a) Based on the location of farms along the field channel: (1) head, (2) middle and (3) tail portion;

(b) Based on the location of field channels along the distributary: (1) head, (2) middle and (3) tail portion;

(c) Based on the location of colony units (i.e. selected distributaries within the units) whether (1) head, (2) middle or (3) tail within the Gal Oya Left Bank system. For purposes of more detailed analysis, we compared specifically units 2 and 21 as 'head' units, with units 3,8 and 10 as 'middle' units, and 7, 14 and Block E as 'tail' units.

The gross comparisons under (c) obscure some water relationships as seen from the fact that the WAI for unit 3 (193) is the highest of the eight units analyzed, though not at the head of the system, while 2, 21, and 10 are similar (187, 184, and 186); 8 and 14 are the same (168); and E is much lower (148). Similar differences can be found within units, where simple head, middle and tail designation do not reveal the exact extent of water distribution down to the field level. One of the purposes of our continuing field research and data analysis is to improve upon these gross designations and to develop measures which are more representative and relevant to water management.

At this stage of our work, we cannot resolve the problem of getting refined criteria of "head," "middle," amd "tail," which to date has not been sufficiently resolved by others with more experience than we have. We hope in future analyses to clarify some of these terms and relationships, but here we will work with the gross comparisons of 'head,' 'middle,' and 'tail,' commonly made in the literature on water management, hoping that our data and analysis will lay a basis for some advances upon the state-of-the-art. We will make comparisons among head, middle and tail units as identified above, and will compare head, middle and tail farms and field channels within units according to conventional criteria. Subsequent data analyses should improve upon these designations. Indeed the subjective Water Problem Index based on farmer responses and reported in Chapter 5 represents one approach to rectifying geographic oversimplifications.

Concerning the second level of analysis, dealing with water deliveries in the channel system, daily measurements were taken at various points -- head, middle and tail -- on the main channel and on the distributary channel being studied, and along the three field channels selected as head, middle and tail ones. The number and location of measurement points along the main channels were selected so as to illustrate the flow of water at a given time in various parts of the main channel system. Height of water was measured daily by means of a calibrated stick, and all measuring points were located in places where the 'floor' was more or less smooth and flat.

The water level data considered in this analysis can be categorized for three levels of water delivery:

(1) Main channel system: points in the Left Bank main channel relating to Unit 2 and along Mandur channel serving units 8, 10, 3, 7 and 14; points elsewhere in the Left Bank main system were measured also but are not included in this analysis;

(2) Distributaries: points within the following D-channels: LB 6, U 9, M 5, M 16, M 12, M 31, M 18 and G 12.

(3) Field channels: points along the following channels, listed by units;

Units	Field Channel
2	LB 6-1, LB 6-4, LB 6-5
21	U 9-2, U 9-3, U 9-4-0
8	M 9-2-1, M 5-2-4-1, M 5-2-4, M 5-2-3
10	M 16-2-1, M 16-6, M 16-4-4
3	M 12-1-1, M 12-6, M 12-8-1
7	M 31-6, 31-5
14	M 18-1-6-2, M 18-1-6-3, M 18-1-6-3-1-2
E	T 12

Farmers in unit 7 were the first to commence cultivation in Maha 1979/1980, early in October. Almost all the farmers in the selected colony units, except 21 and 2, had completed their harvesting operations by the first week of March 1980. Therefore, the six-month period from early October to early March was selected to observe the frequency, reliability and adequacy of water flow in the channel system.

Daily water flows at each measuring point during the period under study are illustrated graphically in the Appendix. Actual heights of water levels are drawn in all graphs, so that the scale on the Y axis, indicating height of water in inches, is not identical for all graphs. However, the period for water delivery, shown along the X axis, is the same for all graphs, i.e., October 1979 to March 1980. The main thing the graphs as a whole illustrate is the fluctuation in flows relative to the maximum delivery (indicated by the highest level shown on the particular graph). In addition, these graphs also show lengths of issue periods and intervening non-issue periods at the selected parts of the Gal Oya Left Bank system. Although the graphs do not give volumetric measurements, gross water availability and the rotational deliveries can be observed from them.

It should be stressed that substantial water deliveries in the channel system may not indicate adequate water input at the farm level, since the latter depends on other factors as well, such as rainfall, condition of field channel structures and maintenance, and on-farm water management. Thus analysis of water flow data tells us little unless linked with observations and calculations of water adequacy at the farm/field level.

It is obvious that whenever a point at the head portion of a given channel shows delivery of water at full capacity, any point at the tail or middle of the same channel should also be delivering water unless:

(a) There are rotational deliveries being provided along the channel;

(b) There are unplanned losses in the channel due to breached bunds, etc.

(c) There is inequitable distribution of water among farmers along the channel under consideration, such as illegal tapping of water at the head portion.

If there are differences between water flow at the head and tail, it may be due to any of these conditions, or in field channels, it will represent distribution of water along that channel between the head and the tail.

Interpreting water flow data requires some knowledge of each channel and field situation, so trying to calculate volumetric flows from simple measurements does not seem particularly rewarding. Our research program will undertake more specific water measurement and analysis as it gets into the problems of farmer organization for water management and as the rehabilitation effort gives some change in water delivery to be measured.

2.2 Analysis of Water Deliveries

Water Deliveries in the Main Channel System. From the graphs illustrating water deliveries measured by our investigators (see Appendix) one can see, not surprisingly, that reliability, frequency and adequacy of water flow all tend to decrease toward the tail end of channels, whether main distributary or field channels.

The term "reliability" here refers to the degree to which actual water issues follow the water schedule decided at the cultivation (kanna) meeting before the season begins. In other words, this measurement attempts to find out to what extent farmers could rely upon the water schedules promised at the cultivation meeting. When a time table of water issues is published or announced, indicating the type of rotation deliveries planned, it is understood that water will be delivered in adequate quantities. Therefore, reliability encompasses both adequacy and timing of water deliveries. The lengths of the periods during which water flows in a channel tend to decrease gradually from the head end towards the tail end. (For instance, compare the main channel flow charts for unit 2 with those of tail end units such as 7 and 14.) That the length of intervening "non-issue" periods tends to increase toward the tail end represents an increasing inadequacy of water issues as the amount available to the tail end drops due to head and middle offtakes.

In addition, as observed from the flow charts, in the extreme head end units, continuous flow in the channel system is provided throughout the crop season, whereas at the other extreme, most of the tail end colony units are rainfed. Thus one can see even without any volumetric analysis, that the adequacy of irrigation supply declines as one moves down the channel system.

The main channel, which flows past unit 2, had a continuous flow of water, irrespective of irrigation schedules announced at the kanna meeting to provide water intermittently. Rotation begins only at the Uhana regulator, below which there is some control over water issues, sending them down the Uhana and Mandur branch canals or down the Left Bank canal. Moving down the system, it was also observed that water deliveries along Mandur channel were almost identical to those along the Uhana branch channel, suggesting no effective control over water at the Mandur regulator. (However, at times, it was observed that water was diverted to the Chadayantalawa tank.)

Regular water issues from the main reservoir (Senanayaka Samudra) were made to the head and middle portions of the system after the first week of January. Water flows prior to that were indications either of rain or of issues to provide domestic water supply.[4] Given effective control structures, units 2 and 21 at the head of the system got significantly higher deliveries of water during this period when the lower reaches were supposed to be getting more water.

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[4]The ground water situation in the Left Bank is so poor that the water table needs to be recharged through issues along the channel system every 10-15 days to keep wells able to provide water for domestic use. This is not efficient in hydraulic terms but necessary in human terms.

Tail end units are almost entirely rainfed. For instance, a single issue of water, around the 120th day, is indicated in the graph drawn for unit 14. By this time, the majority of farmers were about to commence their harvesting operations. Unit 7 and Block E also received that issue. So the main system is not providing enough water to reach the tail, and indeed, little effort seems to be made in this direction.

Water Deliveries in the Distributaries. Water deliveries in the distributary canal systems also followed the same pattern of delivery as in their respective main channels, indicating a lack of water control. However, the time between rotations was not so marked in the head-end channels in the middle of the system. A relatively continuous flow at the head contrasts with the clearcut rotations that can be observed in the distributaries of units 8, 10 and 3. The degree of fluctuation in water deliveries also seemed to be greater in the middle units.

Only one issue of water was observed in the distributaries of units 7 and 14 and as mentioned above, this was too late for use for agricultural production. A relatively greater delivery was observed for Block E distributary channels which run off the Gonagolla secondary, during the 50th-75th days.

Water Deliveries in the Field Channels. Water flow along field channels was the least reliable and resulting problems were most prominent: (a) in field channels located toward the end of a distributary, (b) along longer field channels, and (c) generally in the middle and tail-end of the LB system. It was interesting to note that unreliability occurred to a certain extent even in the field channels of unit 2 (see graph for F.C. 3 of unit 2, in Appendix; this is a field channel in a head end unit but located at the tail end of the distributary). We thus see that the system of distribution through secondary channels (D-channel) affects field supply quite apart from the primary location of the area, whether head, middle or tail.

It should be noted that head, middle and tail differences were significant along the field channels, especially in the 'middle' units of the system (see graphs for field channels for unit 3, unit 8 and unit 10, pages 7, 5 and 10 of Appendix). Probably one would have noticed this also in field channels in tail-end units if there had been any water deliveries there in the season under consideration.

In addition to the problems of main system management and the lack of farmer participation in irrigation decision-making, a number of other factors also contribute to the irregularity, unreliability and inadequacy of water supply in the system. Among them, the more common problems would be:

(1) Absence of proper control structures, especially in the distributaries and in the field channels;

(2) Defects in the channel network, breached and silted channels, etc. so that the delivery capacity of channels, etc., is not proportional to the acreage served by the respective channels;

(3) Varying length of field channels;

(4) Varying number of bifurcations per distributary;

(5) Varying number of pipe outlets per field.

Proper design, construction and maintenance of conveyance and control structures are prerequisites for successful operation of an irrigation project and their importance cannot be over-emphasized. Equitable distribution of irrigation water in the Gal Oya Left Bank system has become impossible until improvements or adjustments in the irrigation and drainage facilities have been made in the form of realigning canals, replacing control gates and check structures, desilting and deepening, etc.

The configuration of the channel network and the varying lengths of distributary and field channels have led to difficulties in the "wholesale" and "retail" distribution of irrigation water. Flow capacities of channels, in certain areas, are not proportionate to the respective area fed by each channel. In addition, sometimes one could observe a "field channel" supplying water to an area of more than 100 acres whereas in some other places a "distributary" would be carrying water to feed an area less than 15 acres.

The determination of an individual farmer's "access" to water also includes (a) the number of pipe outlets that serve farmers ahead of him, (b) the effective length of the field channel, (c) the number of bifurcations in the distributary and its effective length, (d) the location of the distributary in relation to the main reservoir or sub-tank and how close it is to an effective main regulator. A separate analysis is being undertaken to analyze these relationships.

2.3 Water Availability at Farm Level and Farm Productivity

A Water Availability Index (WAI), computed to analyze water inputs as discussed above, gives us an indication of the degree of water adequacy relative to water stress for plants in the field. The lower the score, the more stress is indicated, and a higher score indicates more total water available throughout the growing season. Timing of water application is of crucial importance to a paddy crop, so it can be argued that the WAI is a better indicator for assessing adequacy, because it is calculated at the field level, than are measures of water flow within the channel system. However, the WAI has its own limitations because it does not, as presently calculated, distinguish between continuous stress and intermittent stress. (Future analysis introducing more refined distinctions of amount and timing of water will be done to introduce this factor.)

One cannot expect there will be a perfect relationship between yield and the WAI because yield is affected by other factors than water availability--e.g., on-farm water management, pest attacks, application of fertilizer, soil quality, etc. No effort was made in this analysis to account for other factors, however, though subsequent analysis will undertake to introduce more of them. Here we deal only with WAI-yield relationships.

It should be said at the outset that this analysis is for the Maha season, when water alone is not so crucial for production as it is during Yala season.[5] This may account for some of the statistical results not being as strong as one would expect. Also, the large number of other factors, noted above, is found to dilute any real relation between water and yield. Still, with this said, some rather definite, if gross, relationships become evident. Some other relationships were not so evident, or were not statistically significant given the size of sample.

Mean Yield. First, there was no significant correlation between yield and the location of farms along the field channel, i.e., whether they were at the head, middle or tail of the field channel (see Table 2-1). The average yield of head-end farms was 35.6 bushels per acre, compared to 35.4 for those at the tail-end. This suggests that which distributary channel serves a farm is more important than which field channel serves it.

The location of field channels along a distributary also did not appear to influence the level of yields of farms along the respective field channels, whether they were head, middle or tail (see Table 2-2). There are some problems with the comparison which should be pointed out. The designation of field channels as 'head', 'middle' or 'tail' along a distributary studied was fixed within each unit under study--and since D-channels sometimes cross unit boundaries, a 'head' field channel within a unit could be middle or tail according to the whole distributary configuration.[6]

As indicated in Tables 2-1 and 2-2, variation of yield among units was seen to be significant. As seen from Figure 2-1, there is a general tendency for yield to decrease

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[5]Yala is the minor season, when no monsoon rain falls in the Dry Zone of Sri Lanka, including Gal Oya, and farmers there must rely entirely on the irrigation system for water supply.

[6]Alternatively, a field channel designated as 'tail' within the unit's boundaries could be ahead of field channels along the same distributary if it stretched into another unit. So, because of overlapping between administrative and hydrological boundaries, the comparisons we are able to make with the data as presently organized are limited in the fashion described. We have more reason to place some confidence in the comparisons reported in the previous paragraph, which are not subject to the same boundary problem.

as colony units are farther away from the point where Uhana Channel branches from the main channel.[7] Still, as discussed in the first section with regard to water problems (and as indicated by the Water Problem Index discussed in Chapter 5), severity of water problems is not simply a function of distance from water sources.

If we make a comparison among units according to 'head', 'middle' and 'tail' by general location, there are some step-wise differences, especially toward the tail, but we find some anomalies. The top third of units would be 2, 23, 24, 21, 17 and 26, which have an average yield of 39 bushels per acre, compared to 36 bushels per acre for the middle third (30, 8, 3, 10, 32 and J). The tail units (35, 36, 39, 7, 14 and E) average only 24 bushels per acre. Yet, unit 24 at 26 bushels per acre is hardly better than the average at the tail, and unit 3 at 49 bushels per acre is the best of all.[8]

In a more detailed analysis, using 8 selected units to represent head, middle and tail, we found the results reported in Table 2-3, with the respective average yield for units 2 and 21 to be 39 bushels per acre, units 3, 8 and 10 to be 33 bushels, and 7, 14 and E to be 27 bushels. A regression analysis was done for farms in these three sets of units, with yield regressed on WAI. No significant correlations were found for the head and tail units (-.17), but there was a correlation of .42 for the middle farms. The coefficients for yield increase with respect to WAI were interesting to observe. The coefficient was positive (.51) for the middle but insignificant for head and tail units. As discussed elsewhere, the majority of tail end units are rainfed whereas some head-end units, especially unit 2, experience excessive water conditions throughout the crop season, and this might be one of the reasons for the insignificant correlation between WAI and yield in those areas. More analysis remains to be done on these relationships.

2.4 Water Availability Index and Yield

As indicated elsewhere, WAI for each farm does not depend solely on channel flow. In the Maha season, rainfall is a major contributor to water availability at the farm level (especially in units 7, 14 and E). However, as expected, mean WAI of tail end units was substantially lower than for head and middle units (161, compared to 185 and 183). (See Table 2-4.)

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[7]This point was suggested by Prof. Randy Barker during one of his consultancies with the Water Management Research Group.

[8]Even though unit 24 is classified as a "head end unit" on the basis of its geographical location, the entire area selected from this unit is fed by "tail end" field channels of a "head end" distributary. Thus, despite its location, unit 24 could be classified as a "tail end" unit.

Figure 2-1:
Left Bank-Gal Oya Yields of Sample Units - Maha 1979/80

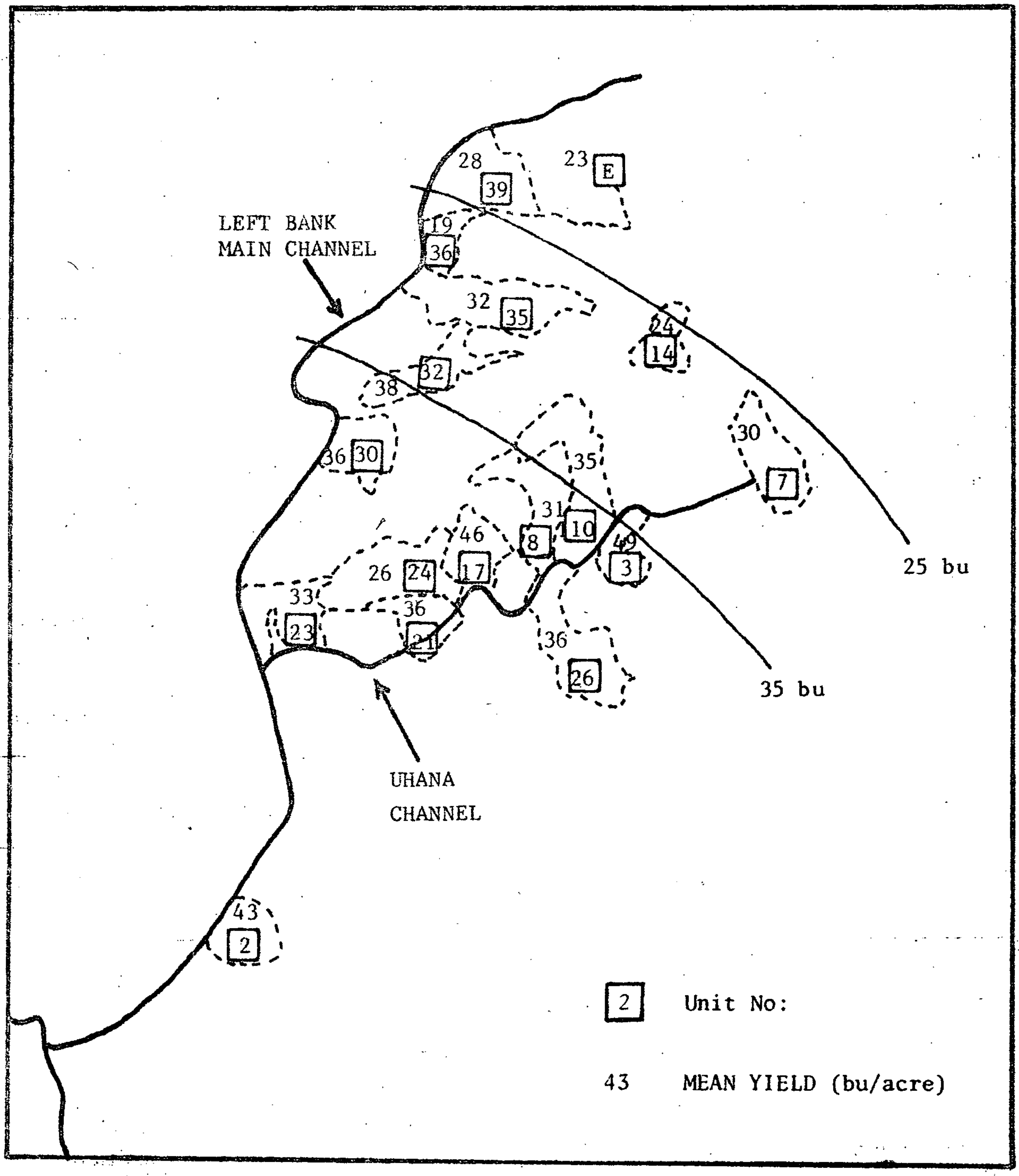


Table 2-1:
Yield Classified by the Location of Farms*

Location of Units	Unit Nos.	Yields			Mean Yield of the Unit
		Farms at the head position of field channel	Farms at the middle position of field channel	Farms at tail position of field channel	
HEAD	02	56 (S=25)	36 (S=13)	40 (S=8)	43 (S=18)
	21	48 (S=18)	32 (S=20)	39 (S=27)	36 (S=22)
MIDDLE	08	33 (S=7)	28 (S=13)	38 (S=13)	31 (S=11)
	03	44 (S=14)	53 (S=20)	51 (S=16)	49 (S=16)
	10	39 (S=14)	27 (S=7)	41 (S=25)	35 (S=17)
TAIL	07	25 (S=8)	33 (S=15)	29 (S=11)	30 (S=12)
	14	20 (S=6)	26 (S=6)	27 (S=6)	24 (S=6)
	BLOCK 'E'	21 (S=7)	30 (S=11)	20 (S=2)	24 (S=6)

*Mean yields and standard deviation of (a) farms located at the head position of field channel, (b) farms located at the middle position of field channel, and (c) farms located at the tail end of field channel. (Standard deviations are in parentheses.)

Table 2-2:

Yield Classified by the Location of Field Channel*

Location of Units	Unit Nos.	Yield			Mean Yield of the Unit
		Head Field channel	Middle Field channel	Tail Field channel	
HEAD	02	57 (S=7)	38 (S=8)	49 (S=27)	43 (S=18)
	21	31 (S=22)	35 (S=18)	41 (S=18)	36 (S=22)
MIDDLE	08	40 (S=11)	32 (S=10)	23 (S=8)	31 (S=11)
	03	41 (S=10)	50 (S=21)	55 (S=16)	49 (S=16)
	10	37 (S=12)	26 (S=7)	39 (S=24)	35 (S=17)
TAIL	07	21 (S=6)	25 (S=8)	36 (S=14)	30 (S=12)
	14	27 (S=8)	20 (S=6)	20 (S=17)	24 (S=6)
	BLOCK 'E'	22 (S=10)	23 (S=5)	24 (S=11)	24 (S=6)

*Mean yield and standard deviations of H, M, T field channels in each unit. (Standard deviations are in parentheses.)

Table 2-3:

Relationship Between Yield and Water Availability at Head, Middle and Tail of the System

Unit Nos.	No.of Farmers N	Means and standard deviation		Co-efficient of linear cor-relation (r)
		Y	W.A.I (50 days)	
2,21	74	39 (S=20)	185 (S=9)	-0.17
8,3,10	69	33 (S=17)	183 (S=14)	0.42
7,14 BLOCK 'E'	50	27 (S=10)	161 (S=18)	-0.17

*Mean yield and mean water availability index for the head, middle and tail of the system. (Standard deviations are in parentheses.)

Table 2-4:

Water Availability Index Classified by the Location of Farms*

Location of Units	Unit Nos.	Water Availability Index (50 days)			Mean value for entire unit
		Head Portion of the field channel	Middle Portion of the field channel	Tail portion of the field channel	
HEAD	02	190 (S=5)	182 (S=6)	189 (S=5)	187 (S=6)
	21	182 (S=13)	184 (S=11)	185 (S=10)	184 (S=11)
MIDDLE	08	173 (S=7)	166 (S=8)	167 (S=14)	168 (S=8)
	03	194 (S=9)	193 (S=3)	190 (S=6)	193 (S=7)
	10	187 (S=11)	188 (S=8)	182 (S=18)	186 (S=12)
TAIL	07	167 (S=6)	165 (S=4)	163 (S=5)	165 (S=5)
	14	168 (S=10)	170 (S=11)	168 (S=7)	168 (S=9)
	BLOCK 'E'	164 (S=23)	122 (S=17)	151 (S=24)	148 (S=28)

*Mean WAI and standard deviation of farms located in the head, middle and tail portions of the field channels. (Standard deviations are in parentheses.)

To take the analysis further, there was not a significant relationship between the location of field channels and their average WAI (see Table 2-4). The average WAI along head portions of field channels was 178, compared to 174 along tail field channels. This suggests a similar finding to that discussed above, that there may not be as much difference along field channels in the Maha season as often assumed, or as found elsewhere.

Some differences however, were seen in comparing WAI of farms along head field channels within a unit, compared to those along middle or tail field channels. The average WAI for the first set of farms was 178.3, compared with 176.7 for middle FC farms, and 169.6 for tail FC farms. In none of eight units analyzed in Table 2-5 are there higher WAIs for tail FCs than for head or middle FCs.

Overall, however, the correlation between yield and WAI (within units) was not significant as seen from Table 2-2. This may be understood if there is considerable within-unit variability for WAI and yield, as noted previously. However, as seen from Figure 2-2, an interesting relationship among units is seen between mean yields and mean water availability indices. This supports the general conclusion that level of agricultural productivity is significantly influenced by the adequacy of water.

As noted already, from Table 2-3, the relationship between WAI and yield is most prominent in the middle area of the system. This could be an important consideration in organizing farmers for better water management with the ultimate objective of increasing yields.

The observations reported in this section are, in most respects not surprising and can be summarized as follows:

(a) Unreliability of water increases downstream;

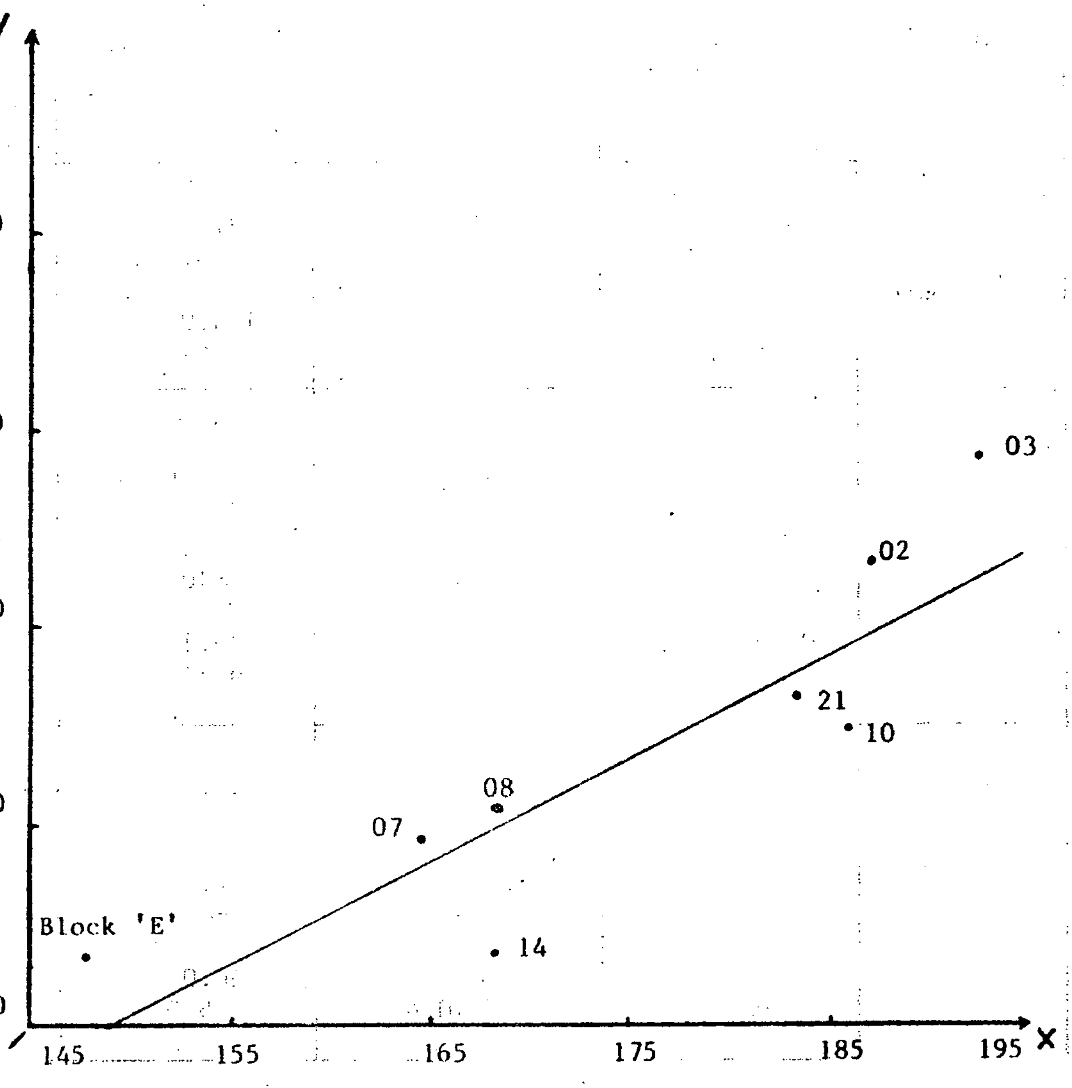
(b) Mean yield level decreases downstream;

(c) Unreliability of water in terms of water deliveries in the channels decreases towards the tail end of given distributary.

These aspects should be considered as important in organizing farmers for better water management. However, it should be noted that factors such as the length of distributary, carrying capacities and length of field channels, as well as various socio-economic factors, not just water management variables, also affect yield performance. The analysis here represents a first cut into the large body of data which ARTI has been collecting on the Gal Oya Scheme. Further analyses are underway and will be reported in the future.

Figure 2-2:

Relationship Between Mean Yields and Mean Water Availability Indices of the Units



Y = a + bx where Y = mean yield, and x = mean W.A.I. for each Unit

$\bar{Y}$ = 33.83 (S=8.9)

W.$\bar{A}$.I. = 174.83 (S=15.11)

a = -55.94

b = 0.51

Correlation coefficient (r) = 0.88

Table 2-5:

Water Availability Index Classified by the Location of the Field Channels*

Location of Units	UNIT NOS.	Water Availability Index			
		Head Field Channels	Middle Field Channels	Tail Field Channels	Mean water availability Index of the Unit
Head	02	192.8 (s=5.02)	184.69 (s=5.3)	187.56 (s=5.1)	187.15 (s=5.84)
	21	186.63 (s=8.41)	187.34 (s=8.85)	178.97 (s=11.78)	183.78 (s=10.62)
Middle	03	196.68 (s=4.45)	193.06 (s=6.13)	187.95 (s=6.53)	192.68 (s=6.65)
	08	168.33 (s=11.6)	169.5 (s=4.99)	166.25 (s=10.4)	168.13 (s=8.39)
	10	192.9 (s=6.77)	181.88 (s=4.33)	183.17 (s=16.81)	186.07 (s=11.97)
Tail	Block 'E'	148.71 (s=17.53)	159.9 (s=37.18)	127.8 (s=24.11)	148 (s=28)
	07	171.83 (s=5.0)	162.0 (s=4.4)	164.95 (s=4.3)	164.66 (s=5.3)
	14	169.6 (s=3.86)	174.9 (s=10.67)	160.0 (s=5.0)	169 (9)

*Mean water availability index and standard deviation of farms along the head, middle and tail field channels in each unit. (Standard deviations are in parentheses.)

Table 2-6:
Relationship Between Yield and Water Availability, Within Units*

Location of Units	Unit Nos.	No.of Farmers N	Means and Standard Deviation of Yield and Water Availability Index		Co-efficient of linear correlation (R)
			Y	W.A.I (50 days)	
HEAD	02	27	43 (S=18)	187 (S=6)	0.28
	21	47	36 (S=22)	184 (S=11)	-0.33
MIDDLE	08	24	31 (S=11)	168 (S=8)	0.18
	03	30	49 (S=16)	193 (S=7)	-0.04
	10	15	35 (S=17)	186 (S=12)	0.26
TAIL	07	22	30 (S=12)	165 (S=5)	0.04
	14	12	24 (S=6)	168 (S=9)	0.43
	'E'	16	24 (S=8)	148 (S=28)	–0.6

*Mean yields, mean water availability indices and standard deviations. Water availability index was calculated for 50 day critical period. (Standard deviations are in parentheses.)

Chapter III

INPUT USE AND AGRICULTURAL PRODUCTION

C.M. Wijayaratne

The use of complementary inputs, i.e., agricultural inputs other than water, clearly influences water use efficiency, as the optimum economic returns to irrigation water can be achieved only through the proper use of complementary inputs in a timely fashion and in adequate quantities. On the other hand, the use of certain technologies such as the application of fertilizer depends on the reliability and adequacy of water supply.

This chapter focuses on such aspects of input use as the alternative sources and allocation patterns of farm labour and offers analyses of production costs, the net returns to various factors of production and the relative profitability of paddy farming in the selected colony units. It cannot, however, be an exhaustive analysis of farm management economics with regard to the productivity of water and complementary inputs for rice production. Such an analysis would require a separate volume by itself. Rather here we will highlight the relationships that emerged from analysis of baseline and record keeping data for Maha season 1979/80.

