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MAHAWELI ENTERPRISE DEVELOPMENT

MED/EIED PROJECT

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STUDY ON POSSIBILITY OF YEAR ROUND IRRIGATION IN MAHAWELI SYSTEMS C, G, H AND UDA WALAWE

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INTERNATIONAL SCIENCE AND TECHNOLOGY INSTITUTE, INC.

WITH :

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HIGH VALUE HORTICULTURE, PLC.
SPARKS COMMODITIES, INC.
AGROSKILLS, LTD

CONSULTANTS TO THE MAHAWELI AUTHORITY OF SRI LANKA

The Mahaweli Enterprise Development Project

The development of the natural and human resources of the Mahaweli river basin has been a high priority of the Government of Sri Lanka and international agencies since the late 1970's. Largely completed are the construction of dams, irrigation and power systems, roads and other physical infrastructure, the settlement of the land and the formation of the agricultural production base. The challenge for the 1990's is to build a diverse, dynamic economy generating higher incomes for Mahaweli families. In meeting this challenge, the private sector has a leading role to play.

The Mahaweli Enterprise Development Project (MED) is a special initative of the Mahaweli Authority of Sri Lanka, with the support of the United States Agency for International Development. MED promotes private investment and job creation in agribusiness, manufacturing, tourism, minerals and services by directly assisting entrepreneurs and companies with technical expertise, marketing support, training, business advisory services and credit. MED also provides policy analysis support to improve official frameworks for sustainable enterprise development in the Mahaweli areas.

The Employment, Investment and Enterprise Development Division of the Mahaweli Authority is responsible for MED implementation. Technical consultancy is provided by a consortium led by the International Science and Technology Institute, Inc., a private consulting firm with head offices in Washington, D.C. Also in the consortium are Agroskills, Development Alternatives, Ernst and Young, High Value Horticulture and Sparks Commodities.

STUDY ON

POSSIBILITY OF YEAR ROUND IRRIGATION

IN MAHAWELI SYSTEMS

C, G, H & UDA WALAWE

PREFACE

Market demands and prices for fresh fruit and vegetables fluctuate during the year. Farmers must schedule their cultivations in sync with time-specific market windows. The availability of irrigation water right round the year is a key factor in creating the conditions for such market oriented production.

This MED study was undertaken to ascertain to what extent and how it might be possible to provide farmers with year-round irrigation water in Mahaweli Systems B, C, G and Uda Walawe. A earlier MARD study had found that it was possible in System B of Mahaweli to supply water to farmers as and when needed throughout the year, a situation which should remain at least until the right bank is developed.

The main finding is that it is not possible for year round irrigation to be practiced throughout these systems due to the serious shortages of water experienced in the dry or Yala season.

In some instances it may be possible to provide irrigation water as an extension to the normal season. This would depend on the rainfall during the cultivation season and the water that has been "saved" as a result. It also may be possible to provide water under certain small reservoirs just after the regular season, depending on the quantum of water left over due to higher rainfall than expected during the season.

The report recommends that controlled use is made of the available ground water by pumping during the drought periods. It also recommends appropriate crops.

The study recommends that an operations and maintenance plan be drawn out for the main and branch canals, in consultation with the farmer organizations. The plan should be flexible enough for maintenance to be done when the canals are not in use. The study also recommends training in various aspects of water management targeting staff at different levels and the farmers.

This report reflects the findings and views of the group of Teams Consultants who carried out the assignment and prepared this document.

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LIST OF ANNEXURES

LIST OF ACRONYMS

ACP	Africa, Caribbean and Pacific
AO	Agriculture Officer
Av.Tem	Average Temperature
BM	Block Manager
Br.C	Branch Canal
CEB	Ceylon Electricity Board
CIE	Chief Irrigation Engineer
DC	Distributory Canal
EA	Engineering Assistant
EC	European Community
EDB	Export Development Bank
EEC	European Economic Commission
EIED	Employment Investment & Enterprise Development
EMYE	Elahera Minneriya Yoda Ela
FA	Field Assistant
FO	Farmer Organisation
FOB	Freight on Board
ft	Feet
GSP	Generalised Systems of Preferences
ha	Hectare
HAO&M	Head Works Operation and Maintenance
ID	Irrigation Department
IE	Irrigation Engineer
IMD	Irrigation Management Division
INMAS	Integrated Management of Irrigation Scheme
JICA	Japan International Cooperation Agency
LB	Left Bank
LDCC	Leased Developing Countries
LHG	Low Humic Gley
LU	Labour Unit
MASL	Mahaweli Authority of Sri Lanka
MC	Main Canal
MCM	Million Cubic Meters
MD	Managing Director
MEA	Mahaweli Economic Agency
MECA	Mahaweli Engineering and Construction Agency
MED	Mahaweli Enterprise Development
MW	Mega Watt
NCP	North Central Province

LIST OF ACRONYMS (contd.)

O&M	Operation & Maintenance
OFC	Other Field Crops
PE	Project Engineer
RB	Right Bank
RBE	Reddish Brown Earth
RH	Relative Humidity
SOP	Seasonal Operating Plan
SW	South West
TO	Technical Officer
TOR	Terms of Reference
UM	Unit Manager
WMP	Water Management Panel
WMS	Water Management Secretariat

STUDY ON THE POSSIBILITY OF YEAR ROUND IRRIGATION IN MAHAWELI SYSTEMS C, G, H AND UDA WALAWE

EXECUTIVE SUMMARY

This study involved a series of inspections and collection of data from the field and from relevant offices to ascertain the availability of water for year round irrigation and to assess farmer attitudes towards crop diversification. It also focussed its attention on the cultivation pattern of suitable high value crops and the development of a more efficient and diversified agricultural sector which will have the capacity to respond to changing market conditions.

The possibility of increasing the hectarage under Other Food Crops both during the wet season and the dry season can be achieved if crops are selected to suit soil conditions coupled with judicious management of water. A simple forecast will be to lay off paddy from the well drained soils and instead cultivate OFCs which will have lower crop water requirements.

A summary of the availability of water and the proposed cultivation patterns is given in Table 5 of this report. This indicates that 10,200 ha in System C, 4690 ha in System G, and 5770 ha under Kalawewa in System H can be brought under cultivation for a 3rd crop. Possibility exists in Uda Walawe for an increase in extent by 1025 ha in the proposed L.B. extension area, although a 3rd crop is not recommended. Already nearly 1400 ha of Bananas are being cultivated in the irrigable area under the RB scheme.

Crop production in the Mahaweli Systems had been primarily subsistence, almost 100% of low land in the wet season is cultivated with paddy. In the dry season, if water is made available farmers prefer paddy cultivation. However, there is evidence of semi-commercial and commercial farming in the Mahaweli Systems. Progressive farmers have cultivated cash crop like chillie in raised beds or ridges in low land RBE soil and paddy cultivated only in the poorly drained LHG soils. Judging by the tables (3.4.1, 3.4.2 & 3.4.5) prepared from the data collected from the WMS of MASL (November 1992), there has been a progressive increase in the hectarage cultivated under these systems and that there has been a trend by the farmers to cultivate paddy exclusively during the wet season (October to March) and Other Field Crops (OFC) during the dry season, with reduced hectarage for paddy.

Chillie is the most popular cash crop. Vegetables, big onions, cowpea, green gram, black gram, ground nuts, gherkins and baby corn are also grown, though marketing has been the farmers bug bear.

Table 7 shows the crops recommended for Irrigated Uplands and Lowlands, whilst Table 8 shows the perennial and short term crops of Export Potential, grown in the Mahaweli Systems by private investors.

A study has been made and the crops selected for mass scale production in the Mahaweli Systems are shown in Table 18. Here the services of the settler farmers as outgrowers have been taken into consideration.

Detail studies have been made with regards to the operation and maintenance of the systems. In this context the farmer participation in all activities connected with the system from operation, maintenance and rehabilitation, is considered vital. A training programme for farmers has also been suggested.

The setting up of a rapid deployment maintenance unit equipped with necessary machinery and equipment to attend to emergency dewatering and repairs, based on a programme prepared in consultation with the farmer organisations, will be very essential if Year Round Irrigation project is to be a success.

Monitoring and Progress Control will be the key to success of the system. Efficiency of the system will depend on timely and accurate reporting of data necessary for both adjustments in water management to suit demands as well as help in planning future operations and checking the efficiency of the operation. This exercise will need accurate measuring devices and for this purpose it is suggested that all regulators and turnout structures be modified to incorporate Parshall flumes or Weirs with gauges. The staff working in this unit too should be trained for accurate reporting of data from the field.

Institutional strengthening of Farmer Organisations is of primary importance. Farmers will have to eventually take over the O & M of the system. Initially the Field Canals and thereafter the D Canals will be handed over to farmer organisations for their management.

1. INTRODUCTION

The Mahaweli ganga Development Programme is intended to utilise the waters of the Mahaweli, the longest river in Sri Lanka. The Mahaweli authority of Sri Lanka, the implementing agency, has undertaken an accelerated programme of development work to provide irrigation water to 245,000 acres (99,176 hectares) of new lands, 185,000 acres (74,888 hectares) of lands that were to get supplementary irrigation, and to generate 540 megawatts of hydropower. The new lands being developed are in various location in the Dry Zone and have been divided into several systems and projects. The allocation of diverted Mahaweli water to each project for each season is decided by a central Water Management Secretariat.

1.1 System H

System H is located in the Dry Zone in the North - Central Province of Sri Lanka. The area lies within the Kala Oya Basin about 16 kilometres (km) South-West of the historic town of Anuradhapura, the capital of the North Central Province. The project area covers a centiguous area of 106,000 acres (42,898 ha) of irrigable land, out of which 35,000 acres (14,165 ha) are old irrigated areas and 71,000 acres (28,734 ha) are newly developed lands. The old and new irrigated extent amount to almost 12% of the total irrigated area in the country.

The major part (90%)of the project area falls within the Anuradhapura district with some sections falling within the districts of Matale and Kurunegala. The elevation ranges from sea level to 182 m. The topography is gently undulating and slopes average 1 to 5 percent.

System H is made up of 12 subsections, of which H_1, H_2, H_4, H_5, and H_9 are new settlement areas, and the other are old colonization schemes. Sub-systems H_1 to H_9 (32,700 ha) are coming under the Resident Project Manager - Tambuttegama and the other sub-systems are managed by the Irrigation Department.

The irrigable extent of land receive irrigation water from three reservoir: Kandalama, Dambulla Oya and Kalawewa.

1.2 Uda Walawe

Walawe project area falls within the provinces of Sabaragamuwa, Southern and Uva. It covers the districts of Ratnapura, Moneragala and Hambantota and electorates of Kolanne, Wellawaya, Tissamaharama and Tangalle. The project is about 160 kilometres (100km) South East of Colombo. The region is linked to Colombo by two main roads. One along the coast and the other via Ratnapura.

The irrigable extent (27,000 ha) is situated on the right and left banks towards the lowest part of the Walawe Ganga basin, below the 76 metre (250 ft) contour. Dr. C.R. Panabokke's soil survey report describes the landscape in the region North of Embilipitiya as undulating with slopes generally ranging from 0-4 percent, where erosional remnants and hillocks are common.

generally ranging from 0-4 percent, where erosional remnants and hillocks are common. The river, streams and gullies are deeply incised with the result that surface drainage is excellent and the extent of poorly drained soils is comparatively small. The Southern portion is largely rolling with slopes ranging from 0-8 percent. Erosional remnants and hillocks are less common and the drainage does not have an incised character.

The right bank consists of five blocks: Embilipitiya Chandrikawewa, Murawasihena, Binkama and Angunukolapellessa and the left bank has two blocks: Kiri Ibbanwewa and Suriyawewa. The left bank is being developed to include another 23,340 acres (9,240 ha) of irrigated land.

1.3 System C

System C is in the Dry Zone in the North - Central Province of Sri Lanka. The two main areas of System C are Girandurukotte and Dehiattakandiya falling within the districts of Badulla, Ampara and Polonnaruwa. The project area covers an area of 170,430 acres (69,000 ha) of which 53,540 acres (21,675 ha) are irrigable.

The system has been subdivided into six geomophological zones. Zones I is a developed area and embraces the Mahiyangana old town and has 5 major colonization schemes. Mapakada, Dambarawa, Nagadeepa, Mahawewa and Sorabora. Zone I is not part of the accelerated Mahaweli programme. The rest of the area, Zone II to VI, is administered by a Resident Project Manager, stationed at Dehiattakandiya.

System C receives Mahaweli waters from diversion at Minipe Right Bank through Ratkinda and Ulhitiya reservoirs.

1.4 System G

System G is in the Dry Zone in the North Central Province of Sri Lanka. The main township is at Bakamuna in Polonnaruwa district. The project area lies between EMYE and Ambanganga. The gross land area of the system is about 10,000 ha and irrigable area is only 5400 ha. The main supply of water for the system is from diversion of Ambanganga at Elahera. The irrigable area belongs to two regimes. The old area which is about 2500 ha has been in operation for several decades. The new area has been taken up in 1985 with rehabilitation of old area. The system is administered by the Resident Project Manager at Welikanda.

2. BACKGROUND

The work on the consultancy services for possible Year Round Irrigation in Mahaweli Systems C, G, H & Uda Walawe special project commenced in October 1992 with Mahaweli Enterprise Development Project of the Mahaweli Authority, as client.

The main objective of this study is to ascertain the possibility of Year Round Irrigation in Mahaweli Systems C,G,H & Uda Walawe special project. It was mentioned that a preliminary study carried out in System B of the Mahaweli has indicated that Year Round Irrigation was possible in terms of water availability and maintenance of canals in System B. The main canal & branch canals are concrete lined where as in the other Mahaweli systems they are not lined.

2.1 Scope of Work

The Terms of Reference as given by the Client can be summarised as follows:

(i) Ascertain the availability of water in Systems C,G,H & Uda Walawe to issues Year Round Irrigation for cultivation of crops.

(ii) Recommend methods that could be used to carry out the routine maintenance work during the issue of irrigation work.

(iii) Recommend the machinery and equipment that could be used to carry out this maintenance work. A suggested programme of work should accompany this.

(iv) Recommend the period and interval of canal dewatering necessary to carry out the accumulated maintenance work.

(v) Recommend emergency dewatering plans for each of the individual irrigation systems in the project.

(vi) Recommend an irrigation programme for the regular inspection of the irrigation systems to ensure the safety of the infrastructure.

At the stage of submitting the proposals, TEAMS Consultants (Pvt) Ltd, carefully examined features and characteristics of each system in respect of source of water, age, and socio economic background and the TOR was slightly amended to constitute the following points:

(i) Determine the availability of water in System C,G,H & Uda Walawe to issue year round in the light of the actual crop types and water usage methods and habits, while assessing potential water requirement for introducing high value crops.

(ii) Recommend ways and means of optimising the use of available water for better productivity via improved crop diversification programmes, and use patterns, water application methods, water management procedures and institutional development measures.

(iii) Recommend procedures for system operation which can maximise the possibility of year round issue of water.

(iv) Recommend methods that could be used to carry out the routine maintenance work during the issue of irrigation water.

(v) Recommend the machinery and equipment that could be used to carry out this maintenance work. A suggested programme of work should accompany this.

(vi) Recommend the period and interval of canal dewatering plans for each of the individual irrigation systems to ensure the safety of the infrastructure.

(vii) Recommend emergency dewatering plans for each of the individual irrigation systems in the project.

(viii) Recommend an inspection programme for the regular inspection of the irrigation system to ensure the safety of the infrastructure.

The ammended TOR has been accepted by the client.

2.2 Methodology of Work

The TOR lists 8 objectives for the study. At the inception of the study, the consultants had a useful and lengthy discussion with the client on the methodology & the tasks to be performed in the execution of the study as given below.

Task 1 - Project Mobilisation & Preliminary Review.

Task 2 - Detailed investigation on available stock of water, present water use and O&M procedures.

Task 3 - Detailed investigation on water requirement for different crops and different production technologies.

Task 4 - Deriving conclusions on water availability for Year Round Irrigation.

Task 5 - Review the experience of the other countries on Year Round Irrigation and other related topics.

Task 6 - Formulation of recommendation which can help to ascertain Year Round Irrigation and necessary operation and maintenance.

Task 7 - Preparation and presentation of Draft Final Report.

Task 8 - Preparation of the Final Report.

2.3 Project Mobilisation

Consultants had their first meeting on the 12th of October with the client. They spent 2 days consulting relevant officials of the Ministry of Lands, Irrigation & Mahaweli Development and Mahaweli Authority of Sri Lanka (EIED/MEA/MECA) in Colombo. They visited the Mahaweli Systems C,G,H and Uda Walawe special project where they met respective Resident Project Managers, Deputy Project Managers, Block Managers in charge of Agriculture, .pa

Engineering & farmer organisations. They were given necessary assistance & cooperation by the project officers, to persue available past records in different sub offices. Block managers & Unit managers gave access to the available files & briefed the consultants on present procedures for operation & maintenance. Consultants were able to meet a fair number of farmers & farmer leaders in four areas to review the present status of farmer involvement in operation and maintenance through the farmer organisations.

During the field visits it was possible to gather information on cropping patterns and review the crops grown especially for the export market at present in the Mahaweli systems. Farmers perception of the development of export crop production and the advantages and disadvantages were discussed with the farmers themselves. Different views on the Year Round irrigation and cultivation of high value crops were of great value to the consultants to arrive at certain conclusions on Year Round Irrigation in Mahaweli Systems.

Unstructured surveys were conducted in the field on availability of water, control and operation of the systems, climatic and hydrological conditions such as Rainfall, Water issues, Resource storage, drainage facilities etc.

Consultants were able to visit System B of Mahaweli to aquaint themselves with the export oriented crop production by the private sector organisations with the out growers. This visit had given the consultants an opportunity to arrive at certain conclusions on the crops to be recommended for the systems C, G, H and Uda Walawe special project.

3. AVAILABILITY OF WATER

3.1 General

It is observed that these systems exhibit diverse characteristics due to their physical locations and consequent climatological and hydrometeorological features, methods of control, operation and maintenance, soil types, farming practices etc. For example, the Uda Walawe Reservoir lies in the Walawe Basin in the Southern part of the island and exists as an independent entity, in that it is away from the direct influence of Mahaweli Ganga whereas the other three systems are linked with each other and come under its influence. Of these, system C lies on the Right Bank of Mahaweli Ganga, taking its water from the new Minipe Anicut. The water available at Minipe is controlled by the reservoirs and diversions upstream, viz Kotmale Reservoir, Polgolla Barrage (diversion to NCP), Victoria, Randenigala and Rantambe reservoirs. The highly interlinked reservoirs cum channel and drainage water systems are G and H (in the NCP) which largely derive water from the bifurcated flows at Bowatenna. They represent a system of a multitude of interlinked reservoirs such as Kalawewa canals, Huruluwewa tank, the Minneriya Yoda Ela and the Minneriya Kantale Yoda Ela to name a few.

A given reservoir or system would take a period of about five years to stabilise itself, particularly when there are additions of new components to the system. Taking cognisance of this fact and also other factors such as the need for the farmer to adapt himself to his new environment etc. it was considered that the best available past records for analysis were those from the water years 1986/87 to 1990/91, ie. 5 years of records. Moreover, certain deficiencies in recorded data for this period as observed both in the field and the Water Management Secretariat have acted as a major constraint in the detailed analysis of the water resources. The year 1987 to 1989 (3 years) were periods of unrest in most parts of the island and some field activities had to be necessarily curtailed or abandoned.

The discrete time interval used in the study is one month. This has been arrived at taking into account (a) the purpose of the study (b) volume of work involved in the study and (c) the reduction in information by assuming too large an interval of time.

3.2 Source

3.2.1 System C

System C extends north of Minipe along the right bank of Mahaweli Ganga, which forms the western boundary, while the right bank Transbasin Canal, Ulhitiya - Rathkinda Reservoirs and Pimburettawa tank form the Eastern Boundary. The main conveyance system which has been completed to feed the Mahaweli waters into these new areas in the System C comprise of :

(1) The new Minipe Anicut across Mahaweli Ganga and the Minipe right bank Transbasin Canal which is lined and about 31.0km in length. It has a carrying capacity of 64 cumecs at the headworks.