Even though the analysis of water situation in Chapter II was limited to 8 selected units, which represented the 'head,' 'middle' and 'tail' situations of the Gal Oya Left Bank system, data gathered from 16 colony units of the Left Bank will be used in this chapter to analyse the input-output relations.

An attempt is also made to identify locational differences affecting the cost structure and profitability of paddy production. In this respect the 16 units are subdivided into 3 groups, namely:

I.	Uhana-Mandur sub-system	Colony units 22/23, 24, 21, 17, 8, 3, 10, 7 and 14.
II.	Gonagolla sub-system	Colony units 30, 32, Block 'E' and Block 'D'.
III.	Left Bank Main system	Colony units 2, 35 and 39. Unlike the first two groups, here the boundaries of the sub-system are not well demarcated. However unit 2 is located at the (extreme) head end of the LB System while the other two units are located in the downstream well below the Navakiri tank. Therefore it could be argued that unit 2 would represent the 'head' of the Left Bank main system and units 35 and 39 would represent the 'tail' despite the

fact that all three do not come under the command area of a single branch channel.[1]

This chapter will examine the head/tail differences within each of the above sub-systems with respect to input-output relations, classifying the units as follows:

	Uhana-Mandur Sub-system	Left Bank Main System	Gonagolla Sub-system
Head	Units 22/23, 24, 21 and 17	Unit 2	Units 30 and 32
Middle	Units 8, 3 and 10	---	---
Tail	Units 7 and 14	Units 35 and 39	Block 'E' and Bock 'D'

3.1 Limitations of the Analysis

Most of the economic surveys conducted in Sri Lanka, both by public and private institutions were based on "direct questionnaire" method. Inaccuracy is high in this technique, mainly due to two factors:

1. Poor recall of the informants, especially with regard to costs of production, use of owned resources, etc.
2. General tendency of some of the informants either to overstate or understate certain things. For instance, in some cases the cost of agro-chemicals, fertilizer, etc. declared to enumerators is rather on the high side while lower figures are quoted for yields, etc.

Therefore the use of such information for pricing or other kinds of economic analysis can be misleading.

To overcome these problems a carefully supervised intensive record keeping programme was used in the present study, as the major source of data gathering especially for the analysis of production aspects. However, one may observe two major limitations in the present analysis.

[1] Subsequent to this analysis, a different classification has been introduced by dividing the entire Left Bank System into 8 sub-systems. An indepth analysis using computer-processed data and interpretation is in progress.

1. The sample for the Left Bank was selected only from colonisation tracts (16 units). The extents of land added by the colonists to their respective "operational holdings" through encroachment on "channel reservations" and other land are also included in the sample. However, other forms of encroachments and private holdings were not taken into account in the sampling process because these lands were not originally covered by the proposed "rehabilitation" project. Therefore the costs of production and yield figures do not represent such private holdings and encroachments.[2]

2. As stated earlier, almost all the colonists have added land, of varying extent, to their operational holding. In addition a considerable amount of illegal land transactions have taken place since the inception of Gal Oya Project. As a consequence one may come across with holdings varying in size (from 0.25 acres to 7 acres) which makes it difficult to estimate the actual size of a given holding with 100% accuracy.[3]

It should be noted here that in this season a significant incidence of leaf hopper attack ("hopper burn") was reported in most parts of the scheme, but especially in areas where "water availability" was much higher than the average. Therefore 1979/80 Maha season could be considered as an unfavourable Maha season for the Gal Oya Scheme, as can be seen if one compares the per acre yield figure with those of a typical Maha.[4]

3.2 Cost of Production of Paddy

Input Categories. In the cost computation, seven input categories were identified:

(a) Labour
(b) Farm (draught) power
(c) Seed material
(d) Fertilizer
(e) Weedicides
(f) Other agro-chemicals
(g) Other inputs (fencing material, etc.)

Labour Inputs. Four major sources of farm labour were identified, namely:

(a) Family labour,
(b) Hired labour,
(c) 'Attam' (exchange labour), and
(d) Contract labour.

[2] An indepth study is underway to analyse the situation of such holdings.

[3] The only remedy is to measure the individual holdings and steps are taken to do so in the present record keeping programmes.

[4] See Table 3-6.

In the cost calculations, labour was treated in terms of man equivalents and the following assumptions were made.

(A) 1 man-day	=	8-hour day of a male in the age group of 15-65 was taken as a man-equivalent.
(B) 1 man equivalent	=	1.25 female working days 2.0 child working days

In all cases, 8 hours of work was considered to be equivalent of a work day.

Wage Rates. The actual cost incurred by each individual farmer in hiring labour for his own farm operations was extracted from individual farm-record sheets and was used in the calculation of the cost of production. In other words, the "per acre cost" of production for each colony unit was calculated by using actual cost figures of each farm in that unit.

However, a computed cost figure was used in costing the family and exchange labour. The average wage rate for hired labour in each colony was used for this purpose. A significant difference between the wage rates for threshing and other operations was observed, especially in the tail-end units. The difference was highest in unit 7 where contract labour played a significant role in farm operations. The average wage rates for each unit are given in Table 3-1A in the annex to this chapter.

Farm Power. The farm power category was also sub-divided into two, namely buffaloes and tractors. Whevenver an operator used his own resources (either buffalo or tractor), the local rate of hiring was used in costing.

Other Costs. Land rent was not included in the computation of costs. The (zero) opportunity cost concept with regard to family labour was ignored in cost calculations. However, the net returns to major factors of production (such as land, labour and capital) were calculated in two ways, namely:

(a) including family labour cost, and

(b) excluding family labour cost (FLC).

Costing of production and net returns for factors of production for the selected units are given in Table 3-2A in the annex.

An attempt was made to prepare a "cost of production chart" for the entire Left Bank area of the Gal Oya scheme, making the assumption that the 16 units represented the range and distribution of production relations in the Left Bank as a whole. Given the method of selecting the units by random sampling procedure, this seems reasonable. The resulting values are shown in Table 3-1.

Table 3-1:

Estimated Average Per-Acre Cost of Paddy Production in the Left Bank System, Maha 1979/80

Input Category	Cost/Acre in Rs.		Standard Deviation
1. Labour			
Family	271		103.6
Hired	306		130.1
Exchange	43		48.0
Contract	20		54.9
Total Cost		640	128.7
2. Tractor	110		64.4
Buffaloes	143		58.2
Total Cost		253	50.0
3. Seeds	151		56.1
4. Fertilizer	100		32.0
5. Weedicides	46		23.0
6. Other Agro Chemicals	61		23.4
7. Other	23		18.0
Total Cost/Acre inc. FLC		1274	172.0
Total Cost/Acre exc. FLC		1003	225.0
Cost/Bushel of Paddy inc. FLC		38.4	
Cost/Bushel of Paddy exc. FLC		30.2	

Total No. of Respondents (Farms) = 479 Total Acreage = 1149 Ac.

As evident from the table, the average cost per acre of paddy in the Left Bank in Maha 1979/80 amounted to Rs. 1274/ — when the cost of family labour was included in the cost computation, and it was reduced to Rs. 1003/ -- when the cost of family labour was ignored. In the former case, the cost of production of a bushel of paddy works out to Rs. 38/40; whereas when the cost of family labour is ignored the cost of production of a bushel of paddy comes down to Rs. 30/20. It should be noted here that this figure, estimated by using information gathered from day-to-day observations in the project area, is much higher than the corresponding values used for the economic/financial analysis in the project paper.[5]

[5] See Part IIC of the Project paper: Sri Lanka - Water Management Project (383-0057).

The composition of the cost structure illustrates that almost half the cost involved in cultivating one acre of paddy was on labour. However this is lowered to one-third of the cost when the cost of family labour is ignored. It is also seen that another 20% of the total cost was on farm power while fertilizer component accounted for only 8% of the total cost.

Despite the fact that labour formed the single most important cost factor, labour application per acre averaged only around 40 man-equivalents, which is relatively low compared to labour use intensity observed in other areas of the country.[6]

In the next section attention is focused mainly on a detailed analysis of production costs in different production situations or localities.

3.2.1 Labour

Almost in all production situations examined, labour could easily be singled out as the most significant cost element in the production process, ranging from about one-third to two-thirds of total cost per acre, including family labour. Composition of labour and the amount in man-equivalents are illustrated in Figure 3-1. The amount of labour that went into the production of one acre of paddy was highest in Colony Units 2 and 35, while in some other units, for instance in Units 3, 7, 32 and Block 'E', the per acre application of labour is reported as considerably lower. However, as was observed from Table 3-1, per acre costs of labour do not follow the same pattern because of the variation in wage rate in different locations.

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[6] In Maha 1976/77, 92 and 51 man-equivalents had been used respectively in Polonnaruwa and Hambantota for cultivation of one acre of paddy. See A.S. Ranatunga and W.A.T. Abeysekera, Profitability and Resource Use Characteristics in Paddy Farming, ARTI Research Study No. 23 (1977). In Yala 1977 and Maha 1977/78, average labour application per acre in Mahaweli 'H' area was reported as 50 man-equivalents. See A.S. Ranatunga et al., An Analysis of the Pre-Mahaweli Situation in H_4 and H_5 Areas in Kala-Oya Basin, ARTI Research Study No. 33 (1979).

Table 3-2:

Composition of Per-Acre Labour Input in the Left Bank System

Labour		Average Man Equivalents/Acre	Standard Deviation
Family	M	15.0	5.4
	F	2.0	1.7
	C	1.0	0.9
Hired	M	16.0	6.2
	F	2.0	2.3
	C	0.0	0.3
Exchange	M	1.0	0.2
	F	0.5	0.4
	C	0.5	0.04
Contract		4.0	9.9
TOTAL		42.0	---

A striking feature of the pattern of labour application seen from Table 3-2 and Figure 3-1 is the marked variation in the "Family labour input" in the 16 units. Colony unit 2 reported the highest application of family labour per acre (nearly 60% of total labour input) while an average household in unit 7 has applied only 3-4 man-equivalents of family labour (only about 8% of total labour input). The major reasons that unit 7 farmers depend much on hired and/or contract labour would be:

a) Households of some of these farmers are located some distance from their paddy fields. As a result they find it difficult to devote the labour of all family members to day-to-day operations in the paddy field.

b) Some of them are not full-time farmers, instead they are engaged in some other activities such as business on a part-time basis (mainly in the coastal towns).

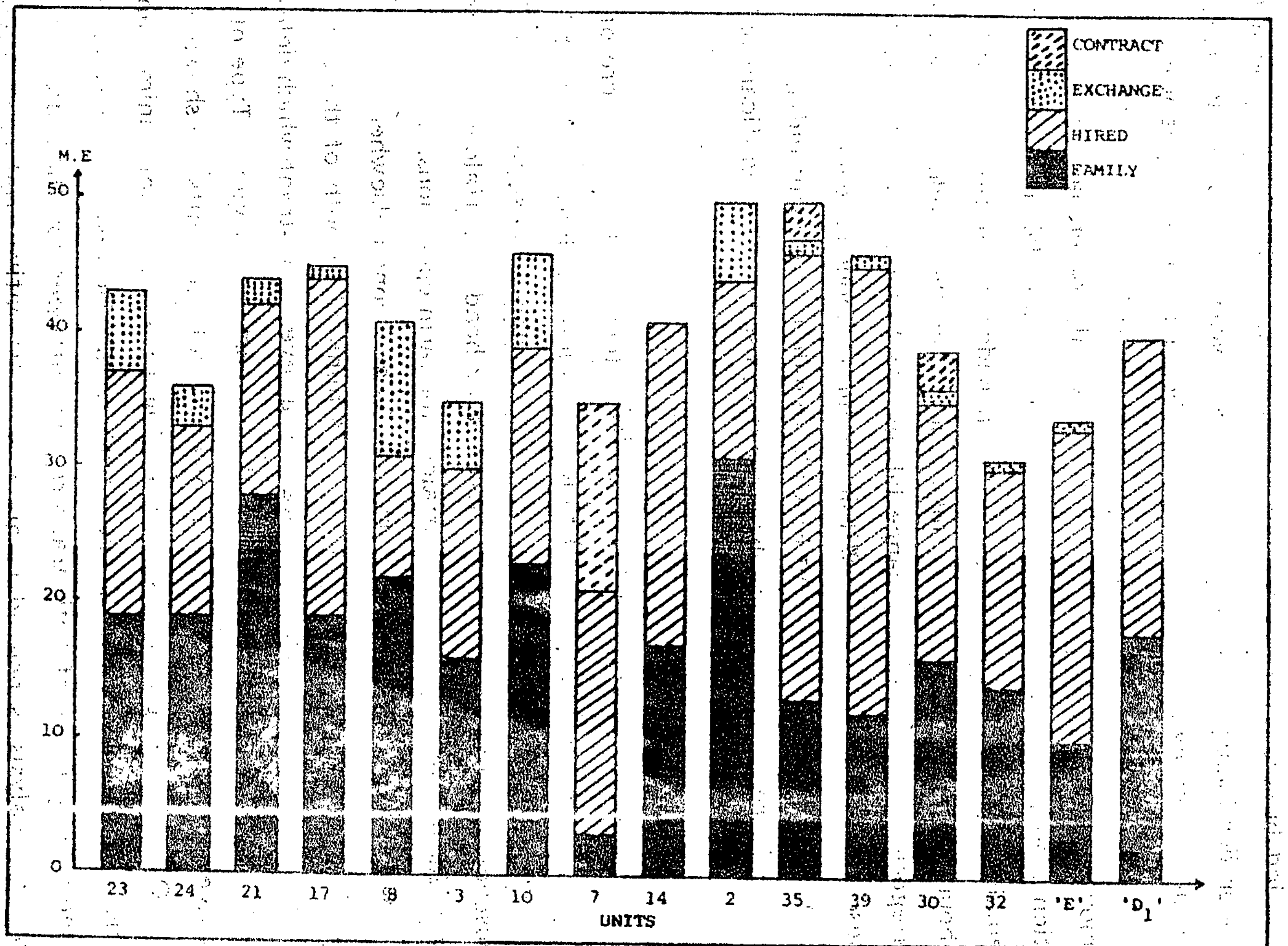
c) They are not assured of reliable or adequate irrigation supplies, and as a consequence they are compelled to complete some of the labour-demanding operations, especially land preparation, within a limited time period. Therefore they have to depend on outside sources of labour.

The above reasoning is also common to some parts of other tail-end units: 14, 'E', 39 and 35. It should be mentioned here that almost all of these units are rainfed even during the Maha Season.

Figure 3-1:

Quantity and Composition of Labour Input in Paddy Production (Per Acre)

(Labour is in man equivalents)



Another noteworthy feature in the pattern of labour utilisations is the low level of dependency on "exchange labour" especially in

a) non-Sinhala colony units (7, 14, 'D', 39) and/or

b) colony units located closer to small towns (21, 17).

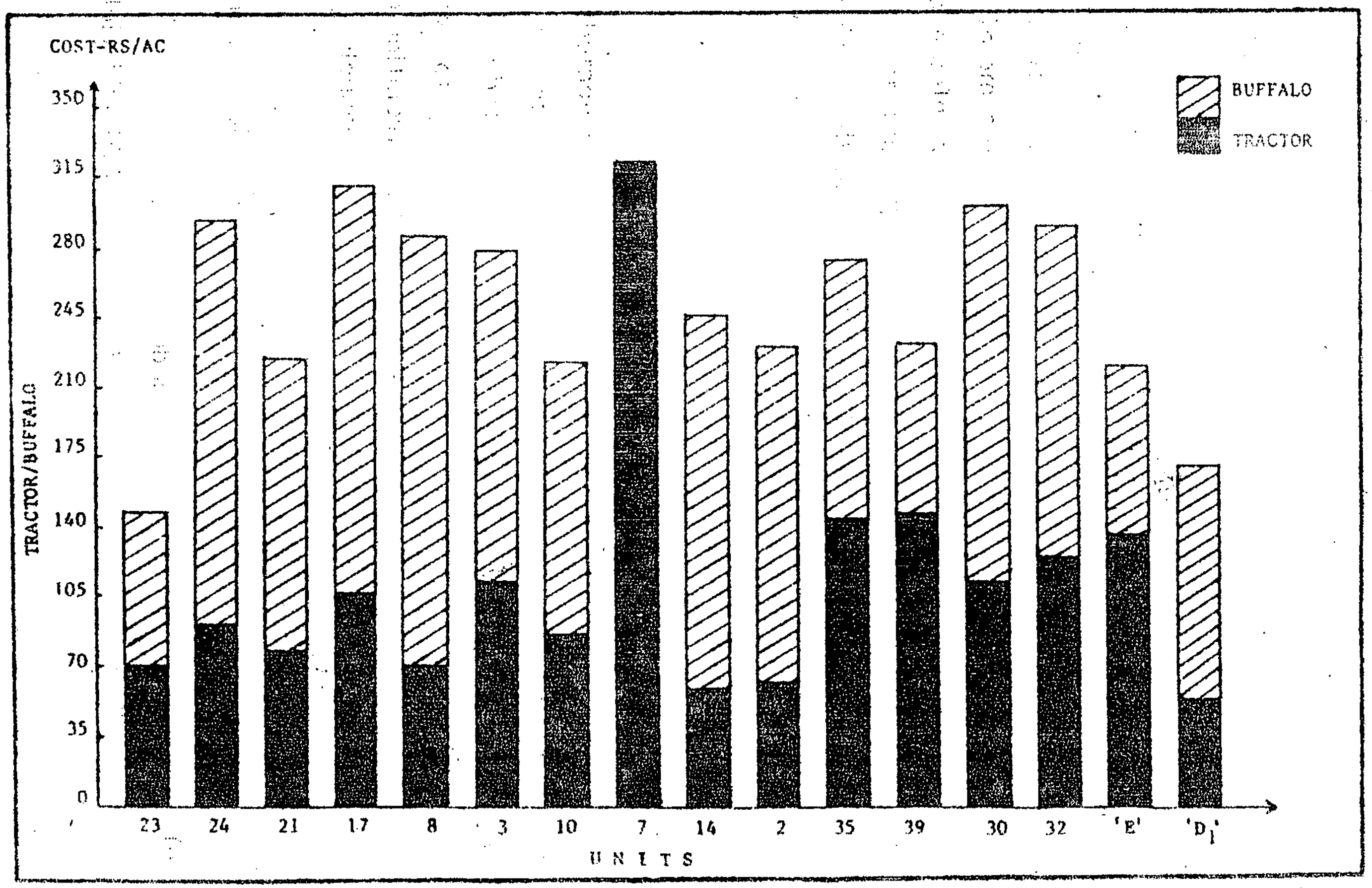
The composition of labour utilised for paddy farming was seen in Table 3-2 and a detailed breakdown by colony unit is seen in Table 3-3A in the appendix. A "male labour dominant production process" was observed in all areas covered by the study. Within the category of family labour, the male labour input was highly significant in units 2 (27 days) and 21 (23 days) while in units 7 and block 'D', the corresponding amounts were 2.7 and 9.3, respectively. On the other hand, there was no marked variation among units in regard to the use of female labour except for the fact that no female family members participated in paddy production in units 14 and 39. Child labour input was seen to be insignificant in the production process, especially in categories of hired and exchange labour. Male labour was observed to be dominant in these two labour categories. Within the hired labour category, male labour input varied from 33.4 (unit 39) to 7.8 (unit 8) while female labour input did not exceed 9 (unit 22/23) days per acre. The contract labour input was seen to be significant only in unit 7.

3.2.2 Farm Power

The average cost of farm power (tractor/buffaloes) per acre of paddy production varied from Rs. 147 (unit 22/23) to Rs. 323 (unit 7). Farmers in unit 7 were exclusively dependent on tractors as a source of farm power, despite the fact that an average household reported ownership of more than 2 head of buffaloes. In contrast, the majority of farmers in unit 14 used buffaloes for farm operations. (Buffalo population in unit 14 was much lower than that of unit 7.) As mentioned elsewhere, the staggering of land preparation and planting operations was minimal in both of these units. Therefore it could be argued that farm power was not a severe constrant which delays farm planting. Observations in other colony units also supported this view. Type of farm power used and average cost per acre of farm power for selected units are shown in Figure 3-2.

On the average, it is seen from Figure 3-2 that both animal and tractor power assume equal importance in the study area. However, it was observed that most farmers used a mix of both tractors and buffaloes for their draught power needs. A separate analysis is needed to analyse the costs incurred in different types of land preparation activities and threshing when alternative draught power sources are used. The tyne tiller was observed to be the commonest implement used in association with the tractor for land preparation.

Figure 3-2:
Type and Average Cost Per Acre of Farm Power



3.2.3 Fertilizer

A significant variation among the selected units was observed in relation to the quantity and cost of fertilizer applied for an acre of paddy. Colony units 39, 7 and 3 reported a significantly higher application of fertilizer. On the contrary, unit 2 reported the lowest average value in the use of this input.

3.2.4 Seed Paddy

Seed paddy, with average cost ranging from Rs. 81 to Rs. 296, ranks first among the costs of material inputs used in paddy production. It is striking to note that the average cost of seed paddy is even higher than the average cost of fertilizer. This is mainly due to the high rate of seeding used by the farmers in the tail end colony units.

The seed rate ranges from about 1.5 bushels per acre at the head end of the system to a very high rate of about 7 bushels per acre in some of the tail end units. As was mentioned earlier, most of the tail end units are rainfed and therefore farmers in these areas adopt "dry sowing," a method demanding high rates of seeding.[7] In addition it was also observed that the majority of farmers in these areas prefer a thick plant density to overcome the weed problem as they are not used to spend much on weed control (see Table 3-1).

3.3 Yields and Profitability

An analysis of paddy yields, net returns to some selected factors of production, variation of yields and net returns among the selected colony units, and the relationship between these indicators and water availability are presented in this section.

A statistical analysis of paddy yields according to water availability was attempted in the previous chapter. Even though the correlation between yield and the Water Availability Index (WAI) for farms or field channels <u>within units</u> was not significant, it was observed that

a) Mean WAI of tail end units were substantially lower than for head and middle units

b) Variability of water decreases downstream

c) A significant relationship exists between WAI and yields, <u>among units</u> (see Figure 2-2).

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[7]This is mainly because a higher percentage of germination is not assured due to the risk of a continuous dry spell which might occur just after sowing. In addition an allowance should also be made by the farmer for the losses of seed between sowing and germination, such as due to bird damage.

Further, it can be argued that the most important single difference between 'head' and 'tail' units with regard to yields and productivity, if any, is the difference in water availability. This argument is mainly based on the observations made in the previous section, that is, there was no significant variation between 'head' and 'tail' units in regard to the "input use characteristics" of the production process which could explain the differences in productivity.[8] In this context a "head-tail" analysis is attempted below.

Table 3-3 shows a marked variation in the average productivity per unit of land between seasons/years in the recent past. As stated earlier, Maha 1979/80 was not a "favourable" season. 1981 Yala, too was not so favourable.[9] However, when the mean productivity values for the period 1979/80 Maha to 1981 Yala are used, the estimated per acre productivity in the Left Bank System for Yala and Maha seasons would be 43 Bu/Ac. and 45.5 Bu/Ac, respectively. This in turn would yield an average of 44.3 Bushels per acre per season.[10]

The "head-tail" difference in per acre productivity can be observed in Table 3-3 and this is more significant in the Uhana-Mandur and L.B. Main systems. It is also interesting to note that in Yala 1981, the average yield per acre at the head end of the Gonagolla system was 37 Bu/Ac, whereas the tail end portion of the same channel reported a complete crop failure.

Returns and profitability of paddy farming in the selected colony units are summarised in Table 3-4 and Figure 3-3. Further, by using the information from this table, a similar productivity-profit sheet was prepared to represent the entire Left Bank System (Table 3-5). In addition, to observe "head-tail" differences, the values for each input were divided into three groups (depending on the magnitude), namely "High," "Medium," and "Low," and the sub groups are indicated in Tables 3-6 and 3-7.

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[8]Soil, which is not taken into consideration in this analysis, is one of the major factors which could influence the productivity of a given location. However we can assume that the "drainage quality" and water holding capacity are already taken into consideration when we talk of WAI.

[9]Due to failure of the monsoon rains, the storage of the major reservoir at the beginning of 1981 Yala season was considered to be inadequate for a good yala crop. As a consequence it was decided, by the authorities, to limit the Yala cultivation (of Left Bank of Gal Oya) to 4,000 acres. Farmers did not follow this decision and the extent cultivated was much higher than 4,000 acres. Despite the occurrence of rains later in the season, the yala crop was damaged significantly in certain parts of the Left Bank.

[10]Again it should be noted that the corresponding value used in the economic analysis of the rehabilitation project was 52.5 (see project paper).

Table 3-3:

Average Yield/Acre Classified by Sub-System

Subsystem	Location of Units	Number of Households (Farms) included in Sample				Total Extent (Acres) included in Sample				Average Yield Bu/Ac.			
		79/80 Maha	80/81 Maha	80 Yala	81 Yala	79/80 Maha	80/81 Maha	80 Yala	81 Yala	79/80 Maha	80/81 Maha	80 Yala	81 Yala
Uhana-Mandur	Head	159	19	153	40	308.86	33.75	319.45	67.0	36	69	52	57
	Middle	93	61	197	28	225.54	138.50	221.75	54.0	37	59	46	42
	Tail	41	39	13	16	160.00	112.50	48.00	27.0	27	44	36	26
L.B. Main	Head	36	17	37	20	73.00	37.00	60.00	35.0	41	47	47	56
	Tail	41	40	27	40	123.00	115.50	76.50	102.5	29	46	30	28
Gonagolla Channel	Head	78	19	80	36	167.15	28.25	165.75	60.0	39	52	51	37
	Tail	31	20	--	11	91.50	5.30	---	22.0	22	52	--	2*
Malwatta-Weeragoda	Head	24	20	29	--	74.00	63.00	83.00	---	44	57	47	--
	Tail	17	--	20	--	56.00	---	59.40	---	23	--	59	--
Left Bank		520	235	556	191	1279.00	534.00	1034.00	367.0	34	57	48	38

*Only 2 had harvested

Table 3-4:
Returns and Profitability - Summary Sheet

Returns & Profitability \ Sub System, Units	UHANA - MANDUR SUB SYSTEM (U-M Branch Channel)									LB MAIN SYSTEM			GONAGOLLA CHANNEL			
	Head				Middle			Tail		Head	Tail		Head		Tail	
	Unit 22/2	Unit 24 **	Unit 21	Unit 17	Unit 08	Unit 03	Unit 10	Unit 07	Unit 14	Unit 02	Unit 35	Unit 39	Unit 30	Unit 32	Block 'E'	Block 'D'
Yield/Ac. (Bushels)	35	26	40	46	30	48	33	29	25	41	32	26	40	37	23	20
Income/Ac.	1416	1046	1598	1832	1200	1923	1331	1160	1000	1644	1276	1040	1600	1480	920	800
Average Farm Size	1.5	3.5	1.6	2.0	2.5	2.0	3.1	3.9	3.9	2.0	3.0	3.0	1.9	2.6	2.9	3.0
Income/Farm	2255	3685	2278	3663	3014	3809	4092	4481	3962	3333	3828	3174	3081	3897	2647	2420
Net Income/Farm (Exc. F.L.C.)	800	742	1323	1438	718	1784	2201	-1073	-289	1764	-348	-552	1264	1609	-423	-75
Net Income/Acre (Inc. F.L.C.)*	160	-43	407	441	-53	661	369	-320	-352	412	-354	-374	420	449	-343	-301
Net Income/Acre (Exc. F.L.C.) *	533	212	827	719	287	892	710	-275	-74	882	-116	-184	665	619	-146	-25
Net Profit/Rs.100 Investment (Inc.F.L.C)	13	-4	34	32	-4	52	38	-21	-26	33	-22	-26	36	44	-27	-27
Net Profit/Rs.100 Investment (Exc.F.L.C)	60	25	52	65	31	87	112	-19	- 7	116	-8	-15	71	72	-14	-3
Net Income per man day	4	-1	9	10	-2	19	9	- 9	- 5	7	-7	-10	11	14	-11	-8
Net Returns to a Family Labour Day (Exc. F.L.C.)	28	11	30	40	14	56	32	-92	- 4	28	-8	-14	44	44	-15	-1

* Inc. - Including
Exc. - Excluding
F.L.C. - Family Labour Cost

** Even though Unit 24 is classified as a "head end unit" on the basis of its geographical location, the entire area selected from this unit is fed by a "tail end" channel off a "head end" distributary. Thus despite its location, Unit 24 could be classified as a tail end unit.

Table 3-5:

Profitability of Paddy Production in Gal Oya Left Bank System - Maha 1979/80

Selected Indicator	Mean Value	Standard Deviation
Yield/Acre (Bushels)	33.2*	8.3
Income/Acre (Rs.)	1329.0	331.5
Average Farm Size	2.7	0.8
Income/Farm	3351.0	686.9
Net Income/Farm (Exc. F.L.C.)	680.0	1009.7
Net Income/Acre (Inc. F.L.C.)	73.7	376.0
Net Income/Acre (Exc. F.L.C.)	345.4	428.7
Net Profit/Rs. 100 Investment (Inc. F.L.C.)	7.8	30.1
Net Profit/Rs. 100 Investment (Exc. F.L.C.)	39.0	46.5
Net Income/Man Day	1.9	9.6
Net Returns to Family Labour Day (Exc. F.L.C.)	12.0	35.6

*When the yield figures of Malwatta - Weeragoda area is included the mean value for the Left Bank System was estimated as 34 Bushels/Acre.

Figure 3-3:

Mean Values of Cost, Gross Income and Net Income Excluding Family Labour Cost per Acre of Paddy

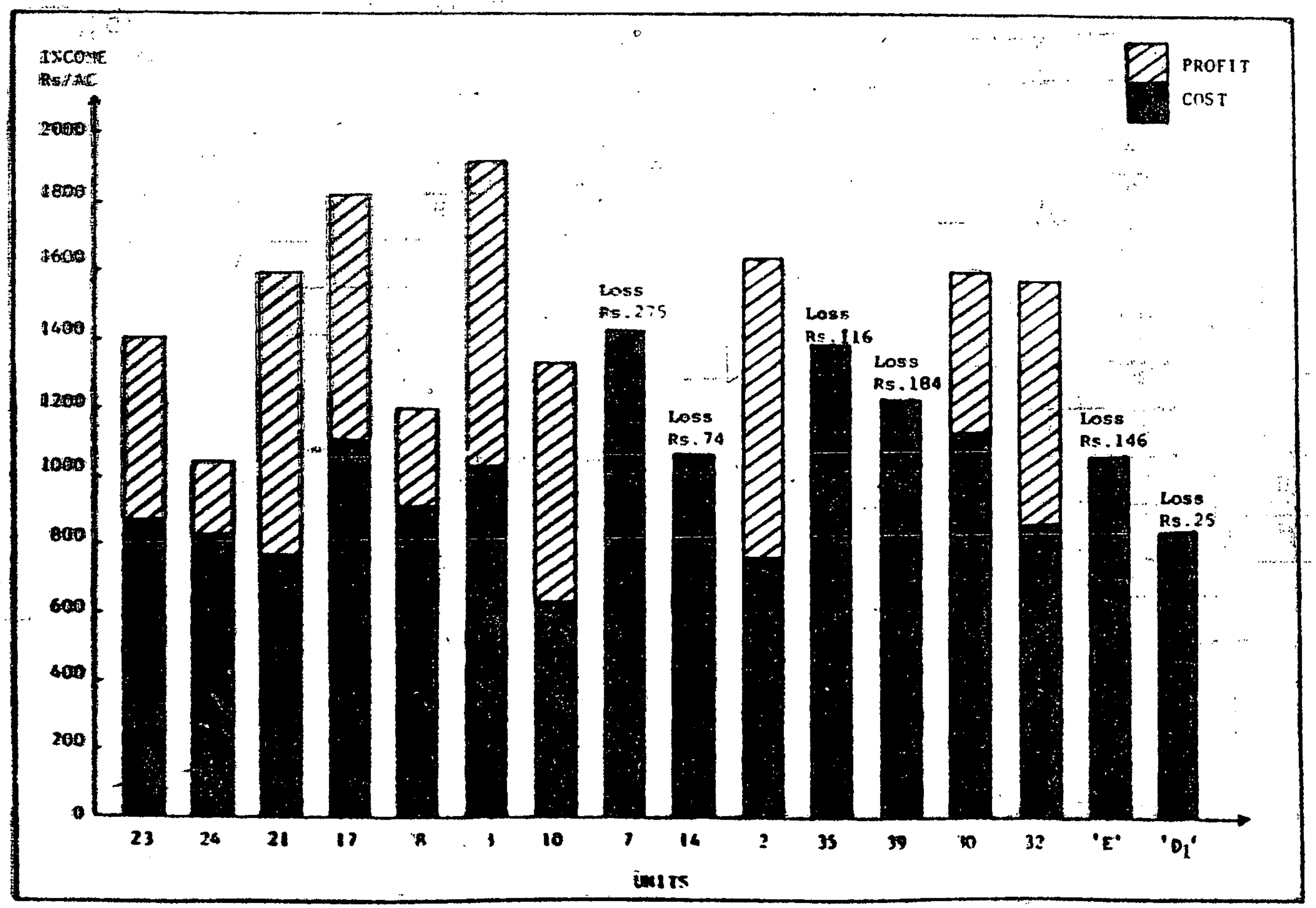

Table 3-6:

Classification of Colony Units by Location, Cost of Selected Inputs and Per Acre Yield

UNIT/BLOCK	LOCATION	Total Cost of Labour	Cost of Fertilizer	Cost of Farm Power	Cost of Other Agro. Chemicals	Total Cost Per Acre including FLC	Total Cost Per Acre excluding FLC	Yield/ Acre
22/23	U-M, Head	H	M	L	M	M	L	M
24	U-M, Head	L	L	H	M	L	L	L
21	U-M, Head	M	H	M	M	M	L	H
17	U-M, Head	M	H	H	M	M	M	H
8	U-M, Middle	M	M	H	M	M	M	M
3	U-M, Middle	L	H	H	H	M	M	H
10	U-M, Middle	M	M	M	M	L	L	M
7	U-M, Tail	L	H	H	H	H	H	L
14	U-M, Tail	M	M	M	L	M	M	L
2	L-B, Head	H	L	M	L	M	L	H
35	L-B, Tail	H	M	H	M	H	H	M
39	L-B, Tail	M	H	M	H	H	H	L
30	G, Head	M	L	H	L	L	M	H
32	G, Head	L	M	H	M	L	L	M
Block 'E'	G, Tail	M	M	M	L	M	M	L
Block 'D'	G, Tail	M	L	L	M	L	L	L

H = High M = Medium L = Low

U-M = Uhana Mandur L-B = Left Bank G = Gonagolla

Table 3-7:

Classification of Colony Units by Location, Per Acre Yield, Net Income and Water Indicators

Unit/ Block	Location	Yield/ Acre	Net Income/ Acre exc FLC	Net Returns to Rs 100/= Invest exc FLC	WAI
22/23	U-M, Head	M	H	M	H
24	U-M, Head	L	M	L	H
21	U-M, Head	H	H	M	H
17	U-M, Head	H	H	M	M
8	U-M, Middle	M	M	M	M
3	U-M, Middle	H	H	H	H
10	U-M, Middle	M	H	H	H
7	U-M, Tail	L	L	L	L
14	U-M, Tail	L	L	L	L
2	L-B, Head	H	H	H	H
35	L-B, Tail	M	L	L	L
39	L-B, Tail	L	L	L	L
30	G, Head	H	H	H	M
32	G, Head	M	H	H	H
Block 'E'	G, Tail	L	L	L	L
Block 'D'	G, Tail	L	L	L	L

H = High M = Medium L = Low

U-M = Uhana Mandur L-B = Left Bank G = Gonagolla

Even though the differences between sub-systems was not so significant (35, 33 and 20 Bu/Ac., respectively for Uhana-Mandur, L.B. Main, and Gonagolla sub-systems), considerable differences in per-acre yield among colony units can be observed in Table 3-4. It is evident both from Table 3-4 and 3-7 that the differences in yields are significantly related to the location of the respective units along the major channel (Branch or Main). In other words, we would note again that head/middle/tail position is a major determinant of per acre yield of a colony unit.

Per acre yield varied from 20 Bu/Ac (Block 'D') to 48 Bu/Ac (Unit 3). The high level of productivity in unit 3, despite its location in the middle of a sub-system needs to be examined further. Based on field observations, the following could be given as the possible reasons:

a) High degree of water availability during the crop season, as a result of
   I. better network of channels,
   II. better water management
b) Adoption of improved practices, e.g., high degree of fertilizer application and weed control (see Table 3-2).

The estimated income per average household in Maha 79/80 (average farm size x income per acre) was highest in unit 7 (Rs. 4881) while unit 22/23 reported the lowest income, mainly because of its small size of family holdings. However, in regard to the net farm income (per acre profits),[11] units 7, 14, 35, 39, 'E' and 'D' reported a net loss, when the cost of family labour was included in the cost computation.

Analysis of net returns to factors of production, as illustrated in the tables, indicates that paddy production had been profitable in Maha 1979/80 in 'certain' localities, despite the damage done by "hopper burn", whereas in some other areas farmers had ended up with a net loss.

Table 3-7 illustrates an interesting relationship between the "location" of units (i.e., head/middle/tail position) and net returns to selected factors of production, namely to land and rupee investments.[12] With the exception of per acre yield in unit 35, all the tail end units report low values for yield per acre, net income per acre, net return to rupee investment, and WAI.

Farm Size and Productivity. We note further the following relationship between farm size and yield. As seen in many countries, smaller farms, usually with more labour input per acre also get higher output.

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[11] Rental value of the land is not included in the computation.

[12] Cost of all inputs except family labour is included in the cost computation.

Farm size (acres)	Mean yield (bushels/acre)
0.1 - 1.0	42.4
1.1 - 2.0	35.9
2.1 - 3.0	34.3
3.1 - 4.0	32.3
Over 4	25.3

3.4 Staggering of Paddy Cultivation

An attempt was made to identify the factors influencing timing of operations and the staggering of paddy cultivation in each of the units selected. Date of planting and the date of harvest were obtained for each farm from the record keeping excercise. Cumulative frequency curves have been drawn to show the percentage of the farms reporting that they had planted or harvested at any given time in the cultivation season.

The location of farms along the field channel and the location of the field channel along the distributary are also marked in the same curve. The following observations could be made on the basis of these curves.

(a) There was no relationship between the location of individual farms along the field channel and the staggering of cultivation.

(b) The location of the field channel had no significant influence on the staggering of cultivation. (Cultivation frequency curves drawn for unit 2 are shown in Figure 3-4 to illustrate these two propositions.)

(c) The degree of staggering of plant and harvesting operations was minimal in tail end units. Farmers in units 7 and 14 planted first and harvested earlier, while farmers at the head end units (closest to the main reservoir) did just the reverse. It was interesting to note that the head/middle/tail grouping of colony units was significant in relation to staggering of planting (Figure 3-5).

A number of factors influence the farmer behaviour in relation to staggering agricultural operations. Although farm power was not seen as a significant limiting factor, labour was seen to be an important constraint on timeliness of agricultural operations. Tail enders were depending on hired/contract labour and this would have helped them to complete the "high labour demanding" operations quickly.

A comparison of these cumulative frequency curves with water flow charts of the respective units shows that farmers who had a reliable water supply tended to stagger cultivation to the greatest extent while farmers who cultivated purely under "rainfed conditions" did the reverse. The latter group had no other alternative but to adjust themselves and manage to complete planting operations with the use of initial rains, whereas farmers upstream, having an assured water supply, were not compelled to do so. Perhaps improvements in water management would reduce incentives for timely cultivation unless farmer co-operation had been attained for co-ordinated cultivation.

Figure 3-4:

Cumulative Frequency Curves for Date of Planting and Date of Harvest

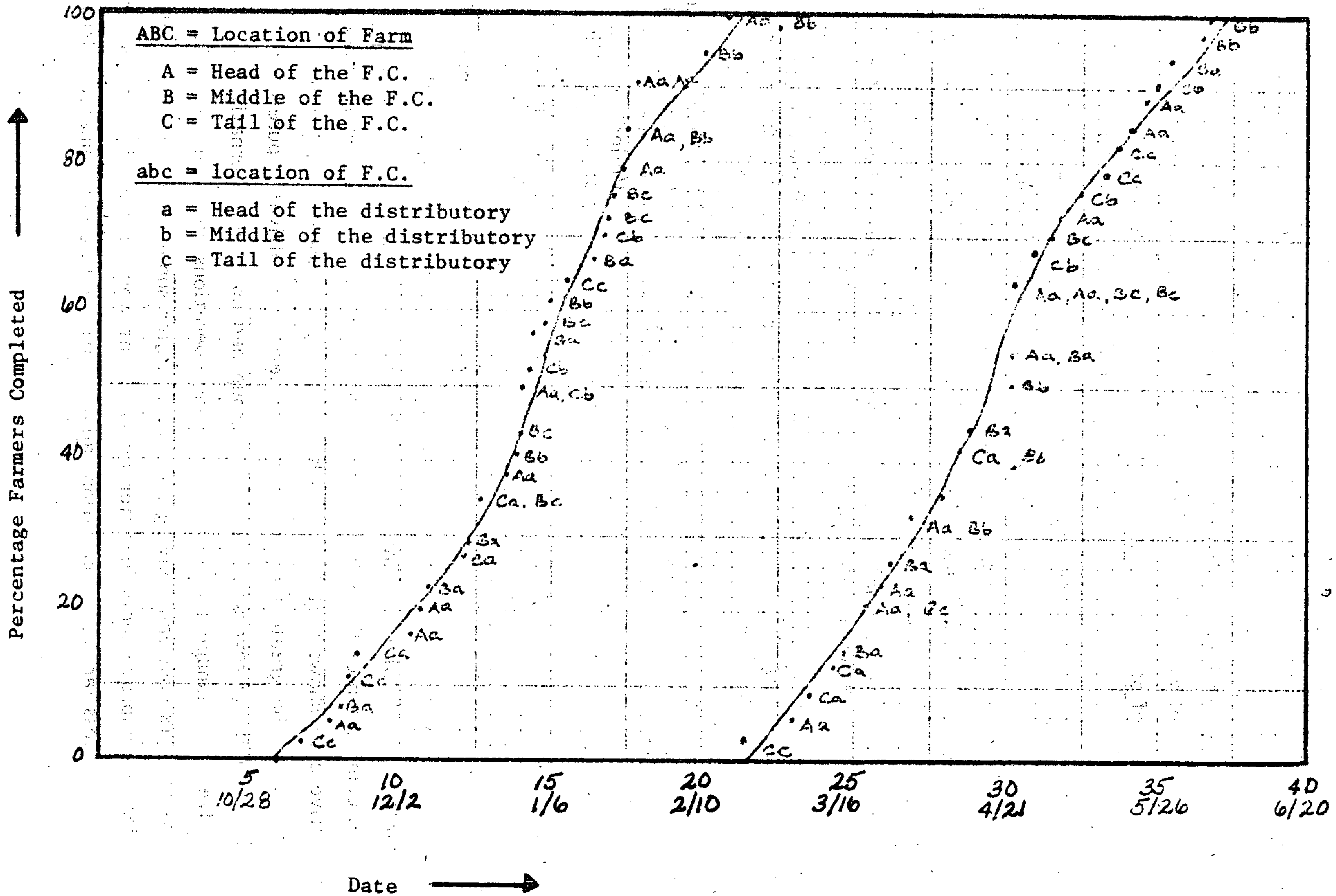
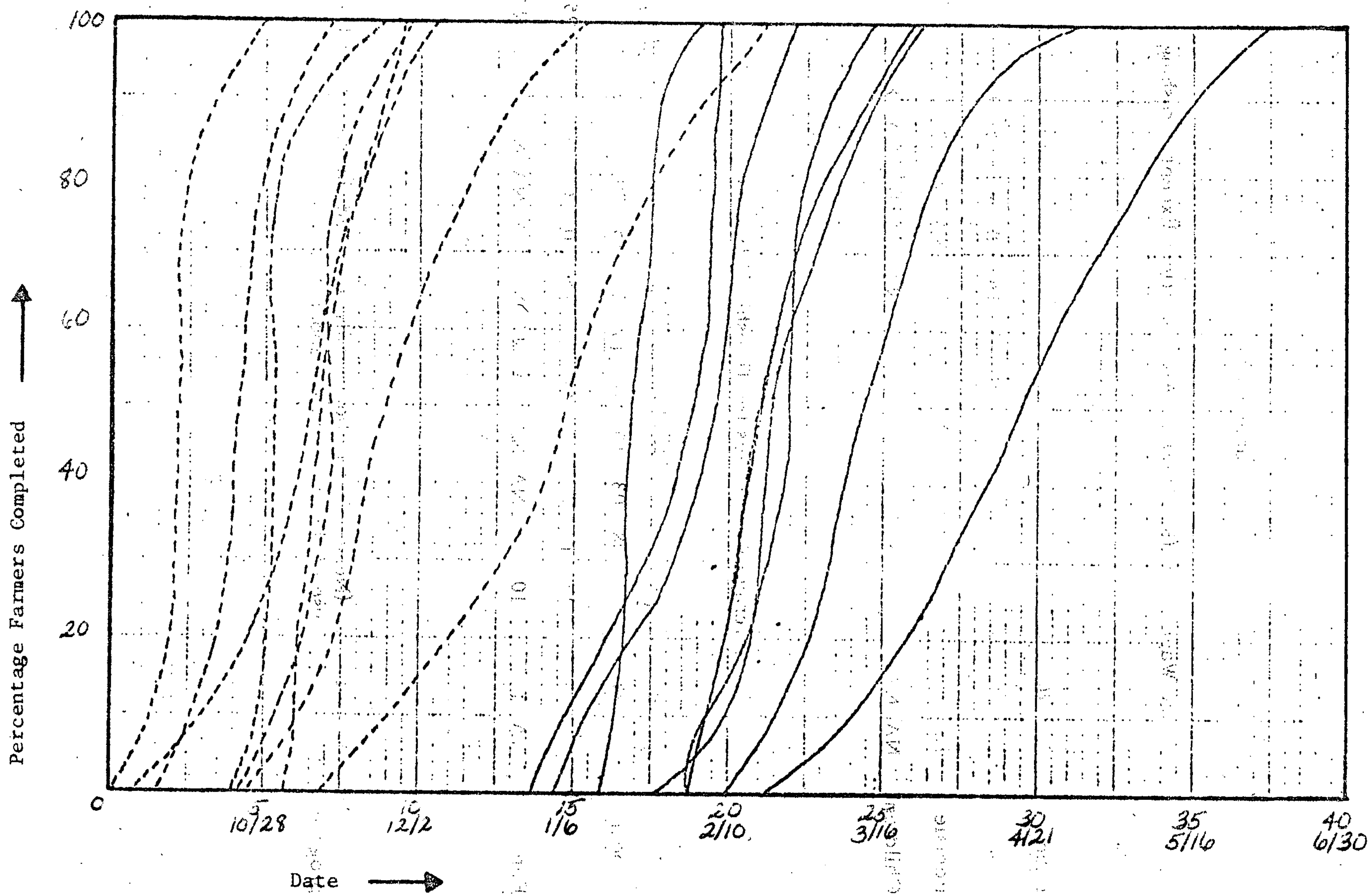


Figure 3-5:

Cumulative Frequency Curves for Date of Planting and Date of Harvest



ANNEX

Table 3-1A:

Average Wage Rates (Rs./Day) for All Operations Except Threshing

Labour	Units 22/23	24	21	17	08	03	10	07	14	02	35	39	30	32	BLOCK E	BLOCK D 1
Male	19	14	15	15	15	15	15	15	16	15	18	15	15	12	20	15
Female	12	10	13	10	12	10	NA	12	NA	12	NA	12	15	10	NA	NA
Children	NA	NA	10	10	NA	NA	NA	10	NA	NA	NA	10	NA	8	NA	NA

Average Wage Rates for Threshing (Rs./Day)

Labour	Units 22/23	24	21	17	08	03	10	07	14	02	35	39	30	32	BLOCK E	BLOCK D 1
Male	21	15	15	17	16	20	18	35	21	15	30	35	30	15	25	25
Female	NA	12	12	10	NA	NA	NA	NA	NA	NA	NA	NA	NA	10	NA	NA

NA = Not Applicable. (None of the households included in the record keeping programme reported the use of this category of labour.)

TABLE 3 - 2A.

Cost of Production - Summary Sheet

Input Cost/Ac. \ Sub Systems Units	UHANA - MANDUR SUB SYSTEM (U - M Branch Channel) Head				Middle			Tail		LB MAIN SYSTEM Head	Tail		GONAGOLLA CHANNEL Head		Tail	
	Unit 22/23	Unit 24	Unit 21	Unit 17	Unit 08	Unit 03	Unit 10	Unit 07	Unit 14	Unit 02	Unit 35	Unit 39	Unit 30	Unit 32	Block 'E'	Block 'D'
1. Labour - Family	373	225	421	279	340	231	341	44	278	471	238	184	245	170	197	276
Hired	320	200	209	373	133	202	237	270	385	190	594	502	294	191	470	330
Exchange	125	36	36	20	153	65	102	0	0	91	11	10	12	12	17	0
Contract	0	0	0	0	0	0	0	215	0	0	55	0	50	0	0	0
Total Cost of Labour	818	491	666	672	626	498	680	529	663	752	898	696	601	373	684	606
2. Tractor	69	90	77	105	70	112	85	323	59	61	143	146	112	124	136	53
Buffaloes	78	203	147	205	216	167	137	0	188	170	132	86	189	167	86	118
Total Cost of Tractor /Buffaloes	147	293	224	311	286	279	222	323	247	231	275	232	301	291	222	171
3. Seeds	81	105	83	157	137	114	147	296	204	118	212	180	109	125	195	154
4. Fertilizer	92	65	118	120	88	138	108	153	84	36	103	154	69	98	96	75
5. Weedicides	53	45	37	52	51	120	130	27	41	41	52	55	42	46	13	30
6. Other Agro Chemicals	63	57	54	53	53	95	72	110	36	31	73	87	41	72	23	53
7. Other	0	32	[illegible]	26	-2	18	13	42	77	21	17	10	17	26	30	12
Total Cost/Acre Inc. F.L.C.*	1254	1088	1190	1391	1253	1262	1962	1480	1352	1230	1630	1414	1180	1031	1263	1101
Total Cost/Acre Exc.F.L.C.	882	834	771	1112	913	1031	1636	1435	1074	762	1393	1230	935	861	1066	825
Cost/Bushel of Paddy	34	42	33	30	42	26	29	51	54	30	51	54	30	28	55	55

*F.L.C. = Family Labour Cost

Table 3-3A:

Composition of Labour Applied for the Production of One Acre of Paddy in the Maha Season - 1979/80

LABOUR \ UNITS		UNIT 22/23 Days/AC	UNIT 22/23 Cost/AC	UNIT - 24 Days/AC	UNIT - 24 Cost/AC	UNIT - 21 Days/AC	UNIT - 21 Cost/AC	UNIT - 17 Days/AC	UNIT - 17 Cost/AC	UNIT - 08 Days/AC	UNIT - 08 Cost/AC	UNIT - 03 Days/AC	UNIT - 03 Cost/AC	UNIT - 10 Days/AC	UNIT - 10 Cost/AC	UNIT - 07 Days/AC	UNIT - 07 Cost/AC
FAMILY	M	16.5	335	14.2	199	22.9	343	17.3	260	19.3	290	13.1	196	18.6	278	2.7	41
	F	2.8	34	5.6	55	5.5	70	1.7	17	2.6	33	3.3	33	5.3	58	0.3	4
	C	0.4	4	0.04	1	0.8	8	0.2	2	1.8	18	0.2	2	0.5	5	0	0
	M.E	19	373	19	255	28	421	19	279	22	340	16	231	23	341	3	44
HIRED	M	10.8	221	12.3	173	13.0	181	23.6	356	7.8	117	11.9	179	15.0	255	24.5	218
	F	9.0	99	2.7	27	2.2	27	1.1	11	1.2	16	2.3	23	1.1	12	3.4	41
	C	0	0	0	0	0.1	1	0.6	6	0.2	2	0	0	0	0	1.1	11
	M.E	18	328	14	200	14	209	25	373	9	133	14	202	16	237	18	270
EXCHANGE	M	5.6	117	1.8	24	2.2	32	1.2	19	8.4	126	3.5	53	5.9	88	0	0
	F	0.6	7	1.2	12	0.3	4	0.1	1	2.2	26	1.2	12	1.3	14	0	0
	C	0.01	1	0	0	0	0	0	0	0.6	1	0	0	0	0	0	0
	M.E	6	125	3	36	2	36	1	20	10	153	5	65	7	102	0	0
CONTRACT	M.E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	215
TOTAL/AC	M.E	43	818	36	491	44	666	45	672	41	626	33	498	46	680	35	529

LABOUR \ UNITS		UNIT - 14 Days/AC	UNIT - 14 Cost/AC	UNIT - 02 Days/AC	UNIT - 02 Cost/AC	UNIT - 35 Days/AC	UNIT - 35 Cost/AC	UNIT - 39 Days/AC	UNIT - 39 Cost/AC	UNIT - 30 Days/AC	UNIT - 30 Cost/AC	UNIT - 32 Days/AC	UNIT - 32 Cost/AC	BLOCK E Days/AC	BLOCK E Cost/AC	BLOCK D 1 Days/AC	BLOCK D 1 Cost/AC
FAMILY	M	17.3	277	27.3	410	12.4	223	11.6	174	14.11	212	12.1	145	9.3	185	14.6	220
	F	0	0	2.9	35	0.6	7	0	0	1.5	23	1.8	18	0.3	3	2	21
	C	0.24	1	2.6	26	0.8	8	1.0	10	1	10	0.8	7	0.9	9	3.5	35
	M.E	17	278	31	471	13	238	12	184	16	245	14	170	10	197	18	276
HIRED	M	24.0	385	12.3	183	33.0	594	33.4	502	19.0	285	13.9	167	23.0	470	22.0	329
	F	0	0	0.3	3	0	0	0	0	0.6	9	2.3	23	0	0	0.02	1
	C	0	0	0.1	2	0	0	0	0	0	0	0.1	1	0	0	0	0
	M.E	24	385	13	190	33	594	33	502	19	294	16	191	23	470	22	330
EXCHANGE	M	0	0	5.9	89	0.6	11	0.7	10	0.7	10	0.8	9	0.8	16	0	0
	F	0	0	0.2	2	0	0	0	0	0.1	2	0.3	3	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0.1	1	0	0
	M.E	0	0	6	91	1	11	1	10	1	12	1	12	1	17	0	0
CONTRACT	M.E	0	0	0	0	3	55	0	0	3	50	0	0	0	0	0	0
TOTAL/AC	M.E	41	663	50	752	50	898	46	698	39	602	31	373	34	604	40	608

Chapter IV

FARMERS' PERCEPTIONS OF WATER PROBLEMS AND THEIR RESULTING BEHAVIOUR

Lakshman Wickramasinghe

This chapter undertakes to clarify farmers' perspectives on problems of water management in the Left Bank area (LB) of Gal Oya. Having offered an analysis of objective data on conditions of water availability in different parts of LB Gal Oya in Chapter 2 and an analysis of the relationships among agricultural inputs including water and outputs in Chapter 3, this chapter examines farmers' own assessments of these factors, based on their responses during the baseline survey in March 1980. Here we further sketch the perceptions and attitudes which shape farmer behaviour in LB Gal Oya, trying to see the system through farmers' eyes as much as possible, attempting to build up certain appreciations which would be useful in the implementation of the Water Management Project in Gal Oya.

Hitherto, in all major irrigation schemes in Sri Lanka, perhaps with the exception of the Minipe scheme, managerial decision-making has been based on technocratic criteria. No serious effort has been made to incorporate farmer concerns and needs in managing the systems. Farmer perspectives and needs are the logical starting point, however for any effective water management program, especially in any effort at rehabilitation of a system which is expected to be operated efficiently.

The questions we are interested in include the following:

**What are the farmers' needs with regard to irrigation?

**What attitudes do they hold on key issues relating to water management?

**How do they perceive the other key actors in the system?

**Why do farmers behave in certain ways with regard to water use and agricultural production? What factors influence this behaviour?

**Are there contradictions between actual farmer behaviour and farmer attitudes? What factors cause them?

**What are existing leadership patterns in the colonization units? How do they effect formation of farmer groups?

**What institutional mechanisms do farmers prefer to distribute water more effectively?

**What implications do these questions have for the program of farmer organization?

The analysis of farmers' behaviour toward irrigation and water management in Gal Oya and their responses to system operation and maintenance is based on the premise that people's behaviour is shaped as a conscious adaptation to the social and environmental conditions under which they live and work. Farmers are no exception.

Oppenheim suggests the following formula based on work by the psychologist Lewin to discuss the main determinants of behaviour:

$$B = F(P, E)$$

According to Oppenheim, "behaviour (B) is a function of the interaction between P (all of a person's determinants, such as temperment, attitudes, or character traits) and E (all the environmental factors, as perceived by the individual)."

In an irrigation system, in addition to the specific personality traits of individual farmers, P represents collective attitudes of farmers toward conservation of water, their perceptions of fellow farmers, system managers, certain irrigation practices including distribution schedules, etc. E represents the physical structures and the conveyance network of the irrigation scheme, agro-ecological factors, socio-cultural factors such as relationships with fellow farmers, irrigation bureaucracy, etc.

The words perceived by in the above formulation by Oppenheim are especially important in understanding the behaviour patterns of farmers in Gal Oya. Their behaviour is to a substantial degree determined by their perception of P and E factors. This is why we say that a program for system rehabilitation and for operaton and maintenance of an irrigation scheme should be well grounded in farmer concerns and needs.

Until and unless the managers of irrigation schemes undertake to study the reasons for certain behaviour patterns among farmers, not simply attempting to label the behaviour of farmers as destructive, negative or irrational, etc., there will invariably be a chasm between the behaviour patterns expected of farmers and their actual behaviour toward irrigation and water management in the scheme.

It should be emphasized that the analysis at this point is not as full or rich as it can and will be with more information on the Left Bank of Gal Oya and on the farmers and families living there. Further reports will pull together the findings more completely. Here we offer analysis and findings from our data that relate most directly to the work which ARTI and the Irrigation Department will be doing in year two of the Water Management Project and in subsequent years.

4.1 Problems of Water Reported by Farmers

The baseline study covered 480 farmers in 18 colony units, out of a total of 40 colony units on the Left Bank (LB) of Gal Oya. Of the 475 farmers interviewed (the effective sample), 13 percent reported that they have no problems pertaining to irrigation water in Maha season. The figure for Yala season was 3 percent. This indicates that a large majority of farmers face problems in irrigation. The following table gives the types of problems faced by farmers distinguished by Maha and Yala seasons.

Table 4-1:

Percentage of Farmers Reporting Various Types of Irrigation Problems for Maha and Yala Seasons

	Type of problem	% farmers reporting (N=475) Maha	Yala
1.	Too much water	9	12
2.	Unreliable supplies	29	25
3.	Shortage of water	36	42
4.	Lack of water	19	31
5.	No problems	13	3
6.	No response	6	9

The above data, it should be said, are only averages and conceal striking variations across the LB system and to some extent within individual units. For a detailed unitwise breakdown of irrigation water problems (see Tables 4-2 and 4-3).

4.1.1 Lack of Water

In particular, such aggregate data underemphasize the severity of water shortages experienced in the tail-end units of the system. In fact, the tail-end units studied, such as 35, 7 and Blocks D and E, experience a lack of water in both Maha and Yala. As Table 4-2 indicates, even the comparatively better-off units at the tail-end such as 24 and Block J register lack of water scores much above the mean for the system.

In effect, the tail-end areas are functioning almost as a separate sub-system. Observations made by resident investigators on water availability and water flow along channels in these units corroborate the above finding. The degree of independence of the tail sub-system in hydrologic terms can be assessed in terms of water flow data analyzed in Chapter 2.

Table 4-2:

Percentage of Farmers in Tail-End Units Reporting Various Types of Irrigation Water Problems for Maha and Yala Seasons

% farmers from tail-end units reporting (N=140)

	14		3		7		35		D		39		E		Av.	
Problem Type	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y
Too much water	5	0	5	0	5	5	0	0	0	0	0	0	0	0	2	1
Unreliable supplies	10	0	14	0	5	0	0	0	0	0	0	0	0	0	4	0
Shortage of water	74	11	52	9	55	18	86	71	5	22	35	15	5	39	44	26
Lack of water	16	58	19	52	41	68	24	43	100	94	40	55	79	100	45	67

We find, however, that the adverse characteristics of tail-end areas are also found in small pockets, scattered in the rest of the system. Even in the middle of the system, we find some areas which experience periodic lack of water. In unit 8, 40 percent of respondents indicated a lack of water in Yala, and in unit 10, there were 15 percent of respondents who reported lack of water for both Maha and Yala seasons. In unit 30, though less than ten percent of farmers reported lack of water for Maha or Yala, 65 percent experienced shortages of water in Yala. Similarly, in unit 32, although only four percent of respondents indicated lack of water in Maha, some 67 percent reported shortages in the Yala season.

4.1.2 Shortage of Water

Shortage of water is the biggest overall problem identified by farmers in the LB system. This is seen from the fact that farmers even in a head unit like unit 2 report shortages, much like farmers in a tail unit such as Block E. Our acceptance in the survey of multiple responses by farmers may have blurred the extent of shortage of water, since both the third and fourth types of water problems could be reported at the tail, just as both the second and third by farmers in the head or middle units. Even after making allowance for multiple response overlap, there is definitely a substantial extent of shortage. The base-line survey (BLS) showed water shortages in all sampled units on the Left Bank, even if with varying degrees of intensity. Personal observations over a period of one-and-a-half years corroborate this conclusion from the survey.

It is surprising to note that unit 2, situated at the head very close to Senanayake Samudra, ranks as the third highest in the water shortage category. Why do farmers, in fact, complain of shortage of water, when one would expect them to experience no such shortage? The answer may lie in socio-cultural and economic factors. Unit 2 was settled by inhabitants whose villages were situated on the tank-bed of the proposed Senanayake Samudra reservoir. They were mainly chena (highland rainfed) farmers, with little or no experience in lowland paddy cultivation. Some of them were even unwilling settlers, brought and resettled in units 1 and 2 through force of circumstances. Today, some of them have left the unit, opting to make their homes in the catchment area of Namal Oya reservoir. They subsist on chena cultivation. Their allotments have been leased-out, and in some instances have been virtually sold to outsiders (although in an unofficial manner). The majority who continue to live in the unit are still wedded to traditional cultivation. Cultivation is done almost exclusively through family labour.

The low priority afforded to paddy cultivation in their value systems, their preference for chena cultivation, higher use of family labour, high leasing out rates, and greater availability of water compared to other units could have led the farmers initially to delay the Maha cultivation. We found that only 70% of farmers in unit 2 reported using Maha rains for paddy land preparation, the lowest percentage of any unit. The later dates of planting their paddy crop would be one reason for the reported shortages of water in this unit. If this interpretation is correct, reduction in water problems could result from getting farmers' cooperation in following a better planting schedule where water is basically plentiful and actual physical scarcity is not a problem as elsewhere in the system.

4.1.3 Unreliability of Supply

Poor timing of water supply, or uncertain timing, considered as 'unreliability', is the most significant problem in the head and middle units. Not surprisingly, the tail-end units like 3, 7, 35, D, 39, E and 14 (see Table 4-2) make no complaint of timing or unreliability, since their primary need is simply for water, not better or more predictable timing. The severity of unreliable supplies in the head and middle units can be discerned from Table 4-3.

It may also be that some of the perceived shortages of water at the head and middle could be the result of bad timing or unreliability. If water does not reach the farmer in the quantity he needs, at the time he needs, he may interpret and report this

Table 4-3:

Percentage of Farmers in Head and Middle Units Reporting Various Types of Irrigation Water Problems for Maha and Yala Seasons

% farmers from tail-end units reporting (N=334)

	2		23		24		17		21		8		26		3		10		30		32		Av.	
Problem Type	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y	M	Y
Too much water	17	7	18	5	21	5	24	7	0	0	27	0	0	0	11	0	0	0	10	0	17	0	13	2
Unreliable supplies	63	60	21	24	58	42	45	27	46	36	53	47	30	41	14	28	35	40	20	22	83	79	59	40
Shortage of water	67	47	10	37	26	58	14	41	33	59	20	50	59	64	17	44	45	45	14	65	17	67	29	52
Lack of water	3	3	0	0	0	5	0	0	0	0	7	40	0	9	0	0	15	15	4	8	0	4	3	8

as water shortage. In the eyes of the farmer, if water does not flow to him in time, this can amount to 'no water' or 'not enough' water.