(2) Twin service reservoirs viz. Ulhitiya and Rathkinde with a combined spillway

(3) Ulhitiya left bank main canal which has a carrying capacity of 11 cumecs and 10.9km in length feeding zone 2 of the system

(4) Rathkinde Right Bank Main Canal which has a carrying capacity of 50 cumecs and 17.35 km in length feeding zones 3 to 6 of the system

Zone 1 of system C constitutes the Old Mahiyangana Colonisation scheme irrigated mainly by the Horabora, Mapakada, Dambarawa and Nagadeepa tanks and several other smaller tanks which also derive their water from the Transbasin Canal, but are excluded from System C Project Management.

3.2.2 System G

System G is bounded on the east and south by the Ambanganga, on the West by the Elahera Minneriya Yoda Ela (EMYE) and on the north by Radawige Oya. This area includes the Old Elahera Colony and the land that lies between the old colony and the Amban Ganga. System G has at its source of water the direct issue from EMYE which is a conveyance canal taking off Amban Ganga at Elahera Anicut and feeding Giritale, Minneriya and beyond them to Kaudulla and Kantale tanks as well (System D1). The anicut at Elahera derives its water from Amban Ganga which flows are augmented by the Mahaweli Ganga diversion at Bowatenna and the intervening catchment between Bowatenna and the Elahera Anicut. The discharge capacity of the EMYE is 52 cumecs at the headworks.

3.2.3 System H

The project area designated as System H lies within the Kalawewa Basin. In order to augment the water resources of the Kalawewa Basin, water is diverted from the Huruluwewa Canal to:

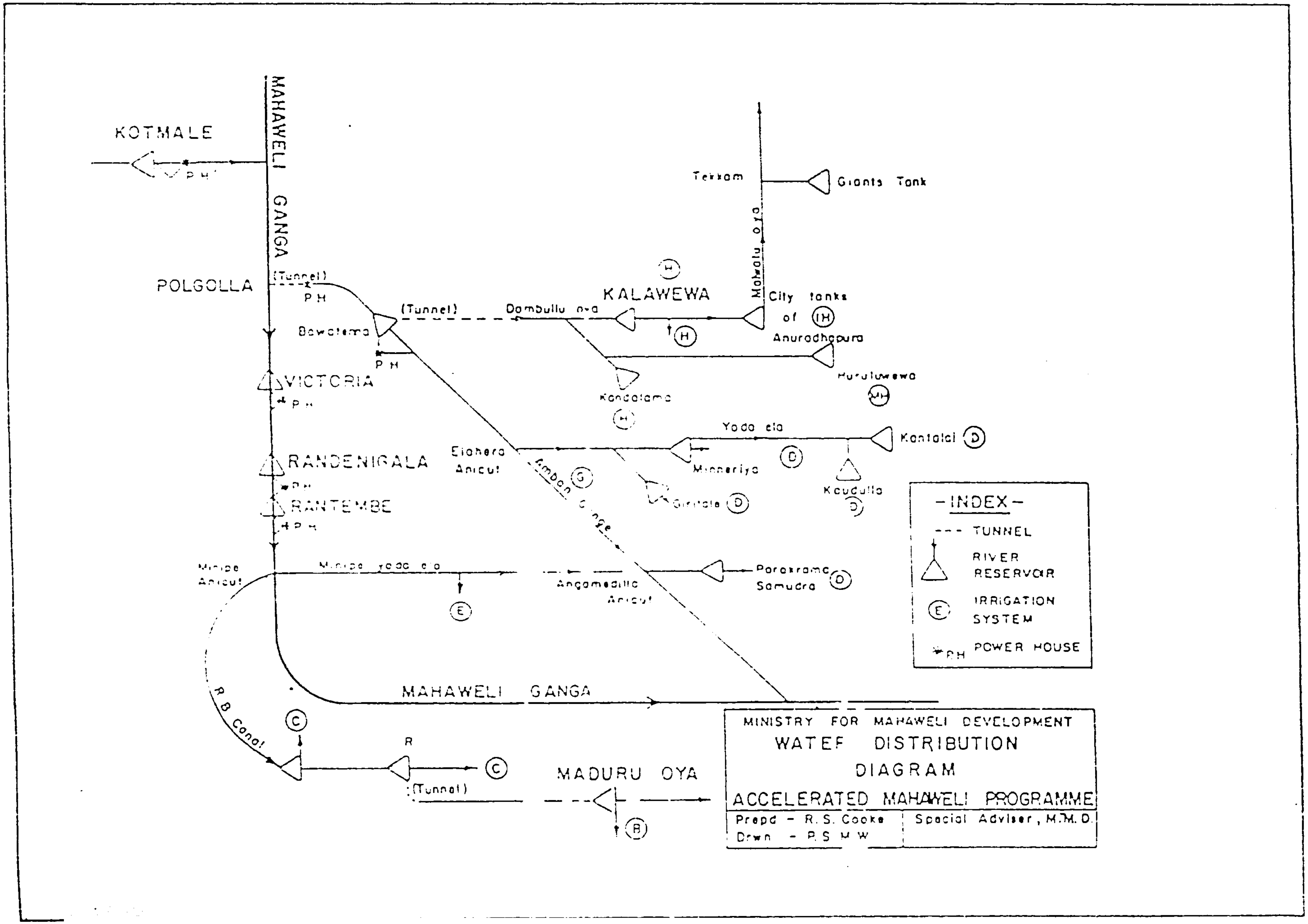
(i) the Dambulu Oya reservoir, the Kalawewa tank and beyond to Rajangana tank, and

(ii) the Kandalama tank, the drainage water of which fall into Kalawewa tank.

The tanks considered for this study under system H are the Kandalama tank (capacity 33.8 MCM), Dambulu Oya Reservoir (Capacity 11.7MCM) and the Kalawewa tank (123.7MCM).

Exhibit 1 illustrates the respective systems C,G & H discussed above and their placement relative to other components of the system.

Exhibit - I


MAHAWELI GANGA
KOTMALE
P H
POLGOLLA
(Tunnel)
P H
Bowatenna
(Tunnel)
Dambulu oya
KALAWEWA
Mahalu oya
Tekkam
Giants Tank
City tanks
of
Anuradhapura
IH
H
Huruluwewa
MH
Kandalama
VICTORIA
P H
RANDENIGALA
P H
RANTEMBE
P H
Elahera
Anicut
Amban Ganga
G
Yoda ela
Kantalai
D
Minneriya
Giritale
Kaudulla
Minipe
Anicut
Minipe yoda ela
E
Angamedilla
Anicut
Parakrama
Samudra
D
R B Canal
MAHAWELI GANGA
C
R
(Tunnel)
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B
-INDEX-
TUNNEL
RIVER
RESERVOIR
IRRIGATION
SYSTEM
P H
POWER HOUSE
MINISTRY FOR MAHAWELI DEVELOPMENT
WATEF DISTRIBUTION
DIAGRAM
ACCELERATED MAHAWELI PROGRAMME
Prepd - R.S. Cooke
Special Adviser, M.M.D.
Drwn - P.S M W

3.2.4 Uda Walawe

The Uda Walawe irrigation project, which has at its source the Walawe Ganga lies about 180 km from Colombo and is located in the Dry Zone having a mean annual rainfall varying from about 935mm to 1585 mm. The mean monthly temperature varies between 26°C to 33°C and the relative humidity from 76% to 81%. The rainfall distribution indicates the existence of four seasons, viz.

- a long rainy season. October to December.
- Short dry season. January to March
- a short rainy season. April to May.
- a long dry season. June to September.

The Uda Walawe catchment is intercepted by the Samanalawewa Hydro Project. Dam embankment construction work in this project commenced in February 1989 and was completed in December 1990.

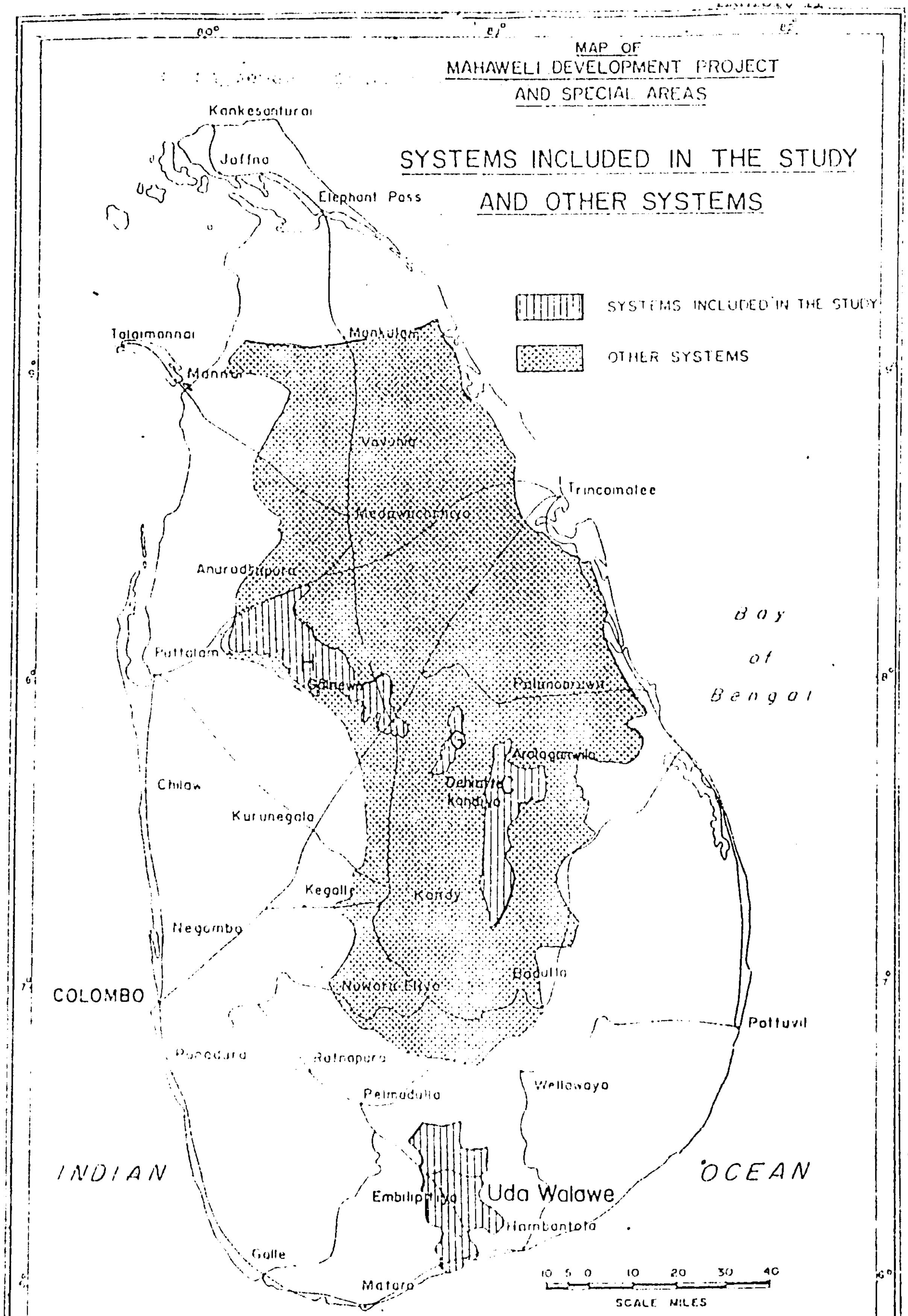
The more important hydro data of the Uda Walawe reservoir is as follows:

- Catchment area 1152 sq. km (of which 342 sq.km is intercepted by the Samanalawewa Hydro Project).
- Capacity at full supply level is 268.9 MCM
- Capacity at minimum draw down level is 28.3 MCM
- Active storage 240.6 MCM
- Spillway consists of 5 radial gates, each of which is 18.96m wide. Sill level 82.18 m, top level 88.39m.
- Natural spillway 366m in length.
- Bund length 4km
- Power Generation RB 2 MW, LB 4 MW Inoperative

Exhibit 2 shows the placement of Uda Walawe in relation to the other systems described above.

3.3 Management, Control and Operation of Water Resources

The overall objective of the management, control and operation of the water resources available is to ensure a reliable, timely, efficient and predetermined supply of water to the farmer along with optimisation of hydropower generation. Thus water management in the Mahaweli Systems has to be viewed at three different levels - System (Macro) Level, Sub-system (Micro) level and farm level.


MAP OF
MAHAWELI DEVELOPMENT PROJECT
AND SPECIAL AREAS
SYSTEMS INCLUDED IN THE STUDY
AND OTHER SYSTEMS
SYSTEMS INCLUDED IN THE STUDY
OTHER SYSTEMS
Kankesanturai
Jaffna
Elephant Pass
Talaimannar
Mankulam
Mannar
Vavunia
Trincomalee
Anuradhapura
Puttalam
Polonnaruwa
Chilaw
Kurunegala
Aralaganwila
Kegalle
Kandy
Negombo
Badulla
COLOMBO
Pottuvil
Ratnapura
Wellawaya
Pelmadulla
INDIAN
OCEAN
Bay
of
Bengal
Embilipitiya
Uda Walawe
Hambantota
Galle
Matara
SCALE MILES

The policy making body of the Mahaweli Authority of Sri Lanka (MASL) as regards water distribution is the Water Management Panel (WMP) which is responsible at National Level for achieving optimum benefits from both irrigation and hydropower generation. The WMP is also responsible for the overall cultivation programmes in the areas served and is advised and serviced by a technically specialised Water Management Secretariat (WMS) which body functions under the MASL.

Each year the WMS draws up Seasonal Operating Plans (S.O.P.) for the half year periods 1st October - 31st March and 1st April - 30th September corresponding to the wet season and the dry season respectively in any given water year. The S.O.P. gives details of planned cropping schedules, diversions and irrigation issues as well as projected hydro power generation. The other agencies responsible for drawing up the S.O.P. are the Ceylon Electricity Board (CEB), Irrigation Department (ID) and the Mahaweli Economic Agency (MEA) and the S.O.P. is based on the basic data supplied by each agency. At a meeting of the WMP convened before each cultivation, the S.O.P. is approved after discussion and necessary adjustments made. The operation of the Macro system is thereafter directed under the supervision of the WMS. The sub-system (Micro) Level water management is primarily the responsibility of the organisation in charge of the irrigation system e.g. the MEA or the ID. A micro model has been developed for the H area and has been installed in a Computer at Galnewa for more efficient water management in System H. Farm irrigation requirements are planned with the objective of meeting estimated demands for,

(1) Land preparation
(2) Crop water requirements and,
(3) Percolation losses

The S.O.P. prepared by the WMP gives the monthly sluice issues for each sluice, monthly diversion to other systems etc. and serves largely as a guideline because actual diversions and rainfall may vary from the assumptions used in evolving the S.O.P. Hence in the operation of a system, in order to optimise rainfall for irrigation, the Block Managers with the help of the Irrigation Engineers, Agricultural Officers and Unit Managers prepare detail cultivation schedules for their blocks taking into account factors such as farm power and labour available as well. The water requirement in respect to the distributory and branch canals in the block are prepared by the irrigation engineer who gives his weekly requirements to the main canal engineer a week in advance. The latter collects the requirement of irrigation water of all the blocks and prepares the schedule for issues from main and branch canals taking into consideration conveyance losses. Water issues to blocks are based on the schedule, but are adjusted periodically, taking into consideration local rainfall and other variations in the planned programmes.

The Headworks Operation and Maintenance (HAO & M) Division of the MASL is the Agency responsible for the care and operation of all aspects of Mahaweli Headworks except those facilities specifically related to power generation (which devolves on the CEB which takes care of power intakes, tunnels, power houses and switch yards and draw their own water requirements from the reservoirs subject to approval by the WMP).

The various agencies responsible for the operation and maintenance of the four systems C,G,H and Uda Walawe are as follows:

System	Component	Agency
System C	Minipe Anicut and Transbasin Canal Ulhitiya Rathkinda Dam	HAO & M
	Head Sluices of Ulhitiya Rathkinda Reservoirs and distribution system	MEA
System G	Bowatenna dam and irrigation tunnel	HAO & M
	Elahera Anicut and Elahera Minneriya Yoda Ela distribution system	ID
System H	Bowatenna dam and irrigation tunnel, Lenadora- Kandalama Canal and the three tanks Kalawewa, Kandalama and Dambulu Oya (excepting operation of head sluices)	HAO & M
System H	Kalawewa, Kandalama and Dambulu Oya tank head sluices and distribution system	MEA
	Uda Walawe dam (except operation of head sluice)	HAO & M
	Uda Walawe head sluice and distribution system.	MEA

3.4 Climatic Conditions

The following factors are considered for the water years 1986/87 to 1990/91.

(a) Representative monthly rainfall in the project area
(b) Monthly storage where applicable
(c) Monthly water issues and,
(d) Drainage facilities

Items (a), (b), and (c) are summarised for the water years mentioned above in Tables 1,2,3 & 4 for systems C,G,H and Uda Walawe respectively. Item (b) is not applicable for System G where irrigation is dependent on the amount of water issued for irrigation from the Elahera, Minneriya, Yoda Ela. This is indicated in Table 2.

It is proposed to discuss the performance of each system for the water years under consideration as indicated below. (These tables below are based on the data obtained from the Water Management Secretariat of MASL - November 1992). OFC refers to "other food crops".

3.4.1 System C

Water Year	Hectarage Cultivated	
	Wet Season ha. Oct.-March	**Dry Season ha. April-Sept.**
1986/87	10100 Paddy Oct.23rd to 15th March 0 ofc " ----- 10100	10500 Paddy May 4th to Sept.12th 0 ofc ----- 10500
1987/88	12470 Paddy Oct.15th to March 15th 0 ofc " ----- 12470	13400 Paddy April 20th to Sept. 4th 0 ofc ----- 13400
1988/89	15000 Paddy Oct.15th to March 31st 0 ofc " ----- 15000	12500 Paddy April 17th to Sept. 10th 500 ofc April 17th to Sept. 17th ------ 13000
1989/90	13600 Paddy Oct.15th to March 15th 0 ofc " ----- 13600	12000 Paddy April 1st to Sept. 10th 700 ofc ------ 12700
1990/91	15400 Paddy Oct.15th to March 15th 0 ofc ----- 15400	16100 Paddy April 16th to Sept. 15th 600 ofc April 10th to Sept 15th ----- 16700

The tables above indicate that from 1986/87 to 1990/91 there has been a progressive increase in the hectarage cultivated under System C and that there has been a trend by the farmers to cultivate paddy exclusively for the wet season October to March and other food crops as well during the ensuing dry season with reduced hectarage for paddy.

Table 1 whicn gives the end storage of Ulhitiya Rathkinda reservoirs at the end of each month shows a favourable balance of water in the year 1990/91 in the combined reservoir systems, i.e. the reservoir system is above the minimum stipulated storage of 63.4 mcm for irrigation. This indicates the possibility of commanding a more intense and expanded irrigable command under this system.

3.4.2 System G

Water Year	Hectarage Cultivated	
	Wet Season ha. Oct.- March	**Dry Season ha. April- Sept.**
1986/87	2794 Paddy Oct. 15th to March 31st. 0 ofc " " ---- 2794	3590 Paddy April 15th to August 1st 0 ofc " ---- 3590
1987/88	4229 Paddy Oct. 15th to March 31st 0 ofc " ---- 4229	1965 Paddy May 1st to August 31st. 1310 ofc " ---- 3275
1988/89	5060 Paddy Oct. 19th to March 31st. 0 ofc " ---- 5060	3500 Paddy May 15th to Sept. 15th 0 ofc " ---- 3500
1989/90	5400 Paddy Oct. 10th to March 15th. 0 ofc " ---- 5400	2700 Paddy May 1st to Sept. 15th 1950 ofc " ---- 4650
1990/91	4500 Paddy Oct. 22nd to March 28th 150 ofc " ---- 4650	2600 Paddy April 10th to Sept. 21st 2100 ofc " ---- 4700

The above table read in conjunction with Table 2 indicates the continued trend of the farmers to cultivate paddy during the wet season and an also the expansion of the cultivation of other food crops during the comparatively dry season. However owing to the paucity of hydrological data even for the period under study, no clear trend is identifiable.