How do farmers meet the problem of unreliability? How do they adapt to unreliable supplies? Among farmers' responses to the question on "causes of over-utilization of water," we find that farmers have adopted the most common strategy used elsewhere, i.e. of "storing" excessive amounts of water in the field, as a form of "insurance" against unpredictable scheduling and delivery so common in Gal Oya. Standing water in the field is an inefficient storage means, but it is the one farmers can control and have some confidence in. While in overall terms, this strategy, with 26% of responses, is only the second most frequent, it is the only reason for over-use of water that is given by all units.

Another reason given by farmers for over-utilization of water is weak canal management and canal control. This reinforces the significance of overall reliability of water supply in the eyes of farmers as a factor causing over-utilization. In effect, what the farmers say is that if farmers had more confidence in the system's overall management, there would be less wastage.

It is revealing to compare the units that scored high in this category of water problem--32, 2, 8, 24, 26, 21, 10, 17--with those scoring high on the importance of storing water in the field as insurance--14, D, 10, 32, 26, 24, 21. There is quite a substantial overlap between the two lists. This reinforces the view that reliability is a critical problem generally in many head and middle units of the system but especially in some units--32, 10, 26, 21, 24.

4.1.4 Too Much Water

Although 'too much water' is a minor problem of water management for most of the system, we find it serious in a few situations. The problems reported by farmers in units 2, 23, 24, 17 and 8 bear this out (see Table 4-3).

In attempting to solve the more critical problems of water distribution such as lack and shortages, minor problems such as 'too much water' would rightly occupy low priority. But the problem must not be subsumed under a central planning approach. A fairly representative case is unit 8 which has a full range of problems, from lack of water to too much water (see Table 4-4).

Table 4-4:

Percentage of Farmers in Unit 8 Reporting Various Types of Irrigation Problems for Maha and Yala Seasons

	Problem category	% farmers reporting (N=30) Maha	Yala
1.	Too much water	27	0
2.	Unreliable supplies	53	47
3.	Shortage	20	50
4.	Lack of water	7	40

This shows the advisability of giving thought to locality-specific factors, both techno-economic and socio-cultural, in attempting to seek solutions for problems of water management in Gal Oya. A macro approach usually preferred by planners and engineers in designing rehabilitation, should accomodate a locality-specific approach under which farmer viewpoints and particular locational characteristics will also be given due weight.

4.2 Reasons for Identified Water Problems

Farmers identified about 10 problems which in their opinion were the main causes for their water difficulties. The most often cited reason was 'bad channel maintenance' (36%). Unfortunately, it is difficult to assess their opinion on who is responsible for this situation, the ID and/or farmers, since no breakdown was obtained on the various categories of channel referred to. Observational data, however, indicate that all categories of channels suffer such neglect, so this suggests that responsibility is shared. The units reporting the most problem with channel maintenance were: 35, 32, D, 10, 2, 14 and 26.

The major reasons identified by farmers (more than 20%) are listed below, with those units listed as "high" reporting units where more than 30% of farmers named that particular problem as applying in their area (see Table 4-5).

Table 4-5:
Main Reasons for Water Problems According to Farmers, Total and by High Units

Reason	% reporting	High reporting units (30%+)
1. Bad channel maintenance	36	35, 32, D, 10, 2, 14, 26, 7, 21, 8, 17, 39
2. Inequitable distribution	32	D, 35, 26, 8, E, 14, 39.
3. Stealing of water	22	32, E, J, 24
4. Poor drainage channels	22	35, D, E
5. Officer ignorance/neglect	21	35, 8, 24
6. Damaged structures	20	7, 14, E, 39, 2

All of the units with the most severe reports of problems (3 or 4 problems each reported by 30% or more of their farmers) are in the middle of the system (8 and 26) or at the tail (14, 35, D, 39 and E).

It is a common view among most government officers, that farmers unfairly and emotionally blame government officers for irrigation problems when in fact the fault for such problems lies with the farmers. In analyzing the responses received for various reasons, it is seen that farmers have apportioned blame rather evenly. In pointing to stealing, damaged structures, and bad channel maintenance, they have identified areas in which farmers have responsibility depending on the circumstances of commission and omission, whereas in the other areas (and in channel maintenance) officials have some responsibility. Farmers thus do not see their problems in a one-sided light.

4.3 Over-Utilization of Water as Adaptation to Unreliable Supply

One does not have to take accurate measurements or make sophisticated technical studies to conclude that there is over-utilization of water in the head and middle sections of the Left Bank and in some areas of the Right Bank and River Division of Gal Oya. In asking farmers about over-utilization, we did not introduce any elaborate definition. We simply asked them whether in their opinion any farmers used more water than was necessary to nurture their crops. In fact, this was recognized by farmers as a widespread problem in Gal Oya. Only 2% of the respondents of the Left Bank indicated that there is no such problem.

As discussed elsewhere, one significant reason cited by farmers for over-utilization was farmers' storing water in their fields, in effect, as insurance against unreliable supply of water. A few farmers in the course of interviews indeed explicitly argued that while such storing is done, if it is done to ensure that stress conditions do not occur in the fields (due to erratic supplies), it does not constitute 'waste'. They felt that farmers had to resort to that practice even if they knew they were depriving farmers further down the channel of needed water. Thus, one way to reduce the incentive for such ponding is to make the supply of water more reliable.

The most often cited reason for over-utilization was 'to hurt tail-enders' (27%). Predictably, it was the tail-end units which gave this response most often. Ethnic divisions, which roughly coincide with the differences in physical location between head and tail, would have reinforced the polarization of responses in this category. However, there are notable exceptions, as the head and middle units 24, 23 and 8 had 21, 18 and 17 percent, respectively, of their farmers agreeing with this point of view. At the same time, several tail end units, 39, 7 and 3, gave comparatively low responses to this reason, i.e. 20, 18 and 10 percent, respectively.

In the course of informal discussions, some of the head-end farmers said that since all colonists on the Left Bank were peasant farmers, every effort should be made to provide water for cultivation irrespective of ethnic differences since all depended on water for their sustenance. Some other farmers, on the other hand, were less accommodating, indicating that the Left Bank as a whole was discriminated against in overall water allocations vis-a-vis the Right Bank and River Divisions (largely populated by the same ethnic group as at the tail-end of the Left Bank), so they were less sympathetic to the view of other farmers.

The main reasons given by farmers for over-utilization of water are given in Table 4-6, with those units having more than 30% naming that reason listed separately. It is significant that so few farmers gave 'better harvest' as a reason for over-utilizing water. There seems to be little feeling among farmers on the Left Bank that excessive use of water improves production. This suggests that 'educational campaigns' to persuade farmers that they need not use so much water would be of relatively little use, because farmers are not over-utilizing water out of agronomic ignorance. Rather the system's manner of operation seems to be more of a factor, plus any significant attitudes of selfishness, which in any case may not be affected much by moralistic campaigns.

When two reasons given--'insurance' and 'poor canal management'--are combined, one sees farmers focusing on the system's operation. It can be inferred that one of the most compelling reasons for farmers to over-utilize water is the unreliability and unpredictability of supplies. Supporting the view that operational and structural improvement is more important than education is the fact that only 5% gave as a reason for over-utilization that farmers 'don't know the value of water.' Also, only 7% said this was due to efforts at weed control.

Table 4-6:

Main Reasons for Over-Utilization of Water According to Farmers, Total and by High Units

Reason	% reporting	High reporting units (30%+)
1. To hurt tail-enders	27	D, E, 35, 14
2. As insurance	26	14, 10, D, 32, 26, 24
3. Poor canal management	16	35, D, 32, 39
4. Not concerned about other farmers	14	17, 30
5. Better harvest	12	E, 14
6. Damaged structures	11	2

When considering the fact that half the farmers cite 'insurance,' 'poor canal management' or 'damaged structures' as reasons for over-utilization of water, the main message of the farmers in the Left Bank of Gal Oya echoes that of Chambers, Wade and Barker: improve the operation and management of the main system and many of the malpractices that affect the system will be reduced.

4.4 Farmers' Perceptions of the Gal Oya Irrigation System and Their Effect on Farmer Behaviour

A study of farmer's orientation toward an irrigation system is necessary to understand its inner workings. It is a popularly held belief in Sri Lanka that negative farmer attitudes and behaviour are the prime cause for the deterioration of irrigation systems. In order to examine this generalization, an attempt was made to gain some insights into farmers' perceptions of such factors as conservation of water, the participation of farmers in system management, the role of the irrigation officers, the division of responsibilities beween farmers on the one hand and the government agencies on the other, and the present and potential irrigation practices of farmers.

The method used was to present statements on the above subjects. Farmers were asked whether, when they heard the statements, they: (a) completely agreed, (b) somewhat agreed, (c) somewhat disagreed, or (d) completely disagreed. The percent falling in each category for each unit was tabulated. In order to summarize the orientation of farmers in each unit into a single number, representing the overall degree of agreement or disagreement with the statement in that unit, we made the following weighting of responses. The % strongly agreeing was counted as a double positive, the % agreeing as positive, the % disagreeing as negative and the % strongly disagreeing as double negative. Thus if everyone (100%) strongly agreed (which meant nobody in the unit had any other opinion), the score would be 200. At the other extreme, completely strong disagreement (100%) counted as -200. A score of zero would mean that the opinion were equally divided between agreement and disagreement. The attitudinal statements in the order they were presented to the farmers are reproduced below.

ATTITUDE STATEMENTS

1. Water is a limited resource; everyone should try to conserve water.

2. It is the duty of the Government to provide water for all the farmers in the scheme.

3. There is enough water in the Senanayake Samudra. Negligence of officers leads to water shortages.

4. Land preparation for Maha season could be done by using the first rains (instead of water issues from the reservoir).

5. If the Government spends millions of rupees in building tanks and canals, it is the duty of the farmers to maintain the field channels by providing voluntary labour.

6. If sufficient water is not available for paddy cultivation, then other types of subsidiary food crops should be cultivated in the fields.

7. The best way to distribute water equitably is to establish 'Jala Sabha' (water councils) consisting of farmers.

8. Farmers who steal water should be punished.

9. Government officers do not know about the problems of the farmers.

10. Farmers at the head-end waste water.

11. It is a crime against society to tamper with water control structures.

12. If a farmer can steal water without getting caught, then there is nothing wrong in doing so.

13. Farmers in the Gal Oya scheme get precedence over all others in the distribution of water.

14. Farmers must learn new techniques of conserving water for paddy cultivation.

15. Along with the officers, farmers also should be blamed for poor maintenance of the Gal Oya irrigation system.

By asking about a subject in several ways, one can get a more reliable idea of attitudes. Thus with regard to water conservation, we asked two separate questions, whether farmers agreed or not that (a) it was farmers' duty to conserve water (#1), and (b) farmers should learn to conserve water (#14). The questions about attitudes toward government irrigation staff (a) water scarcity is due to staff neglect (#3) and (b) staff do not know farmer problems, (#9) were stated negatively to elicit opinions one way or the other; farmer could agree or disagree. What we were looking for were differences, if any, between units, so the absolute numbers reported are not so important as the differences among them. In this case, however, a positive number represents a negative attitude towards the commitment and knowledge of government staff.

In seeking attitudes toward farmer participation, we asked whether farmers agreed or disagreed that a farmer council was the best mechanism to handle water problems at local level (#7). We wanted to know their opinion about farmer responsibility, and asked whether they agreed that farmers should maintain field channels (#5). At the same time we wanted to know their attitude toward government responsibility, asking how strongly they thought it was the government's duty to give water to all (#2). In assessing their attitude towards current farmer use of irrigation water, (a) we asked whether they thought head-enders wasted water, (#10) and (b) their attitude toward damaging structures, whether this was anti-social. The attitude toward water stealing is complex, so we asked (a) whether those who steal water should be punished assuming they are caught (#8), and (b) whether it was okay to steal water if not caught (#12). The attitude score for each of the above items for the Left Bank area is given in Table 4-7.

The attitude scores given in the table could range from +200 to -200 along a continuums of 'completely agree' to 'completely disagree'. For purposes of analysis the degree of agreement or disagreement may be assessed as on page 15.

The sample of farmers on the Left Bank displays a very strong positive attitude toward conservation of water according to the mean attitude score for this item (160). It is significant to note that even in other areas which directly affect water conservation, farmers hold strongly or very strongly positive attitudes, e.g., farmers should maintain field channels (142); it is anti-social to damage structures (154); those who steal water should be punished (143) etc. These data suggest that farmers have healthy, positive attitudes toward the need to conserve water and are genuinely aware of the importance of conserving water.

Agree			Neutral				Disagree
Very Strong Agreement	Strong Agreement	Medium Agreement	Weak Agreement	Weak Dis-Agreement	Medium Dis-Agreement	Strong Dis-Agreement	Very Strong Agreement

Table 4-7:

Distribution of Average Attitude Scores for the Left Bank Sample Area (Range +200 to -200)

Farmers' attitudes	LB score
A. To Water	
Farmers' duty is to conserve water	160
Farmers should learn to conserve water	120
B. To Farmer Participation	
Farmer council best mechanism	13
C. To Government Staff*	
Scarcity of water is due to staff neglect	93
Staff do not know farmer problems	59
D. To Farmer Responsibility	
Farmers should maintain field channels	142
E. To Government Responsibility	
Duty of Government to give water to all	155
F. To (Changing) Behaviour Toward Water	
Head-enders waste water	83
Anti-social to damage structure	154
Punish water stealing	143
Stealing okay if not caught	-39
Use Maha rains for land preparation	85
Plant subsidiary food crops	-6

*A positive score represents a negative attitude.

However, there seems to be an apparent contradiction between farmer perception of the need to conserve water and their actual behaviour toward water. For example, when the reasons given by farmers for over-utilization of water are considered, there appears to be definite contradictions between farmer behaviour and their attitudes. Twenty six percent of farmers indicated that ponding of water as insurance is a reason for over-utilization of water, while only 11% agreed that damaged structures too contributed toward waste (Table 4-6). Some of the reasons given by farmers for current water problems (Table 4-5) were, bad channel maintenance (36%), damaged structures (20%), and stealing (22%). The above data give an indication that farmers 'say one thing' and 'do something else'. But the question to be asked is whether there are other, hidden causes for this apparent contradiction?

Levin's formula cited above, which describes determinants of behaviour, helps us to understand the circumstances which lead persons to behave in a manner contrary to the attitudes held by them. Despite positive intentions and attitudes, adverse environmental conditions, in this case the present level and form of management of the system, can lead farmers to behave differently.

This is borne out by the fact that on an average, about 52% of farmers had experienced shortages of water during both seasons, while 27% complained of unreliable and unpredictable supplies. Twenty one percent were of the view that officer neglect contributed to the above conditions, while 32% complained of inequitable distribution (Table 4-5). The negative attitude of farmers toward government officers (Table 4-7) is consistent with the above data. There was a fair agreement that one reason for scarcity of water was the negligence of the staff (score=93). They also believed that government staff did not understand farmer problems (score=59). This indicates that farmers definitely feel that the irrigation system does not cater to the needs of the cultivators. And through years of experience, farmers have begun to realize that they have no control over this situation. They possess no power to change the status-quo. Under these circumstances, farmers have only one course of action, i.e. to adapt suitably to a situation over which they have no control.

The attitudes to stealing of water are interesting in this respect (Table 4-7). Farmers were in strong agreement that those who steal water should be punished (score=143). In the same breath, however, almost half agreed that a farmer may steal water if he could avoid detection (score=-39). Although some may feel that farmers are hypocrites, we observe that most of the above negative behaviour traits displayed by farmers are rational adaptations to conditions they cannot themselves change.

General acceptance of negative irrigation behaviour like water stealing points to the fact that these practices receive covert legitimization, at least among small informal peer groups.

This does not allow us to conclude that farmers are immoral or that the farmers have ganged up to disrupt the irrigation system. It is true that through social acceptance, farmers attempt to legitimize unlawful acts. But they do this through a desire to obtain the water to which farmers feel they have a right. Farmers jealously affirmed this 'right' when they strongly felt that it was the duty of the government to give water to farmers (155). Under these circumstances, farmers perceive negative behaviour to be an acceptable, sometimes necessary course of action to obtain what is their due right, i.e., access to an assured supply of water.

Social legitimization of illegitimate acts has far-reaching implications for the future operation and management of the irrigation scheme. For one thing, it is certain that neither administrative and legal procedures nor moralizing educational campaigns will eliminate negative irrigation practices. In the absence of effective policing activity, recourse to law will only create a vicious cycle resulting in a game of hide-and-seek between irrigation officers and the farmers. The most urgent activity should be to improve the capacity of the system to control water distribution and to equip irrigation officers to utilize this control capacity in a positive and effective manner for farmers. Simultaneously, attempts should be made to minimize social legitimization of unlawful acts by organizing groups exerting positive social pressure. This indicates need for farmer organizations and, through organization, the creation of conditions in which stealing or breaking structures will not be viewed as justifiable. The organizations should work towards promoting self-discipline to ensure that negative practices are not resorted to.

Even in advance of actual physical rehabilitation, small but rational changes in operational policy may bring about positive changes among farmers. Attitude statements 4 and 6 which call upon farmers to use Maha rains for land preparation and to plant subsidiary food crops under water stress situations (both are techniques for greater water conservation) receive relatively low or very low scores, 85 and -6 respectively (Table 4-7). The environmental realities which inhibit farmers from adopting the first of these water conservation methods are the variability of the monsoon rains and the resulting uncertainty of the later water supply, and the condition of the soil which makes dry tilling almost impossible. A small change could be made in operational policy either to supplement Maha rains with a single well-timed irrigation issue or to give a guarantee to farmers that if the Maha rains peter out without providing sufficient water to complete land preparation, they will get water from the reservoir to complete land preparation. If such an irrigation issue would enable farmers to complete land preparation, farmers can be expected to respond in a more positive manner. This would not only save more water in the long run, but reduce pest damage arising from staggered cultivation.

But a decision such as above creates more work and a risk situation for the irrigation staff. A fixed date for the first water issue decided well in advance of the season at a cultivation meeting makes the work of the operation staff easier and less risky. If a decision is taken to provide supplemental irrigation, the operational staff has to monitor rainfall and its adequacy in various areas and to institutionalize an effective communication network both within the different strata of the Irrigation Department and between the Irrigation Department and the farmers. If, as argued earlier, farmer behaviour is a rational adaptation to an existing situation, then the appropriate course of action is to change the situation in such a way as to evoke more positive responses from farmers. If system management does not wish to change, it is ungenerous to expect farmers to change since farmers' risk of change is greater than for bureaucracy.

4.5 Organizational Approaches for Water Management

Since independence, Sri Lanka has had a variety of institutions for water management. In the early post-independence era, the institution of Vel Vidane, or Irrigation Headman, established during the British colonial period was continued. The Vel Vidane was a demi-official usually appointed by the provincial agent of the central government and was given power and authority to execute decisions for the proper maintenance and operation of the minor irrigation schemes in his area of authority.

In late fifties, the institution of Vel Vidane gave way to an elected committee of farmers known as the Cultivation Committee. The scope of this committee was wider. In addition to water allocation and distribution, this committee was charged with the responsibility for planning agricultural devlelopment programs in its area of authority.

In the early seventies, Agricultural Productivity Committees (APC) were established as an umbrella organization for the Cultivation Committees. Each APC overlooked the work of about a dozen Cultivation Committees. The fundamental difference was that the members of the APC were nominated by the Minister of Agriculture on the recommendation of the local Member of Parliament. By the time of our survey, the APC's stood abolished and a new institution was about to be born. Hence the survey was conducted during an institutional hiatus. It was not the most opportune moment to obtain the views of the farmers on institutions preferred by them for water management. However, since the survey could not wait until the new institution was established, it was decided to include a section to get farmers' views on institutional alternatives.

Since then, a new institution known as the Agrarian Service Committee (ASC), has been established. The ASC is comprised of six farmer-representatives and 8 field and divisional level officers of government agencies directly involved in domestic agriculture.[1] Under this system, field-level water distribution is overseen by an elected

[1] These representatives are appointed by the Minister from among the lower-level farmer representatives, referred to next, who operate within the ASC area, which corresponds to the previous APC area.

Table 4-8:

Alternative Organizations Preferred by Farmers for Water Management within Gal Oya Left Bank System

	Organization or role	Preferences (%) (N=475)
1.	Farmer Council or Farmer and Officer Committee	38
2.	Vel Vidane or Farmer Representative	23
3.	Government Officer	25
4.	Existing Mechanism	2
5.	No response	12

farmer-representative (Yaya Palaka), assisted by an appointed village-level officer titled Cultivation Officer. The following table gives a breakdown of organizations preferred by the farmers for water management within the Gal Oya Left Bank.

The reason for presenting the first category of institutions was to obtain farmers views on a committee approach to water management. The second category of organization gave the farmers the option of being supervised by one of their own representatives in water management activities. The fundamental difference between these two options is that in the first, decision-making will be mainly by consensus, while the second option will give decision-making power to a single person. The third alternative is to appoint a government functionary to take all decisions. A breakdown by units showed the following preferences.

Table 4-9:

Alternative Organizations for Water Management, By Unit Preferences

	Organizations	Units in rank order
1.	Farmer Council or Farmer and Officer Committee	10, 32, E, 30, 39, 2, 24, 23
2.	Vel Vidane or Farmer Representative	D, 7, J, 14
3.	Government Officer	17, 3, 8, 21
4.	Existing mechanisms	Nil
5.	No clear preference	35, 26

It is seen that seven colony units prefer the Committee approach to water management. However, when compared with the responses given by farmers in the attitude section, there seems to be some contradiction. Only units 35, 39, and E were strongly in favor of a farmer council for water management.

This mixed feeling towards farmer councils may stem from the negative experiences the colonist farmers had of the committee approach to agricultural planning and water management. Previous studies have shown that Cultivation Committees had less success in colonization schemes than in other areas.[2] Still, the overall preferences expressed are very similar to responses of a sample of over 600 farmers in Kurunegala and Galle districts in 1979.[3]

It is seen that the Vel Vidane or Irrigation Headman system is preferred by colony units inhabited largely by Tamil speaking farmers. Even at present, a similar informal system is in existence in some of these units. The Tamil equivalent of Vel Vidane is Vatta Vidane. Farmers in these units have informally nominated their own Vatta Vidanes to allocate and distribute water. Vatta Vidanes are paid either in cash or in kind. The Vatta Vidane takes decisions on behalf of all farmers he represents, and the farmers are usually expected to comply with his decisions and directives.

4.6 Conflict and Cooperation: Reasons, Patterns and Implications

It is distressing to note that water, which was expected to improve the social and economic conditions of the colonist farmers in Gal Oya, today has become a source of division and tension. On an average, 54 percent of the sample farmers reported conflicts arising out of competition for water, and in sixteen out of eighteen units sampled, the major reason for conflict was identified as water. The reported causes for conflict are given in Table 4-10 with high scoring units in each category listed separately. The only two units which score more on other reasons than on water are 10 and 17. The reason identified in unit 10 is political disputes, while unit 17 identifies drunkenness as its most common reason. Unit 10 scores very high on water disputes as well.

In order to assess the tendency for conflict, or what may be called the conflict-proneness of a unit, a conflict score was computed by adding the total percentage responses received for each category of cause of conflict for the unit.

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[2] T. Jogaratnam and R. Schickele, Survey of Nine Colonization Schemes in Ceylon, 1968-69. Peradeniya: Faculty of Agriculture, University of Sri Lanka, 1971.

[3] Professor Norman Uphoff of Cornell University, while a visiting fellow at ARTI in 1978-9, studied 16 villages in terms of their use (or not) of local organizations like Cultivation Committees for agricultural and rural development. He found 39% favouring Cultivation Committees, 22% favouring the Vel Vidane system, and 11% favouring the Cultivation Officer of new ASC system.

Table 4-10:

Causes of Conflict Reported by Farmers, Total and by High Units

Causes of conflict	Average %	High ranking units 30%+
1. Water	54	D, 32, 35, 10, 8, 30, 23, 2, E, 21, 39, 24, 26, J, 14, 7
2. Political disputes	14	10
3. Drunkenness	13	17
4. Land disputes	11	30
5. Selfishness and jealousy	10	10, 39
6. Animal tresspass	9	---
7. Heterogenous origins	8	---

The potential for cooperation among farmers in particular units was estimated through the percentage of farmers who participated in cooperative group work during a period of two years preceeding the survey. A further assessment of cooperation potential was obtained by comparing the different percentages of farmers who performed this work on a shramadana (voluntary) basis and on a payment basis. A breakdown of the above categories is given in Table 4-11.

In order to judge whether there is a consistency between the conflict score and pattern of cooperation in the respective units, a rank-order correlation was computed for conflict score and the shramadana or voluntary labor category. The objective was to see whether those units which reported higher conflicts had less voluntary labor in group activity. Although the rank-order correlation of 0.15 does rule out any consistent relationship among all units, some units do show a consistency in different combinations. The reason no correlation converged was mainly due to the "deviant" units. The deviant units are given following the consistent units on page 23.

It is interesting to note that the units' responses have a locational pattern, also corresponding to ethnic distinctions. Most of the tailend units score low on conflict (7, 14, 39, E and J) or medium (35 and D). A majority of these are also low on shramadana work (7, 36, 39 and E), presumably because with little water there is little need for shramadana work, whereas others (14, 35 and J) are high on shramadana, presumably not so much because of water availability or problems but because of greater social solidarity, which could in another direction account for low conflict in other tail-end units even though water is scarce. At the head end and middle, we find high conflict (2, 8, 10, 17, 30, 32) or medium (21, 23, 24, 26), with all of them in the high or medium conflict range, except for unit 3, the deviant case.

Analyzed in terms of unit groups, the average conflict score for head and middle units is twice as high, 168, compared with 79 for tail units. The average percent reporting voluntary (shramadana) labor is interestingly enough the same for the head and middle and for the tail, 30% in both sets of units. However, the tail units are utterly "bimodal," with four cases (7, D, 39 and E) averaging only 3% and the other three (35, 14 and J) averaging 67%, twice the average for the whole group. This analysis suggest how both locational and sociological factors can interact, sometimes in different ways, though both remain important even when producing divergent outcomes.

Table 4-11:

Conflict Score, Participation in Group Activity in the Preceeding Two Years, and Group Work on the Basis of Payment or Shramadana (Self-Help)

		% reporting (N=475)		
Unit	Conflict score (in rank order)	Participation in group activity	Working for payment	Shramadana or voluntary labour
10	260	10	0	5
32	239	17	4	12
17	177	72	21	48
2	168	50	30	17
30	166	59	16	43
8	145	63	13	50
23	142	39	10	29
26	140	68	54	9
21	135	36	2	33
35	116	90	0	86
24	111	58	5	53
D	100	0	0	0
E	99	10	0	10
39	95	20	20	0
3	92	40	11	31
7	55	45	45	0
J	47	57	0	57
14	42	68	5	58
LB Av.	129	45	13	30

Consistent Units	Combinations
14	Lowest conflict Highest shramadana
J	Low conflict High shramadana
21	Medium conflict Medium shramadana
23	Medium conflict Medium shramadana
26	Medium conflict Low shramadana
10	High conflict Low shramadana

Deviant Units	Combinations
7	Low conflict No shramadana
39	Low conflict No shramadana
E	Low conflict Low shramadana
D	Medium conflict No shramadana
35	Medium conflict High shramadana
8	High conflict High shramadana
30	High conflict Medium shramadana
17	High conflict High shramadana

4.7 Leadership

In an effort to assess the leadership patterns among Left Bank/Gal Oya farmers, three types of leadership were studied: (1) opinion leadership patterns relating to agricultural information; (2) leadership built on ability to 'decipher' government forms and documents and ability to mediate with government agencies on behalf of farmers; and (3) leadership in a hypothetical farmer-constituted Water Council for the particular colony. This analysis will be limited to the first and third type of leadership.

4.7.1 Opinion Leadership on Dissemination of Agricultural information

There is a tendency among communication planners in particular and policy makers and administrators in general in Sri Lanka to place heavy emphasis on opinion leadership in disseminating development information to rural people. Perhaps this is due to the influence of Western researchers who identify opinion leaders as one main channel of information in developing countries. The data from Left Bank/Gal Oya on opinion leadership for agricultural information seem to point in a contrary direction. On an average, only 32 percent of the sample farmers said that they go to a particular person to get advice on questions pertaining to agriculture. On an average, each unit has identified four opinion leaders. Put in another way, 130 farmers in the Left Bank sample units have nominated 73 opinion leaders for agriculture. Of the nominated 73 opinion leaders, only 4 received more than 15% nominations. This suggests that the tendency for farmers to go to opinion leaders for advice on agriculture is very low.

One may argue that the Left Bank/Gal Oya, being a colonization scheme, is not representative of rural Sri Lanka. However, studies conducted in twelve villages of Sri Lanka, of which six happened to be purana (old) villages in Anuradhapura District, too confirmed this pattern.[4] Most Western communication researchers generalize from findings based on countries such as India or on South American and African countries. But Sri Lanka has certain distinct features different from those obtaining in most of the above countries. A high literacy rate, a long tradition of universal adult suffrage, less hierarchical social structure, and free education would have combined to undermine perhaps once-strong opinion leadership patterns that would have been in existence in the colonial and early post-independence era.

However, it should be noted that two units, 35 and E, are deviants in this regard. In unit 35, there is strong and unambiguous opinion leadership in that 81 percent of the

[4] A.M.T. Gunawardena, M.L. Wickramasinghe, and S. Abeyratne, Farmer Perception of Improved Technology: A Study of Five Farming Systems, ARTI, 1980.

farmers have nominated a single person as opinion leader for agriculture. In unit E, 89 percent nominated four opinion leaders, of whom one received 58 percent of the nominations. Both these units are inhabited by persons of Tamil origin who were previously settled in the area before the Gal Oya scheme. The fact that the Tamil social structure is more intact and hierarchical could be a causal factor in this regard. However it is imprudent to ascribe definitive factors without further in-depth analysis.

4.7.2 Leadership Possibilities for Farmer-Constituted Water Councils

This section assesses the leadership potential of possible future farmer-constituted Water Councils for water management within the units if such a system were to be introduced. It is the opinion of some students of social anthropology that nominations for leaderhsip for hypothetical organizations will not give an accurate picture of the leadership potential of the community. Despite these limitations, the study sought to obtain some guidelines on how farmers on the Left Bank would select their leaders for such an organization.

Most farmers were more willing to nominate persons as leaders for the Water Council than as opinion leaders. Sixty-five percent of the sample farmers nominated some leader for the Water Council. On the average, 8 leaders were nominated in each unit, with a range from 1 to a high of 16. Put another way, 302 farmers on the Left Bank out of a sample of 475, nominated 132 leaders as chairmen for 18 Water Councils. Of these 132 potential chairmen, only 18 received over 15 percent of the nominations.

The above data show a weak, diffused pattern of leadership. However in the tail-end units inhabited by Tamils originally from the coastal villages, there are comparatively strong patterns of leadership, as seen in Table 4-12. Unit 35 is particularly strong, with 95 percent nominating a single leader. This is consistent with the trends for opinion leadership in agriculture too.

Table 4-12:

Leadership Nomination Patterns in Tail-End Units

	Units					
	7	35	D	39	E	14
1. % of farmers nominating one leader	54	95	72	60	100	63
2. No. of leaders nominated	8	1	4	3	8	4
3. No. of leaders receiving over 15% nominations	1	1	1	1	4	1
4. Highest nomination received by a single nominated leader (%)	23	95	44	50	26	37

The head and middle units, however, display much more diffused patterns of leadership as seen in Table 4-13.

Table 4-13:

Leadership Nomination Patterns in Head and Middle Units

	Units							
	2	24	21	17	8	26	3	10
1. % of farmers nominating one leader	73	75	76	41	89	59	34	10
2. No. of leaders nominated	9	14	13	6	12	10	11	2
3. No of leaders receiving over 15% nominations	1	0	1	0	2	0	0	0
4. Highest nomination received by a single nominated leader (%)	17	10	33	14	27	14	6	5

These data demonstrate the potential or actual leadership struggle to be found in these units, with concomitant problems of factionalism and noncooperation. Unit 21 and 8 seem to possess comparatively strong leadership patterns, combined with a sizeable spread of small disparate groups. However, these factions in combination could form a formidable opposition for emerging leaders.

In this respect, units 3 and 10 stand apart from the rest. In unit 10, ninety percent of the farmers declined to nominate any leader, without volunteering any reason for such a stand. Unit 3 is an interesting case. Only 34 percent of the farmers nominated any leader for a Water Council, the second lowest figure for the whole LB system. These 34 percent of farmers, however, all together nominated 11 potential leaders, of whom none received more than 6 percent of citations each. But the most frequent reason given by farmers in unit 3 for not nominating leaders was that leaders should be selected by consensus, not by individual nominations. With 26 percent giving this reason for not nominating anyone, this unit ranked the highest in 'consensus reason' category.

Usually consensus is used as a tool to reach decisions in communities which have strong, effective consensual groups in action. In social situations of this nature, the groups in question invariably would be highly informal, but cohesive as well. The response of farmers in Unit 3 to the question on conflict (see Table 4-11) reinforces this conclusion in that reported conflicts in unit 3 are very low. Hence, unit 3 in this regard warrants further in-depth study. It should also be borne in mind that ample care must be taken in attempting to develop water user groups in this unit. The pre-conditions seem just right for such activity. But one wrong step in trying to constitute the association which would run afoul of the decision-making process of the informal groups, could generate negative consequences that would destabilize the existing traditional arrangements or undermine any new ones. Another important issue is whether informal groups would continue to be effective when incorporated into formalized structure.

4.8 Cultivation Meetings: A Forum for Cultivators?

The broad objective of the <u>kanna</u> meetings held twice a year under the chairmanship of the Government Agent or his Assistant before each cultivation season is to agree upon a cultivation calendar for the season in consultation with the cultivators of the area. It is supposed to be a forum for cultivators to participate in a decision-making process which is critical for the planning of the cultivation cycle for the season in question. But the Cultivation Meetings could hardly be called a forum for cultivators in the Left Bank of Gal Oya, as only 39 percent of the sample farmers indicated they had ever attended a Cultivation Meeting. Thirty-three percent of the sample indicated that the Cultivation Meetings serve no useful purpose. When requested to give reasons for the alleged uselessness of Cultivation Meetings, however, farmers appeared to hold some information back. There appeared to be a reluctance on the part of some of the farmers even to admit that the Cultivation Meetings were not useful. Their reluctance to speak specifically about the failure of the Cultivation

Meetings in a survey situation was quite evident when one compared the views expressed by farmers in informal meetings with us. The fact that the Meetings were attended by high government officials would have inhibited the farmers from expressing their genuine feelings 'officially'.

It is true that some Cultivation Meetings do turn out to be volatile affairs with farmers speaking up for their 'rights.' But such meetings were very few and far between, and farmers seem to stand up to officers only when they were placed in a back-to-the-wall situation. Farmers answering our questions gave the following reasons for considering the Cultivation Meetings 'not useful.'

TABLE 4-14

Reasons Given by Farmers Why Cultivation Meetings Are Not Regarded as 'Useful,' Total and by High Units

Reason	LB Average (%)	Units scoring 20%+
1. Cultivation Meeting is orientated to needs of government officers	6	21 (40%)
2. Decisions not suitable for farmers	2	7 (21%)
3. Decisions taken at Cultivation Meetings are not implemented	16	17 (40%), 10 (100%), 30 (64%), 32 (43%)

Despite the general reluctance on the part of the Left Bank farmers to criticize the Cultivation Meetings, farmers in units 21, 17, 10 and 30 had no such inhibitions. A large majority of farmers in these units, 98, 82, 90 and 71 percent respectively clearly stated that the Cultivation Meetings were not useful. The data on Cultivation Meetings suggest that these do not really function as farmer forums, and accordingly, they are largely ignored by farmers.

4.9 Field-Level Government Officers in Gal Oya and Their Contact with Farmers

This section examines the degree of contact with the colonist farmers by the field officers responsible for water distribution and input supply on the Left Bank area of Gal Oya. Farmers were asked whether they know the following officers: (i) Jalapalake (Irrigator), (ii) Maintenance Overseer, (iii) Technical Assistant of the Irrigation Department, and (iv) Cultivation Officer of the Department of Agrarian Services. In a second question, farmers were asked how often they had met with each of the above officers for official purposes during the preceeding Maha and Yala seasons. A breakdown of the above two types of data is given below in Table 4-15.

Table 4-15:

Contact with Field Staff, Percentage of Farmers Indicating They Know the Respective Officers and Percentage Reporting Two or More Visits with Officers During Preceding Maha and Yala Season

	(%) farmers reporting (N=475)		
Officers	Know officers	Two or more visits in Maha	Two or more visits in Yala
1. Jala Palake (Irrigator)	61	9	7
2. Maintenance Overseer	50	7	4
3. T.A.	49	8	6
4. Cultivation Officer	84	31	18

Although the Cultivation Officer of the Department of Agrarian Services and the Jalapalake of the Irrigation Department operate more or less at the same level, the Cultivation Officer seems to farmers to be more approachable. Taking into consideration the range of water problems identified by farmers earlier (Sections 4.1, 4.2 and 4.3), it is strange to observe such low contact with officers of the Irrigation Department. Despite the multifaceted problems pertaining to water, the field officers of the Irrigation Department tend to be generally ignored or by-passed. The Cultivation Officer, on the contrary, appears to be fairly sought out by farmers for solutions of their problems.

However, unit 35 appeared to stand apart from all other units with regard to degree of contact with government officers. It has a very high degree of contact with government officers, including those officers of the Irrigation Department.

Table 4-16:
Degree of Contact with Government Officers for Unit 35, Compared with Mean for LB Gal Oya

Officer	% farmer reporting 2 or more visits			
	Unit 35 N=21		LB Average N=475	
	M	Y	M	Y
1. JalaPalake	76	61	9	7
2. Maintenance Overseer	66	48	7	4
3. T. A.	62	52	8	6
4. Cultivation Officer	76	62	31	18

This appears to be puzzling as this unit has very strong attitude in favour of farmer participation in water management (1st rank order) and an equally strong attitude against giving government officers responsibility for water management (3rd rank order). This is, however, also the only unit in which no complaints are made against the Cultivation Meetings. This particular ambivalent relationship may be explained through the strong leadership pattern evident in this unit. Ninety-five percent of farmers in unit 35 nominated one farmer as their choice for the Water Council. The same person was also nominated by 81% as the opinion leader in agriculture. Just as the farmers look up to this particular individual, the government officers also must be maintaining close contact with him. It is a common phenomenon for village-level and field-level government officers to maintain close ties with the 'elites' in the villages. Since this particular 'elite' member enjoys the confidence of fellow farmers, he appears to be acting as a medium of contact between officers and farmers. As the farmers recognize the positive role played by this 'elite' farmer in promoting their cause vis-a-vis the officers, they would naturally prefer a farmer to continue to play the key role in water management.

Farmer leadership is obviously a crucial subject for the improvement of water management and we have only been able to scratch the surface of a major problem area with our initial analysis. Unfortunately, it is also an issue area hardly handled adequately in the existing social science literature. We hope that our continuing involvement in the Left Bank, through ARTI field investigators and institutional organizers, plus field visits by the Water Management Research Group and its Cornell collaborators, can begin making more sense out of this complicated but important subject.

Chapter V

IMPLICATIONS OF FARMERS' PERCEPTION OF WATER PROBLEM SEVERITY FOR PROBLEMS OF WATER MANAGEMENT: METHODOLOGY FOR A WATER PROBLEM INDEX AND ATTITUDINAL ANALYSIS

Norman T. Uphoff and Lakshman Wickramasinghe

The information given thus far gives an indication that farmers have a reasonably sober and informed view of water management problems in their areas. The following presentation goes into this in more depth and detail. It shows a considerable correspondence between attitudes and outcomes in the Left Bank and also points up areas (units) where making improvements in water management should be easier or more difficult than the average. The analysis combines various assessments and attitudes of farmers to produce a profile showing units facing more severe water problems and units facing less severe ones. The analysis presents instructive correlates of this degree of water problem severity which should guide efforts at institutional-organization as well as physical rehabilitation of the Left Bank system.

5.1 Methodology for a Water Problem Index (WPI)

In Chapter 2 of this report, we introduced an <u>objective</u> measure of water availability, based on daily observations of water in selected tracts of paddy at the head, middle and tail of distributary channels within the sampled units. This Water Availability Index (WAI) provides a good indicator of the water situation in those parts of the respective units covered by our investigators' surveys. Within each sampled unit, investigators studied a field channel area at the head, at the middle and at the tail of one D-channel in that unit. The objective measure gave some standard against which to assess actual water conditions in the respective parts of the sampled unit.[1]

Separately, in interviewing farmers for the baseline survey, ARTI investigators asked the same sample of farmers about the adequacy of their water supply--what <u>problems</u> they had. This information has been used to construct a <u>reported</u> measure of

[1] Because of the hydrological complexity of the distribution system in Gal Oya, and the fact that colony unit boundaries were <u>not</u> drawn to conform to hydrological boundaries, the classification of 'head', 'middle' and 'tail' is inexact for some units. Thus, the data in this report represent a sample of conditions along the sections of D-channel studied in the respective units rather than strictly samples of the whole unit. Because of the hydrological variation in correspondence between unit and natural physical boundaries, some ambiguity was unavoidable.

water availability, which we call the Water Problem Index (WPI) to distinguish it from the above-mentioned index based on actual observations. The WPI is explained below. As will be seen, its correspondence both to objective physical output measures like paddy yield per acre and to subjective attitudes such as evaluation of government officials' performance is remarkably great. This WPI helps to give many insights into the social as well as physical dynamics of water management in the Left Bank and can illuminate many other variables included in the baseline survey, as reported below.

Farmers in the 18 units sampled on the Left Bank were asked what kind of water problems they had: too much water, unreliable water, shortage of water, or no water at all. This was asked with reference to both Maha and Yala seasons, and as expected, the responses usually varied for the two seasons. The WPI was constructed by considering the latter two responses (shortage of water, and no water), as they represented more serious problems than too much water or unreliable water. To get a weighting of the seriousness of water problems in a unit, the percent of respondents in a unit reporting no water was double-weighted, and then the percent of respondents reporting either problems in the Yala season was double-weighted. This produced an index number for each unit which first assigned importance to the problems of having either insufficient water or none at all, then it assigned extra weight to having none at all, and finally extra weight to having problems in the Yala season, when irrigation is more crucial.

The calculation of the Water Problem Index can be illustrated by showing how the figures for units 23 and E, those with the lowest and highest WPI, indicating the least and most severe water problems, are weighted and combined to produce the index (figures from Table 5-1). We are thus looking only at insufficient or no water in the Maha and Yala seasons. These are not the only problems but they are indicative of the situation facing farmers in the respective units.

	Shortage of Water		No Water		
Percent Responding	Maha	Yala	Maha	Yala	
unit 23	10%	37%	0%	0%	
unit E	5	39	79	100	
WPI Weighting Factor		x 1	x 2	x 2	x4
WPI Calculation					
unit 23	10	74	0	0	= 84
unit E	5	78	158	400	= 641

The score as calculated is perhaps simplistic, but the resulting index is quite illuminating concerning water management issues in the Left Bank. It appears to represent ordinally, if not cardinally, the degree of water problems farmers face.[2] The index distinguishes four sets of units: three with rather modest problems of water supply, seven with moderate problems, six with severe problems, and two with extremely severe problems. These units are ranked and the farmer responses on which the WPI score is based are shown in Table 5-1.

When average yields of the various units, as well as observed Water Availability Index (WAI), are compared with this reported Water Problem Index (WPI), very high correlations result, giving some support for the objective validity of an index based on subjective respondents' reports. This is seen from Table 5-2.

A rank-order correlation of the reported WPI with the observed WAI is 0.67, a satisfactory correlation. However the correlation of WPI with yield is even better, 0.74, than is the WAI correlation with yield, .70. What is more, the groupings of units according to the WPI reveal significant patterns in other variables.

5.2 Specific Kinds of Water Problems

When the farmer responses reported in section 4.3 are analyzed according to the WPI, by distinguishing three kinds of problems that farmers identified: (a) physical--unsuitable soil, poor drainage, and poor drainage channels, (b) behavioural--damaged structures, and stealing, and (c) water management--poor channel maintenance, and inequitable distribution, we see the following patterns from the data in Table 5-3.

We would naturally expect the average number of farmers in a unit reporting specific problems to increase as the WPI goes up, and this is seen in the far-right column of Table 5-3. What is more interesting is the specific trends for different kinds of problem. There are some drainage problems in the most favored units, relatively well-watered, but nothing to compare with the great drainage problems of those at the tail of the system, accounting for the sharp rise in total physical problems reported for categories III and IV (severe and extremely severe water problems). These tail end units are low lying and near to the coast.

When it comes to behavioural problems -- both damage to structures and water stealing -- these also mount sharply as water problems increase. Of special note is that

[2]For one thing, WPI correlates somewhat higher with yield than does the WAI, as reported below. Subsequent analysis will do similar analysis at the individual farmer level rather than for units as aggregations of farmers. Such analysis will be reported in subsequent Yearbooks.

some units in category II report many fewer behavioural problems (10 and 26) than the average for the group, while unit 32 reports many more such problems. In categories III and IV, units 35 and 36 stand out for many fewer behavioural problems than would be expected for their water-scarce condition. Such information would give encouragement for getting more farmer cooperation in units like 35 and D, and would send up warning flags for a unit like 32.

When it comes to more specific water management problems, it is interesting that the upward trend is not seen with regard to channel maintenance. Units in the best-situated category (17, 23 and 3) report poor maintenance much less often than do most units in the other three categories (II, III and IV), which are all at about the same level. Still, there are some exceptions that should be noted. Particularly units J and E stand out among the other units of III and IV--suggesting that maintenance has been better provided (by farmers and/or the Irrigation Department) in the middle-class blocks than in the colony units.[3] Units 35 and D look very unpromising in this regard, while unit 32 also looks very poor considering its relative water availability.

Problems of 'inequitable distribution' also mount rapidly as a rule as the WPI increases--with J and E again exceptions within their groups. That unit 7 compares so well on this score is also worth noting; it is a unit where there is relatively more social cohesion relating to ethnic solidarity. But there may be other reasons for this phenomenon. Most farmers in Unit 7 have direct outlets to their fields from the main distributary. In fact, nearly 90% of our sample farmers in this unit fall into this category. Also, there is a very strong Vatta Vidane (water headman) system operating in this unit for allocation and distribution of water.

Conflicts over water are much less in unit 7 (see Table 5-4). On the one hand, one can argue that greater social cohesion among farmers in unit 7 accounts for the relatively fewer behavioural and water management problems within the unit. On the other hand, one may argue that the greater social cohesion is due not so much to intrinsic characteristics of the people but rather is an outcome of their situation with regard to physical distribution of water. If any water flows in the distributary, equitable distribution poses no great obstacles since there are direct outlets to fields. Overall, unit 7 receives much less water than other units in the system and this can encourage cooperation to utilize in the best possible way whatever water becomes available.

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[3] Sample farmers in both blocks J and E were drawn from the colony allot-ments. Unfortunately land-tenure relationships were not taken into account in this ini-tial analysis; hence the assumption that most colony units must be leased in by some middle class farmers can not be fully tested out. This could be a reason for the phenomenen.

Table 5-1:
Categories of Units by Severity of Reported Water Problems, Based on Computed Water Problem Index (WPI) (M = Maha Season, Y = Yala Season)

Unit	Too Much Water M	Too Much Water Y	Unreliable Water M	Unreliable Water Y	Shortage of Water M	Shortage of Water Y	No Water M	No Water Y	Water Problem Index (WPI)
Category I: Modest WPI									
23	18	5	21	24	10	37	0	0	84
17	24	7	45	27	14	41	0	0	96
3	11	0	14	28	17	44	0	0	105
								Average:	95
Category II: Moderate WPI									
21	0	0	46	36	33	59	0	0	151
24	21	5	58	42	26	58	0	5	162
32	17	0	83	79	17	67	0	4	167
2	17	7	63	60	67	47	3	3	179
30	10	0	20	22	14	65	4	8	184
26	0	0	50	41	59	64	0	9	223
10	0	0	35	40	45	45	15	15	186
								Average:	179
Category III: Severe WPI									
8	27	0	53	47	20	50	7	40	294
J	5	0	14	0	52	9	19	52	316
14	5	0	10	0	74	11	16	58	360
39	0	0	0	0	55	15	40	55	385
7	5	5	5	0	55	18	41	68	445
35	0	0	0	0	86	71	24	43	448
								Average:	375
Category IV: Extremely Severe WPI									
D	0	0	0	0	5	22	100	94	625
E	0	0	0	0	5	39	79	100	641
								Average:	633

Table 5-2:

Categories of Units by Water Problem Index (WPI), Water Availability Index (WAI) for Maha 1979/80, and Yields for Maha 1979/80 (in bushels per acre)

Unit	WPI	WAI	Yield
	Category I		
23	34	191	32.5
17	96	177	45.9
3	105	193	48.5
Average:	95	187	42.3
	Category II		
21	151	184	36.3
24	162	182	26.0
32	167	182	37.6
2	179	187	43.3
30	184	173	35.8
26	223	196	35.9
10	225	186	34.7
Average:	179	184	30.4
	Category III		
8	294	168	31.0
J	316	114	25.1
14	360	168	23.5
39	385	NA	28.1
7	445	167	29.5
35	448	NA	31.6
Average:	375	154	28.1
	Category IV		
D	625	NA	19.4
E	641	148	23.5
Average:	633	148	21.4

Table 5-3:
Identified Water Problems in Units Ranked by Severity of WPI (responses in percent)

		Physical				Behavioural			Water Management			
Category	Unit	Unsuitable soil	Poor drainage channels	Poor drainage	TOTAL	Damaged Structures	Stealing of water	TOTAL	Poor channel maintenance	Inequitable distribution	TOTAL	Average
I	23	5	8	3	16	5	5	10	11	10	21	7
	17	22	15	3	40	10	3	13	31	12	43	13
	3	9	9	0	18	3	8	11	21	14	35	9
		12	11	2	25	6	5	11	21	12	33	10
II	21	8	2	0	10	15	17	32	34	15	49	13
	24	5	13	0	18	10	31	41	21	21	42	14
	32	0	12	0	12	12	56	68	77	23	100	26
	2	5	15	1	21	31	15	46	51	20	71	20
	30	7	3	2	12	7	23	30	20	25	45	12
	26	16	6	0	22	0	11	11	41	50	91	18
	10	5	12	0	17	5	0	5	75	25	100	17
		6	9	0	16	11	22	33	45	25	71	17
III	8	13	7	0	20	23	27	50	33	43	76	21
	J	0	26	16	42	19	40	59	21	16	37	20
	14	5	16	5	26	55	26	81	44	36	80	27
	39	0	25	0	25	40	22	62	30	32	62	21
	7	2	20	25	46	72	24	96	36	13	49	27
	35	0	86	0	86	0	28	28	81	85	166	40
		3	30	8	41	35	28	63	41	37	78	26
IV	D	0	58	0	58	0	22	22	75	97	172	36
	E	0	55	26	81	55	42	97	15	42	57	34
		0	57	13	70	28	32	60	45	70	115	35

Table 5-4:

Reasons Given for Over-Utilization of Water and Conflict Over Water Score, in Units Ranked by Severity of WPI (responses in percent)

Category	Unit	Insurance	Weed control	Damaged Structures	Better harvest	To hurt tail-ender	No concern for others	Do not know value of water	Poor canal management	Average Percent	Conflict over water score
		Reasons Given for Over-Utilization of Water									
I	23	16	8	3	10	18	21	31	5	13	60
	17	7	0	7	7	3	48	3	0	9	31
	3	11	0	6	0	9	20	8	8	8	23
		11	3	5	6	10	30	14	4	10	38
II	21	28	15	13	13	13	5	5	10	11	46
	24	32	10	0	0	21	10	5	0	10	42
	32	41	38	0	0	25	25	12	42	23	100
	2	10	0	30	7	7	10	27	10	13	57
	30	16	8	4	2	6	41	12	4	13	61
	26	36	5	5	23	0	0	0	0	9	41
	10	45	15	25	0	15	0	0	5	13	70
		30	13	11	6	12	13	9	10	13	59
III	8	20	13	23	27	17	20	3	0	15	63
	J	10	0	5	14	10	24	0	0	8	33
	14	84	5	21	32	32	10	5	0	24	32
	39	20	0	5	20	20	0	0	35	13	45
	7	23	0	23	5	18	14	0	0	10	27
	35	14	5	10	0	86	0	0	90	26	96
		28	4	15	15	31	11	1	21	16	49
IV	D	44	0	6	0	94	5	0	72	27	100
	E	5	0	5	57	89	0	0	0	20	47
		25	0	5	29	92	3	0	36	24	74

The reasons given for over-utilization of water, discussed in section 4.4 above, can be further interpreted according to the WPI (Table 5-4). We see that over-use of water as a form of insurance is least reported in the units with least water problems, and also in unit 2 (at head end) and in the units E and J, which are more middle-class units. Attribution of over-use to damaged structures follows a similar pattern, the exception being units D and E in category IV. So does the explanation of 'better harvest' as a reason for over-use.

It is not surprising that the percent of farmers saying over-use is due to head-enders wanting to hurt the tail-enders goes up sharply according to the WPI. On the other hand, we note that those with better water supply (category I) themselves head-enders, are more inclined to attribute this to lack of concern (or perhaps carelessness) than to deliberate intentions. The same fall-off in response is seen concerning whether or not over-use is due to farmer's not knowing the value of water. Farmers with less water do not see the over-use as a matter of ignorance. What they do see as a cause is poor canal management in the main system, the percent reporting this way rising from 3% to 10% to 21% to 36% as we move from category I to category IV.

It is interesting to look at the percent of farmers in the different units reporting conflict over water, shown in the last column of Table 5-4. Units 23, 10 and 32 report conflicts more often than would be expected based on reported water problems, whereas units, J, E, 7, 14 and 39 report conflicts much less often than might be expected given their water scarcity. Such information should be useful in directing the institutional-organization effort to places where there may not be informal institutions to handle local conflict, or where such institutions may now be operating.

5.3 Farmer Attitudes as Related to Water Problems

Farmer perceptions of some aspects of the Gal Oya irrigation system presented in section 4.5 above, can be further analyzed using the water problem index (WPI). In this analysis, we summarize as follows some of the information obtained from attitudinal statements reported in section 4.5.

ATTITUDE TO CONSERVATION OF WATER: Since the responses received for the two separate statements on attitudes toward water conservation correlated very strongly, for this analysis we computed an average score for both statements.

ATTITUDE TO GOVERNMENT STAFF: In this instance too we combined the scores of both statements and computed an average score for both. It should be emphasized that in this case a positive score represents a negative attitude towards government staff.

ATTITUDE TO STEALING WATER: To arrive at a common score, we subtracted the score on the statement, whether it was acceptable to steal water if not caught, from the score on the statement whether those who stole water should be punished. Since the first statement favors water stealing, by this subtraction, we would get a net score reflecting the attitudes of respondents towards stealing of water. E.g., if a farmer endorsed punishment but accepted stealing, provided the culprit was not caught, the two responses would cancel each other out, thus giving a nil score representing neutrality or ambivalence.

All other attitude scores are the same as those scores reported in section 4.5.

There is no correlation between favourable attitudes toward water conservation and the score on the Water Problem Index, though some of the units with the most severe problems such as E, 39 and J score the highest on this scale as seen in Table 5-5.

The strongest correlation of attitudes with the WPI is with regard to government staff, an inverse relation of -0.76. The worse the reported water problems, the higher the score indicating negative attitudes, regarding government as at fault for water scarcity and considering government officers ignorant of farmers' problems. This suggests that alleviation of water problems could markedly improve farmer attitudes toward the Irrigation Department.

At the same time, and consistent with the previous attitude, farmers with worse water problems are more favourably disposed to have farmers themselves handle water through elected Water Councils. This association too is quite significant, and the two attitudes, being critical of government staff and favouring Farmers Councils, are correlated 0.65, indicating consistent thinking. It seems that Farmers Councils should get more support from farmers where water problems are more severe though as discussed in the last section of this chapter, other responses indicate that when water problems are most severe farmers favour water "executives" rather than "councils" chosen from among themselves.

Other attitudes are not so clearly patterned. On farmer responsibility for field channel maintenance, and government responsibility to provide water, both attitudes correlate negatively but low--those with fewer water problems on the average feel less strongly about these responsibilities, except for unit 17. The two attitudes themselves correlate 0.66, however. Not surprisingly, those with more water problems were more inclined to feel that head-enders wasted water.

There is little correlation between water problems and an attitude that breaking irrigation control structures is anti-social, or with punishing water stealing. The scores on these two variables are, indeed, not themselves correlated.

Table 5-5:

Distribution of Units by WPI and Attitudes Toward Water Conservation Measures, Government Staff, Farmer Water Councils, Farmer Responsibility, Government Responsibility, Head-End Wasting Water, Damage to Structures and Water Stealing, in Units Ranked by Severity of WPI

Category	Unit	Water Conservation	Government Staff	Farmer Water Council	Farmer Responsibility	Government Responsibility	Head-end Wasting Water	Damaging Structures Anti-Social	Punish Water Stealing
I	23	140	11	-36	153	140	95	155	122
	17	161	49	-70	180	173	68	186	88
	3	142	81	-72	150	176	40	163	69
		148	47	-59	161	160	68	168	90
II	21	129	10	-46	128	134	30	140	110
	24	153	63	37	149	127	53	174	92
	32	60	79	- 3	104	112	101	101	6
	2	164	61	-50	164	186	73	182	129
	30	144	24	-81	140	155	97	148	94
	26	124	76	70	142	153	17	95	178
	10	90	3	30	110	130	55	135	-8
		123	45	-43	134	142	61	139	88
III	8	130	74	-42	44	161	119	134	104
	J	176	120	34	142	186	33	184	134
	14	148	113	137	153	163	111	158	127
	39	180	155	145	175	185	155	185	53
	7	118	107	5	150	188	91	156	142
	35	133	121	157	167	124	144	123	117
		147	115	73	139	168	109	157	113
IV	D	-	-	-	-	-	-	-	-
	E	192	149	151	167	153	100	195	0
		192	149	151	167	153	100	195	0
Correlation with WPI		-.15	-.76	-.59	-.16	-.17	-.48	-.05	-.12

Attitudes, as we explained in Chapter 4, are not in themselves causal. The picture that emerges from an analysis of attitudinal responses is not very sharp except with regard to two very important items for water management--attitudes toward government staff and toward farmer councils being preferred to manage water equitably. The negative attitude toward staff complements a positive attitude toward farmer participation. Whether improving water distribution would make farmers less disposed toward Farmer Councils is not clear, but it does appear that farmers would have a more positive opinion of irrigation staff.

5.4 Water Problem Index and Farmer Preferred Organizations for Water Management

When we initially figured correlations between the observed water problems of farmers and their preference among water management roles, there was no significant relation between WPI and having a farmer council (or a farmer/officer committee) (r=-.28). Preferring some form of Vel Vidane (irrigation headman) system correlated .75, while there was a significant negative correlation (-.75) between the WPI and farmers' attitude toward relying on government officers for water management. (It will be recalled that those with lower WPI had more favorable attitudes toward officials.) Farmers with fewer water problems tended to suggest that a government officer exercise responsibility for water management (see Table 5-6).

One of the reasons the relationships are so simple is that we are dealing with three, not two modes of water management. Moreover, they have historical roots. Traditionally, water management was a local responsibility, though it is not clear to what exent this was exercised by a village council (Gam Sabha) or an irrigation headman (Vel Vidane). When British colonial authority was established, all such local institutions werre abolished, but the declining condition of irrigation systems and falling paddy production led it to experiment with reinstituting village councils after 1856. These were successful enough that by 1871 it instituted an ordinance providing that villages should decide whether to have a council, a headman, or both, to manage its irrigation affairs.[4]

The Vel Vidane role became the dominant one in this century, as the Village Councils never took deep root under colonial administration. This role was replaced by Cultivation Committee in the Paddy Lands Act of 1958. This farmer-elected council

[4] Michael Roberts, 1967, "The Paddy Lands Irrigation Ordinances and the Revival of Traditional Irrigation Customs, 1856-1871." Ceylon Journal of Historical and Social Studies, 10, 1967, pp. 114-30.

Table 5-6:

Preferences (in percent) for Farmer Council/Farmer/Officer Committees, Vel Vidane, or Government Officer to Manage Water, in Units Ranked by Severity of WPI

	I			II							III						IV		IV
Preference	23	17	3	21	24	32	2	30	26	10	8	J	14	39	7	35	D	E	Correlation with WPI
Farmer Council, Farmer/ Officer Committee	44	28	28	33	53	58	54	57	36	60	37	25	42	55	18	0	0	58	-.28
Vel Vidane	13	7	11	18	37	4	13	4	18	10	23	48	47	25	50	5	100	32	.75
Government Officer	29	62	57	38	11	38	33	37	36	25	40	14	10	5	27	0	0	5	-.75

became politically-appointed in 1973 and was abolished in 1977, being replaced the next year by a government-appointed Cultivation Officer.[5] This is the origin for a current government official having some direct responsibility for overseeing water management, though some government officials have had a role in superintending irrigation since time immemorial.

The three roles can be placed along two dimensions, which makes their analysis more complicated. On the executive decision-maker vs. elected council continuum, we find the Cultivation Officer and Vel Vidane at one end, and the Farmer Committee at the other. On the other hand, with regard to government-appointed vs. farmer selection, the Cultivation Officer and Farmer Committee are at either end of the continuum, with the Vel Vidane at the latter end on this criterion. Even if confirmed by government officials, as in earlier times, he is more readily accountable to farmers because he lives in the community. A compromise along the latter dimension is a joint committee of elected farmers and appointed officials.

Farmers preferences stood out sharply, even starkly, when we compared the average WPI scores for those units which preferred handing responsibility for water

[5]A comparative recent historical background on the three types of irrigation management is offered by M.M. Karunanayake in "Farmer Organizations and Irrigation Leadership in Sri Lanka: Retrospect and Prospect," MARGA Quarterly, 6:1, 1969, pp. 1-13.

management over to government officials, those which favoured having a Farmer Council (or a joint farmer-official committee) and those who would choose a Vel Vidane. The average Water Problem Index for those units favouring a Government Officer is 129, while that in units favouring Farmers Council is 260. The units preferring a Vel Vidane are some of the worst off, averaging 460.

This seems to support the finding of Robert Chambers' in a separate study conducted in Hambantota District in Sri Lanka.[6] He found that those with severe water problems favoured a Vel Vidane system over the elected Cultivation Committee because such an executive official was able to take quicker and less likely reversible action. They would rather have predictable water supply, even if a lesser amount, than to have more water in a less assured manner. Having just one person make water allocations does make them more certain, even if more arbitrary.

There is no direct relationship between WPI and preference for an executive versus a council form of authority for water management, since Government Officers and Vel Vidanes are both individual decision-makers. The difference is in their accountability to farmers, or simply their accessibility to farmers. Where problems are least, farmers appear to be more satisfied with Government Officers handling the tasks of water management, perhaps sparing them the effort of this job. "Participation" in water management activities, after all, does have some personal, if not necessarily financial "opportunity costs" to farmers. In the middle range of problem severity, farmers opt more often for a more participatory approach, whereas at the extreme of scarcity, they are more inclined to entrust decision-making to a single person. Chambers' analysis indicated that promptness and certainty of action weighed heavily in farmers' minds. Indeed, they were willing to put up with some degree of arbitrariness and inequity in water distribution in order to have assurance that at least some amount would be provided at a certain time.