3.4.3 System H

Only the Kalawewa tank is taken into consideration in this system as the other two tanks Kandalama and Dambulu Oya are relatively small and have lesser command areas in comparison than under Kalawewa.

Water Year	Hectarage Cultivated in RB, Yoda Ela and LB	
	Wet Season ha. Oct. - March	**Dry season ha. April - September**
1986/87	22880 Paddy RB Oct. 22nd to March 25th 0 ofc YE Oct. 24th to March 30th. ----- LB Oct. 19th to March 22nd 22880	3650 Paddy RB May 7th to Sept. 15th 6970 ofc YE May 9th to Sept. 17th. ----- LB Apr. 10th to Sept. 15th 10620
1987/88	23518 Paddy RB Nov. 15th to March 22nd 0 ofc YE ----- LB 23518 RB	4900 Paddy RB May 4th to Sept. 8th. 7500 ofc YE May 14th to Sept. 8th. ----- LB May 8th to Sept. 8th 12400
1988/89		1300 Paddy RB May 1st to Aug. 23rd. 860 ofc YE June 20th to Aug. 22nd ---- LB June 20th to Aug. 25th. 2160
1989/90	15670 Paddy RB Oct. 29th to April 3rd 1400 ofc YE Oct. 4th to March 29th ----- LB Oct. 23rd to March 29th 17070	5850 Paddy RB April 20th to Sept. 1st. 7500 ofc YE May 1st to Sept. 15th. ----- LB April 1st to Sept. 1st. 13350
1990/91	23700 Paddy RB Oct. 12th to March 15th 320 ofc YE Oct. 25th to March 23rd ----- LB Oct. 1st to March 19th 24020	8400 Paddy RB April 25th to Sept 23rd 7800 ofc YE April 20th to Sept. 23rd ----- LB April 20th to Sept. 23rd 16200

It would appear from the above table read in conjunction with Table 3 that the maximum hectarage under the reservoir is being cultivated in the wet season with paddy. It may be possible for increased hectarage under other food crops with judicious management of scarce water resources during the dry season.

3.4.4 Uda Walawe

The total designed command area is 26,690 ha of which the Right Bank Canal which is 40.0km in length is designed for 12,300ha. Of this the present (1992) cultivation is 10,600ha for paddy and other food crops and 300ha for sugar. The capacity of the R.B. canal at headworks is 22 cumecs. The left Bank Canal which is 31.5 km in length presently irrigates 5150ha. According to the water balance study carried out by JICA an additional 9240ha can be developed under the Left Bank.

The consultants carried out a water balance study of Uda Walawe with data available for the years 1986/87 to 1989/90 and arrived at the following :

Water Year	Calculated inflows into reservoir MCM
1986/87	564.0
1987/88	675.0 (Excluding Jan. 1988)
1988/89	348.1
1989/90	441.5

The above inflows do not take into account the impoundment of water in the Samanalawewa Hydropower Project. According to the JICA interim report of March 1992 availability of water increases considerably by incorporating Samanalawewa Reservoir based on the power generation pattern given by the C.E.B. Hence it is observed that the inflows calculated above by the Consultants are on the conservative side. It is therefore reasonable to conclude that Uda Walawe can satisfactorily meet the water requirements of the 12,350ha on the RB and 14390ha (which includes the additional 9240ha) on the LB. Cultivation success depends on adopting stringent water management and crop diversification to include other food crops. The flexibility of operation of the Samanalawewa Hydropower Project by the C.E.B. to suit demands under Uda Walawe as in the case of hydropower projects in the Mahaweli system, enhances this position. Table 4 gives the representative rainfall end storage of Uda Walawe and water issue to crops on a monthly basis for cultivation years 1986/87 to 1990/91.

3.5 Availability of Water and Proposed Cropping Pattern

A summary of the availability of water and the proposed cultivation patterns in the systems studied above is given in Table 5. Two scenarios have been considered for computation of crop water requirement for paddy assuming

i. current duties of water (Annex I)
ii. only 178 mm of water for the land preparation as per the "Technical Guidelines for Irrigation Works" by A.J.P. Ponraj (application efficiency as 55% and conveyance efficiency as 70%) - (Annex II).

For OFCs, crop water requirement was computed using data from Agriculture Department - (Annex III).

Last 2 rows of the table 5 illustrates the incremental benefits from changes in cropping intensity. This is evident in System C where 10,200 ha can be brought under cultivation for a 3rd crop, 4,690 ha in System G and 5,770 ha under Kalawewa.

With the economies predicted using 178 mm water only for land preparation a 3rd crop is not feasible under Kandalama, Dambulu Oya or Uda Walawe. Even though a third crop is not feasible there is an increase in the total extent cultivated.

3.6 Land Preparation

This is another important aspect that cannot be overlooked. This should be included in the main objective under improvement of farmers technical knowledge of increased soil productivity, erosion control and judicious water management. This will help in the long term sustainability of agricultural production.

Land preparation using minimum water of 178 mm (7") as per "Technical guidelines for Irrigation Works" by A.J.P. Ponraj (application efficiency 55% and conveyance efficiency as 70%) should be rigidly practiced if incremental benefits from changes in cropping intensity is to be a reality and a third crop a possibility.

Training of farmers in agricultural techniques and soil protection measures will be of lasting benefit. Removal of top soil during land preparation should be avoided. Farmers should be encouraged to undergo training and as an incentive, they could be compensated for their time spent during training.

Dry ploughing is still being practiced in the North and East successfully, hence there is no reason why this cannot be practiced in the south, except for the fact that farmers in the south had got used to inundation irrigation from time immemorial and depended heavily on the water storage in to reservoirs and did not make maximum use of the rain.

If the practice of using 178 mm of water for land preparation can be effectively practiced, an year round irrigation will be a possibility in the Mahaweli systems and where a 3rd crop is not recommended, certainly an increase in the total extent cultivated could be achieved transforming the landscape into flourishing form lands.

3.7 Drainage Facilities

Provision of drainage facilities is needed for almost all irrigation schemes. Sound irrigation embodies sound drainage. Under OFC, Water logging of the plant root zone for extended periods can cause loss of yield or even crop failure. The aim of drainage is to remove the unwanted water in order that soil structure and aeration are maintained and access to the field for cultivation and harvesting is possible.

Surface drainage is needed to cope with intense storms to effectively drain the rainfall in excess of the crop requirements and thus avoid water logging and for the collection and disposal of surface irrigation run-off.

The drainage channels in systems C,G, and H and in Uda Walawe except in certain sections near Hungama, were considered to be adequate to accommodate the excess water both under irrigation and during average storm run-off.

Since the most commonly found soils in the Mahaweli areas were RBE, well drained and imperfectly drained, surface drainage was not a major problem and existing drainage channels did not show signs of major erosion. However, clearing of drainage canals once in about 3 to 4 years will be useful.

3.8 Water Logging

Generally the landscape in all these 4 systems are similar, undulating with slopes generally ranging from 0 to 5 percent, where erosional remnants are common and water ways deeply incised. The surface drainage therefore, functions efficiently and poorly drained LHG soils are comparatively less. For example the southern end of Uda Walawe Area where the slopes ranges from 0-8 % gets water logged and this leads to build-up of salinity. Even in the Mahaweli Systems studied, in this report there are smaller extent of low lying area where water logging takes place due to soil erosion, water run-off and seepage. Poor drainage being the main cause. Hence, due to salinisation these sections of the land loses much of its productivity. Therefore, good planning, constant supervision and control is necessary to identify problem areas and deal with them before they become unmanageable. If not this can result in waste of scarce water, salinisation, water logging and possibly the spread of water borne diseases.

To prevent this, efficient drainage systems are vital. Seepage losses can be prevented by lining weak sections.

Here again, training plays are important role. Farmers must know how to operate and maintain the system, how to grow crops using minimum water necessary and which crops are salt tolerant and require less water.

Table 1

System C - Climatic Conditions

Year 1986/87	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total Oct. - Mar.	Apr.	May	Jun	July	Aug	Sept.	Total Apr-May	Total Water Year
1. Representative rainfall in Project Area mm															
2. End Storage in Ulhitiya Rathkinda mcm	131.0	102.0	144.0	145.0	140.0	146.0		144.0	107.0	94.0	98.0	101.0	124.0	668.0	
3. Water issues to crops mcm	8.7	69.1	45.2	47.1	55.0	22.3	247.4	0.0	0.64	0.66	0.49	0.59	0.09	2.37	249.77
Year 1987/88															
1. Representative rainfall in Project Area mm															
2. End Storage in Ulhitiya Rathkinda mcm	142.0	128.0	126.0	125.0	126.3	141.8		143.0	95.0	104.3	103.4	116.6	146.3		
3. Water issues to crops mcm	16.7	43.5	41.9	42.5	45.4	5.3	195.3	11.8	74.2	65.6	60.3	55.8	6.0	273.8	469.1
Year 1988/89															
1. Representative rainfall in Project Area mm	126.6	185.7	480.7	245.6	0.0	67.1	1105.7	11.4	150.4	18.2	62.3	2.0	18.0	262.3	1368.0
2. End Storage in Ulhitiya Rathkinda mcm	106.6	74.2	148.7	141.1	132.2	138.1		146.1	102.4	101.5	133.4	123.3	144.4		
3. Water issues to crops mcm	32.3	84.4	54.1	40.8	76.1	38.9	326.6	12.8	86.8	82.8	67.4	73.4	23.2	346.4	673.0
Year 1989/90															
1. Representative rainfall in Project Area mm	99.3	474.2	194.2	193.2	0.0	108.0	1068.9	10.0	22.5	0.0	0.0	0.0	71.1	103.6	1172.5
2. End Storage in Ulhitiya Rathkinda mcm	138.3	146.0	141.8	140.0	138.3	148.7		141.8	145.3	131.7	129.5	137.1	140.9		
3. Water issues to crops mcm	34.7	80.5	69.7	Not Available		15.1		61.0	99.2	92.8	90.5	59.9	NA		
Year 1990/91															
1. Representative rainfall in Project Area mm	191.7	238.9	666.5	488.7	24.1	144.7	1754.6	134.5	38.0	119.0	0.0	28.0	56.5	376.0	2130.6
2. End Storage in Ulhitiya Rathkinda mcm	110.0	88.0	141.8	136.2	111.9	146.5		106.4	100.3	119.7	118.2	124.4	117.8		
3. Water issues to crops mcm	33.5	91.7	27.7	55.3	69.3	10.9	228.4	40.5	120.1	87.5	93.8	77.5	9.7	429.0	657.4

Source : Water Management Secretariat of the Mahaweli Authority of Sri Lanka (November 1992)

Note:

1. Capacity of Ulhitiya Rathkinda at F.S.L. is 146.0 mcm
2. Minimum operation capacity for diversion to Maduru Oya is 100.0 mcm
3. Minimum operation capacity for irrigation is 63.4 mcm

System G - Climatic Conditions

Table 2

Year 1986/87	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total Oct. - Mar.	Apr.	May	Jun	July	Aug	Sept.	Total Apr-Sept	Total Water Year
Year 1986/87															
1. Representative rainfall in Project Area mm															
2. Water issues to crops mcm								6.4	14.4	21.3	15.9	16.8	4.5	79.3	
Year 1987/88															
1. Representative rainfall in Project Area mm	0.0	25.5	18.5	15.1	14.1	5.1	78.2	0.0	23.6	25.5	23.3	20.9	0.0	93.3	171.5
2. Water issues to crops mcm	451.9	186.4	255.7	48.3	30.9	103.1	1076.4			Not available					
Year 1988/89															
1. Representative rainfall in Project Area mm	2.6	0.0	13.3	9.9	9.5	9.4	44.7								
2. Water issues to crops mcm			Not available					Not available							
Year 1989/90															
1. Representative rainfall in Project Area mm	0.0	30.2	26.1	20.7	21.0	11.6	109.6	0.0	25.5	23.7	24.6	23.9	10.7	108.3	217.9
2. Water issues to crops mcm	203.8	444.7	169.9	277.2	167.4	92.1	1355.1	33.0	102.3	0.0	0.0	37.16	101.6	274.6	1629.7
Year 1990/91															
1. Representative rainfall in Project Area mm	5.0	35.3	18.7	18.7	23.2	18.0	118.8	7.0	25.5	21.4	25.8	24.7	8.6	113.1	231.9
2. Water issues to crops mcm	409.9	291.8	449.8	197.8	0.0	108.4	1457.7	40.0	53.3	48.3	2.5	40.4	38.2	222.7	1680.4

Source : Water Management Secretariat of the Mahaweli Authority of Sri Lanka.

Table 3

System H - Climatic Conditions

Year 1986/87	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total Oct. - Mar.	Apr.	May	Jun	July	Aug	Sept.	Total Apr-May	Total Water Year
1. Representative rainfall in Project Area mm															
2. End Storage in Kandalema Tank mcm	13.7	6.5	8.9	9.5	5.9	4.4		31.6	21.4	10.4	9.7	5.9	5.8		
3. Water issues to crops from Kandalama Tank mcm	2.2	14.9	6.4	8.2	7.5	5.0	44.2	6.1	11.9	11.2	11.8	8.7	1.4	51.0	95.2
4. End Storage in Dambulu Oya Reservoir mcm			Not Recorded								Not Recorded				
5. Water issues to crops from Dambulu Oya Reservoir mcm	3.1	10.8	5.4	4.3	5.7	2.0	31.3	3.2	7.8	6.7	6.6	6.3	2.0	32.5	63.8
6. End Storage in Kalawewa Tank	103.9	33.5	44.4	48.2	26.2	12.4		95.1	82.3	62.7	33.2	16.4	53.9		
7. Water issues to Crops etc. from Kalawewa Tank mcm	31.1	118.7	74.2	68.5	64.1	33.2	389.8	47.2	67.9	70.4	72.8	69.1	2.7	330.1	719.9
Year 1987/88															
1. Representative rainfall in Project Area mm	406.3	169.0	90.1	15.1	2.4	45.9	728.8								
2. End Storage in Kandalama Tank mcm			Not Estimated					5.0	12.1	9.0	6.8	3.4	3.5		
3. Water issues to crops from Kandalama Tank mcm	0.0	3.4	9.3	10.8	11.3	5.4	40.2	0.0	1.2	4.7	4.2	3.9	0.3	14.3	54.5
4. End Storage in Dambulu Oya Reservoir mcm			Not Recorded								Not Recorded				
5. Water issues to crops from Dambulu Oya Reservoir mcm	0.0	0.0	6.3	5.5	5.3	1.9	18.9	0.1	1.7	2.9	3.3	3.0	0.7	11.7	30.6
6. End Storage in Kalawewa Tank	70.8	110.1	84.7	59.6	22.2	14.2		35.2	57.1	47.6	27.6	18.0	5.9		
7. Water issues to Crops etc. from Kalawewa Tank mcm	0.0	49.1	86.7	83.0	77.9	37.3	334.0	0.0	30.2	38.0	40.4	36.8	12.1	157.5	491.5
Year 1988/89															
1. Representative rainfall in Project Area mm	37.3	162.0	111.9	107.5	0.0	51.4	470.1	93.9	19.5	34.4	107.5	0.0	22.0	277.3	747.0
2. End Storage in Kandalama Tank mcm	3.4	9.4	12.7	15.1	4.8	7.5		6.1	5.1	9.0	13.6	10.9	7.9		
3. Water issues to crops from Kandalama Tank mcm	0.0	0.0	6.1	10.1	11.5	10.5	38.2	0.0	0.0	5.8	3.2	7.2	6.0	22.1	60.3
4. End Storage in Dambulu Oya Reservoir mcm			Not Recorded								Not Recorded				
5. Water issues to crops from Dambulu Oya Reservoir mcm	0.5	6.6	6.7	6.7	6.5	4.1	31.1	0.0	4.3	4.1	4.1	6.6	2.8	21.8	52.9
6. End Storage in Kalawewa Tank	50.6	63.8	40.2	61.5	42.4	20.7		27.1	20.2	15.8	47.3	65.0	92.6		
7. Water issues to Crops etc. from Kalawewa Tank mcm	13.2	29.8	92.5	63.7	69.9	68.8	337.9	0.0	4.0	10.3	14.3	25.1	0.0	53.7	391.6

Table 3 (Contd.)

System H - Climatic Conditions

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total Oct. - Mar.	Apr.	May	Jun	July	Aug	Sept.	Total Apr-May	Total Water Year
Year 1989/90															
1. Representative rainfall in Project Area mm	123.9	400.7	33.6	194.5	38.5	150.9	942.1	120.7	120.9	0.1	0.8	118.7	84.8	446.0	1388.1
2. End Storage in Kandalama Tank mcm	17.8	16.7	19.2	20.9	15.0	25.6		32.4	25.4	14.9	11.7	11.4	10.6		
3. Water issues to crops from Kandalama Tank mcm	4.7	10.4	11.2	11.7	12.1	3.3	53.4	0.0	8.6	11.2	13.2	8.8	5.8	47.5	100.9
4. End Storage in Dambulu Oya Reservoir mcm			Not Recorded								Not Recorded				
5. Water issues to crops from Dambulu Oya Reservoir mcm	1.1	6.8	6.5	4.2	6.2	1.6	26.4	0.0	4.3	5.1	5.1	3.2	2.1	19.8	46.2
6. End Storage in Kalawewa Tank	30.3	112.1	74.9	73.8	74.8	117.1		95.7	91.5	80.4	63.0	51.5	65.6		
7. Water issues to Crops etc. from Kalawewa Tank mcm	107.6	68.4	78.0	77.1	78.0	4.6	413.7	21.5	61.1	60.9	68.7	58.5	31.3	302.0	715.7
Year 1990/91															
1. Representative rainfall in Project Area mm	384.4	129.5	156.9	201.8	1.5	51.2	889.3	63.7	59.2	69.2	4.0	53.9	69.9	319.9	1209.2
2. End Storage in Kandalama Tank mcm	15.6	8.2	22.0	30.8	19.5	12.0		13.8	10.3	8.7	11.0	8.7	5.9		
3. Water issues to crops from Kandalama Tank mcm	2.0	13.5	6.2	11.2	13.7	8.1	54.7	1.6	6.6	5.5	8.4	7.9	2.3	32.3	87.0
4. End Storage in Dambulu Oya Reservoir mcm			Not Recorded								Not Recorded				
5. Water issues to crops from Dambulu Oya Reservoir mcm	0.6	7.9	3.9	4.1	7.0	3.8	27.3	0.2	3.5	2.4	3.5	4.1	0.9	14.6	41.9
6. End Storage in Kalawewa Tank	103.0	66.1	105.6	100.4	57.7	62.2		92.4	25.6	43.2	36.2	30.4	43.2		
7. Water issues to Crops etc. from Kalawewa Tank mcm	57.4	111.4	65.9	84.1	98.8	32.6	460.2	5.6	70.8	43.4	59.1	58.9	32.8	270.6	730.8

Source : Water Management Secretariat of the Mahaweli Authority of Sri Lanka (November 1992).

Note:

(1) Capacity of Kandalama tank at F.S.L. is 33.8 mcm
(2) Minimum operating capacity for irrigation is 3.8 mcm
(3) Capacity of Dambulu Oya tank at FSL is 11.7 mcm
(4) Minimum operating capacity for irrigation is 5.4 mcm
(5) Capacity of Kalawewa tank at FSL is 123.7 mcm
(6) Minimum operating capacity for irrigation is 15.0 mcm.