There is another way of looking at this which is worth introducing here, expecting to delve into the issue more thoroughly in subsequent analysis. It would appear that there is some "optimum" range within which participation by farmers in self-management activities is fruitful. At one extreme, where water is abundant (as in category I), there is little payoff to "better" water management since farmers have enough practically without management. Then entrusting responsibility to officers, and saving themselves the bother, makes sense. At the other extreme, where water is very

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[6] Robert Chambers, Water Management and Paddy Production in the Dry Zone of Sri Lanka, Colombo: Agrarian Research and Training Institute, 1975.

scarce, very strict rationing is called for, with less scope for deviations or appeals. There is little information needed in water management, such as farmers could provide, because allocations are on a fixed water per acre basis, which can be more efficiently implemented by a single person than a group. In the middle range, referred to above, information has a higher payoff in terms of production. If there is enough water to try to "optimize" production, moving it around to places where it has the most effect, not depriving anyone of his necessary minimum however, farmer participation becomes quite "cost-effective," for the individuals as well as society. This "theory" cannot be established from one set of data such as gathered in this first round of analysis of baseline survey results on the Left Bank of Gal Oya, but there is a logic which engineers and social scientists, particularly political scientists, might find worthwhile to investigate further.

Chapter VI

HYDROLOGIC CONDITIONS IN GAL OYA L.B. COMMAND AREA: PRELIMINARY FINDINGS AND IMPLICATIONS

Hammond Murray-Rust

A preliminary investigation of water measurements collected by ARTI in both Maha 1979-80 and Yala 1980 reveals that much valuable information has already been obtained, and that this aspect of the record-keeping program will be of very great value in assessing the impact of the rehabilitation process. However, it should be recognized that the volume of data already collected is very substantial and a more rigorous analysis will have to made in the future.

The tentative conclusions presented below have been grouped into two main categories: those relating to the control and distribution of water within Gal Oya Left Bank, and those relating to the significance of water measurements for other aspects of the record-keeping program and subsequent data analysis.

6.1 Control and Distribution of Water in Gal Oya Left Bank

6.1.1 Distinction Between Maha and Yala Seasons

Although much of the published literature draws a clear distinction between Maha and Yala seasons, particularly with respect to water management, the evidence derived during the 1979-80 is less definite. From mid-October until late December, the LB system appears to have been entirely rain-fed although some irrigation releases may have been made (this was the case at the start of Maha 1980-81 season too). From late December, 1979 onwards, no rainfall of significance was received, so that from 7 January 1980, the entire LB system operated exactly as if it were a Yala season. Due to staggering of cultivation, with increasingly later starting dates toward the head end of branch and main canals, the Maha season 1979-80 saw three very distinct water management zones:

(1) Tail-end units (e.g., units 7, 14, 39, D Block, J Block) were essentially rainfed. Early preparation and planting meant that the rice crop was grown using only rainfall. In some cases, irrigation water received during January, 1980 was unwelcome as it interfered with harvesting.

(2) Middle area units (e.g., units 3, 10, 8) received some irrigation water during the latter stages of crop growth and thus could be classified as intermediate in terms of dependency on irrigation issues.

(3) Head-end units (e.g., units 21, 23, 24) did much of their land preparation and some transplanting using rainfall, but relied on the irrigation issues

for the bulk of crop growth. These areas can be thought of as having two Yala seasons once land preparation for the Maha season has been completed.

So far, the analysis does not permit a clear distinction between these three zones as there are few sharp divisions in planting dates. There is also substantial within-unit variation. Nevertheless, it is apparent that during Maha 1979-80, at least 50% of the area relied to a large extent on irrigation water rather than making optimal use of rainfall. Changes in the Maha cultivation practices, particularly within the top end units could save significant amounts of water, provided that any dry periods during the rainy season were compensated for by supplementary irrigation.

6.1.2 Main Channel Operation

The evidence from the past year indicates that the LB System can be divided into three subsystems that have similar operating schedules, but separate issue timetables.

(1) Uhana-Mandur-Gonagolla subsystem covers the bulk of the LB system. The key control structures are at Himidurawa Reservoir, Uhana Regulator, Mandur/Weeragoda Regulators and Gonagolla Regulator. (Small control structures exist within Mandur Branch channel, but these appear to be only partially functional). The typical operating policy in this subsystem involves a 10-day cycle, initially controlled at Himidurawa Reservoir. For 5 days, water is issued to Uhana-Mandur, including some flows to Weerogoda Tank, followed by 4 days issue to Gonagolla Distributary. For the 10th day, Himidurawa Regulator is closed and no water is issued.

(2) Weeragoda subsystem (unit 26, J Block and issues to Chadayantalawa Tank) is controlled at Weeragoda Sluice. Although it receives most of its water from the Uhana-Mandur subsystem, the issue timetable is different and a simple 5-day-on and 5-day-off rotation is adopted once rainfall has ceased. The irrigable area is approximately 3000 ha.

(3) Navakiri subsystem, with a potential command area of 10,000ha., operates independently of the rest of the LB system. Navakiri Tank receives considerable water from its own catchment area as well as some water issues along the LB Main channel from Gonagolla Regulator. Again, a 5-day-on and 5-day-off rotation is nominally adopted for this area. The limited capacity of Navakiri Tank and of the LB Main from Gonagolla on downstream have severely constrained the area that can be supplied with reliable irrigation water. During Yala 1980, only units 34 and 36, plus small areas of units 35 and 39 received enough water for rice cultivation. Because of the administrative split of this subsystem between Ampara and Batticaloa Ranges (only units 34 and 36 are under the authority of DD/Ampara), water allocation and delivery decisions are particularly complex.

In all of these subsystems it is apparent that considerable variation exists in the length of each irrigation issue, the volume delivered, and the interval between issues.

These variations were much more marked during the latter part of the Maha 1979-80 season and that part of the Yala 1980 season immediately following the period of continuous issue for land preparation. The last six weeks of issues in the Yala season, however, were much more reliable and there was widespread agreement among farmers and Irrigation Department officials that Yala 1980 was significantly better in terms of water issues than in preceeding years. (Analysis of Irrigation Department records for previous years should confirm this).

The major points of concern regarding reliability of water supply to farmers focus on two factors. First, unreliability appears to be more a function of the interval between issues rather than the duration of each issue. If an issue is delayed, it is probable that competition for water among farmers is increased as crop stress is a real danger. It will be of considerable value to overall management if the interval between issues is kept constant, rather than keeping constant the duration of the issue. Second, there is no existing mechanism to inform farmers either of the planned issue schedule, or of any changes to the schedule. The Irrigation Department readily allows one or two day variations in their internal timetable for issues and while this may be acceptable agronomically, it inevitably increases the uncertainty element for cultivators.

6.1.3 Operation of Gates on D Channels[1]

Analysis of the water data indicates only minimal control over most D channel offtakes. In only 3 units of the 14 so far analyzed is there any evidence that the offtake has been fully closed for at least a day when water is flowing in the Main or Branch channel, and at only a few locations have the gates been operated so as to alter significantly the flow of water entering the D channel. Three causes for this lack of control can be identified: broken gates (an increasingly severe problem downstream along Branch channels); lack of effective operation of gates by patrol laborers; and operation of gates by farmers themselves using homemade wrenches. These circumstances are well-known and not confined to Gal Oya.

The implication is very severe, however, for the prospects of improving short-term control of water, particularly the ability to deliver guaranteed volumes of water to specific locations. At present, effective control of water reaching the top end of a D channel is concentrated if anywhere at the upstream regulator on the Main or Branch

[1]Throughout this section, a 3-fold definition of channels has been adopted:
--Main and branch channels (LB Main, Uhana Branch, Mandur Distributary,etc.);
--D channel: any channel branching directly from a main or branch channel;
--Field channel: any channel branching off a D channel.

channel. There is plenty of evidence to suggest that for the vast majority of both Maha 1979-80 and Yala 1980, the control of water was concentrated at Uhana Regulator, Weeragoda Sluice and Navakiri Sluice. Minor control was applied at Mandur, Weeragoda and Gonagolla Regulators. Issues of water into the LB system were concentrated at Senanayake Samudra and Himidurawa Sluices.

Under such circumstances, it is not surprising to find a gradual increase in unreliability downstream from Uhana Regulator and Weeragoda and Navakiri Sluices. With some D channels lying as much as 27 km. downstream from an effective regulator, it is impossible to expect that flow into the D channel system can be appropriately controlled. A major factor in between-unit variation of water management inputs and general agricultural behavior is distance from Uhana Regulator and, to a lesser extent, from Weeragoda and Navakiri Sluices.

6.1.4 Flow Along D Channels and in the Field Channel System

In almost every D and Field channel system, there is an absence of functional control structures. With the exception of a very few gates at the head of some field channels (most of these are strap gates with high leakage rates), all control has to be effected by using temporary dams or checks. These operations are almost invariably controlled by farmers. It appears valid to assume that currently the Irrigation Department is delivering water to the top end of a D channel; below that point, farmer control of water is the norm, <u>de facto</u> if not <u>de jure</u>.

Because of the design of the scheme, each D and Field channel system is unique. Some D channels supply water to only one or two Field channels; others supply 20 Field Channels and additional Sub-Field Channels. The ARTI sample of D channels permits a number of generalizations to be made:

6.1.4.1 Supply of water to field channels appears to be largely a function of the <u>number</u> of channel bifurcations between the field channel and the top of the D channel system. There is an increasingly poor relationship between water stage (height) in the top end of the D channel and stage (height) in both the lower end of the D channel and in the head of selected field channels as the number of intervening bifurcations increases. Distance from the head of the D channel and the number of intermediate farm pipes, while having some relationship with stage readings, are apparently less significant. It still remains to be seen if a general relationship is applicable throughout the LB area. If it is, then the amount of water entering each D channel and field channel system may be approximated from existing information and give a general indication of the relative water supply to individual field channels. This would be important in predicting the potential for success in farmer organizing activities.

6.1.4.2 With few exceptions, most field channels receive water whenever there is more than a threshold level of water in the D channel. This indicates that there is little internal rotation between field channels on the same D channel system. Consequently, since some diversion of water occurs at bifurcations, the availability of water in field channels is almost entirely a function of main and branch channel operation. If Uhana Regulator is open, for example, then virtually every field channel commanded by Uhana Regulator receives water, the amount determined by hydrological location rather than by overt management of water.

6.1.4.3 Once water enters a field channel, the distribution of water appears to be largely a function of either distance or the number of pipe outlets below the field channel turnout. (These two variables are effectively the same at field channel level, but begin to vary a little in the context of an entire D channel system, as some D channels have many pipe outlets, others virtually none). If stage is known at the head of a field channel, it can be fairly confidently predicted at various downstream locations, particularly at higher flow levels. At low flow levels, the opportunity for upper end farmers to take a significant proportion of the flow increases.

6.1.4.4 Within-season variations in water deliveries do exist within most units. It is not yet clear, pending more detailed analysis, to what extent this is significant, but there are indications that as season progresses, upper end farmers do deliberately use less water and that reliability increases downstream. Further analysis of existing data should indicate if this is widespread, or only restricted to D channel systems that have barely adequate water supplies. Conversion of stage readings to volumetric data will help to answer this question as well as define adequacy in different parts of the scheme.

6.1.5 Advance and recession times

Whenever an irrigation issue is made into a dry channel system, there is a certain delay in obtaining water at any particular point, because of water absorption as the head of water moves down the dry channel bed. In the LB system, it appears that almost every channel in the command area will receive water within 24 hours of opening Himidurawa Sluice. The only exception to this appears to be during the initial issue of water in a season when channels are excessively dry. Under these circumstances, advance times up to 48 hours in distant channels may be experienced. Because stage readings have been taken at 24-hour intervals, it is not possible at present to derive more accurate assessment of advance times, but further measurements toward this end will be taken. Subjective assessments indicate relatively uniform advance times, allowing a fairly predictable time delay in water delivery to any given point in the scheme. This will be advantageous to farmers, for if gates are operated at set times, each turnout group should know when water will arrive.

After a regulator is closed, water levels recede fairly rapidly in the LB system. Because of this, it should be possible to control within reasonable limits the volume of water delivered to each D channel system. Further data collection in this area is envisaged for 1981, with a view to deriving more optimal irrigation schedule. There is some evidence to suggest that the 5-day-on and 5-day-off rotation has been followed for many seasons without significant alteration or testing. Better understanding of both farm-level requirements and hydraulic conditions should be valuable in developing more appropriate issue schedules.

6.2 Significance of Water Measurement Data for Farmer Organizations

The tentative conclusions discussed above have a number of implications for the farmer organization program as well as for further data collection activities by ARTI. While more rigorous analysis of water-based data, including work on water status in sampled liyaddes remains to be done, three main aspects can be discussed.

6.2.1 Operation of Main and Branch Channels

There is no doubt that little effective control of water occurs in main and branch channels below the major regulators. At present, the Irrigation Department has little ability to keep water levels in these channels at design levels so that flow into D channels is frequently quite varied. From the viewpoint of providing an adequate and timely delivery of water to D channels, the lack of effective main or branch channel control means that timeliness and adequacy must be provided at major regulators and sluices until repair of existing, or provision of additional, regulators is carried out. This may not be feasible before water user organizations are established.

The experience of last Yala season shows that timeliness can be achieved under present conditions of both irrigation facilities and staffing, and it would seem far more fruitful to concentrate on timeliness in the first instance. Once a regular supply has been provided to farmers, then a second phase, that of adjusting volumetric issues to farmer groups, can be contemplated. However, provision of infrastructure and trained manpower will inevitably lag behind establishment of farmer groups. Regularity of delivery is the only method by which the Irrigation Department can demonstrate their ability and willingness to provide improved water service to farmers given present conditions.

It should also be added that strict adherence to a pre-set timetable is not the only definition of regularity. Changes in such timetables are frequently necessary in order to accommodate short term fluctuations in water supply and demand. If adequate notice of changes is given to farmers so that they are aware of when water will be delivered, a major advance in Irrigation Department-farmer relationships will have been made.

The flow of water down main and branch channels is predictable given any initial flow condition at the head end of a channel. If a particular area is deficient in water, it should be relatively simple for the Irrigation Department to adjust deliveries to ensure that a sufficient head of water reaches the top end of the appropriate D channel.

The indicated lack of control at most D channel gates means that the relative water supply into each D channel area is largely a function of the depth of water in the main or branch channel at the offtake and the size of the offtake orifice. The original design of the scheme provided different sized orifices for different D channel command areas, but only in discrete sizes (e.g. 6", 9", 12", 18", 24" diameter pipes). This means that certain D channels will inevitably get more water per unit area commanded than others for any given water level in the channel. A second factor here is the relative height of the offtake below channel water level, lower offtakes receiving more water than ones at higher relative locations. These variations become more significant as channel water levels decrease; consequently, more distant D channels are likely to suffer greater fluctuations in water supply than upper end D channels.

The importance of the above discussion is that even relatively small changes in elevation or size of offtakes may significantly affect water availability to D channel systems. To talk too glibly of head, middle and tail units can be dangerous, as a top end unit with poorly designed or constructed offtakes will have less water than a lower end unit with an overdesigned orifice at a low relative elevation. The water data do indicate a gradual decline in water availability and reliability down main and branch channels, but until each offtake is properly calibrated, it cannot be said definitely that hydrological location is synonymous with geographical location. This aspect needs more work in order to determine relative hydrologic position.

6.2.2 D Channel Flow Problems

The least clear-cut relationships of channel flow data are those related to stage along D channels and into the head of field channels. This is the most marked when referring to D channels with large numbers of subsidary field and sub-field channels where there is ample opportunity to divert flow into field channels.

Two important issues emerge from this:

(1) A continuing water measurement program should concentrate much more on how water is controlled along D channels: where flow is controlled, by whom and with what authority.

(2) If farmer organizations are established only at field channel level, then water distribution between field channels is presumably the responsibility of the Irrigation Department. However, if any form of federation of field channel groups is anticipated, the federation must take D channel water control as one of its major functions.

Because D channel water control appears to be by far the most complicated aspect of water control in the entire LB system, the importance of knowing more about present practices there cannot be overstressed. Those who assume control of flows along D channels must understand how water is controlled at the present time. Failure to do so is likely to lead to antagonism toward farmers by these outside agencies.

A further corollary of this argument is that head, middle and tail field channels are not easily defined. Again, geographical and hydrological definitions may be used, but they are likely to be incompatible. Further analysis should reveal a better understanding of the locational parameters that can help to define the relative advantages or disadvantages of different field channels.

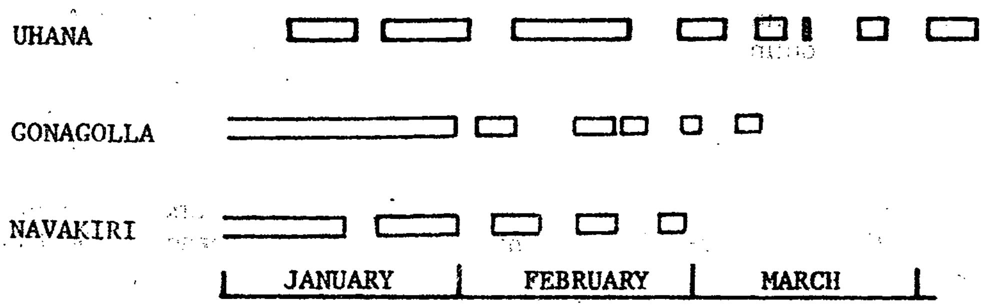
6.2.3 Field Channel Flow Measurements

Because field channels will form the initial basis of farmer water user organizations, it is important to know the amount of water received at the top end of the channel. The data indicate that once water flows down a field channel, decrease in flow is approximately proportional to distance. It also seems that identification of head, middle and tail blocks along field channels is extremely difficult if based on the rice yields obtained; water is only one parameter in a complex of parameters that affect rice yields.

If the amount of water delivered to the head end of a field channel is both adequate and timely, then the water user group should be able to manage the water itself, albeit with some initial advice and guidance. It does not seem particularly important to measure water variability in field channels if this detracts from the apparently far more important study of D channel flows that ultimately determine how much each field channel receives.

Figure 6-1:

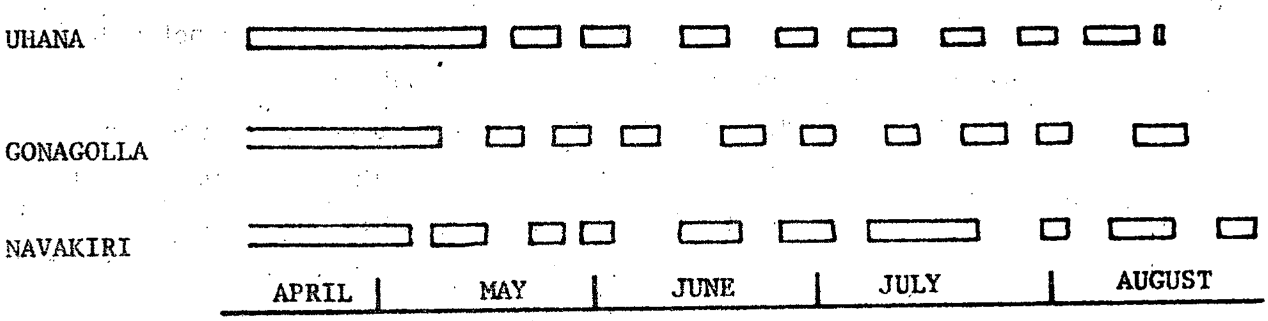
Water Issues Along Uhana Branch, Gonagolla Distributary and Left Bank Main Channel Below Navakiri Tank, Maha 1979-80



The rectangles represent periods of water issue along each of the three channels. It can be seen that there is little consistency in either the lengths of issue periods or the intervening non-issue periods.

Figure 6-2:

Water Issues Along Uhana Branch, Gonagolla Distributary and Left Bank Main Channel Below Navakiri Tank, Hala 1980



Compared to the preceding Maha season (Figure 6-1) there is much greater uniformity in both issue and non-issue periods along both Uhana and Gonagolla channels. Following the initial issue for land preparation issues were rotated between these two channels at Uhana Bifurcation.

There is less consistency in the issues along the Left Bank Main below Navakiri Tank, indicating that it is operated independently and with less rigid scheduling than the rest of the Left Bank scheme.

Figure 6-3:

Variance of Average Yield Per Unit Along Uhana-Mandur Branch Channels as a Function of Distance from Uhana Regulator, Maha Season 1979-80

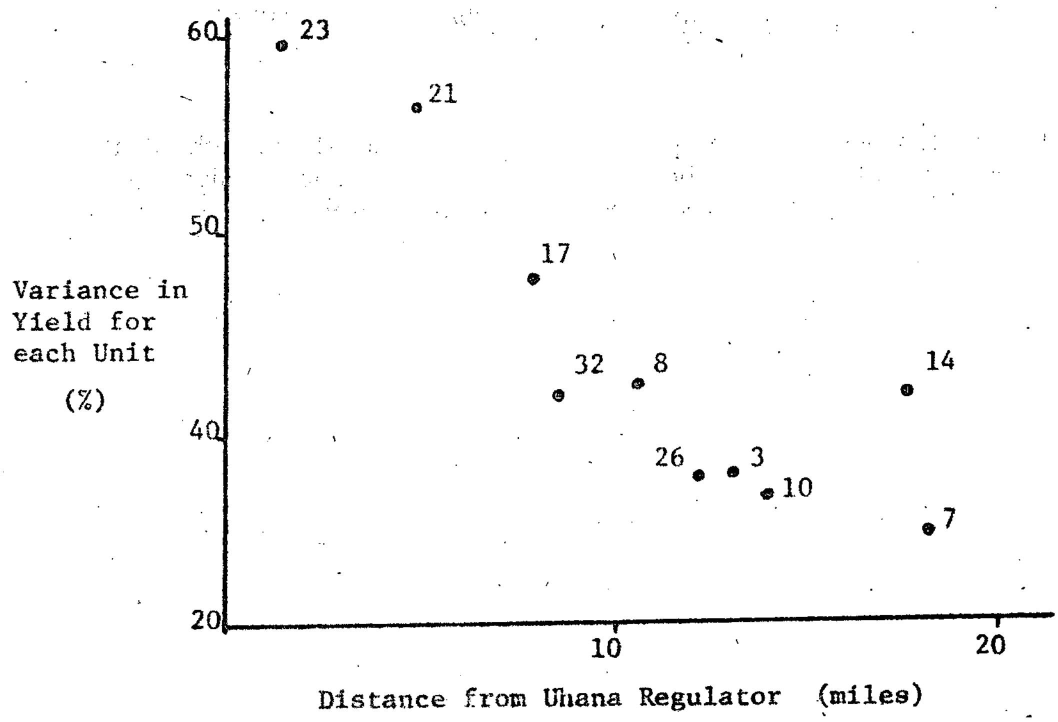


Figure 6-4:

Relationship Between Yield and the Number of Channel Bifurcations Between the Top End of the Distributary Channel and the Farm

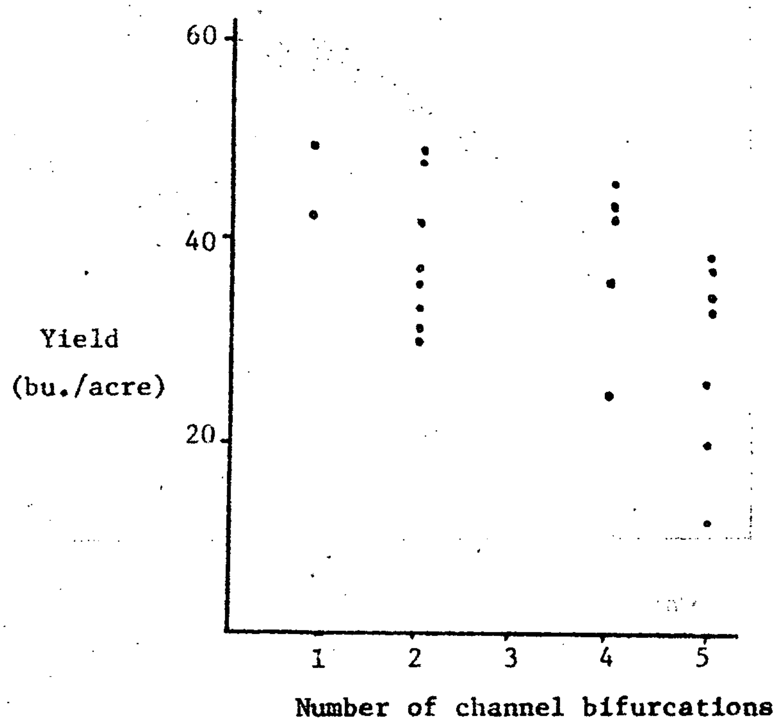
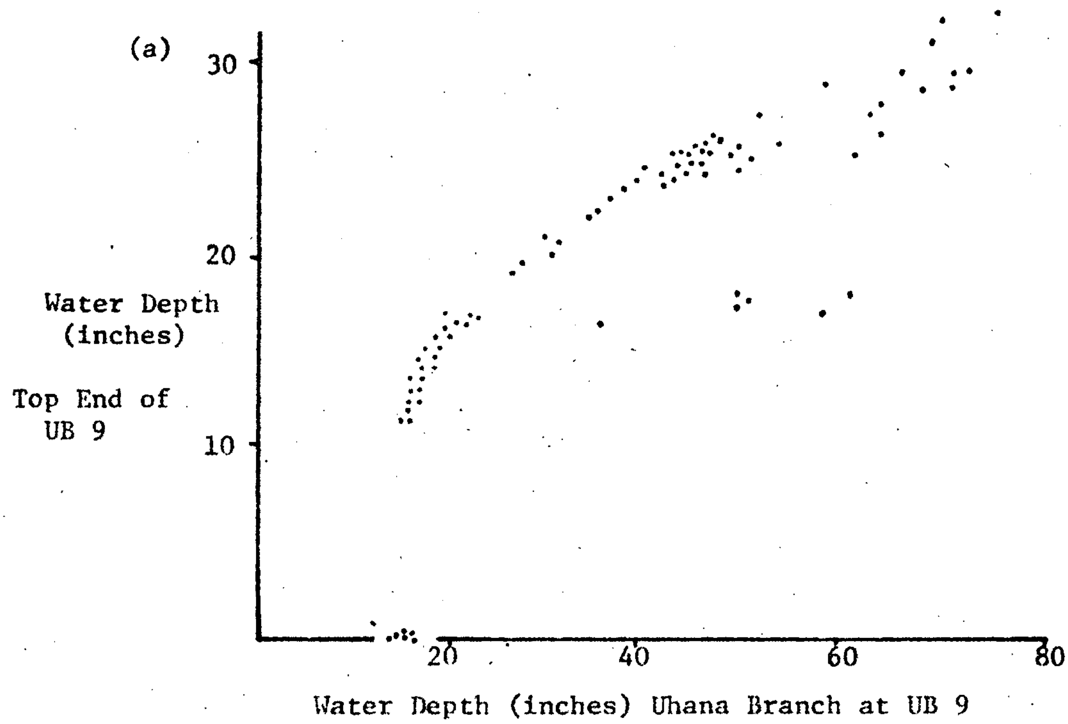
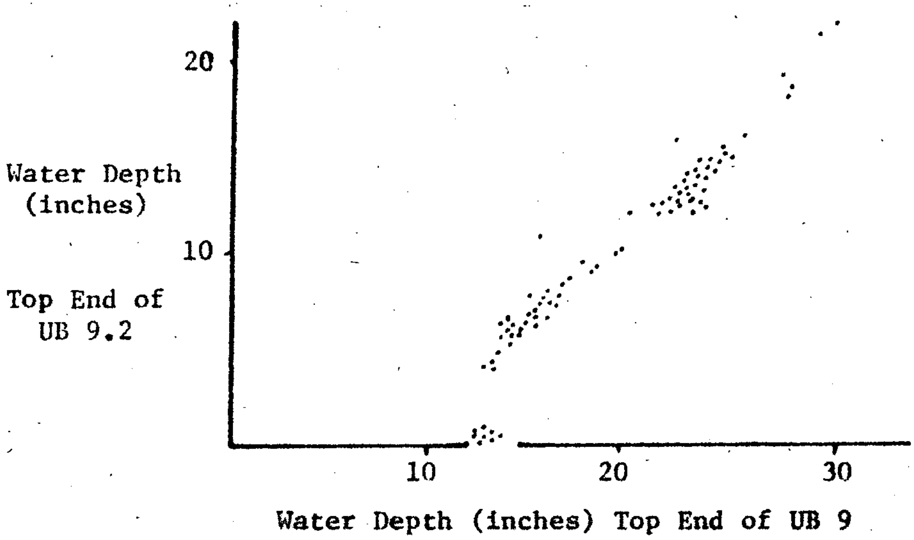


Figure 6-5:

Relationships Between Water Depths in Main, Distributary and Field Channels, Units 21 and 10, Maha Season, 1979-80

(For explanation, see next page)

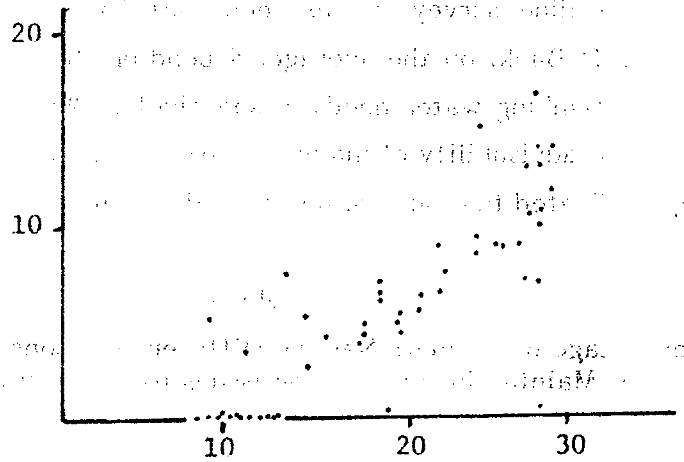




(c)

Water Depth (inches)

End of M 16.5 Field Channel

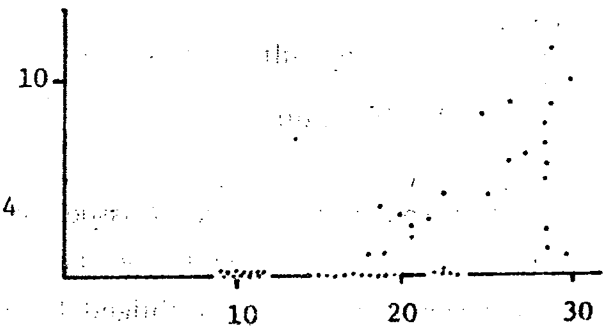


Water Depth (inches) Top of M 16

(d)

Water Depth (inches)

End of M 16.4.4 Filed Channel



Water Depth (inches) Top of M 16

Figures 6-5 (b) - (d) indicate the progressive lack of relationship between water levels in different field channels as the number of channel bifurcations increases. Between UB 9 and OB 9.1 there is only one bifurcation; between M 16 and M 16.5 there are five bifurcations; between M 16 and M 16.4.4 there are eight bifurcations. Guaranteed deliveries of water to the head end of field channels is going to be more difficult in more complex field channel systems, even if all control structures are replaced.

Figure 6-5 (a) indicates that there is a general lack of control at UB 9 turnout, a situation typical of all units monitored. There are only six days identifiable where the gate was operated in order to reduce the water level in UB 9 channel.

Chapter VII

DILEMMA OF DOMESTIC WATER ISSUES: IMPLICATIONS FOR SYSTEM REDESIGN

Lakshman Wickramasinghe

From the baseline survey it was seen that 13 and 53 percent of the sample farmers on the Left Bank, on the average, depend on the irrigation channel system for their bathing and drinking water needs, respectively. When farmers were asked what they thought of the advisability of making off-season issues along channels for domestic use, 83 percent indicated that such issues were desirable for the following reasons:

Table 7-1:

Percentage of Farmers Naming Different Reasons for Desirability of Maintaining Off-Season Issues for Domestic Purposes

Reason	Percent
Domestic purposes	57
To support livestock	27
For highland and home garden cultivation	19
Only source of water	18
To maintain water table (for well recharge)	13

It is evident that off-season irrigation water issues are used for extra-domestic purposes, though not in the extent that might have been supposed. This creates a dilemma for the Irrigation Department. It is obliged to supply irrigation water for domestic use, but cannot control any misuse. This confirms the urgency of planning for the rehabilitation of the irrigation system in a way that provides for the supply of domestic water since the two aspects are closely linked.