Udawalawe - Climatic Conditions

Table 4

Year 1986/87	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total Oct. - Mar.	Apr.	May	Jun	July	Aug	Sept.	Total Apr-Sept	Total Water Year
1. Representative rainfall in Project Area mm	190.24	99.31	242.19	45.72	8.89	152.90	739.55	197.86	25.57	44.45	-	127.50	44.19	439.57	1179.12
2. End Storage in Udawalawe mcm	180.6	160.4	146.8	114.4	78.0	91.5		142.2	166.0	128.5	77.7	53.8	53.7	282.6	583.9
3. Water issues to crops mcm	25.0	70.8	63.7	71.2	48.5	22.1	301.3	18.0	61.2	64.3	60.8	52.9	25.4	-	-
Year 1987/88															
1. Representative rainfall in Project Area mm	325.37	182.62	226.06	66.04	162.05	258.06	1220.2	223.34	25.65	76.2	22.09	46.22	120.65	514.15	1734.35
2. End Storage in Udawalawe mcm	194.7	282.8	252.0	212.0	203.9	249.7		255.7	257.6	217.6	180.6	142.7	162.1		
3. Water issues to crops mcm	3.2	65.8	56.9		33.9	3.6		13.1	38.6	35.3	40.1	37.7	8.4	173.2	
Year 1988/89															
1. Representative rainfall in Project Area mm	157.98	312.16	196.50	34.29	17.27	58.67	776.07	211.58	95.50	39.75	83.79	49.62	52.33	532.57	1308.64
2. End Storage in Udawalawe mcm	115.0	242.3	244.9	201.3	157.5	165.6		133.9	117.5	113.4	117.2	85.8	86.6		
3. Water issues to crops mcm	39.6	24.5	30.4	38.4	26.5	6.8	165.5	16.9	39.6	33.4	32.4	36.0	12.7	171.0	336.5
Year 1989/90															
1. Representative rainfall in Project Area mm	196.95	203.63	43.17	102.90	132.35	21.04	700.04	59.21	114.6	20.51	30.27	3.3	21.33	249.22	949.26
2. End Storage in Udawalawe mcm	87.9	184.3	158.9	133.9	108.9	198.7		242.6	238.3	210.0	160.0	96.9	76.6		
3. Water issues to crops mcm		34.1	34.3	36.7	35.4	9.5	150.0	31.3	41.3	42.4	44.6	37.0	13.1	209.7	359.7
Year 1990/91															
1. Representative rainfall in Project Area mm	264.79	333.35	122.14	144.03	29.46		893.77	140.22	69.33	98.63	27.10	47.02	72.75	455.05	1348.82
2. End Storage in Udawalawe mcm	146.7	252.0	242.7	243.8	196.1	221.1		239.3	239.3	244.8	193.0	141.2	118.9		
3. Water issues to crops mcm	11.7	30.3	32.7	37.2	33.1	15.7	160.7	37.3	95	82.5	98.6	74.3		387.8	548.0

Flow Monitoring Unit - MEA - Udawalawe

Note:

1. Capacity of Udawalawe at FSL is 268.9 mcm
2. Minimum operation capacity for irrigation is 28.3 mcm

Table 5

Year Round Irrigation - Availability of Water & Proposed Cropping Pattern

Irrigable area			System C 21675 ha	Sys G 5400 ha	Kandalama 4900 ha	Dambuluoya 2160 ha	Kalawewa 24640 ha	Udawalawe 17450 ha + 9240 ha	Case II
Season 91 Yala		Paddy	16100	2600	425	250	8400	10102	
		OFC	600	2100	2525	1100	7800	1675 + 2353 (Sugar)	
91/92 Maha		Paddy	16200	5000	4550	2150	23985	10636	
		OFC	NC	NC	NC	NC	665	1135 + 2353 (Sugar)	
Extents recommended on soil suitability									
		RBE %	44	70	60	60	60	37	
		LHG %	56	30	40	40	40	63	
Yala		Paddy	12138	1620	1960	864	9856	16815	8600
		OFC	9537	3780	2940	1296	14784	9875	9875
Maha		Paddy	12138	1620	1960	864	9856	16815	8600
		OFC	9537	3780	2940	1296	14784	9875	9875
Water required at current water	Yala	Paddy	303	41	45	22	246	368	188
		OFC	115	46	36	16	179	119	119?
Consumption in MCM	Maha	Paddy	247	35	25	12	164	294	151?
		OFC	105	42	36	16	183	109	107?
Total Reqd			770	164	142	66	772	890	[illegible]
Water Available MCM are of 5 year data 1986-91			732	207	98	51	761	507	507
		shortage MCM	38		-44	-15	-11	-383	-60
		excess MCM		43					
Water needed using 7" = 178 mm water for land preparation									
Yala		Paddy	244 MCM	41	39	17	198	339	173
		OFC	115	46	36	16	179	119	119
Maha		Paddy	135	17	24	11	126	205	104
		OFC	105	42	36	16	183	109	107
		Total MCM	599	146	135	60	686	772	505
		Excess MCM	133	61			75		2
		Short MCM			-37	-9		-265	
Area that can be taken up for 3rd crop of O.F.C at Q = 1.3m			10200ha	4690 ha	No 3rd Crop Reduce Yala paddy to 480 ha. but total extent increases from 4550 to 4900 in Maha	No. 3rd crop Reduce yala paddy to 250 ha	5700 ha	Reduce paddy area to 8600 ha see case II	No. 3rd crop but can work 1025 ha from extension area on L.B.
Proposed C.I.%			247	287	170	172	223		200
Present C.I. %			152	180	153	162	166	162	

4. PRESENT CROPPING PATTERN IN MAHAWELI

4.1 Scope

The present study, evaluates the optimum use of water for export oriented high value crop production, and determines the availability of water for year round irrigation in Mahaweli Systems H, C, G and Uda Walawe.

Water requirements of crops are provided in Sri Lanka primarily by rainfall, gravity and by lift irrigation. This study limits its scope to use of rain water in crop production and storage of rain water for gravity irrigation of crops. The principle normally followed in the Mahaweli systems in Sri Lanka is the use of gravity irrigation for lowland cultivation, which supplements direct rainwater use in crop production. It also refers that Mahaweli uplands and homesteads (generally, occupying 0.25 ha per farm family) need lift irrigation to supplement direct rain water use.

On account of this study's scope, emphasis will be given to determine cropping patterns in lowlands and depending on the extent of availability of water for year round gravity irrigation or otherwise, the type of export potential crops that could be economically (mainly, from point of view of overseas marketability and export prices vis a vis local cash crop prices) grown in the lowlands of Mahaweli Systems H, C, G and Uda Walawe. Nevertheless, an overview will be made on high value crops of export potential that are suitable for highlands in Mahaweli Systems.

4.2 Cropping Patterns in Mahaweli

Lowland farming takes place in family allotments and generally a family is provided with 1 ha of lowland and 0.25 ha of homestead. However, variations in farm allotments are common. For instance in Uda Walawe, a family allotment had varied from 2 to 2.5 ha of lowland and 0.5 to 2.5 ha of upland for the homestead. In System H, some farm families were given only 1 ha of lowland and non-farm families were given only 0.25 ha of homestead. In System C, 3 ha of highland had been allocated to second generation farm families for cashew growing. It is significant that those farm families who received lowland, the extent had not been less than 1 ha per family.

The Mahaweli Systems consist of four main soil types: Reddish brown earth (RBE) well drained, Alluvial soils and Low Humic Gley soils and in some blocks Reddish brown earth - imperfectly drained soils (an attempt to clearly identify different soil types in different Mahaweli Systems and Blocks are described under 'Environmental Suitability)'.

Crop production in Mahaweli project areas had been primarily subsistence; almost 100% of lowland in Maha being used for rice cultivation. In Yala, if water is made available, farmers prefer rice cultivation. In System H, water is released only to 50% of lowland (0.5 ha per farm family) for OFC cultivation. Farmers are relocated with 0.5 ha of lowland in Yala to optimise water usage. Instances are many in Mahaweli Systems, where rice was preferred in Yala (Table 6), even with limited release of water. Rice cultivation and storage carry a social prestige in farming communities in Sri Lanka and moreover, rice is comparatively an easy crop to grow.

However, emergence of semi-commercial and commercial farming is evident in Mahaweli Systems. For instance, in Systems C and H, progressive farmers have cultivated cash crops like chillie in raised beds or ridges in lowland reddish brown earths and rice had been cultivated only in poorly drained low humic gley soils ('Vagal' lands in Sinhala). Some farmers have even experimented cultivating cash crops in heavy maha rains and many had cultivated cash crops and OFCs, soon after heavy maha rains in October-December.

Table 6 : **Irrigated Cropping Pattern: Five Year Average (1987/88 to 1992 in hectares)**

	Uda Walawe		System H*		System C		System G	
	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
Paddy	10636	10392	25633	4826	14228	13674	4518	2086
OFCs	1136	1084	-	7732	2010	572	329	1977
- Chilli	102	155	-	5967	92	169	29	636
- Red Onion	26	40	-	58	19	46	4	4
- Big Onion	4	7	-	316	-	26	-	21
- Green Gram	67	19	-	207	53	67	23	618
- Black Gram	-	1	-	132	7	1	2	-
- Cowpea	26	27	-	358	92	70	14	23
- Soya Bean	-	1	-	137	5	39	1	46
- Groundnut	2	55	-	-	6	3	66	519
- Gingelly	2	3	-	-	-	-	-	-
- Maize	-	-	-	-	1564	1	93	-
- Baby corn	-	-	-	-	1	-		-
- Gherkins	-	-	-	-	3	45	-	-
- Vegetables	150	136	-	451	119	105	20	34
- Yams	-	-	-	-	47	-	40	2
- Banana	731	639	-	-	-	-	-	-
- Other	26	1	-	106	2	-	37	74

Source : Computed by TEAMS (Pvt) Ltd, from data received from Agricultural Sections of MASL offices in different Systems.

* Average of 3 years - 1987/88 to 1990.

From Table 6 it is evident that rice is still an important crop in Uda Walawe and System C; farmers have resorted to rice in Yala, even with limited supply of water. However, this phenomenon is changed in System G and the change is more evident in System H, where only half the lowland extent per farm family (0.5 ha) is permitted to be cultivated in Yala and farmers have taken advantage to grow cash crops such as chilli and big onions.

In Uda Walawe and System C, the extents under rice production in Maha and Yala have been almost the same, respectively. In System G and H, less than 50% of the total maha extent had been cultivated with rice in yala; cultivation of other field crops had been significant, compared with Uda Walawe and System C.

The most popular field crops during maha have been Vegetables (including exotic vegetables, since of late) and maize. Vegetable cultivation is equally popular in Yala. Maize is an easy crop in Maha. Chilli is the most popular in Yala.

Each System seems to specialise in a crop or two. In Uda Walawe, Banana had been an important crop throughout the year, followed by vegetables and chilli. In System C, maize and vegetables are the most popular in Maha and chilli in Yala. Banana and Maize are easy crops. Chilli, Red Onion, Big Onion, Green Gram and Cowpea are increasing in popularity in Uda Walawe and System C. Gherkins and Baby corn, the newly introduced cash crops were also seen in System C.

Chilli is the most popular cash crop in System H in Maha and Yala. Vegetables, big onions, cowpea, green gram and black gram are the other crops of importance. Gherkins have also been grown in Yala but without success due mainly to marketing problems.

In System G too, chilli is the most popular, followed by green gram and groundnut.

During interviews with farmers, it was revealed that farmers have adapted well to new technology involved in the cultivation of new introductions, Gherkins and Baby Corn. Farmers economically evaluate new introductions vis a vis chilli and sometimes big onion. Both these new crops are more popular in the highlands of these Systems (except System G). Lowland outgrower cultivation of Gherkins and Baby corn have not been successful, due mainly to marketing problems. It is also seen that Black gram, Groundnut and Gingelly, which are export commodities, are unpopular among farmers, primarily because the returns are less when compared with Chilli or Big Onions. Any plans to grow these three export commodities should be backed up by package of new technology that is acceptable to the farmers and also will optimize returns. In this respect, introduction of these commodities as a relay/sandwich crop should be investigated.

4.3 Crop Recommendation and Cropping Pattern

The Department of Agriculture, Sri Lanka, in its publication (1990) 'Agrotechnical Information' had recommended crops, according to agro-ecological regions in Sri Lanka. The present study, while following the principals of Crop Recommendations laid down by the Department of Agriculture, have investigated the irrigated lowlands and the uplands (in accordance with the TOR of the present study) and have adjusted the Cropping Calendar with the intention of introducing export crops and increasing the cropping intensity based on past data and soil and climatic factors and marketability in the respective Mahaweli systems. The alterations will only be worthwhile if there is adequate irrigation water to supplement rainfall. This aspect has been studied in detail and is given separately in the study.

A comparison of Table 6 and 7 will show that the cropping pattern in irrigated lowlands have followed the crop recommendations except in few instances. During Maha, the recommendations suggest only Chilli, Green gram and Soya beans for the Systems. However, many field crops have been grown, especially maize and vegetables. This is an indication that well drained reddish brown lowlands of the Systems, can be used to cultivate a range of short term cash/field crops even during maha by adapting to good land preparation and cultivation periods. This is specifically evident in Uda Walawe, where Maha cultivation of Chilli, Red Onion, Big Onion and Vegetables have been significant, compared with Yala extents. Though economics of other field crops in Maha have not been evaluated, it is assumed that farmers' adoption of new technology are based on economics carried out by farmers on a 'trial and error' approach, for a period of time.

Table 7 : Crop Recommendations - Irrigated Upland and Lowlands

Mahaweli System	Group**	Irrigated Lowland* Maha	Irrigated Lowland* Yala	Irrigated Upland* Maha	Irrigated Upland* Yala	Perennial
H and G	i	Rice	Rice	Chilli	Chilli	Banana
		Chilli	Chilli	Red Onion	Gherkins	Grapes
			Gherkins	-	Big Onion	-
			Big Onion	-	Red Onion	-
			Red Onion	-	-	-
	ii	Greengram	Blackgram	Capsicum	Capsicum	Banana
		Soyabean	Cowpea	-	-	Mango
		Greengram	-	-	-	Papaya
		Soyabean	-	-	-	-
	iii	-	-	-	-	Cashew
						Castor
						Coconut
						Lime
C	i	Rice	Rice	Chilli	Chilli	Banana
		Chilli	Chilli	-	Gherkin	Grapes
			Gherkin	-	Big Onion	-
			Big Onion	-	Red Onion	-
			Red Onion	-	-	-
	ii	-	Greengram	Capsicum	-	Banana
			Soyabean	-	-	Mango
	iii	-	Brinjal	-	-	Coconut
			Cucurbits	-	-	Lime
			Okra	-	-	Cashew

Mahaweli System	Group**	Irrigated Lowland* Maha	Yala	Irrigated Upland* Maha	Yala	Perennial
Uda Walawe	i	Rice	Rice	Chilli	-	Banana
		Chilli	Chilli	Red Onion	-	Banana
			Big Onion	-	-	-
			Red Onion	-	-	-
			Gherkin	-	-	-
	ii	Capsicum	Cowpea	-	-	Coconut
		Cowpea	Greengram	-	-	Lime
		Greengram	Groundnut	-	-	Mango
		Groundnut				
		Soyabean	Soyabean	-	-	-
	iii	-	Sweet Potato	-	-	Cashew

* Irrigated Lowland: Valley lands, bottom lands, terraced lower slopes of hills and upland's where the dominant land use is under gravity irrigation.
Irrigated Upland : Uplands with well drained soils, irrigated by lifting water from wells, rivers, channels or streams and not gravity fed.

** Group i : Crops important for national food security, crops with high profitability and crops with a high export potential.

Group ii : Crops capable of providing moderate to high returns, crops important for a particular region for some special reason and crops that are in demand locally.

Group iii : Crops important for local food security and crops that provide relatively by low profits.

Source : Agro-technical Information, Department of Agriculture, 1990.

Yala in irrigated lowlands is the best season for other field crops even in Reddish brown imperfectly drained and alluvial soils. This is evident by the fact that as recommended,many field/cash crops have been grown successfully in Yala in lowlands.

Irrigated uplands are again useful for any field crops, provided water by lift irrigation is available, especially in Yala. Cultivation of Big Onions, Gherkins and Baby corn is not recommended in Maha even in irrigated uplands. Perennial export crops such as Banana, Grapes, Mango, Papaya, Cashew and Castor have been recommended for uplands with lift irrigation facilities. Some of these, such as Banana and Cashew have already been grown in commercial scales. Especially in the cultivation of perennial crops, adequate attention should be given to soil depth, water table height, soil pH, infiltration and drainage properties, wind velocity and temperature variations because soil and climatic factors have an influence on crop growth as well as on the quality of the final product. These factors will be discussed in detail in selecting export oriented crops, suitable for the Mahaweli Systems under study. The perennial crops already grown on a commercial scale in the Mahaweli uplands are identified in Table 8. This table also includes short-term export crops grown in upland conditions.

Table 8: <u>Perennial and Short Term Crops of Export Potential in Mahaweli Uplands-Lift Irrigated</u>

Mahaweli System	Crop	Extent (ha)	Ownership	Remarks
Uda Walawe	*Mulberry	38	Star Silk Pvt. Ltd.	
	*Gherkins and Fruit	20	Aitken Spence Ltd.	
	Gherkins	20	C.P.H. Agro Products Pvt. Ltd.	
	Jojoba	100	Mahaweli Farms Development Pvt. Ltd.	
	Banana	20	S.A.M. Naja & Farook	
H	Oil Seeds	10	Lakcraft Associates Pvt. Ltd.	
	Seeds	10	Illeperuma & Co.	
C	Gherkins and Pepper	8	C.J. Karunaratne	
	Gherkins and Grapes	20	Vanathawillu Vineyard	
	Gherkins	20	Volanka Ltd.	
	Cashew and Cash Crops	400	Informatics Pvt Ltd.	
	Fruits and Vegetables	10	Agroline Process Systems Ltd.	
		20	CTC	
G	Nil			

* Gravity irrigated

Source : Mahaweli EIED Division, Colombo.

4.4 Lands not Suitable for Irrigated Agriculture

Some soils in lands leased to investors/farmers are not suitable for irrigated agriculture. There are in the Mahaweli Systems small extents of lands that fall into this category and depend only on rain.

Land surveys should be carried out and such lands identified, blocked out and earmarked for conservation programmes focused on improving the vegetative cover to arrest soil and land degradation. Reforestation programmes should be planned. First trees could be grown, planting fodder and developing pasture land for livestock farming could be encouraged as viable commercial ventures.

4.5 Factors Influencing the Selection of Export Crops

Correct selection of export crops is an important exercise which will influence the success of the project. For each selected criterion, a 'high value', 'average value' and a 'low value' was given. All commodities were evaluated and those scoring more 'high values' (3 or above) were considered to be more suitable for commercial cultivation in Mahaweli systems, in lowlands and in uplands, respectively. (The extents of land available in Mahaweli systems under study, for year round gravity irrigation and uplands for lift irrigation will be discussed in detail, separately). The range of crops that have been selected for Mahaweli lowlands (with year round gravity irrigation facilities or otherwise) and uplands have not been ranked by a scoring system as it is beyond this study. Existing methodologies that are available in selecting priority products/commodities such as that of 'Export Marketing Strategies' by S.R. Daines of SRD Research Group, USA, undertaken on behalf of EIED Division of MASL, 'Labour absorption and Import Intensity of the Sri Lankan Export Selector', an ad-hoc study of Sri Lanka Export Development Board (EDB) and 'Examination of Priority Export Products and Identification of New Export Products for Development and Promotion in Sri Lanka', by S. Kelegama and G. Wignaraja, undertaken on behalf of EDB, have been extensively referred in arriving at the selection criteria of the present study. Following are the criteria selected for selection of commodities for the Mahaweli systems.

4.6 Marketability

Marketability is highly volatile and what is marketable today may be out of date tomorrow. Consumer demand is not static and can be influenced both by market promotion and by the supply of high/special quality produce. Moreover, Asian fresh produce in European markets are expanding very rapidly: an increasing number of outlets stock a wide range of fruits and vegetables indigenous to Asia and a greater section of the population are going for non-traditional fruits and vegetables. With the increase in demand in this highly perishable sector, overseas competitiveness is inevitable. Domestic market at these instances can be the only steady outlet.

Under 'Marketability', following criteria can be considered in selecting priority Mahaweli commodities:

4.6.1 Comparative advantages

(a) Geographical location

Sri Lanka, is centrally located to Europe and Pacific countries, the two major markets for fruits and vegetables. However India (Madras), Sri Lanka's main competitor for fruits and vegetables from South Asia, has a slight distance advantage to all destinations, except Australia (Table 9). The main South East Asian competitors, namely; Thailand, Malaysia and Philippines have a distance advantage only to the Pacific Rim i.e. Japan and Australia.