An analysis of units, following the Water Problem Index categories explained in Chapter 5, looking at the sources of domestic water and their adequacy helps us understand the dependency better and the seriousness of the problems of domestic water (see Table 7-2). Every unit except unit 14 is dependent on the irrigation system for domestic water in varying degress. Units 24 and 32 depend exclusively on channels for bathing, while units D, 2, 26 and 23 depend considerably on the irrigation system for their drinking water needs.

Ironically some units, such as 35 and E, which face severe and extremely severe irrigation water problems, have minimal problems of domestic water. Even unit J has

Table 7-2: Sources of Water for Drinking (D) and Bathing (B) and Percentage of Farmers Reporting Inadequacy of Domestic Water, in Units Ranked by WPI

WPI Category	Unit No.	Own Well (D)	Own Well (B)	Neighbor's Well (D)	Neighbor's Well (B)	Public Well (D)	Public Well (B)	Tank (D)	Tank (B)	Channel (D)	Channel (B)	Stream (D)	Stream (B)	% of Farmers Reporting Inadequacy
I	23	47	5	34	0	0	0	0	13	29	87	0	7	43
	17	61	21	34	10	3	3	0	0	7	86	0	0	24
	3	40	17	60	6	0	11	0	8	0	77	0	3	37
Average		49	14	43	5	1	5	0	6	12	83	0	3	35
II	21	44	28	23	3	3	3	0	5	18	69	0	0	28
	24	37	5	58	10	0	0	0	0	5	100	0	31	21
	32	92	4	8	0	0	0	0	0	0	100	0	0	0
	2	33	0	23	1	13	0	0	0	37	93	0	7	43
	30	33	14	61	6	0	2	0	22	4	75	0	2	53
	26	45	0	50	0	0	0	0	100	32	82	0	0	73
	10	70	45	25	5	0	0	5	25	5	35	0	5	85
Average		50	14	35	3	2	1	1	22	14	79	0	6	43
III	8	33	40	67	13	0	3	0	23	0	70	0	13	63
	3	71	43	24	0	5	0	0	0	0	28	0	24	48
	14	68	63	21	10	5	5	0	5	0	0	0	5	68
	39	10	10	55	50	15	15	0	0	15	25	15	10	85
	7	41	18	41	0	0	0	9	23	4	9	0	45	82
	35	0	0	9	9	90	79	0	4	0	14	0	0	0
Average		37	29	40	14	19	17	1	9	3	24	2	16	58
IV	D	28	28	5	0	0	0	0	0	67	0	0	0	78
	E	16	16	74	53	0	16	10	16	5	5	5	0	10
Average		22	22	39	26	0	8	5	8	36	2	2	0	44

comparatively less complaints about adequacy of domestic water. This shows itself in the lack of correlation between reported irrigation WPI and reported inadequacy of domestic water sources. The correlation between them is only .29. Another significant fact is that units with severe or extremely severe irrigation water problems seem to have comparatively more wells, indicating the possibility of higher underground water tables in these units. Units 8, J, 14, 35 and E seem to have a comparatively higher number of wells with satisfactory supply.

It should be emphatically stated that our report provides no conclusive findings on domestic water usage on the Left Bank, as ARTI has no technical expertise in this regard. The objective of the exercise was to identify patterns of domestic water use and of attendant problems. But this much can be stated with certainty. Irrigation in Left Bank Gal Oya cannot be isolated from domestic water, and hence an integrated approach to water resources planning is a requirement for successful implementation of the water management project.

Chapter VIII

SUMMARY AND CONCLUSION: THE ELEMENTS OF IMPROVED WATER MANAGEMENT ON LEFT BANK, GAL OYA

Lakshman Wickramasinghe

The foregoing analysis has enabled us to obtain a reasonably detailed and coherent picture of the state of the irrigation system on the Left Bank of Gal Oya. In this analysis, the system was studied mainly from two perspectives: (i) its operation and management; (ii) farmer behaviour. In the first part of this chapter, the major findings will be presented in summary form. The second part will deal with the implications of these findings and suggested solutions, where possible to extrapolate from our studies.

8.1 Managerial and Operational Problems

Inequitable distribution of water is prevalent throughout the Left Bank system of Gal Oya. In addition to the obvious disparity of water availability between the head areas and the tail areas of the system, inequitable distribution occurs also within the head and middle areas of the system. Inequitable distribution leads to serious shortages of water in the tail-end areas, and to less acute periodic shortages of water in some tail-end-like pockets of the middle areas.

The biggest problem for the head and middle units is the unreliability of water supplies. Since the timing of water issues and the quantity of water supplied vary and are unpredictable, farmers in the head and middle units feel that they too experience shortages of water.

Poor maintenance of channels, at the primary, secondary, and tertiary levels and damaged structures place strains on the already erratic supply situation.

The system managers and the users are placed in an adversary relationship to each other. There is little faith and mutual trust between them. Farmers believe that the officers have no wish to serve the farmers and that they do not understand farmer problems. However, farmers who have less problems of water tend to view officers in a more favourable light.

8.2 Farmer Adaptations

Farmers on the Left Bank of Gal Oya view the system in a reasonably objective manner. they do not apportion blame only to officers for the present state of the system. They accept that they are blame worthy also.

Farmers too possess laudable attitudes toward the system and toward water. They accept that water has to be conserved, that farmers should learn better techniques of conserving water. They too agree that destroying structures is an anti-social act and that farmers who steal water should be punished. But these are mostly confined to intentions of the mind. The pattern of behaviour is quite contradictary to their attitudes. They succumb to temptation to disrupt the system for individual gain not through a pathological tendency toward vandalism or anarchy. Their behaviour is a rational adaptation to conditions they cannot themselves change. Their behaviour mostly is an adaptation to the above-described present level and form of management and operation of the system. Farmers strongly feel that access to water is an unalienable right of colonist farmers. And through years of experience, farmers have come to realize that the operation and management of the irrigation system does not usually cater to the needs of colonist cultivators. Under these circumstances, farmers perceive negative behaviour to be a viable and sometimes necessary course of action to obtain their right to an assured supply of water.

8.3 Consequences

The current less efficient levels of management and operation of the system and the largely resultant negative farmer behaviour have spawned a series of self-perpetuating, adverse consequences such as inefficient use of water, low productivity, disguised leasing of colony allotments, social conflicts and tension and finally, a general lowering of the quality of life of the colonist farmers and families on the Left Bank of Gal Oya. This sad state of affairs underscores the need for an overall improvement of water management practices on the Left Bank of the Gal Oya Scheme.

8.4 Implication for System Rehabilitation, Farmer Organization, and Operation and Management of the Irrigation Scheme

Debates about the necessity for reforms in different functional areas of water management in Gal Oya seem to be irrelevant. The data presented in this report, both objective measures of flow, availability and reliability of irrigation issues, and farmers perception of water problems and their attitudes to operation and management of the system strongly showed that reforms are necessary in all three key areas of water management, i.e., farmer participation and organization, operation and management of the irrigation scheme, and the physical conveyance system. There is at least currently no debate about the need for rehabilitation of the conveyance system.

8.4.1 The Need for Reforms in Organizational Structure, Style of Management, and Operational Policy and Procedures of the Department of Irrigation

(a) Problems of unreliable supplies and poor canal control
A major problem faced by farmers in the head and middle units is the unreliability of water issues. This factor compels farmers to store excessive amounts of water in the field as a form of "insurance" against erratic supplies, thus depriving farmers further down the system of water. Poor canal management is both a cause and effect of unreliable and unpredictable supplies. This results in a vicious cycle of unreliability, poor canal management, over-utilization of water at the head and deprivation at the tail.

(b) Lack of communication between ID staff and colonist farmers
Communication between farmers and ID staff seems to be very low. The better-known field officer is the Jala Palaka. Data on contact between farmers and Jala Palaka would seem to indicate that JPs are neither more or less active in different parts of the system, but rather are ignored by the vast majority of farmers. On the contrary, farmers seem to have more frequent contact with the Cultivation Officers.

(c) Negative attitudes of farmers toward government officers including ID staff
Rightly or wrongly, most of the farmers on the Left Bank display a general lack of confidence in government officers of the area. Farmers feel that officers in the first instance do not appreciate and even attempt to understand the gravity of the problems faced by farmers. Second, that officers do not do everything within their power to bring relief to the farmers; rather they tend to take the least path of resistance. It is desirable to study the reasons for these perceptions rather than to dismiss them as biased statements of an adversary. An important finding of this survey is that farmers generally view the problems of the system fairly objectively. They not only saw the shortcomings of officers, but identified their own weaknesses too.

8.4.2 Suggested Solutions

The most conventional and the most convenient solution is to attempt to motivate and educate farmers on the need to conserve water. We feel that this would be only treating a symptom and not the cause. If as we have shown in the study, farmer behaviour is largely an adaptation to existing level, style and form of management of the system, then change has to occur in management first and not vice versa. The risk of change is far greater for the farmers, whose survival depends on a number of unmanipulable factors, than for the officers.

No doubt there are many constraints and difficulties facing the officers too. But it is imperative that notwithstanding these constraints, attempts should be made:

(a) To improve the operational efficiency of the system. Professor Randy Barker has observed that it is possible even with the existing control capacity to improve the operating efficiency of the system very substantially by changing the present operational policy, procedures, reinforced with imaginative decision-making.[1]

For example, without exhorting the farmers to use Maha rains for land preparation, if a policy decision is taken either to supplement Maha rains with an irrigation issue or to guarantee farmers an irrigation issue, in case the Maha rains peter out, would create positive conditions for farmers to change (p.19).

(b) To treat operation and management of the system as equally important as construction, and not just an adjunct of construction.

(c) To improve the efficiency of communication, among different strata of the Irrigation Department, on the one hand, and between Irrigation Department and farmers, on the other.

(d) To change the present adversary orientation which is characteristic of the ID staff-farmer relationship to one of a cooperating stance of partners in a common venture. A basic pre-condition for this is a change of attitude on the part of all officers of the ID toward farmers, and acceptance of the basic premise that irrigation schemes are to be designed, constructed and operated primarily for the benefit of farmers.

8.5 A Strategy for Improving Water Management in Gal Oya

8.5.1 The Need for Developing Farmer Organizations

Changes in the ID management would not solve all the problems that have been identified in the LB system of Gal Oya. There is a need for corresponding changes among the water-users too. Now this change, as some contemplate, could not be effectively brought about by legal statutes or through moralizing educational campaigns. We have seen that some of the negative irrigation practices of farmers, such as bad channel maintenance, water stealing and irregular manipulation of structures, are in effect sustained by a process of social legitimization through the action of informal peer-groups. Although these practices are considered illegal by the authorities, in the eyes of the farmers they have become socially acceptable and therefore 'legitimate' acts. Under these circumstances the only way to change these practices outside of a rigorous and intensive policing programme (provided of course that the officers do not succumb to the temptations offered by social pressure groups or individuals) is to use the same social process to withdraw social legitimacy for these acts and to impose social sanctions upon those who transgress the newly-accepted code of conduct for water use. This could be done only through group responsibility, social education and group consensus. This clearly indicates the need for a socially acceptable program of non-formal as well as formal institutional development at the farmer level.

However institutional reform at the grass-root level in the absence of reform at Irrigation Department and system management level or vice versa will not solve the problem. For effective long-term results, a sustained program of reforms at both levels should be pursued simultaneously, coupled with the physical rehabilitation of the conveyance network.

8.5.2 Felt Needs and Suitable Pilot Areas for a Farmer-Organization Programme

The data on water problems as perceived by the farmers clearly indicate that the best area for initial farmer organization experiments are some head units and the middle units. In these areas, the biggest problem experienced by farmers is unreliability of water supply. If the objective is to build farmer groups on identified felt needs, then reliability of supplies is one of the most important pre-requisites for success. The strong emphasis given to reliable supplies of water in the ARTI work plan for small group irrigation development program assumes much greater significance now, in the light of survey findings.

8.5.3 The Importance of a Learning Process Approach to Formation of Irrigation Groups

Lack of uniformity of views among the Left Bank farmers on preferred institutional mechanisms and the significance of farmer participation for water management clearly demonstrate the inappropriateness of employing a centrally conceived plan of action for farmer organization. The presence of different ethnic groups on the Left Bank and the resultant variability of socio-cultural factors aggravate the problem created by hydrological variety. In such a variable situation, the best approach is a community-based learning process approach. It is only through such an approach that the locality-specific needs and solutions for problems of the different units could be incorporated into a plan of work. Thus Gal Oya clearly calls for locality-specific bottom-up approach for farmer organization.

8.5.4 Small Groups Approach vs. a Federated Approach

The pattern of leadership in the head and middle areas of the system with a few exceptions is very diffused. Most of the units in attempting to nominate prospective candidate for leadership in Water Councils (within a unit) threw up a substantial number of leaders with small follower-groups. The data amply indicate there could be on-going leadership struggle within these units. In such a situation, the most prudent approach is to start at the bottom, i.e. at field channel level with small-groups. Attempts to promote larger farmer organizations at distributory channel level to begin with could generate struggles for leadership, leading to factionalism and non-cooperation of various sections of farmers.

8.5.5 Concept of Hierarchy of Needs and Its Implication for Farmer Organizations

The concept of a hierarchy of needs (or pyramid of needs) presupposes that within any given time horizon, a person has a set of most immediate needs, the satisfaction of which leads to the appearance of another set of needs.

8.5.5.1 Applying this concept in a simplistic manner, we can say that the primary agricultural needs of a colonist are land and water. There are also a host of other complementary needs that compete for satisfaction. In the head and middle units (assuming that pilot areas for farmer organization will be selected from this sub-system), farmers' primary need seems to be reliability of water supplies. They have also identified a set of complementary needs, among which input supply and credit figure very prominently.

Although initially the focus of a group could be centered on water, as its supply gets more reliable, members would give more attention to input and credit needs. While accepting the fact that too many functions might affect the efficiency of water groups, some mechanism would have to be evolved to satisfy this second set of needs. There are two possible options: (1) let the farmer groups themselves work out suitable mechanisms, or (2) attempt to coordinate with the elected Farmer-Representative and the Cultivation Officer of the area. Depending on the specific situation in a particular unit, a suitable approach will have to be evolved.

8.5.5.2 Domestic water is a primary need in all colony units except in units 32, 35, and E. Since irrigation and domestic water supplies are closely linked, an integrated approach to water resource development is an essential requirement for an effective program of water management in Gal Oya. For a more accurate assessment of need for domestic water improvement and for alternative plans of study, a more comprehensive study with a strong technical component is recommended.