Table 9 : Air Distances to Major Regions (miles)

	Europe (London)	Japan (Tokyo)	ME (Riyadh)	Australia (Sydney)
Sri Lanka	5412	4256	2505	5429
India (Madras)	5101	3984	2324	5663
Thailand	5921	2862	3562	4677
Malaysia	6551	3306	3937	4105
Philippines	6665	1861	4822	3893

The importance in distance is that it is likely that depending on the distance freight rates will also change (discussed later).

(b) Non-tariff Barriers

Some of the non-tariff barriers such as preference for long established trade relationships, ethnic trade relationships and product quality specific trade relationships cut off price competition for trade preferences. Out of possible Mahaweli products, only Cashew exists with some links to Europe and Pacific Rim. However, such trade links are common to Middle East, in regard to Sri Lanka's fruits and vegetables.

(c) Export Service Facilities:

There are many facilities which assist exports to reach the destination on time, in perfect form and in cost effective manner i.e. Simplification of Export Documentation, pre and post shipment finance at competitive rates, packing and packaging know-how and facilities, port facilities and efficiency etc. In this study, only two aspects, namely air and shipping freight frequency to Europe, Pacific Rim and Middle East and Export Market Intelligence have been considered.

The former is considered important especially for fruits and vegetables which are perishable. A commodity like strawberries which has a shelf life of only 8-10 days, air freight frequency and efficiency in handling and transportation are very important. Sweet Melons and Tomato can have a shelf life of 2 weeks and Asparagus, Mango and Papaw upto 3 weeks. Air and Shipping frequencies are given below.

Table 10: Sri Lanka's Weekly Frequency of Air and Shipping Facilities
(Dec. 14th to Dec. 21st '92)

	Europe (Felixstowe)	Australia (Sydney)	Japan (Tokyo)	Middle East (Dubai)
Sea Freight	14	14	9	7
Air Freight (direct)	4 (London)	2	3	9

Source : Daily Shipping List, Air Lanka

Given the low priority for air space for fruit and vegetable cargo and the high air freight rates, sea freight should be encouraged, at least till the time air freight facilities become efficient and competitive (air freight of fruits and vegetables has been a problem for some time inspite of repeated requests to air cargo authorities for better terms and conditions). Under these circumstances, fruits and vegetables with longer shelf lives (at least more than 2 weeks) are more suitable for the export market from point of view of the Sri Lankan situation.

The latter, Export Market Intelligence is the source for market and price information. The best source of market intelligence in Sri Lanka is the ITC, Geneva, sponsored weekly, 'Market New Service' for fruits and vegetables and other commodities. Sri Lanka lacks information from other sources such as the U.S. Department of Agriculture publications, USA based United Fresh Fruit and Vegetable Association publications and Agra Europe publication on Fruit and Vegetable markets. These publications will provide information on a given format. Europe and Pacific countries are fast changing their consumer habits; the number of fresh commodities imported presently to Europe has increased tremendously from what it was a decade back. For instance, Europe now enjoys tropical vegetables, capsicum, chilli (including bird's eye chilli), okra and egg plants and fruits - rambutan, mangosteen, special banana, carambola and durian. There are many more Sri Lankan fruits and vegetables that can become specialties very soon - snake gourd, lufa, young jak, bread fruit, king coconut, bird's eye chilli (for capsaicin extraction), specialty pineapple (mauritius), specialty mango (villard) etc. The information on importers of specialty and new fruits and vegetables must reach producing countries fast; the available publications with a given format will not provide such information. Like India and Malaysia, Sri Lanka should also have specialists representing exporters, stationed in target markets for such information. Presently, Sri

Lanka receives only 'leaked' information such as on bird's eye chilli and specialty banana (apple banana for which Sri Lanka responded with ambul banana).

This factor, Export Market Intelligence, though decisive in achieving comparative advantages, cannot at present be used fully to introduce new products to overseas markets.

4.6.2 Competitive advantage

(a) Export Service Facilities - Competitive air and sea freight rates:

Given the world market price, the cost of production and air freight rates when added up (C and F) leaves little attraction to the exporter from point of view of net profits (i.e. specialty banana). This is inspite of fresh fruits and vegetables receiving a concessionary air freight rate to Europe and Middle East. Sea freight in reefer containers becomes the only alternative; but it will limit to only long shelf life (at least over 2 weeks) varieties.

Sri Lanka (and Madras, India) have a distance advantage to Europe and Middle East (Table 9). The freight rates are given in Table 11A & 11B.

Table 11A : Air Freight Rates from Sri Lanka (US$)

Container Type	Weight Range	Cargo Description	To LONDON	To DUBAI	To TOKYO
LD3 container	100-300 kg	G.C./kg	-	1.98	2.50
	300-500 kg	G.C./kg	2.49	1.60	2.30
	above 500 kg	F and V/kg	1.24	0.82	-
		G.C./kg	2.20	1.10	2.20
	Pivot weight (760 kg)	G.C./Con.	1600	836	1500
	Over Pivot Rate	G.C./kg	1.25	0.55	1.00

SL - Sri Lanka; Mad - Madras; B'kok - Bangkok; KL - Kuala Lumpur; GC - General Cargo; F and V - Fruits and Vegetables; Con.- Container; kg - Kilogram; Pilot Weight - 760 kg for LD3 container; Over Pilot Rate - Freight Rate over the Pilot Weight.

Source : Air Lanka.

Table 11B: Sea Freight Rates from Sri Lanka (US$)

Container Content	Cargo Description	To FELIXSTOWE	To DUBAI	To TOKYO
FCL per	Dry	1150	800	750
20 Footer	Reefer	3075	3450	2000
	(less 2°C)			
	3250	-	-	
	(more 2°C)	-	-	
LCL per	Dry	120.63	6882	66.00
CBM**	Reefer	128.48	113.73	136.84

FCL - Full Container Load; LCL - Less Container Load; * Sea Freight Rate per 40 footer; ** all inclusive rates, after adding Currency Adjustment and Bunker Adjustment Factors.

Source : Central Freight Bureau.

Freight rates which add 50% or more to the C and F price, is an important cost factor in determining price competition. As such, at present Sri Lanka should give more weight to produce/commodities which could be shipped break bulk or in reefer containers in order to be more cost effective. Under this criterion, non-perishable foods such as cashew, blackgram, groundnut, dried bird's eye chillies and long shelf life fresh produce such as grapes, pineapple, and mango, can have a distinct advantage over the easily perishables.

(b) Tariff barriers

Import tariffs have been introduced by importing European countries in order to protect their own fruit and vegetable industry. With the establishment of the Single European Market in 1992, it is expected that protectionism will further increase in order to safeguard two European Community member countries, Spain and Portugal, large exporters of fruits and vegetables to the European Community. In addition, with the expansion of the European Community market, the chances for small scale producers may diminish.

However, the EEC has offered preferential tariffs to Commonwealth countries. They benefit under three categories: those available to Africa, Caribbean and Pacific (ACP) countries, the Generalized Systems of Preferences (GSP), or those available to Leased Developing Countries (LDCC). The rules of origin covering the ACP countries are more straight forward than those governing GSP, so, where both systems offer the same tariff, an exporter would generally opt for ACP. In addition, ACP countries' tariff concessions are generally much larger than the GSP countries. The tariff structures can also vary also vary from season to season; during lean seasons tariffs are lessened to encourage imports, again, tariffs of ACP countries are reduced more than GSP countries.

Most of Sri Lanka's competitors from the same region, India, Thailand and Malaysia and from other regions such as Brazil, Cyprus, Colombia, China, Chile and Egypt are GSP countries and Kenya, Jamaica and Nigeria are the important competing ACP countries.

Tariff rates for GSP countries for the same commodity vary among the EEC countries. It roughly varies from zero for mango and papaw in Germany to 16% in the UK peak season for Asparagus. GSP tariffs for fruits are generally lower (between zero to 9% except strawberries 12-16%) than for vegetables (between 5% for chilli in UK to 16% for peak season Asparagus and Courgettes to a maximum of 18% for cherry tomato in Germany in peak season). Also, EEC countries provide preferential tariffs for identified countries such as the preference given by Germany to Israel, Turkey and Cyprus, all important competing countries for Sri Lanka.

(c) Non-tariff barriers

Phytosanitary and health restrictions, quotas, strict labeling and packaging specifications are the common non-tariff barriers. Fruit and vegetable imports should comply to the European Community Quality Standards for European countries and sometimes to the Commercial Grades Law for fresh fruits and vegetables in Germany.

The Food laws restrict the use of pesticides on fruits and vegetables. It lists the type of pesticides and the type of plants for which the individual pesticides are permitted to be used.

All fresh fruits entering the EEC countries must be accompanied by the original of a phytosanitary certificate, submitted by the authority given that responsibility in the exporting country.

A reference price system exists in the EEC countries for egg plant, courgettes and tomatoes and the mechanism operates with the implementation of a compensatory tax when the imported commodities fetch a lower price in the European market. It is a kind of an anti-dumping regulator.

The non-tariff barriers in general are applicable to all imported fruits and vegetables. There are no special disadvantages to Sri Lanka.

4.7 Mainstream and Niche Market Products

The mainstream products are the first generation products which are available all the year round and often sold by supermarkets at highly competitive prices. Niche market products are second generation products or specialty products of low demanded volume but normally with a premium per unit price, sold either at supermarkets or specialty/gourmet shops.

The mainstream products are generally produced in the importing country and an 'Export Window' is normally identifiable in the winter season (October to March), during which season, tropical country produce is encouraged into European countries by concessionary import tariff benefits. The niche market produce is not normally produced in the importing country and it has a continuous but a small demand throughout the year.

It is believed that for a country like Sri Lanka, just starting on export of fruits and vegetables to sophisticated markets like Europe and still having infra-structural (pre-cooling and refrigerated trucking) and Export Service (freight space, frequency and rates and large scale supply at Export Windows and quality assurance) problems, the emphasis should be oriented to niche marketing, whenever possible. Niche marketing suits to present day Sri Lankan conditions; small export volumes, physical quality standards not as stringent as mainstream produce, larger time lag between freight frequencies, niche produce (specialty produce) have an identified clientele for cost effective promotional programmes, many niche products obtain premium per unit prices, demand though staggered is continuous vis a vis only at 'Export Window' seasons. Good examples of present day niche marketing in Sri Lanka are specialty banana (ambul), specialty pineapple (mauritius), specialty mango (viilard), green chilli and locally popular vegetables to the expatriate population in the Middle East and elsewhere, such as young jak, bitter gourd, snake gourd, lufa, snake beans and others.

This does not, however, mean that mainstream products should be neglected; products such as young gherkins in brine, baby corn, cantaloupe, passion fruit, cashew and sesame have already found lucrative export markets.

Some products such as baby corn, carambola and passion fruit show conditions of monopolistic competition; major suppliers to the European market being Thailand, Malaysia and Kenya, respectively. By following the market leaders, Sri Lanka has a good chance of market penetration.

What is being emphasized is that given the present Sri Lankan conditions, niche produce marketing and products with Monopolistic competition are better approaches in market penetration (vis a vis Export Window marketing).

4.8 Local Marketability

Many of the Mahaweli produce will be perishable fruits and vegetables. Easy access to market, either local or overseas is paramount. Overseas market is large and lucrative, especially in the long run. It is more quality conscious and the competition is more. Local market is small, less quality conscious and the competition is less.

For a country just starting to export fruits and vegetables to Europe, an outlet for the excess production over and above the export demand, an outlet when overseas orders fail and an outlet for the export rejects must be promptly found. It is the local market that can fit-in to this position. In order to cater to the mainstream local market, certain conditions must be fulfilled;

the prices must be within the reach of the normal consumer, new products must provide consumer preference and should fit-in to the culinary habits of the normal consumer. Whereas, the local niche market is small (i.e. through supermarkets), prices may be high and the product may sometimes be new to the consumption pattern of a Sri Lankan. The strawberry rejects and the surplus zucchini and baby corn found that local mainstream market was very repulsive whereas fresh gherkins, though new to the local market, had characteristics of mainstream products and easily found a place in the local market. It is the same for Ambul banana, green chilli, pineapple, mango and passion fruit.

What is being emphasized is that when selecting products, especially perishables for overseas promotion, due consideration should be given to its demand in the local mainstream market.

4.9 Market Profitability (Export and Local)

Having assured the market, the next step an investor/exporter would investigate is the actual net returns by way of profits. Net profits in the export trade will depend on the export price and cost of production/purchase to point of dispatch plus freight, insurance and export documentation charges. Profit margin is not a constant factor. We shall investigate the profit margins of various commodities.

Export and production profitability of some of the agricultural crops that could be grown in Mahaweli are displayed in Table 12. The wholesale prices given in the table are the optimum prices obtained during the Export Window months. Only the UK Market prices of 1992 have been analysed.

The monthly wholesale prices of other European countries, Middle East and Japan can vary, sometimes significantly.

Profitability and practicability of exporting are related to the shelf life of the product. Freighting by sea, increases profitability but the commodity should exceed a shelf life of 21 days as the sea journey to Europe will last 17-20 days. It is the same for Japan but 21 day shelf life commodities (Table 12) will last the sea journey to Middle East which takes around 4-5 days. Best post harvest handling can increase the shelf life by 5-7 days, however, such technological advancements are not considered in this study, particularly because Sri Lanka is still setting-up pre-cooling facilities.

Pineapple may be a difficult crop to Europe; it is not practicable to export by sea (because of 21 days shelf life) and not profitable by air. Only Grapes, Apple Banana, Grape fruit and Passion fruit are practicable and profitable to be sea freighted to Europe from Sri Lanka, although Mango, Pineapple and Melon are being sea freighted to Europe from countries such as South Africa, Brazil and Ivory Coast. To the Middle East, the 14 day or more shelf life commodities, can be transported by sea; thus a larger range of commodities including Green chilli, Baby Corn, Grapes, Pineapple, Apple Banana, Mango, Melon, Grape fruit, Passion fruit and Papaya (Table 12), can be sea freighted to the Middle-East.

Table 12 : An Example on Commodity Profitability - UK Market (per Kg)

	Green Chilli	Baby Corn	Asparagus	Beans	Egg Plants	Apple Banana	Mango	Papaya	Grapes	S'berry	P'apple per Carton of 6
*Wholesale price (UK)	2.40	3.00	3.50	2.25	2.00	2.50	2.25	2.50	2.00	3.00	7.00
Export Window	NO	No	Aug-Jan.	No	Dec-Feb	No	Dec-Apr	Jan-May	Jan-Apr	Oct-Mar	Sept-Apr
C and F (by air unless stated)	1.76	2.18	2.51	1.50	1.50	1.77	1.65	1.95	1.35(Sea)	2.16	4.50(Sea)
FOB - in /Kg	0.76	1.18	1.51	0.50	0.50	0.77	0.65	0.95	1.01	1.16	3.00
- in Rs/Kg	51.68	80.24	102.68	34.00	34.00	52.36	44.20	64.60	68.68	78.88	1.50
Ex-field Rs/Kg	26.68	55.24	77 68	9.00	9.00	24.86	19.20	39.60	43.68	48.88	102.00
Farmgate price - Export Quality (Rs/Kg)	20.00	50.00	75.00	NOT FEASIBLE	8.00	20.00	15.00	30.00	35.00	40.00	80.00
Export's Margin (Rs/Kg) and % on FOB	6.68 (13%)	5.24 (7%)	2.68 (3%)		30.24 (38%)	4.86 (9%)	4 20 (10%)	9.60 (15%)	8.68 (13%)	8.88 (11%)	22.00 (22%)
Production Cost (Rs/Kg)	5.50	10.00	75.00			2.50	1.00	1.50	15.00	30.00	15.00
Farmer's Margin (Rs/Kg) and % on FOB	14.50 (28%)	40.00 (50%)	Nil			17.50 (33%)	14.00 (32%)	28.50 (44%)	20.00 (29%)	10.00 (13%)	65.00 (64%)
Mandays/ha/season	307	200	450/Yr			300/Yr	160/Yr	125/Yr	110/Yr	400/Yr	300/Yr
Profitability	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Shelf life-days (under optimum cond)	21	21	14	10	10	21	21	21	75	10	21

* Wholesale prices are the optimum monthly price obtained during Export Window season - 1992 (MNS Bulletin)

In order to sea freight, pre-cooling should be started soon after harvest. Air freighting is less cumbersome, however, is costly. Some commodities such as strawberries, beans and most of the vegetables can be only air freighted to any destination because of its short shelf life (less than 14 days). Thus shelf life is an important criterion in determining the profitability and practicability of commodity exports, especially fruits and vegetables.

Table 13: <u>Duration of Transit by Sea (days)</u>

	Felixstowe	Marseille	Hamburg	Dubai	Tokyo
Days	18-20	17-19	18-19	4-5	19-20

Source : Central Freight Bureau

Another important criteria to be considered in selection of crops is the labour component. Sri Lanka's labour wage rate structure is low compared to many Asian, African and Central and South American countries, who are the main competitors in fruits and vegetables to Europe and Middle East.

Asparagus and Strawberry have a high labour component (Table 12) but technology involvement is equally high, shelf lives are low and are temperate crops. The lowest labour intake may be in Grapes, Papaya and Grape fruit. All vegetables have a reasonably high labour component.

In an overall perspective, it would suggest that on grounds of profitability, practicability, shelf life and labour intake, Asparagus, Melon, Strawberry, vegetables such as Zucchini and Beans will have the least chance of market penetration, especially to European destinations and to Japan.

4.10 Environment Suitability

By environment, we mean the climate and soil properties. Both these factors, play an important role in crop production. The climatic and soil properties in Uda Walawe and System C,G and H are described below.

4.10.1 Rainfall

Table 14 : Average Rainfall (1987-1991) in Mahaweli System (inches)

	Uda Walawe[1]	Sys C[2]	Sys G[3]	Sys H[4]
January	3.09	13.22	7.41	3.37
February	2.75	3.32	1.56	0.55
March	3.86	4.97	3.33	3.30
April	6.55	7.39	1.21	7.68
May	2.60	3.63	2.34	4.53
June	2.20	0.40	0.63	0.85
July	1.28	1.87	1.70	1.92
August	2.15	2.77	1.30	1.72
September	2.45	5.70	2.75	3.24
October	9.10	7.69	10.57	11.00
November	9.45	8.89	12.25	6.18
December	5.47	18.32	14.31	8.27
Total	50.95	78.16	59.36	52.61

Source:
1) Mahaweli Economic Agency (MEA), Uda Walawe
2) Girandurukotte Research Station
3) Water Management Secretariat
4) Maha Illuppallama Research Station

In the four systems, a similar pattern of rainfall is witnessed, though the time period and duration may have varied.

Long rainy season - it lasts from October to January;
(Wet Season) - the shortest duration and precipitation intensity have been in system H and Uda Walawe. This is the NE Monsoonal rains (Maha rains).
Short dry season - this dry spell is from February to March, though in March Pre - SW Monsoonal rains (gingerlly rains) are evident. This is the time for Maha season paddy harvesting.

Short rainy season - this is the SW Monsoonal rains which is (Dry Season) less in intensity to NE Monsoonai rains, in the Dry Zone. It lasts for two months - April and May, and the precipitation does not exceed 13-14 inches (compared to Maha rains of 45-50 inches). The period of Yala rains is noted for other field crops (OFCs) in the dry zone paddy fields of Sri Lanka, under irrigated conditions

Long dry season - the long dry season lasts from June to September, though in September the Pre- NE Monsoonal rains are evident. During this dry spell of 4 months not more than 10 inches of rainfall is recorded. It is during the short rainy season and long dry season (altogether 6 months) that an intermediate short term crop can be introduced under irrigated conditions.

It is to be noted that out of the 4 irrigation systems under study, Uda Walawe and system H are the driest with an annual average rainfall of around 50 inches. System C has the best annual rainfall and should easily qualify for intensive cropping (including the introduction of an intermediate season). Crop response to rainfall and drought and irrigation necessities are described below.

4.10.2 Crop water requirement

The recommendation of the Department of Agriculture is followed in this study and is given in Annex IV & V.

4.10.3 Other Climatic Factors

Table 15 : Average 1987-91 Temperature and Relative Humidity

	Uda Walawe		Sys C		Sys H		Sys G	
	Av.Tem. (F)	R.H. (%)	Av.Tem. (F)	R.H. (%)	Av.Tem. (F)	R.H. (%)	Av.Tem. (F)	R.H. (%)
January	81.0	74	76.4	87	77.4	87	Not Available	
February	81.7	71	77.4	83	79.2	83		
March	82.6	68	80.6	83	82.9	80		
April	82.9	74	82.2	78	84.2	82		
May	82.4	78	84.9	76	84.2	80		
June	82.4	82	85.8	65	83.1	80		
July	82.0	72	83.9	69	83.1	79		
August	82.0	78	84.6	67	83.3	77		
September	83.7	81	83.8	70	83.7	77		
October	81.9	78	82.4	77	81.9	83		
November	80.0	78	80.3	82	79.9	87		
December	79.3	76	77.1	86	78.6	90		

Source: Hambantota Meteorological Department, Girandurukotte Research Station and Maha Illuppallama Research Station.

The lowest temperatures are during the Maha season from November to February. The highest temperatures are in the months of April, May and June. Temperatures in all irrigation systems are alike; it had varied between 77° to 80° F in December to January and had been around 82° F ± 2 during rest of the period. The Relative Humidity is highest during the months of October to January and low during rest of the period.

A relationship between Average temperature and Relative humidity is seen; when temperature is low, RH is high and vice versa. Average temperature and Relative Humidity fluctuations can influence crop growth and can induce pest and disease problems. These are described below.

Table 16: Average (1987-91) Wind Velocity (Km/hr) and Sunshine Hours per day

	Uda Walawe		System C		System H		System G	
	wind vel. km/hr	sun shine hrs/dy	wind vel. km/hr	sun shine hrs/dy	wind vel. km/hr	sun shine hrs/dy	wind vel. km/hr	sun shine hrs/dy
January	8.4	6.0	2.3	3.7	4.7-8.5	7.6	Not	
February	21.0	7.2	2.5	7.0	3.6-8.8	9.8	Available	
March	16.9	7.8	2.4	7.5	3.3-9.3	9.4		
April	15.7	7.1	2.8	7.2	6.1-11.1	9.0		
May	22.7	6.6	2.6	7.0	6.3-16.7	9.1		
June	24.0	4.9	3.5	6.1	12.7-18.8	7.5		
July	24.0	5.0	3.0	6.0	12.3-32.7	7.8		
August	24.7	5.3	3.0	6.5	10.9-14.6	7.8		
September	24.3	6.5	2.7	6.6	9.3-15.7	7.7		
October	19.7	6.0	2.5	5.9	6.3- 9.4	6.6		
November	14.9	6.5	2.3	5.1	4.5- 6.0	6.5		
December	18.4	5.3	2.3	3.7	4.9- 6.2	5.6		

Source: Hambantota Meteorological Department, Girandurukotte Research Station and Maha Illuppallama Research Station.

As expected, strong winds are in June too August, still, the speed has not exceeded 25 Km per hour except in System H, in the month of July. The wind speed in the Mahaweli area is not a barrier for perennial crops, the most susceptible been banana which may get uprooted at 30 km per hour speed. However, cash crops of short duration such as gherkins on trellis, okra and chillie may get damaged by winds.

Wind breakers such as Ipil Ipil, and Sunhemp should provide adequate wind protection to short term cash crops.

The longest day lengths have been in the months of February to April, and the sunshine hours in System H have been the longest (more than 9 hours per day). From June to December, the day length has reduced.

4.10.4 Soil characteristics

Four different soil groups of agricultural importance are evident in Mahaweli areas. They are as follows:

Reddish Brown Earth (RBE)-well drained

These soils generally occur in the convex, or uppermost positions of the catenary sequence. Most commonly occurring well drained RBE profile comprise an A - horizon of 15 cm of dark brown sandy loam, showing a very weakly developed crumb structure, overlying a B-horizon of some 100 cm of reddish brown sandy clay loam. A 20 cm thick band of gravel is seen at the base of the B-horizon which is only infrequently thick enough to hinder root penetration. The soil is fairly well equipped with weatherable minerals, and its natural fertility is moderately high. It has a infiltration rate of 3-12 cm per hour, a neutral P^H value, a field capacity of 22% by weight, permanent wilting point of 13% by weight and a gradient ranging from 1 1/2 - 6% or more.

Reddish Brown Earth (RBE) - imperfectly drained

These soil generally occur in the concave footslope positions of the catenary sequence. Imperfectly drained RBE profiles are similar to the well drained profiles apart from mottling being notable in the B-horizon. Soils are generally much deeper than well drained RBE and gravel bands are deeper and less marked. The water table is high for short periods of the year and below 120 cm water tables are often present for much of the year. The presence of drainage barriers in the form of semi - permeable undecomposed parent rock, often at depths of 1.75 to 2.50 meters, would preclude the use of this soils for diversified cropping if deeper sub-surface drainage is required. The gradient varies from less than 1 1/2% to 3%.

Alluvial soils and Low Humic Gley soils (LHG)

These soils are found scattered all over the island, the former in the valleys and flood plains of the streams and rivers and the latter in the lowest slopes of the land associated with the reddish-brown earths and non-calcic brown soils in the dry zone and the red-yellow podzolic soils in the wet zone.

Most commonly occurring LHGS show darker, better structured A-horizons with abundant root and animal activity. B-horizons are intensely mottled, often comprising well developed angular blocky structures, with the base of the horizon showing gley colours. Available water holding capacity, cation exchange capacity and plant available nutrients are higher than in the RBEs but drainage is the major problem if dryfoot crops are to be grown. The infiltration rate is lower than in RBEs and the P^H value is neutral. The gradient is less than 1 1/2%.

Alluvials are of two sub groups old alluvials (OALs) and recent alluvials (RALs). The texture of old alluvials is very course to fine and the RALs are more coarser. Both soils have an acidic reaction. These soils are again good for paddy, however, the soil could be worked and made suitable for dryfoot crops. The gradient is around 1 1/2%.

In Table 17, an attempt is made to classify the different soil series according to the four soil groups of agricultural importance present in the Mahaweli areas under study.

Table 17: Classification of Mahaweli Soil Series

	RBE-well drained	RBE-imperfectly drained	Alluvial	LHG
Uda Walawe	1 Walawe series undulating phase	1 Walawe series Rolling phase		1 Malabotu Association
		2 Ranna Association		2 Siyambala Association
System C	1 Ulhitiya Series	1 Horabora Wewa Series	1 Hembarawa Series	1 Kuda Oya Series
System G	1 Migaswewa Series	1 Nikawewa Series	1 Ambanganga Series	1 Wadigawewa Series
System H	Not available			

Source : Land Use Division, Irrigation Department.

4.11 Infrastructure Facilities

The most important infrastructure facilities have been described in detail by SRD Research Group in their study report titled "Export Marketing Strategies" and by Frederick E. Henry MARD/MDS Project titled "Packing House and Cold Chain Requirements". This consultancy accepts the views of the aforesaid two reports and a summary is given below.

The major infrastructural constraints have been identified as follows. These constraints have been identified on the assumption that Mahaweli areas under study will start cultivating high value fruits and vegetables for the export market.

4.11.1 Pre-cooling, cold storage and trucking facilities

It should be noted that pre-cooling, cold storage and refrigerated trucking facilities are a pre-requisite for high value fruit and vegetable cultivation for the export market. At present, only System B is equipped with a 'Cold Chain' and only initial investigations have been made in regard to the establishment of cold chains in other systems in the Mahaweli.

Pre-cooling is essential to lengthen the storage life of harvested fruits and vegetables. Common methods of pre-cooling are - hydro cooling, forced air cooling, and cold storage. Assuming, that two 40' container loads of fruits and vegetables are exported per week, a 40 MT capacity cold chain will be required. The total investment cost for the building, pre-cooling and cold storage equipment, packing house equipment and for refrigerated trucks will amount to US $ 525,000 (Rs 23 million). This is an investment that could be difficult for an individual entrepreneur, especially when the risk element is high for fruits and vegetables and because the overseas competition is high. Only a joint venture with assured buy back arrangements or by state intervention can such an investment take place in the areas of production. (state intervention has been the case in System B and it is presently operated by the private sector).

Except for a few products such as onions, cashew, ground nut and sesame, all other possible fruits and vegetables in the Mahaweli areas require this facility. As such, this is a problem common to almost all crops.

4.11.2 On farm irrigation infrastructure

Release of water in Mahaweli areas has been synchronised to the Paddy growing calendar. On farm irrigation to lowlands were limited to gravity irrigation and the upland commercial cultivations had a combination of lift and gravity irrigation. There was only speculation of a sprinkler system being introduced in a newly established commercial farm in System C. Sprinkler and drip irrigation systems are much efficient than gravity irrigation but are costly. For instance, a drip irrigation system will cost around US $ 2000 per hectare. A precision high cost irrigation system is required to upland crops such as Cavendish banana, grapes, strawberries, asparagus and year round melon. Necessity for high cost irrigation system in lowlands will depend on the availability of water; higher the limitation in water, higher will be the necessity.

In Maha, almost all lowlands are cultivated with paddy. There are signs that farmers are learning to cultivate high value crops like chilli and baby corn, soon after Maha rains in the higher elevations of lowlands which normally have RBE well drained soils. Some farmers have even started cultivating chilli in the midst of Maha rains. In Yala, due to limitation of water, farmers are encouraged to cultivate other field crops in lowlands (and in System H, only half the extent of lowland was permitted to be cultivated).

Formerly, it was the Water Panel Committee that decided on the date of start of the season, Maha and Yala and the frequency of release of water was in the hands of the irrigation officers. A transformation is now seen, especially in System H, where the respective Farmer Organisations in each Yaya, determine the time to cultivate. This is a healthy sign; farmers should be encouraged to control the irrigation system in their own Yaya, given the quantum of water that is available. This will develop close liaison among members of a Farmer Organisation and between Farmer Organisations. Such relationships should encourage alternate cash crop production instead of the traditional paddy.

At present, gravity irrigation has succeeded in providing water to the existing cropping pattern; this study will provide more information on water losses under the present irrigation system and whether an intermediate season is possible with better water use efficiency i.e. sprinkler or drip systems. Also, if certain crops are recommended for intensive cropping, sprinkler or drip irrigation systems may be needed. Control of water release to the respective Yaya should be in the hands of Farmer Organisations; transformation from the traditional officer involvement to farmer involvement should be encouraged and expedited. On farm irrigation infrastructure and methodology are not major constraints but may have to be altered for greater efficiency in crop production.

As much as stressing that farmers should be involved in planning, operation and maintenance of a project, so should the investors too be involved in all these activities including the planning process and in the policy making decisions to patterns of production and marketing.

Clear tenure and ownership policies should be defined so that on farm infrastructure development could be responsibility of the investors with assistance from the MASL in providing access for heavy vehicles, power and telecommunication facilities upto the investors allotments. The investors should be advised to where ever possible utilise local skills and materials. Settler farmers should be their outgrowers and sufficient incentives should be provided by way of technical skills, inputs, credit, etc. with guaranteed buy back arrangements at reasonable prices.

4.11.3 Credit for commercial agriculture

Commercial agriculture, though dealing in perishable fruits and vegetables, is different from traditional agriculture. Commercial agriculture involves a large extent, the produce is supplied on forward orders which emphasises the quality and quantity, the price, time and terms of delivery. This is in contrast to traditional agriculture which is invariably subsistence with less emphasis on quality and quantity. Due to these reasons, in commercial agriculture the capital outlay is high and more so for high technology crops such as Cavendish banana, grapes, strawberries and asparagus. (some of these high investment items- precooling facilities and sprinkler/drip irrigation have already been described). Credit financing to specific items in the capital outlay is paramount. Financial institutions must realize that in commercial agriculture such uncertainties as market availability and crop failure due to lack of rainfall have been greatly reduced and the crop itself will be a reasonable collateral for financing. Even where traditional farmers are involved as outgrowers, the buying company should be deemed credit worthy for high capital outlay investment for the nucleus farm (however it should be agreed that the risk element is more with the involvement of outgrowers who are basically short term profit seekers as against long term profit seeking commercial entrepreneurs)

Unless such financial assistance is provided, commercial agriculture will be the domain of large business houses as is the case today (except a few exemptions). A compromise approach may be the investment encouragement for high market potential and high value crops of moderately high to low capital outlays.

4.11.4 Air and sea transport infrastructure

According to the SRD study the present air and sea transport facilities are adequate for the present out going perishable cargo but port facilities may have to be expanded if the quantum of cargo increases.

Some of the short shelf life perishables such as okra, egg plant, green beans, straw-berries and asparagus have to be air lifted even to the closest market-the Middle East. Although a concessionary freight rate is available (around Rs. 70 per kg to Europe), other cargo is given preferential treatment when it comes to loading. Missing a flight can be disastrous to a consignment of perishables. Air Lanka and the relevant state organisations may have to evolve a suitable freight loading, frequency and rate for Sri Lanka's major markets- Europe (mainly UK, Germany and Netherlands), Japan and Middle East. These are common problems to exporters of fresh fruits and vegetables.

4.11.5 Farmers' skill in technology adaptation

Since of late many outgrower farmers have been encouraged to grow gherkins and baby corn in Yala in lowlands. A package of inputs and the technology were provided by the buying company. The selected farmers in the Mahaweli areas under study, had no problems of understanding and introducing the new technology in the field. (Farmers' complaint were regarding the marketing arrangement). Leaving aside the more complex crops such as strawberries and asparagus, under standing the cultivation of new crops such as Carambola, Bird's eye chillies, Zucchini and Silver Onion will not be a problem to Sri Lankan Mahaweli farmers.

The problem will be the availability of farm labour and farm power. Already labour shortages have occurred in Uda Walawe and System H for labour intensive crops, such as Gherkins and Baby corn. Also, limitations in farm power (draught animals and tractors) have resulted in staggered cultivation. However, these are considered to be temporary phenomena.

4.12 Crop Characteristics

A short description is given on special production features of crops which needs adequate attention. These include crops which could be grown in lowlands as well as in uplands.

Melons

Cantaloupe and Yellow Honeydew, which have the best overseas demand, are best to be cultivated soon after Maha rains, as downy mildew is common in Maha. Defoliation due to downy mildew will effect the size and quality of fruits. High temperature, low humidity and rainfall are important factors determining fruit quality and size. Good for any Mahaweli area.

Gherkins and Baby Corn

Like Melon, both these crops are warm season crops requiring an average temperature of 70-85°F for healthy growth. Though an annual rainfall of 50" is sufficient, moisture stress exceeding 2 weeks, will retard growth. As the products harvested in Gherkins and Baby Corn are the tender and immature forms and as both will not tolerate excessive soil moisture, it is best that these are cultivated at the end of the Maha season rains or provided with good drainage facilities. Gherkins could be harvested, starting from 30 days after planting and Baby Corn from 45 days of planting. Good for any area in Mahaweli. Good local varieties of corn are Badra, Ruwan and Aruna.

Onions

Onions need fairly cool temperatures during crop growth and high temperature of 80 - 85 ° F and low humidity during bulbing, harvesting and curing periods. Soil moisture should be continuously present during the growing phase. Onion is a photosensitive crop; bulbing is initiated by daylength. Around 10-12 hours of daylength is recommended. The best area for onion is System H (refer Table 14 and 15) during the period February to May.

Okra

Okra grows best in warm, humid climates, preferably where temperatures go above 85 ° F. It responds to plenty of water, but will endure drought quite well. Okra has the problem of virus diseases spread by aphids, thrips and white flies. Disease is severe in Yala due to climatic suitability for vector migration. Okra is good as a Maha crop in any area in Mahaweli. A virus resistant variety is HRB 10.

Chillie

This includes Green Chillies and Bird's Eye Chillies (Kochchi Miris). Like Okra, chillies are also prone to virus disease, the vectors being the same. As such, virus problem can be minimised by cultivating in Maha in uplands and in well drained lowland soils. However, it is a popular crop in the low-lands, during Yala. MI -2 is now being recommended by the Department of Agriculture because while being resistant to virus disease the plant is short, the pods are dark green, smooth surfaced and the end is blunt-suitable characters for the export market. Bird's eye chillie varieties are not known locally, however, selections with high Capsaicin content (oleoresin) have a good export market. It is exported in dried form. Chillies are not recommended for System C (and B) because of the widely spread 'narrow leaf disorder'. Yala cultivation should be with the first SW monsoonal rains because delay in cultivation will attract thrips and aphids and will be prone to wind damage.

Egg plant

Like Okra and Chillie, Egg Plant also needs a warm climate for good plant growth, and can be cultivated in both maha and yala. Yala cultivation should not be delayed which may increase the incidence of bacterial wilt and stem and pod borer attack. In order to qualify as specialty egg plants in overseas markets, pod colour and shape could be altered from the dark purple and oblong/oval shape. The local variety SM 164 has specialty features and is moderately resistant to bacterial wilt.

Tomato

Though Tomato is a warm season plant, the introduced salad type varieties of Marglobe and Roma and the local variety Katugastota are not adequately heat tolerant, resulting in flower shedding and fruit cracking. Local varieties Vihara I and II are heat tolerant. Tomato could be cultivated in Maha and Yala with good drainage facilities.

Beans

Beans may be cultivated only in Maha in upland; collar rot may be a problem in lowlands. For flowering and fertilization low temperatures below 80 °F are needed; this condition may not be found in Yala, in Mahaweli areas.

Asparagus

Asparagus is a temperate crop and as a result needs low temperatures for plant growth. Also, it needs a dormant period before spear formation. Low temperatures or dry spell can enforce dormancy. High temperatures will only cause branching at the expense of spear formation. In Sri Lanka spear formation was evident in Maha and in Yala there was only vegetative growth. Sri Lanka needs heat tolerant varieties and the SRD Research Group has recommended a Dutch variety and UC 800, though satisfactory results have not been achieved in System 'B'.

Cashew

Cashew is a hardy crop, drought resistant but needs a gestation period of 3-4 years for the first harvest. Yellow latersols are ideal for cashew and grows well even in Reddish brown earth. It is sometimes said that in RBE, vegetative growth becomes excessive at the expense of yield.

Ground nut

Even at present, ground nut is a popular crop especially in system G (Table 6). It has been grown both in Maha and Yala. The only draw-back is that Sri Lanka is without suitable varieties accepted by the World Market. The Sri Lankan varieties are photosensitive (resulting in low Maha yields) and they do not belong either to the oil type or the confectionery type. White coloured, big bold three seeds per pod varieties are for the confectionery industry and seeds with high oil percentage are for the oil extraction industry. Common varieties in Sri Lanka are MI - 1, X 14 and Red Spanish.

Sesame

This is another popular crop in the Mahaweli, however, the popularity has dwindled due to constant fluctuation in prices. It is a hardy crop and photosensitive like ground nut and is normally cultivated in March for Yala. Pure white seed used in the confectionery industry fetches a higher price in the World Market than the black or mixed oil types. Sri Lanka white variety is MI 3 and black varieties are MI 1 and MI 2. Maintenance of purity in sesame is a problem because 30% of seed production is by cross- pollination. Long periods of storage can increase the FFA content.

Black Gram

Black gram again is a popular crop in the Mahaweli, especially in System H (Table 6). The common variety in Sri Lanka is MI-3, and can be cultivated in both Maha and Yala. It is drought resistant and pests and disease problem are rare.

Pineapple

Pineapple is a drought tolerant crop and is an ideal annual crop in the Mahaweli areas. The fruit quality is determined by its sugar and acid content and by its flavour. These are determined by 3 climatic factors- average monthly rainfall, day-time temperature and night temperature. The rain-fall distribution even in System 'H' (the least rainfall area- Table 14) is amply adequate for pineapple but the most important for fruit quality is hot daytime temperature and cool nights. Some-times irrigation may be required under prolonged drought.

Sri Lanka's Kew variety is genetically related to the popular Smooth Cayenne. It is suggested that Mauritius variety be cultivated in the Mahaweli in order to introduce a specialty product to the World Market, with the special characteristics of yellow orange skin on maturity, golden yellow flesh and more juice and sweet flavoured than Kew.