LIST OF WATER FLOW CHARTS

Unit No.	Measuring Point	Page No.	Chart No.
Unit No.10	Main Channel Point 01 'D' Channel Point 01 'D' Channel Point 02 'D' Channel Point 03 'D' Channel Point 04	XII	01 02 03 04 05
	'F' Channel 01 Point 01 'F' Channel 01 Point 02 'F' Channel 01 Point 03 'F' Channel 02 Point 01 'F' Channel 02 Point 02 'F' Channel 02 Point 03	XIII	01 02 03 04 05 06
Unit No.07	Main Channel Point 01 Main Channel Point 02 'D' Channel Point 01 'D' Channel Point 02 'F' Channel 01 Point 01	XIV	01 02 03 04 05
Unit No.14	Main Channel Point 01 Main Channel Point 02 'D' Channel Point 01 'D' Channel Point 02	XV	01 02 03 04
	'F' Channel 01 Point 01 'F' Channel 01 Point 02 'F' Channel 02 Point 01 'F' Channel 02 Point 02 'F' Channel 03 Point 01 'F' Channel 03 Point 02	XVI	01 02 03 04 05 06
Block 'E'	Main Channel Point 01 Main Channel Point 02 'D' Channel Point 01 'D' Channel Point 02	XVII	01 02 03 04
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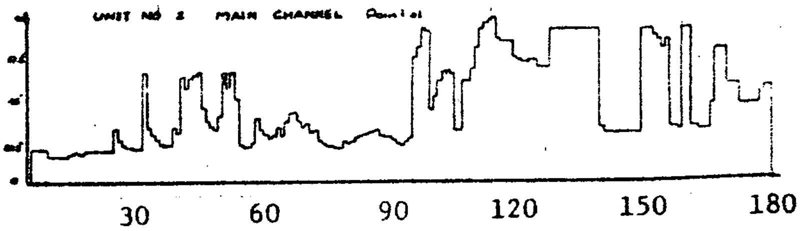
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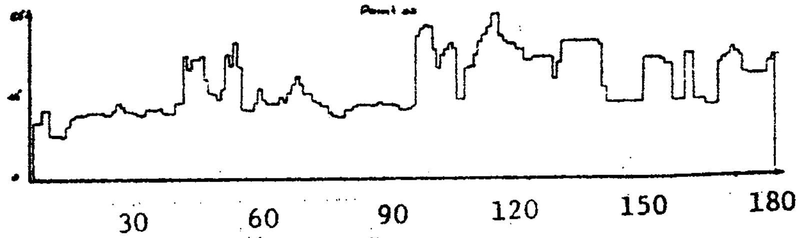
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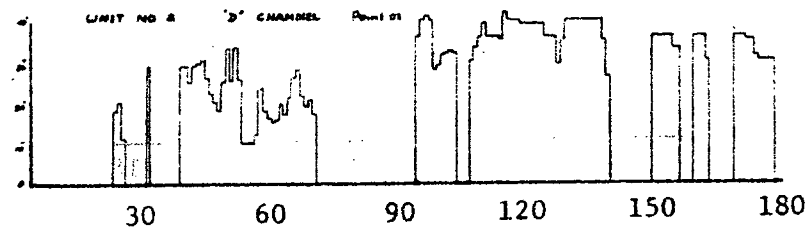
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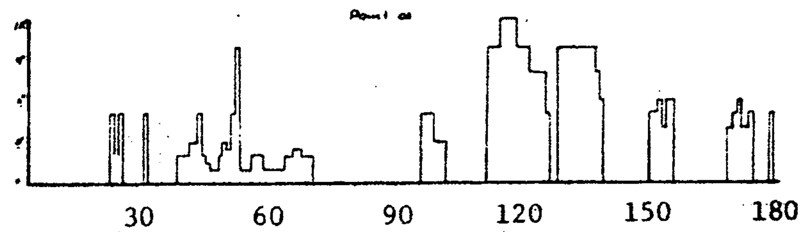
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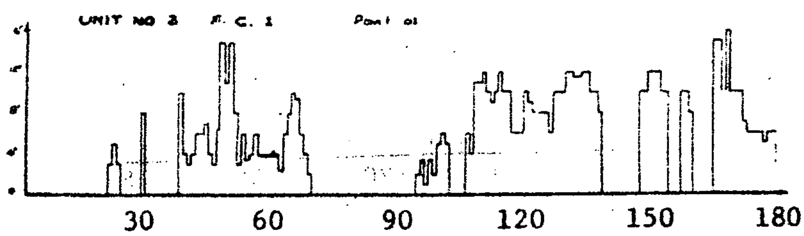
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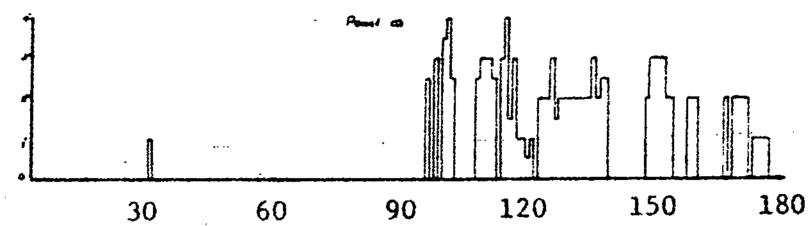
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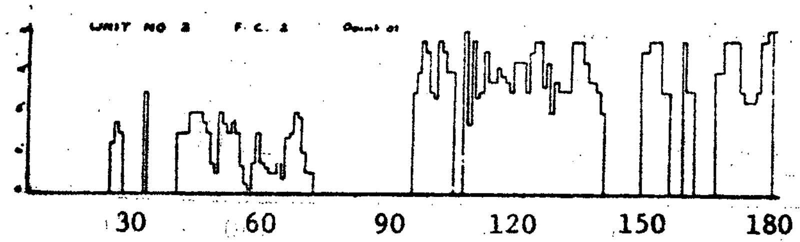
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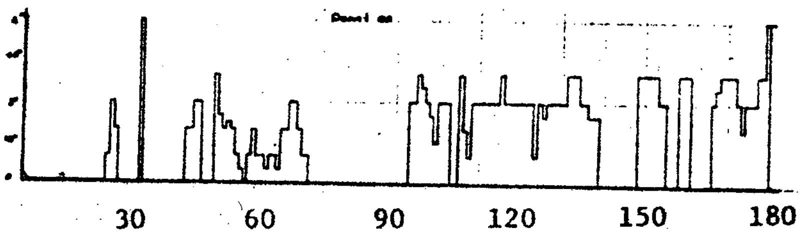
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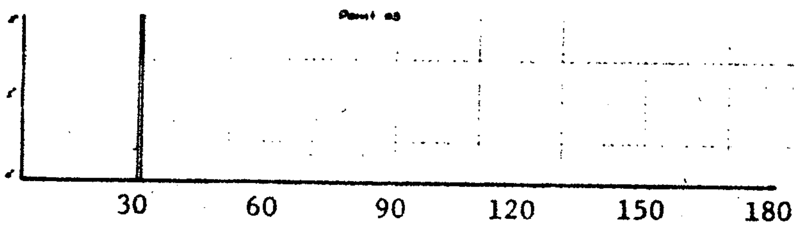
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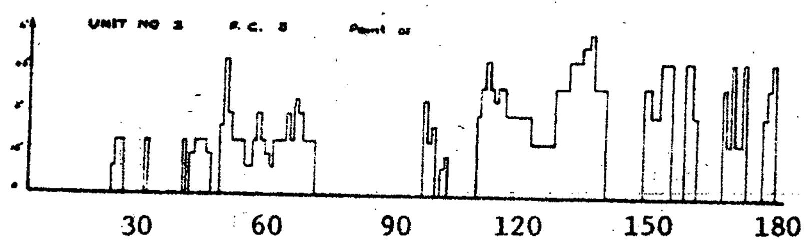
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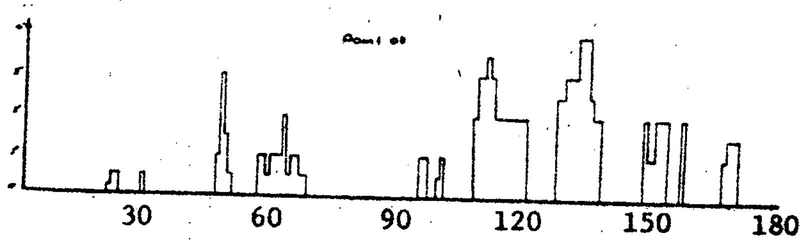
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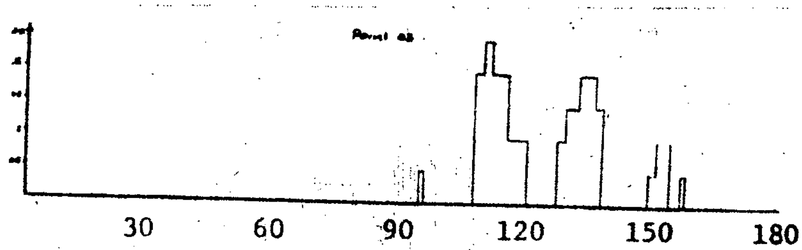
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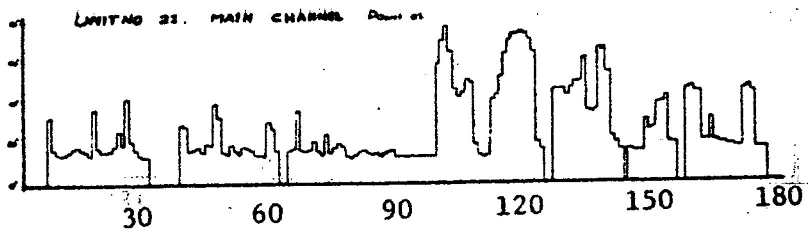
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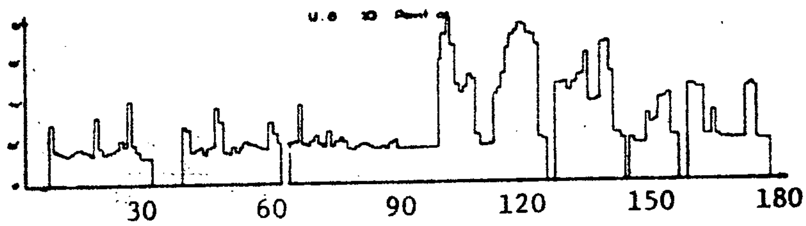
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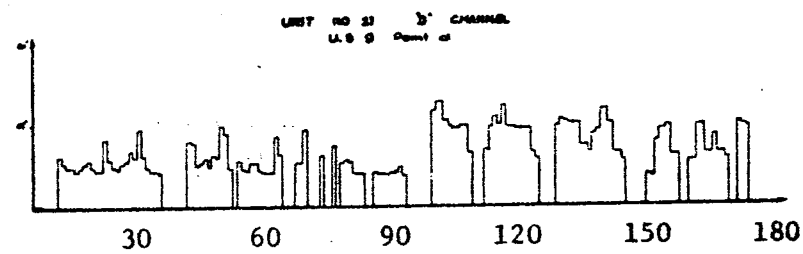
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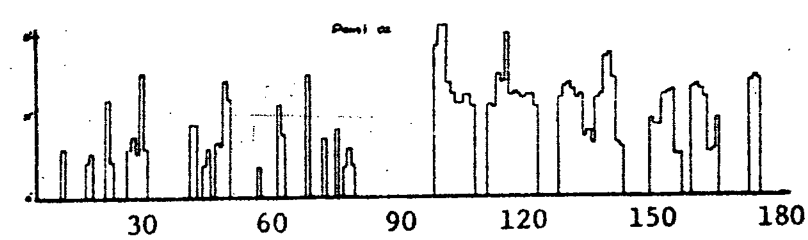
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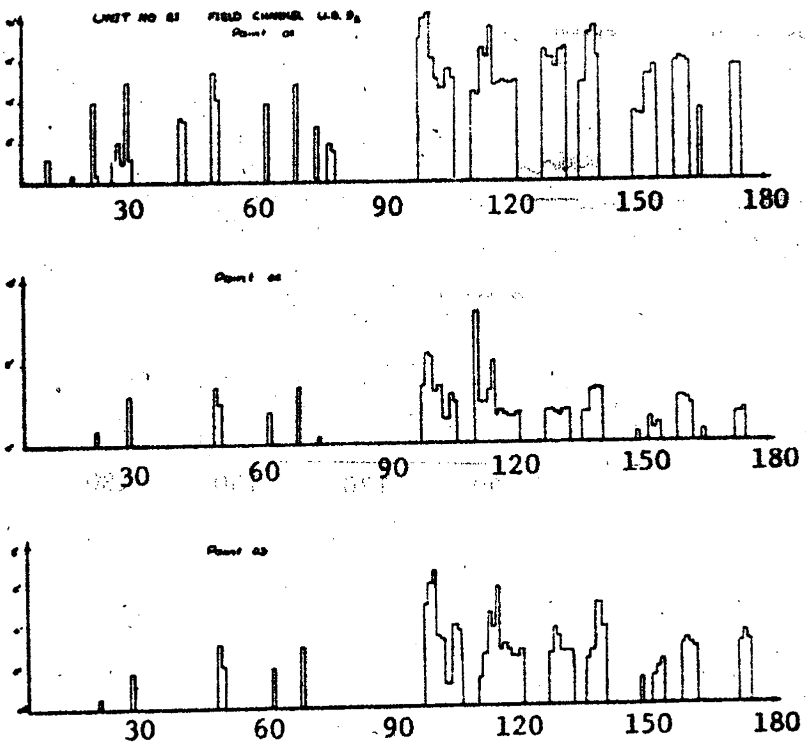
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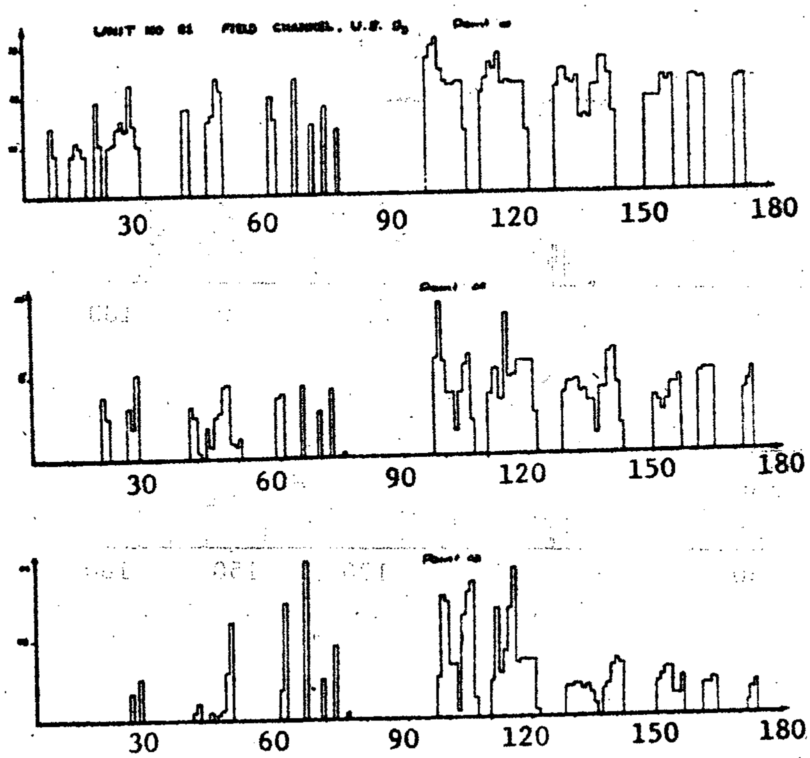
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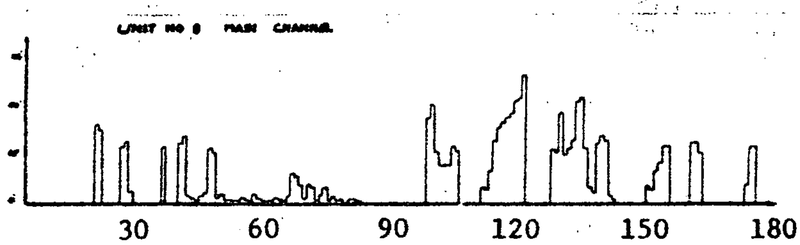
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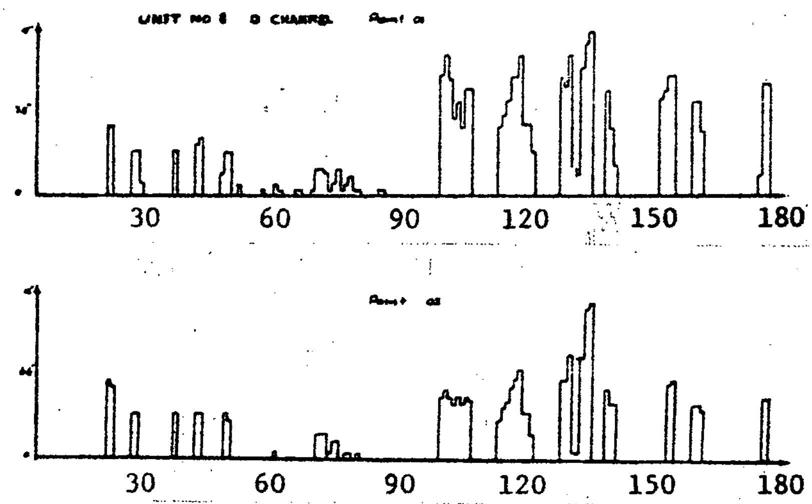
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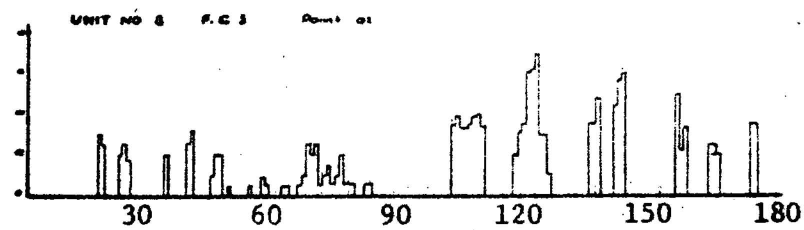
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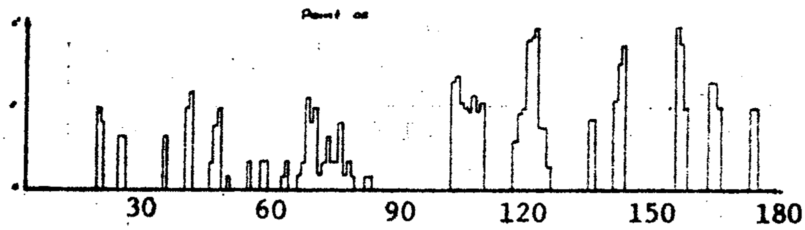
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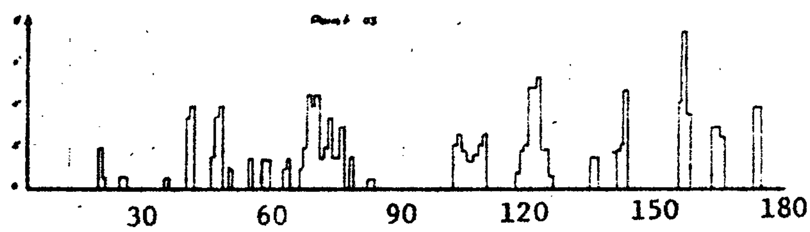
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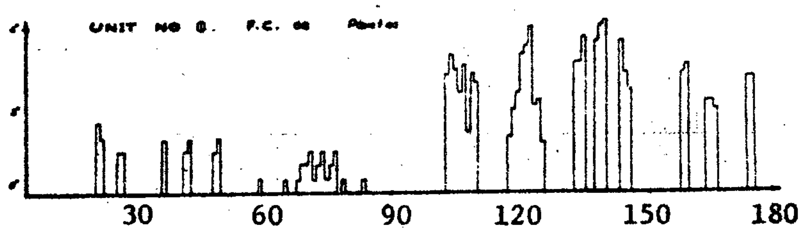
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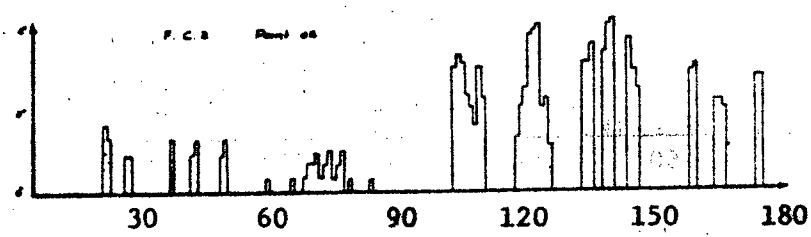
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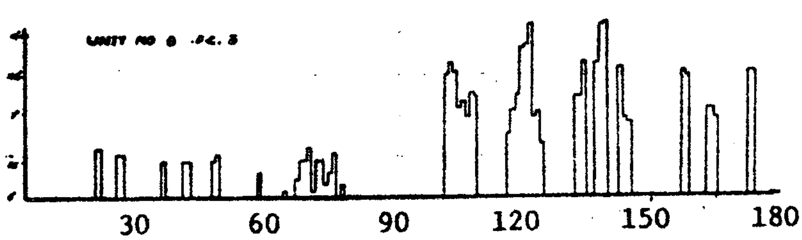
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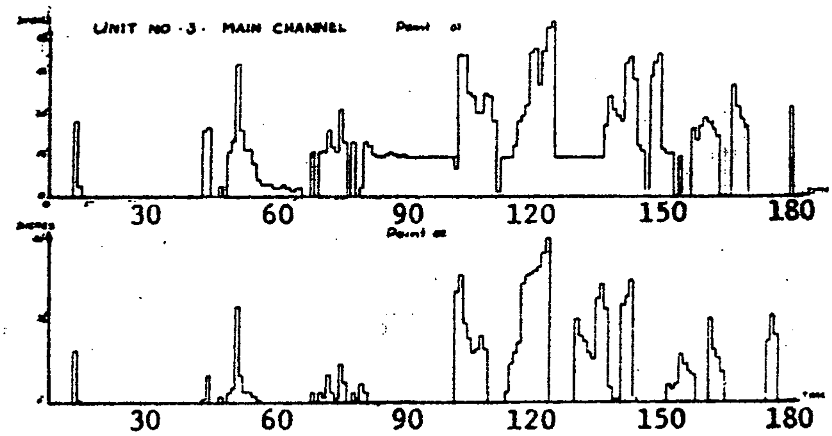
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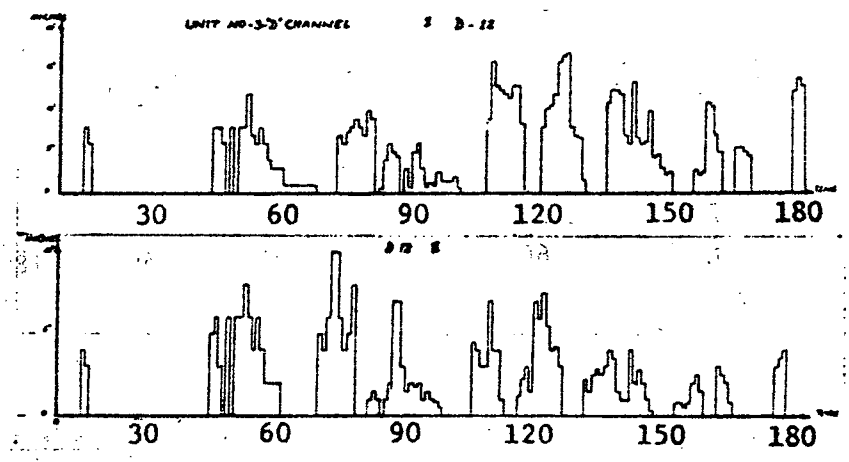
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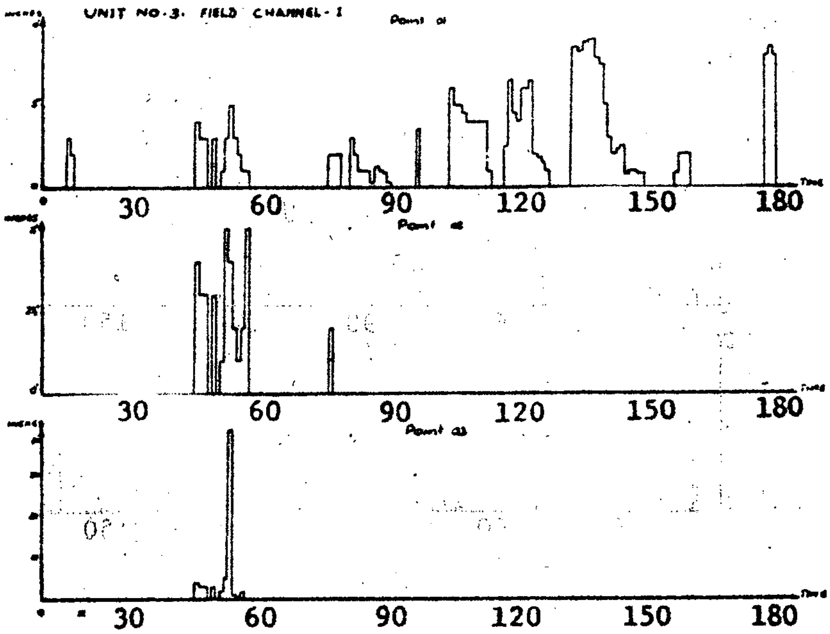
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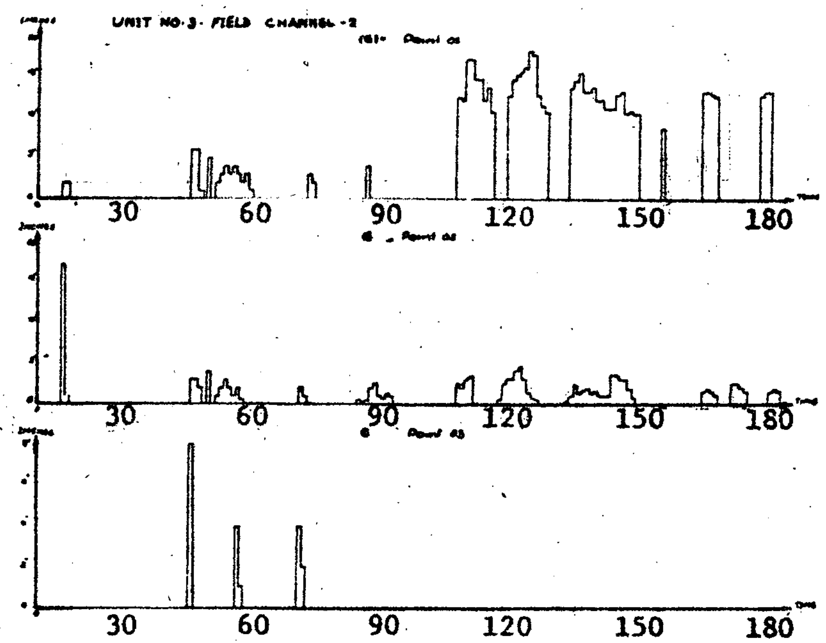
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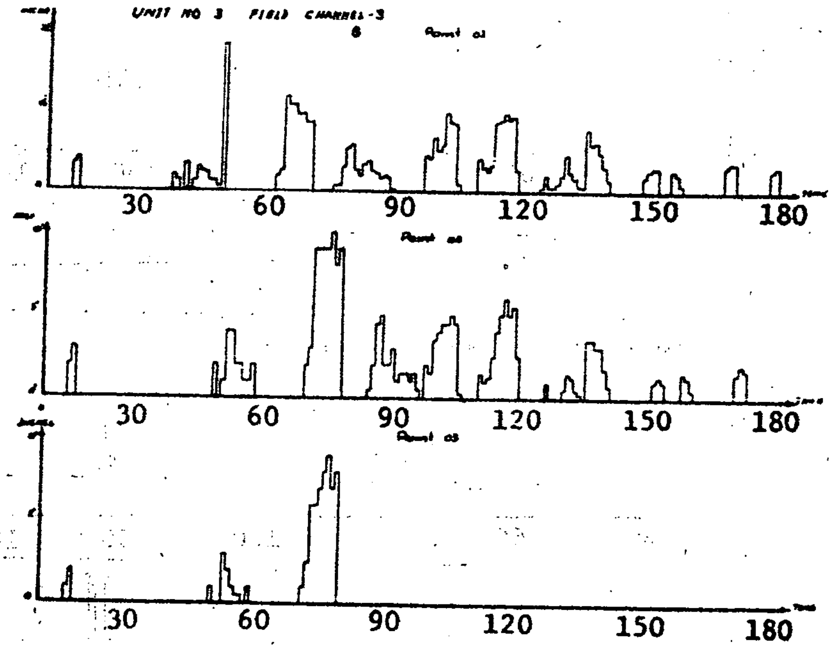
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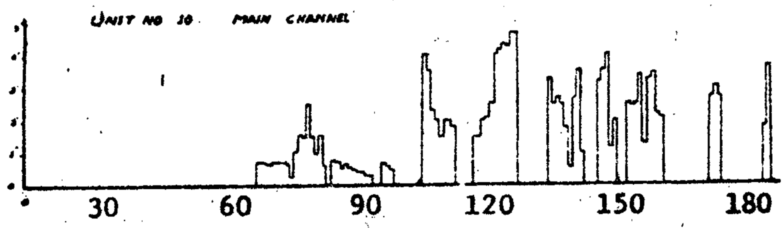
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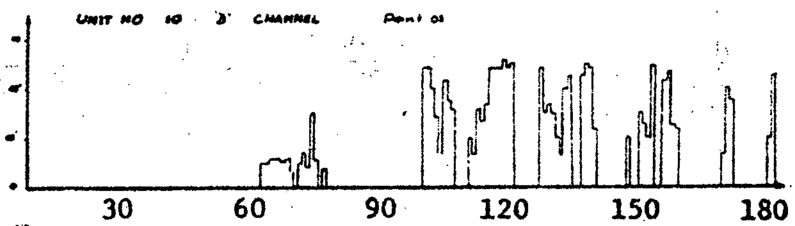
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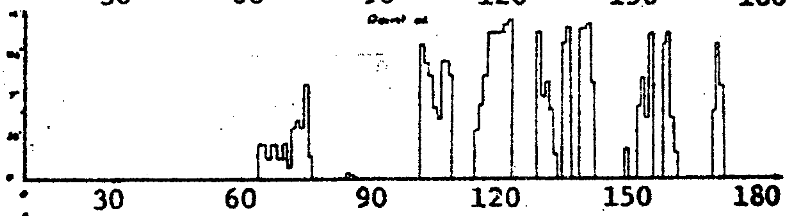
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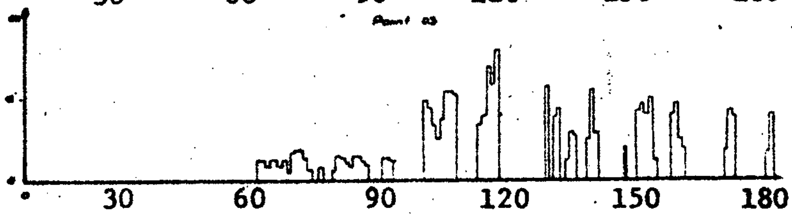
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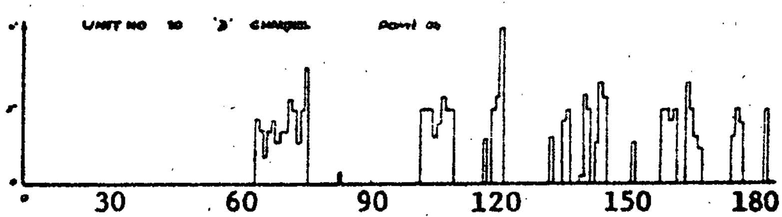
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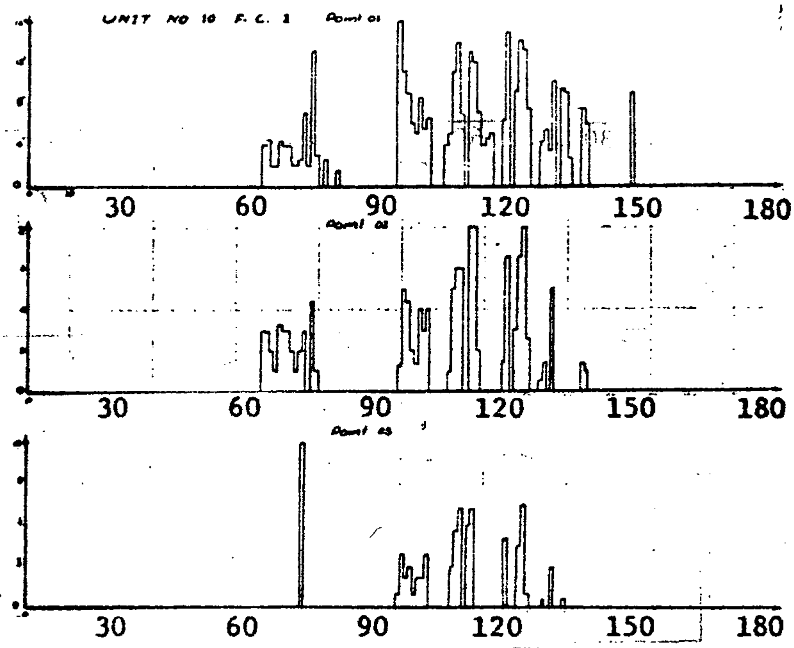
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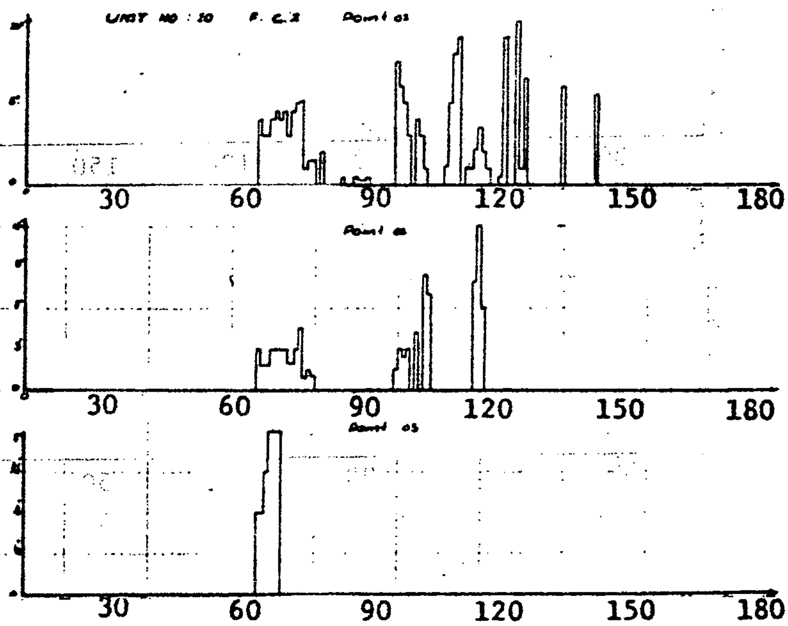
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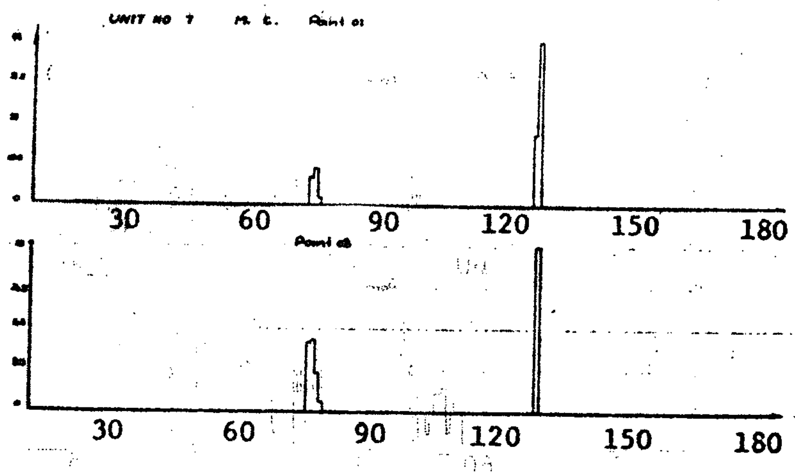
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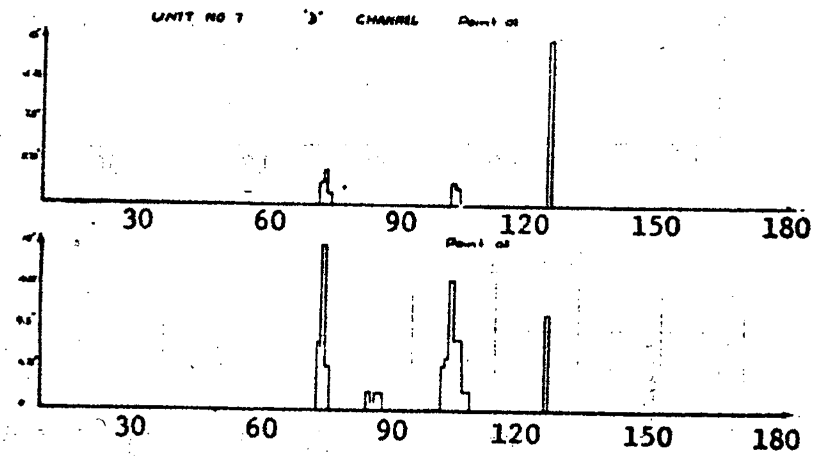
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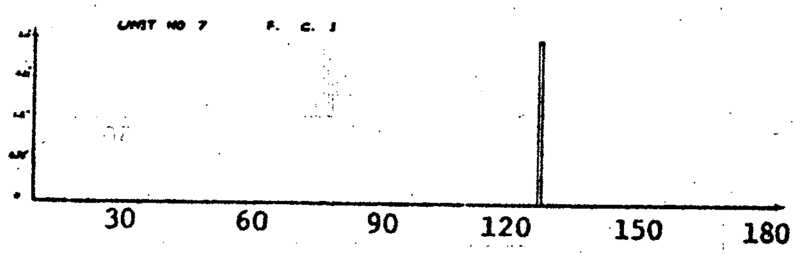
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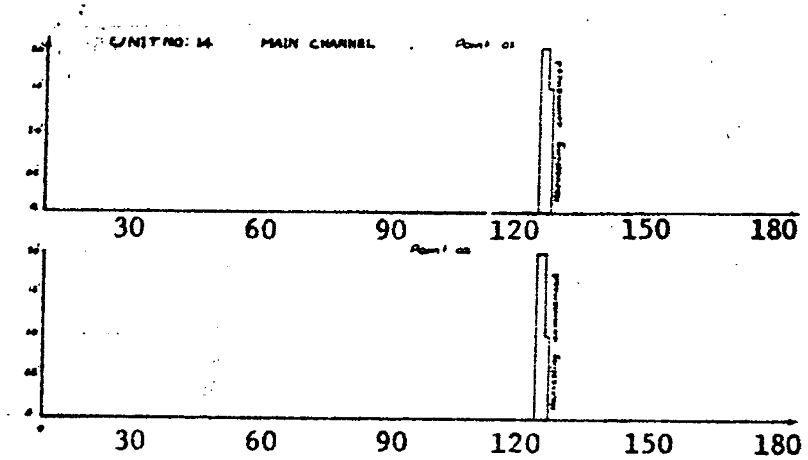
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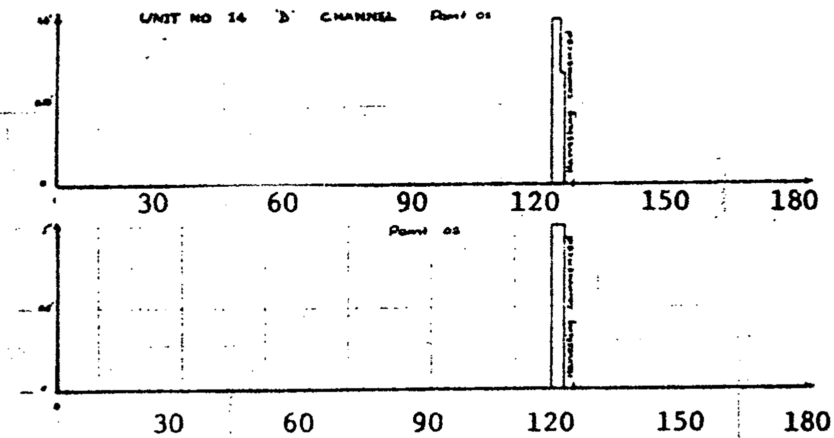
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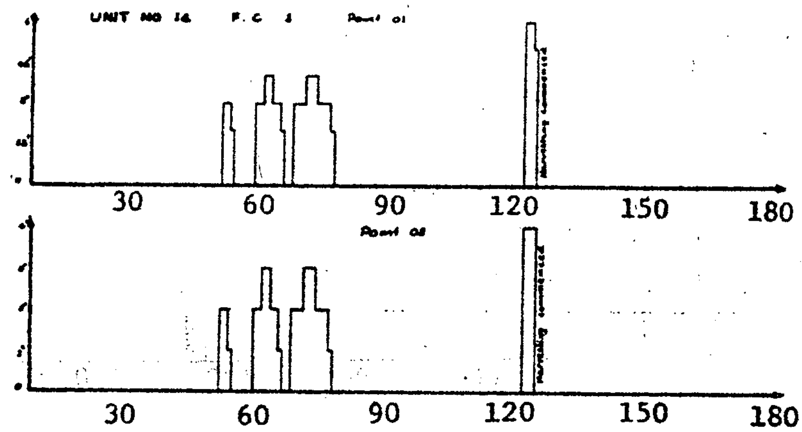
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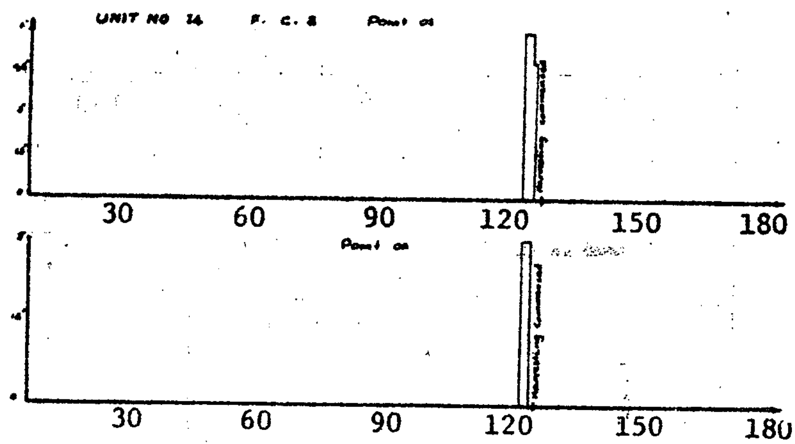
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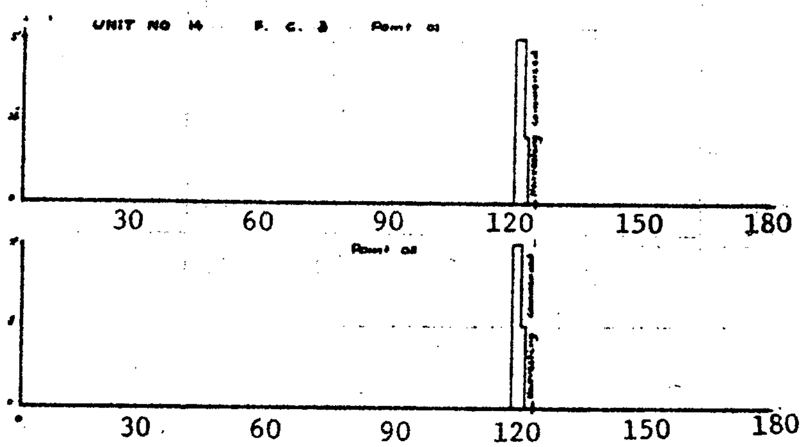
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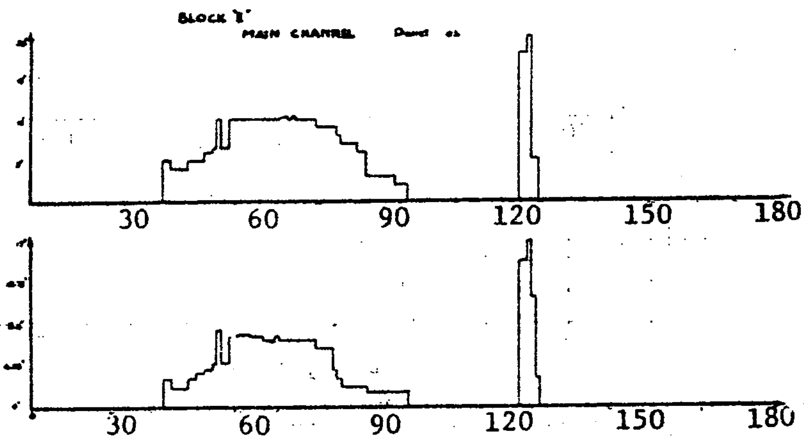
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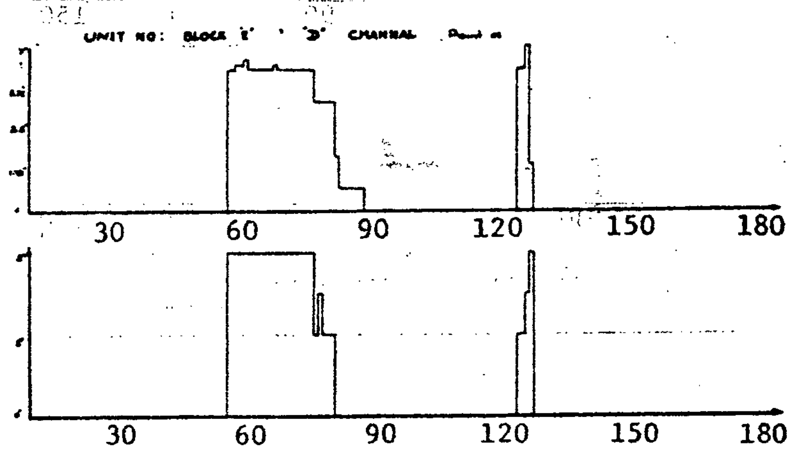
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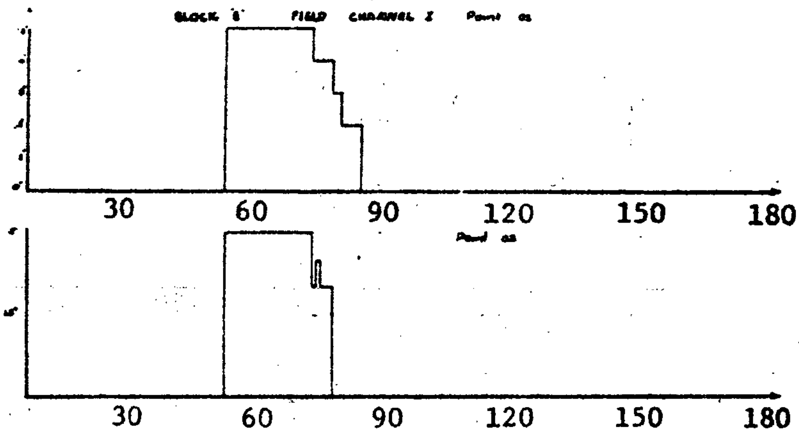
XVIII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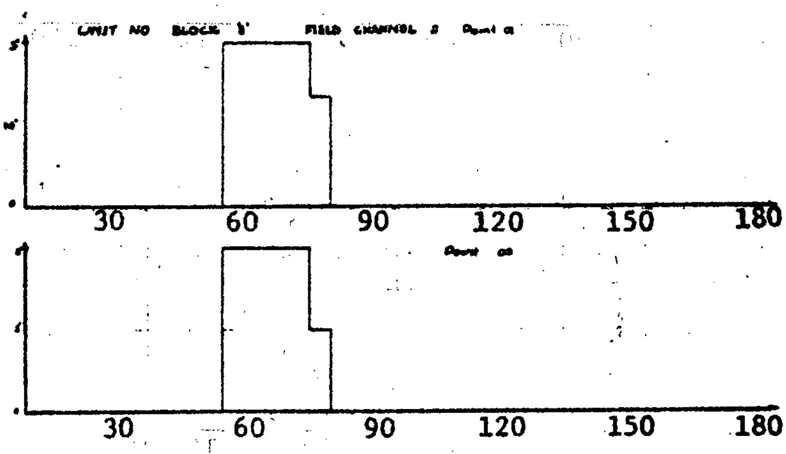
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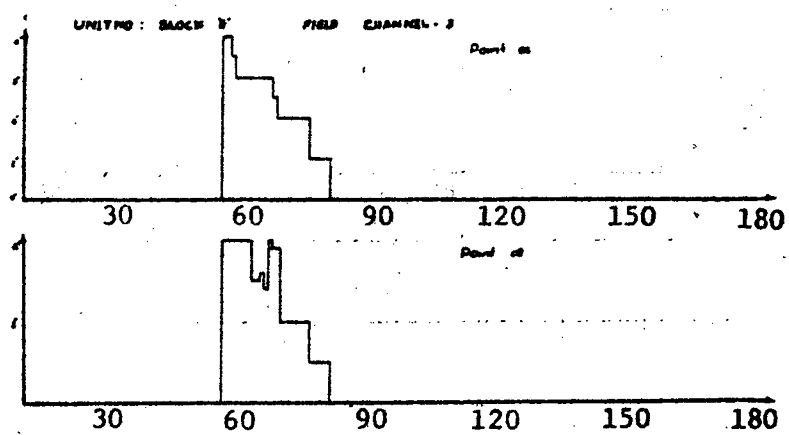
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30 60 90 120 150 180

APPENDIX

Water Flow Charts

Daily water flow at each measuring point during the period under study are given in this Appendix to illustrate the fluctuation in flows relative to the maximum delivery at each point. (Maximum delivery at each point is indicated by the highest level shown on the particular graph.) In addition, these graphs also show lengths of issue periods and intervening non-issue periods. Colony units are arranged in order of head to tail.