Banana

Banana especially Ambul and Kolikuttu are popular varieties in the Mahaweli areas especially in Uda Walawe, which is grown even under irrigation. Like in Pineapple, Banana technology is not new in Sri Lanka and specialty banana as described above should be encouraged in Sri Lanka instead of the conventional cavendish type (similar to local Ambun) which needs year round irrigation and improved technology. It should be noted that prolonged drought may cause defoliation and break down of pseudostem in Ambul and Kolikuttu; supplementary irrigation may become necessary. Also, consistency in physical and chemical properties of the fruit in the selected local strains is very important.

Mango

Dry Zone is the ideal area for high flavoured mango in Sri Lanka. It is the most popular perennial fruit and will grow well in the Mahaweli. As was the principle before, the aim should be to promote specialty mango instead of cultivating the popular World Market varieties such as Tommy Atkins, Haden and Alphonso. Local varieties that could qualify as specialty mango are Villard and Karthakolomban, however, pure strains may be difficult to be identified. Large (250 - 300 gr) even shaped villard could be the initial target mango in overseas markets; consistency in quality is very important. The Mahaweli rainfall pattern is adequate for vegetative growth and the dry spells from February to March and from June to August are adequate for pollination, fruit set and maturity.

Passion fruit

Though passion fruit will grow well in Mahaweli areas under irrigation, the vine is prone to virus diseases after 1 or 2 seasons. Virus diseases are especially evident after dry spells as the vector population of aphids, thrips and white flies multiply during dry spells and spreads the virus soon after. Passion fruit is not recommended for the dry zone.

Papaya

Papaya is another popular perennial fruit which is popular in the World Market. Papaya is also prone to virus diseases but incidence is less in the dry zone including in Mahaweli areas. World Market demand is for Solo types of Papaya where the pure strain is difficult to be located in Sri Lanka, because of cross-pollination. Attempts should be made to promote select local strains of fruit size 300 - 500 gr, high flavoured with smooth yellowish green skin. Like banana, papaya requires irrigation during the dry period.

Grapes

Thompson seedless and a few others have been tested in dry areas of India with success and they have been recommended for Sri Lanka by the SRD Research Group. Pruning is important and should be done before the dry period which should extend at least for 3-4 months. The dry period will determine the quality of the fruit. For growing, low rainfall and humidity are required. These conditions are present in Mahaweli areas especially in System 'C' and Uda Walawe.

Strawberry

According to SRD Research Group, technology of growing strawberries in hot climatic conditions have been perfected. Varieties such as Chandler, Douglas, Pajaro and Cardinal are heat tolerant varieties. Chandler has been selected as the best variety. However, it does identify the necessity in vernalization of the starts in cool climate nurseries and transferring them to the fields in hot climates for transplantation. The varieties selected here are 'day neutral' varieties.

Vernalized starts will yield only for one season and thus strawberry becomes an annual crop in hot climates. A new set of vernalized starts has to be transported to start another season. The problem encountered in System 'B' with strawberries may be the above. This is a difficult task which will escalate cost of production, in a commodity facing stiff competition in the World Market.

Grape fruit

Sri Lanka's indigenous grape fruit have performed well in dry zone. Grape fruit of commercial value belongs to two broad varieties namely yellow fleshed and seedless Marsh and red fleshed Duncan. Strains of these two varieties have shown good results in tropics.

Under high temperature, the rind tends to be thin and the sugar content increases. Also, the rind will retain a green or yellowish green colour. It could be degreened by using ethylene gas.

Grape fruit is a hardy crop and needs only 35 to 50 inches of rain annually; supplementary irrigation may be necessary if rainfall is inadequate. Soil should have good surface and subsurface drainage properties. It can tolerate acidic and alkaline soils ranging from P^H 5 to 8.3. The RBE well drained soils in Mahaweli, which are suitable for grape fruit production, contains a 5-8 inch gravel layer below 2-3 feet from surface. In certain areas the gravel layer is impermeable due to consolidation of clay in between gravel. The gravel layer should be broken when planting citrus by making the planting hole 5-6 feet in depth.

4.13 Crop Selection for Study Areas

In Section 4, many variables influencing the selection of crops were described. Out of these, 5 mutually exclusive variables have been selected to screen the suitable products for the Mahaweli study areas. They are as follows:

4.13.1 Land and climatic suitability

Though many features are common in the four systems, a few are characteristics of the systems. The important criterion is that some common features will screen out some of the commodities from the total Mahaweli area, and some from certain systems only.

4.13.2 Market profitability

Producer's profitability is the next most important factor, without which an entrepreneur/farmer will not take up an alternative export crop at the expense of the existing cash crops/traditional crops - dried chilli, big onions, banana(under irrigation) and paddy, to name a few. An attractive producer's margin will be a minimum of 25% on cost of production. It should be noted that in some cash crops such as dried chillie and big onions, the margin achieved by farmers exceeds 25% and sometimes is in the region of 100%. For this study, a conservative figure of 25% is considered as the margin that will make a farmer change his cropping pattern, in expectation of long term profits.

The second criterion is the exporter's profitability, without which the exporter will not undertake to export the particular commodity. It is considered that an exporter will expect at least 10% as profit from the FOB price for perishables and a 5% margin for non-perishables (cashew, sesame etc.)

4.13.3 Market penetration possibility

Commonly used techniques of market penetration for fruits and vegetables and other agricultural commodities are by price competition, export window marketing, niche marketing and by following the leader in monopolistically competitive products.

In screening products for the Mahaweli area only the last two criteria have been considered because the first two criteria are considered as common strategies adapted by each and every competing country. Niche marketing and Monopolistic competitive product selection have been described under 'Marketability' in this study.

4.13.4 Local marketability

Sri Lanka is new to the export of fruits and vegetables especially to the European markets. Many pitfalls are to be expected. Products with local market potential will be cushioned to a great extent. Importance of local marketability has been described under 'Marketability'.

4.13.5 Regional demand, shelf life and profitability by air/sea

Shelf life exceeding 3 weeks is important for Sri Lankan perishables as sea freight will take at least 17-20 days to Europe. A shelf life of maximum 3 weeks is sufficient for perishables designated to Middle East. This will provide at least a week's duration in retailer's shelf space.

The importance of shelf life is because the sea freight rate is comparatively low to air freight rate. The air freight rate, which is a concessionary rate is still high (as claimed by exporters) and allocation of air freight space receives secondary treatment against other cargo. Air freight rate is, however, competitive for perishables designated to Middle East.

Once products have qualified from Regional Demand and Shelf life, the profitability by air and sea has been considered to the two regions Europe and Japan and Middle East. (Table 18).

4.14 Screening Methodology

The five select screening variables described above, have been phased into four, namely:

1st Phase - Land and Climatic suitability for crop production.
2nd Phase - Producer's Market Profitability
3rd Phase - Exporter's Market Profitability
4th Phase - the three Market Development Strategies, namely Market Penetration, Local Marketability and Regional Demand, Shelf life and Profitability.

In order to qualify for evaluation in the 2nd phase, a commodity should qualify from the 1st phase by receiving at least one mark (x) out of a possible four. Like-wise, for evaluation under 3rd phase, qualification in 2nd Phase is a pre-requisite. The last and the 4th Phase is on Market Development Strategies, in which a score of 6 is the maximum. Commodities which score high from Market Development Strategies will be the products that could be selected for cultivation in the Mahaweli study areas.

4.15 Results

Table 18 gives the results in the last column. What was expected from the results was to select a group of crops that could be suitable for the Mahaweli areas. No attempt is made to rank the crops according to priority.

It was decided that all crops scoring 3 or above from the Market Development Strategies, as identified under columns 3,4 and 5 in Table 18, should be considered for development under the Mahaweli systems. They are as follows:

Vegetables*	Region	Oil seeds, Pulses, Nuts	Region	Fruits	Region
Baby Corn	ME	Cashew***	All	Pineapple**	ME
Onion (Red)	ME	Ground nut*	All	Banana**	All
Okra	All	Sesame*	All	Mango***	All
G. Chilli	All			Papaya***	All
Bird's Eye Chilli (Dried)	Europe			Grapes***	All
Egg Plant	ME			Grape Fruit***	All
Tomato	ME			Carambola***	All
Gherkin (in brine)	Europe			Cantaloupe ***	ME

* - Cash crop
** - Annual crop
*** - Perennial crop
ME - Middle East
All - Europe, Japan and ME

It should be noted that the crops that have been selected are for mass scale production in Mahaweli areas with assistance from settler farmers (as outgrowers). Cash crops and annual crops could be grown even in lowlands, in well drained soils. Water availability is a pre-requisite and a few crops need protection from heavy Maha rains. All crops could even be grown in uplands, if supplementary irrigation facilities are available.

This study should not, however, be generalized as a crop recommendation even for individual commercial projects. For instance, a commercial project with buy back arrangements may decide to grow beans or asparagus (two crops that have not been recommended for Mahaweli outgrowers under study) in a suitable location in Mahaweli, selected after experimentation. This study's crop selection procedure will not influence such projects. Also, this study evaluated only 23 crops: there can be other crops which needs evaluation ie. Jojoba, Zucchini. It is not difficult for anyone to evaluate new crops, by using the given methodology.

Table 18: Selection of crops for Mahaweli System C,H,G and Uda Walawe (Based on 5 point 'TEAMS' approach)

Commodity	(1) Land and Climatic Suitability UW	Sy.C	Sy.H	Sy.G	(2) Market Profitability Prod.	Expo.	(3) Market Penetration Niche Mar.	Monopolistic Competition	Local Mar.	(4) Regional Demand Shelf Life & Profitability Japan & Europe Air	Sea	ME Air	Sea	(5) Total Marketing Score
Vegetable & Pulses														
1. Gherkins in brine	x	x	x	x	x	x	-	x	-	-	x	-	x	3
2. Baby Corn	x	x	x	x	x	x	-	x	-	-	-	x	x	3
3. Onions(R.)	x	x	x	x	x	x	x	-	x	-	x	-	x	4
4. Okra	x	x	x	x	x	x	-	-	x	x	-	x	-	3
5. Grn. Chili	x	-	x	x	x	x	-	-	x	x	-	x	x	4
Dried Bird. eye chili	x	-	x	x	x	x	-	x	x	-	x	-	-	3
6. Egg plant	x	x	x	x	x	x	x	-	x	-	-	x	-	3
7. Tomato	x	x	x	x	x	x	-	-	x	-	-	x	x	3
8. Beans	x	x	x	x	x	-	NOT FEASIBLE		x	-	-	x	-	0
9. Asparagus	x	x	x	x	-	NOT FEASIBLE								0
10 Cashew	x	x	x	x	x	x	-	-	x	-	x	-	x	3
11 Ground nut	x	x	x	x	x	x	-	-	x	-	x	-	x	3
12 Sesame	x	x	x	x	x	x	-	-	x	-	x	-	x	3
.3 Black gram	x	x	x	x	x	x	-	-	x	-	-	-	x	2
Fruits														
14 Pineapple	x	x	x	x	x	x	x	-	x	-	-	-	x	3
15 Banana	x	x	x	x	x	x	x	-	x	x	-	-	x	5
16 Mango	x	x	x	x	x	x	-	x	x	-	x	-	x	5
17 Passion Fruit	-	-	-	-	-	NOT FEASIBLE								0
18 Papaya	x	x	x	x	x	x	x	x	x	-	x	x	x	5
19 Grapes	x	x	x	x	x	x	-	-	x	-	x	x	x	3
20 Strawberry	x	x	x	x	x	-	NOT FEASIBLE							0
21 Grape Fruit	x	x	x	x	x	x	-	-	x	-	x	x	x	4
22 Carambola	x	x	x	x	x	x	-	x	-	x	-	x	x	4
23 Melons (Cantaloupe)	x	x	x	x	x	-	-	x	-	-	x	x	x	3

4.16 Cropping Mix Technology

In the field, crops are mixed basically in two ways: Cultivating more than one crop in the same field in the same season and rotating crops in the same field in adjoining seasons. Crop mixing in the field is done for many seasons. Most important among them is to optimize the farm income. Crop mixing also has other benefits such as it increases productivity of land by increasing the cropping intensity. It will reduce the extent of risk to the farm family, improves the efficiency of resource usage and balances the family dietary system.

Mixing of crops has many advantages: different crop combinations in the field helps to control outbreak of pests and diseases, by having correct crops in the field, the soil nutrient content is improved, weeds are controlled biologically and is a mechanism of soil conservation.

Selection of the crop combination is an important criterion in the success of crop mixing. Many factors play important roles in deciding the crop combination. Two most important factors are the gross income to the farm and the availability of soil moisture to increase the cropping intensity. Other factors are the judicious selection of crops to prevent outbreaks of pests and diseases, inclusion of a legume (even if the land is left fallow, by cultivating a legume such as sunhemp) to improve the soil nitrogen content, a combination that will balance the dietary nutrients and optimize the use of the factors of production (land, labour, capital and management) and nature's resources (rainfall, sunlight, soil nutrients, day length etc.).

4.16.1 Extents for crop mixing

Extents available for crop mixing in the Mahaweli study areas broadly depends on the extent of uplands and lowlands (Table 20). It should be noted that these extents are further controlled by the amount of water available and by the soil types (these two factors are further described later).

Table 19 : Uplands and Lowlands in Mahaweli Areas (hectares)

	Lowland	Upland (Commercial)
Uda Walawe	26,690	2,160
Right Bank	12,300	-
Left Bank	5,150	-
Left Bank - new extension	9,240	-
System H	31,700	620
System C	21,675	1,961
System G	5,400	95
Total	85,475	4,836

Source : Walawe irrigation Improvement Project, Soil Data Tables - Sir M. McDonald and Partners Ltd.
Irrigation Section, MASL, Galnewa
Land Section, MASL, Dehiattakandiya
Issue Tree, Irrigation Section, MASL, Bakamuna
Land for Investors, Allotment Data, Block G,
System B - MED/EIED Project.

4.16.2 Seasons

In Sri Lanka, two cultivation seasons are prominent: Wet season (Maha) and Dry season (Yala). In the dry zone of Sri Lanka (including the areas under study), the wet season experiences heavy North East Monsoonal rainfall and have a reducing day length. The harvesting time (February-March) is relatively dry. Crop water requirement is from rainfall and may be supplemented with irrigation, if necessary. Paddy is the major crop in the lowlands.

The dry season (Yala) receives rainfall from South West Monsoon, but the precipitation is less. It has a period of increasing day length and due to satisfactory humidity, atmospheric temperature and day length, spread of pests and diseases is high. The harvesting time is during the dry period June to August. As rainfall is inadequate, crop water requirement is always supplemented by irrigation. The extent of cultivation of lowlands in Yala depends on the water availability in the tanks. Generally, other field crops are encouraged in well drained lowlands and the extent cultivated is restricted leaving sometimes the ill-drained soils fallow.

The typical Maha season is from October to February and the Yala from March/April to June. There is always the duration for another season, intermediate season, provided that water is available. (Availability of water will be discussed more fully, elsewhere). Assuming water is available, an intermediate season could be introduced either between Maha and Yala or between Yala and Maha. In this study, with the objective of maximizing crop water usage, leaving room for dewatering and canal maintenance and by adhering as far as possible to the existing cropping seasons (described above) tested for many years and to avoid any unusual pest and disease outbreaks, the intermediate season is recommended to be between Yala and Maha. Thus the cropping seasons recommended in this study for select high value cash crops are:

Wet Season (Maha) - November/December - March/April
Dry Season (Yala) - April/May - June/July
Intermediate Season - June/July - September

The intermediate season, sometimes could be even shorter; thus, 2 - 2 1/2 month varieties of recommended cash crops may be cultivated. The water requirement has to be fully met by gravity irrigation or otherwise (by sprinkler or drip irrigation, as the case may be).

4.16.3 Crop-Soil relationship

Almost all cash crops are prone to water logging conditions. As a general rule, this study will follow the principle to avoid periods of heavy rainfall and cultivate cash crops only in soils with good surface and sub-surface drainage facilities.

For these reasons, it is recommended that the Maha cropping season in the lowlands should commence in November-December after the heavy showers from October to November.

Another important factor in Crop-Soil relationship is the selection of the correct soil group for cultivation. Four soil groups were identified before as suitable for crop cultivation, namely RBE - well drained, RBE - imperfectly drained, alluvial and LHG soils. In Maha, only the RBE - well drained is recommended for lowland cultivation of cash crops: cultivation could be on ridges or on raised beds. In Yala and in Intermediate seasons, RBE - well drained and RBE imperfectly drained soils could be used for cultivation on raised beds. Alluvial and LHG soils could be exclusively for paddy in Maha and Yala, depending on the availability of water.

Table 20 : Extents of RBE - Well drained and Imperfectly drained soils in Study Areas (hectares)

	Lowland	Upland (Commercial)
Uda Walawe	9,874	2,160
Right Bank]	6,456	-
Left Bank]	-	
Left Bank - new extension	3,418	-
System H	19,020	620
System C	9,537	1,961
System G	3,870	95
Total - RBE - WD and RBE-Im.D	42,301	4,836

Source : Calculated from Table 19.

The figures given in Table 20 are extents that can be cultivated in Maha. In Yala and in the Intermediate seasons, these extents can be further restricted depending on water availability. The extents in Table 20 can however, be considered as the 'upper limit', in order to calculate the crop water requirements.

4.16.4 Methods in mixing of crops

An introduction had been made on the benefits of mixing of crops and the limiting factors had been identified. Methods of mixing crops that could be commonly used in Sri Lanka are described below:

Combination of Mono Cropping and Crop Rotation. In this method a combination of crop are rotated in the same field from season to season. During a particular season, the field will carry only one crop (mono-cropped).

Combination of Mono Cropping, Crop Rotation and Field Rotation - Here, a particular crop is rotated in different fields during subsequent seasons. Location of fields for cultivation in respective seasons is important; if fields are close in its location (less than at least 1 km), it nullifies the effect of rotation of crops as it will facilitate pest and disease multiplication. The benefit in this system is that continuity in supply in each season is assured, a criterion considered very important in the export market.

Mixed Cropping - In mixed cropping, many crops are grown in the field in the same season. Normally the crops are not cultivated in a particular sequence.

Inter Cropping - This is also a system of mixed cropping, however, a sequence is observed in planting the different crops. The different crops are normally row planted in a particular sequence, in order that the plants will optimize the use of the nature's resources.

Relay Cropping - This is again a system of mixed cropping, the difference being that 2 to 3 weeks before the harvest of a particular crop, another crop is introduced between rows of the former crop.

In all these systems of mixing crops in the field, certain important guidelines have to be followed for better crop sanitation, yields and profitability/marketability.

4.17 Selection of only Recommended Crops

The Department of Agriculture, Sri Lanka has recommended crops based on season, cropping condition (lowland/upland) and on location suitability (refer 'Agrotechnical Information' of Department of Agriculture '90). The present study has also selected a group of crops-cash crops, annual crops and perennial crops (refer contents under 'Screening Methodology' in this study) based on above and marketability criteria. For instance, passion fruit is not recommended to study areas and chillie to System 'C', due to pest and disease problems and beans and zucchini have been left out due to marketability problems. It is suggested that the recommended crops should be cultivated in the Mahaweli areas under study, the exception being the cultivation of non-recommended crops after extensive environmental suitability studies and with buy-back arrangements.

4.17.1 Legumes in crop combination

It is recommended that a legume should be included in the crop combination in order to improve the soil nitrogen content.

4.17.2 Avoidance of crop family members in crop combinations

Some crops belonging to the same family are susceptible to the same pest and disease. For instance members of the Solonaceous family are prone to bacterial wilt and the vectors in leaf curl disease of Chilli and yellow mosaic leaf disease of Okra are the same.

The selected crops have been identified with the family name below, for easy reference.

Solonaceous family - green chillie, bird's eye chillie, egg plant, tomato.

Bulb Family	- Red onion
Legume family	- Ground nut
Cucurbit family	- Cantaloupe, Gherkins
Hibiscus family	- Okra
Cereal family	- Baby corn
Oil plants	- Sesame

4.17.3 Crops for intermediate season

Due to delays encountered in rainfall or water release, seasons can get delayed. Delays in Yala may sometimes extend to Intermediate season. Selection of short crops for the shortened intermediate season, thus becomes necessary. Some crops of short duration are Baby corn, Red onions, gherkins and Groundnut.

4.17.4 Crop combinations

Depending on the duration of the crop, the select crop range can be grouped as short term cash crops, annual crops and perennial crops. As farmers still prefer to cultivate paddy in lowlands, the lower terrains consisting of LHG and alluvial soils could be used for paddy and only the higher terrains could be used for suitable combinations of cash crops and annual crops, respectively. The select crops have been grouped, season-wise, as follows (Table 21):

Table 21

Lowlands : In Systems H, C, G and Uda Walawe

Season	Maha	Yala	Intermediate
Soil Group :	RBE - WD RBE - Im.D.	RBE - WD RBE - Im.D.	RBE - WD
Extent (Table 20):	42300	49496	49496
Duration :	Nov/Dec-Mar/Apr	Apr/May/June/July	Jun/Jul-Sept.
Cash Crops			
Tomato			
Egg plant	x	-	-
Green Chilli	x	-	-
Bird's Eye Chilli	x	-	-
Okra	x	-	-
Red onion	-	x	x
Baby corn	-	x	x
Sesame	-	x	-
Ground nut	-	x	x
Gherkins			
Annual Crops			
Banana	x	x	x
Pineapple	x	x	x
Cantaloupe	x	x	x
Perennial Crops			
Cashew			
Mango	-	-	-
Papaya	-	-	-
Grapes	-	-	-
Grape fruit	-	-	-
Carambola	-	-	-

Uplands : In Systems H, C, G and Uda Walawe

Soil Group : RBE - WD
Extent (Table `0) : 4836 ha
Crops : Annual/Perennial/Cash Crops

Annual Crops : Banana, Pineapple and Cantaloupe
Time of Cultivation : Any time, preferably in November-December, should be supplemented with lift irrigation.

Perennial Crops : Cashew, Mango, Papaya, Grapes, Grape fruit and Carambola.
Time of Cultivation : Any time, preferably in November-December, should be supplemented with lift irrigation especially for Papaya and Grapes.

Cash Crops :	Seasons	- Maha	Yala
	Duration	- October to March	April to June
	Tomato	x	-
	Egg plant	x	-
	Green Chilli	x	-
	Bird's Eye Chilli	x	-
	Okra	x	-
	Red Onion	x (Dec-Mar)	x
	Baby Corn	x (Dec-Mar)	x
	Sesame	-	x
	Ground nut	x (Dec-Mar)	x
	Gherkins	x (Dec-Mar)	-

Cash crops should be supplemented with lift irrigation especially in Yala. A thumb rule in satisfactory lift irrigation, is the capacity to pump 5 litres of water in one minute. Sub surface water resources in the Mahaweli areas have not been evaluated as it is beyond the scope of this study.

Possible Crop Combinations

Season :	Crop Combinations Maha	Yala	Intermediate	Net Returns/ha/Year(Rs.)
Combination 1,	Tomato	Groundnut	Baby corn	60,000.00
Combination 2,	Egg plant	Baby corn	Groundnut	60,000.00
Combination 3,	Okra	Red Onion	Baby corn	67,500.00
Combination 4,	B.E. Chillie	Red Onion	Groundnut	57,500.00
Combination 5,	Green Chillie	Sesame	Groundnut	45,000.00
Combination 6,	Egg plant	Sesame	Groundnut	45,000.00
Combination 7,	B.E. Chillie	Sesame	Groundnut	40,000.00
Combination 8,	Tomato	Sesame	Groundnut	45,000.00
Combination 9,	Green Chillie	Red Onion	Groundnut	62,500.00
Combination 10,	Egg plant	Groundnut	Red Onion	62,500.00
Combination 11,	Okra	Sesame	Groundnut	40,000.00
Combination 12,	Okra	Groundnut	Red Onion	57,500.00
Combination 13,	B.E. Chillie	Groundnut	Baby corn	55,000.00
Combination 14,	Tomato	Groundnut	Red Onion	62,500.00
Annual Crop 15,	Banana	Banana	Banana	100,000.00 (first 14mth)
Annual Crop 16,	Pineapple	Pineapple	Pineapple	50,000.00 (end of 3yrs)
Annual Crop 17,	Cantaloupe	Cantaloupe	Cantaloupe	15,000.00

In addition to the given guidelines, in deciding the correct crop combination, the quantity demanded is another important factor to be considered. A particular crop may have a higher overseas and local demand than others. Taking into consideration the importance of respective crops and crop rotation, a plan (crop calendar) may have to be drawn, with the co-operation of farmers in a particular area/yaya.

4.17.5 Co-ordination

It is the view that the provincial staff of the Mahaweli Employment, Investment and Enterprise Development Division should carry out the task of preparation of the cropping calendar.

In co-ordinating, the following matters need attention:

1. Co-ordinate with the buyer, in regard to the demanded quantity, quality parameters and price;

2. Determination of the correct mixed cropping system; it is recommended that a system of 'Mono-Cropping, Crop Rotation and Field Rotation' be followed for best results;

3. Negotiate with the provincial Irrigation Division of the Mahaweli Authority, as to the release of water according to the cropping calendar;

4. Co-ordinate the distribution of the buyer's package of inputs and the extension service, to the contact farmers.

5. Supervise the operation of the buy-back arrangement at the time of harvest. This is an area where lot of allegations have been made by the buyers and by the farmers.

Extent of dedication in performing the above tasks, may well decide the success or failure of the Buyer-Contact Grower linkage. Above co-ordinating role has been recommended because Buyer-Contact Grower linkage without a co-ordinator has proved unsuccessful in most of the study areas. However, the task of the co-ordinator, the provincial EIED officer, is not easy and involves authority over many specialist fields-Soil Chemistry, Agronomy, Quality Control, Marketing and above all his 'Public Relations' with the grower, buyer and with officers of other supporting services. This tasks may be in addition to the present work load of co-ordination of release of commercial upland extents to prospective investors.

5. SYSTEM OPERATION PROCEDURES

5.1 Rehabilitation Necessary for System Operation

This is considered separately for systems C.G.H and Uda Walawe.

(a) System C

The canals have been in use for the last decade and the condition of maintenance is generally satisfactory, the work being done under contract by F.O.O. This system has 56% LHG soil in valley bottom lands (Ref. Nippon Koei July 92, p.13) and such land is best suited for paddy cultivation. This system has 19048 ha. of irrigable area [MEA Implementation plan 1992/93. Maha and Yala] The command area under this system is 21675 ha. (MECA). Necessary rehabilitation is to line the canal in sections where seepage is heavy, provide retaining walls or rip-rap protection on the outer bends of the canals and clearing drainage lines. The RB sluice Ratkinda has a leak at the gate. This is estimated at 1.7 MCM per week. This needs repair. In this system there are 26 small tanks with irrigation canal networks. These tanks are useful in that they collect the drainage waters which can be reused. The system is fed by Ulhitiya and Ratkinda reservoirs. Damaged measuring devices and leaking turn out gates need repair.

(b) System G

This system has the highest percentage of well drained soils up to 70% (MEA Bakamuna) and is best suited for O.F.C. cultivation and also a high proportion of canal lining is desired to reduce loss.

In this system, canals are overloaded to enable farmers to get water at the tail ends. In many places, water flow is up to bund top level.

The system has a gross area of 10,000 ha. of which 5400 ha are irrigable. The total encroachment in the system is estimated at 1,500 ha. This is one of the causes for high water usage in the system.

Control structures in D. canals where head walls and wing walls have been exposed due to erosion need earth filling and rubble packing. Measuring devices, mainly the humps that are damaged need repair.

(c) System H

The area under the system comprises H1 to H9 sub areas. H6 and H8 are the old schemes under Kandalama. H9 is new area under Dambulu Oya. The command area is 38,462 ha, consisting of 12,146 ha under LB and 26,316 ha. under RB (MEA 1985). This system has regulatory reservoirs on the main canal and some small tanks in the distributory system. The system has 60% distribution of well drained soils and 40% of LHG. H1 and H2 come under Kala Wewa LB, and H4. H5 are under Kalawewa RB and H3 is the old area under Yoda Ela. Erosion of canal bund at critical sections need protection. Head walls and wing walls exposed due to erosion too need repair. Faulty measuring devices have to be repaired and calibrated.

(d) Uda Walawe

The reservoir in Uda Walawe has 2 main canals. The RB is 40 km long with a design discharge of 22 cumecs to irrigate 12,300 ha. land.

The LB is 31.5 km long, design discharge 36.8 cumecs and irrigating 5150ha. The LB is proposed for extension to take up a further 9240ha.

The canals are overloaded that the spills of all structures have been lifted by 150mm on the RB. The RB canal is heavily eroded, perhaps due to overloading the canal and higher velocities maintained.

Canal embankment at critical sections need to be protected. Measuring devices to be checked and corrected. Leaking Wooden gates to be repaired.

5.2 Redesigning of Structures & Canals

The Present status of the Systems has been described in the report. The canals conveyance is exceeded and is therefore a strong indicator that either the area benefitted has exceeded or the water duty is high because of high conveyance and distribution losses. Both these factors were evident in all four systems. The area benefitted included reservations and as a result of encroachment on to F.C. bunds, improper levelling of fields, and excess use by head enders the losses were high.

The quality of workmanship is generally satisfactory. However, it is thought advisable to reduce overloading of canals and maintain free board as per design in the canal networks. Measuring devices to be checked and once again calibrated for accurate monitoring.

5.3 Rectification of Construction defects

Many of the current defects stem from the reason that many constructional defects have been degraded to unnecessary low levels of priority and postponed.

Most field canal bunds have been weakened by encroachments and such bunds tend to lose more water by seepage. The main canals need cleaning of weeds and hydrilla infestation.
Restoration of the free board originally designed for the canal is very essential.

Measuring devices have been constructed, but many of them in the Field Canals cannot be used for accurate readings because of damage or the absence of reading gauges. Correct flow measurements are necessary to detect faulty design or construction.

5.4 Improvement to On Farm Water Management

The canal network is designed for one cusec [28.3 litres/sec). discharge at the turn-out. A Field Canal irrigates 6 to 16 one ha lots [15 to 40 acres] D. Canals feeding FCC have been designed to deliver one cusec to all FCC at the same time. The Main and Branch Canals which feed the D. Canals have also been designed accordingly.

Improvement of on farm water management can be undertaken after facilities for monitoring water issues are installed in the relevant canals and arrangements made to reduce canal seepage by strengthening bunds, proper land levelling and improvement made to gates and control structures.

Simultaneously the command area cropping has to be restructured so that only ill drained bottom lands continue under paddy and all well drained and moderately drained areas are brought under OFC. This will make the water deficit areas to be transformed into water adequate areas that could promote high value cropping with less water use.

The scope for large scale commercial agriculture as opposed to the existing subsistence level farming has great potential in the Mahaweli Area with the improvement of on Farm Water Management.

The crops proposed in the design were paddy for the imperfectly and poorly drained soils and OFC for the well drained soils during both Maha and Yala. But in practice nearly 80 to 90% of the land is cultivated with paddy in Maha requiring 30 days of water issue for land preparation and a rotational issue for 120 days for a long term [4.5 month] variety and in Yala too a short term (3 month) variety of paddy is cultivated to some extent together with OFCs. Again a continuous issue for 30 days for land preparation and a rotational issue for 90 days is provided.

Though on farm water management is based on the SOP, but due to operational difficulties and other exigencies the efficient distribution of water within the units will be of primary importance. This will require the close participation of the agency and the farmer.

5.5 Present Operation and Maintenance Procedure Distributary System in Systems C, G, H & Uda Walawe

A. Uda Walawe

The RB main canal was inspected and showed that the canal had been eroded on bed and sides, indicating that canal had been overloaded to make available water to the command area. It will be noted that the command area is mostly well drained soils and the conveyance system thus taxed to the utmost.

As water resources are scarce, loss in conveyance as deep percolation has to be stopped. The present cross section has vegetation in the sides which reduces flow velocities. Hence lining of RB main canal is recommended in at least critical sections.

The length of the RB main canal is 40km. 37% of the project area is well drained and imperfectly drained area is 25% while poorly drained area is 38%. The total area benefitted is 12,300ha. RB canal design capacity is 22 cumecs . Uda Walawe LB canal is designed for 36.8 cumecs to irrigate 20,000 ha. Uda Walawe has a perennial flow of 1057 MCM, and the reservoir capacity is 268.98 MCM.

At present the Headworks of Uda Walawe and all other systems under the Mahaweli project are maintained by the Head Works O & M Division of the MASL. The Main Canal, Branch and D. Canals by MEA and all Field Canals by the farmers through their Farmer Organisations. This system is working satisfactorily except that due to lack of funds only urgent maintenance work is given priority.

B. H Area

The System H Consists of 31700 ha of farm land lying under the command of Kandalama, Dambulu Oya and Kalawewa reservoirs. The whole area is divided into 09 Sub Systems H1 to H9. The Development of this area has taken place in two stages, viz (i) area developed before Mahaweli Project (6700 ha) (ii) area developed under Mahaweli Project (25000 ha).

The area is mostly well drained and releases from Kalawewa are inadequate. The cropping intensity is about 150%

Kandalama tank irrigates 4900 ha in H6,H1,& H8 through 2 main canals (43.2 km), one branch canal (2.7 km) and 85 km of Distributory canals. There are 08 nos small tanks in the irrigation systems.

Dambulu Oya reservoir irrigates 2160 ha in H9 area through LB main canal (5.9 km), one branch canal (8.7 km) and 47.3 km of distributory canals, There area two tanks in this systems.

Kalawewa tank irrigates 24640 ha in H1 to H5 through 3 main canals viz Left Bank, Right Bank & Yoda Ela (105 km), 279 Km of Branch Canals and 542 km of distributory Canals. There are about 100 small tanks and 14 Anicuts within the System.

The Maintenance is carried out in the system as outlined under Uda Walawe Project

C. Systems G

The present practice at system G is for the Irrigation Department Officials at Bakamuna to handle the operation and maintenance of the Headworks and the Main Canals. The MEA handles the operation and maintenance of the Branch and D. Canal since 1990.

Several changes and improvements were effected to the anicut structure across Ambanganga at Elahera with the commissioning c liversion at Polgolla and Bowatenna. The Modifications incorporated with the anicut structure and the main canal (EMYE) facilitated increasing of conveyance of water to 42.5 cumecs.

As in the H area, development has taken place in two stages viz. 2500 ha before Mahaweli and 2500 ha after Mahaweli. The main source of irrigation water to system G is from EMYE. There are about 96 km of distributory canals within the command area.

The Field Canals operation and maintenance is managed by the Farmer's themselves through their Farmer Organisations (F.OO) From this year the MEA had offered the maintenance of the D. Canals on a contract basis to the Farmer Organisations and only if they are unable to undertake this work, does the MEA attend to the maintenance. This arrangement appeared to be working satisfactorily. Maintenance had to be on a priority basis depending on the allocations received.

The Soil types in System G composed as 70% of RBE and 30% of LHG.

D. System C

System C consists of 21675 ha of irrigable area and 19,048 ha have been developed up to now. This area is sub divided into 5 zones viz. zone 2,3,4,5 & 6. Soil type of the system is composed as 44% RBE and 56% LHG.

Zone 2 of system C is irrigated through 10.9 km LB main Canal, 19.2 km of Branch Canals and 170 km of distributory canals.

Zone 3 to 6 are irrigated through 17.0 km RB main canal and 100 km of Branch Canals. There are about 26 Nos small tanks in system C. Operation and Maintenance of field canals are carried out by farmer organisations while MEA carries out the maintenance of Main, Branch and distributory canals awarding contracts to FOO and Contractors.

5.6 Existing Procedures for Water Management and Water issues at Macro and Micro Level

From the extensive research and the various model studies that have been carried out and still continue to be carried out in the Mahaweli Systems, one fact that can be clearly seen, is that, crop production in an irrigation system largely depends on Management and not so much on water. This was evident in the systems visited. For instance in System G and H, the total amount of water released was adequate for the acreage under irrigation, but due to the uncertainty of a reliable and timely delivery and the inability to control excess use of water by head-end farmers, or due to lack of farm power and labour or the delay in obtaining seed material in time or lack of finances, there were delays in the agricultural activities, which in turn affected productivity. This was an indication that management depending on the needs of the water user was not effectively implemented. This probably was due to administrative control or lapses in the physical system or demand for hydro power, or outside interference. Whether these were constraints or not, depended on how the management reacted.

The hierarchy of the MASL and the MEA are all based in Colombo Head Office. The organisation at the field level consists of the Resident Project Manager for each project under the System who comes directly under the control of the Managing Director based in Colombo. Each project consists of about 25,000 to 30,000 ha. Each of these are sub-divided into blocks of 2500 Ha. with a Block Manager incharge and each of these blocks are further sub-divided into units of about 250 Ha. incharge of an Unit Manager.

The officials involved in the Water Management at field level are the Block Managers under whom the Irrigation Engineer and Technical officers handle the operation and maintenance of the system.

The Water Management Panel (WMP) under the MASL consists of the following members:

a) representatives of Mahaweli Agencies
b) Members of Parliament of the area receiving Mahaweli Water and
c) representatives of projects earlier under the Irrigation Department but receiving Mahaweli Water.

The present procedure is for the WMP to meet before a cultivation season and on the advice of the Water Management Secretariat WMS which is also an umbrella organisation under the MASL, decide on the operational policy and decides on dates for the cropping calendar for the irrigated areas under the Mahaweli Project. This includes the coordination of the diversion and distribution of the water. On this basis two Seasonal Operating Plans (SOP) are prepared each year. The 1st date of issue and the last date of issue, and the extent to be cultivated is included in this SOP and this is sent down to the field for operation. This year the MASL even published these decided dates in the daily papers so that farmers too will be aware of the dates.

In the field, the MEA officials summon a Kanna Meeting before commencement of the season and formally gets the dates set by the WMP approved by the farmers. At this stage farmers have no option but to adhere to these dates. This, in a way, is a good practice, for farmers will all have to fall in line with the decisions, but in practice, due to various reasons as stated elsewhere in this report, some farmers are late to commence their cultivation. This usually causes problems in having to make ad-hoc changes of water issues in the field to those who are late as well as to the extra extent some have cultivated on encroachments. Invariably these changes that the field level staff had taken, mostly due to demands from farmers and with their participation are not reported in the Seasonal Summary Report SSR which is submitted at the end of every season. They have in most cases not been either recorded at field level.

In practice, the distribution in the Main, Branch and D. Canal are handled by the MEA, except in system G whe:- the Main Canal, operation and maintenance is handled by the Irrigation Department. However, the release of water is as per WMP decisions.

The operation and maintenance and the distribution of water in the Field Canals is hanuled by the farmers through their Farmer Organisations. This system is working satisfactorily in all the systems we visited. There had been instances where the issues in the Main Canal, Branch and D. Canal had to be deviated from the SOP at times of crisis but done in consultation with the farmers. The efficiency of the water distribution within the block has to be on a participatory basis with farmers and this should be given high priority.

The main problem faced by the agencies were the illegal tapping of water from the main canal, which drastically effected water issues in the field and water management made very difficult.

5.7 Irrigation Methods

a) <u>Trickle or Drip Irrigation</u>

Drip irrigation had been long established as a method for glass house crops. and it is only since of late that it has been developed for use in the field. The cost is high and there are flow problems which are not easily overcome, but the advantages are considerable.

The basis of the system is a perforated plastic pipe laid along the ground at the base of a row of plants and supplied from a field main. All field pipes are left in place during the duration of the crop and water is supplied daily by turning on the tap. The method lends itself to the application of fertilizer in solution and this is the usual practice. The perforations or outlets are designed to emit a trickle rather than a jet, and spacings are selected to produce a wetted strip along the crop row or a wetted bulb of soil at every plant.

Simple perforations in a pipe tend to block specially if the calcium content is high and do not give uniform emission over the length of the pipe necessary for the method to be practical. Various methods have been devised to overcome this problem which is mainly caused by pressure drop along the pipe. An Israeli system uses field pipes of 10 mm dia. polythene tubing at a water pressure of 1 to 2.3 atmospheres. Holes are punched in the tubing and dripper heads attached at spacings of 0.5 m to 1.0m. The pipe pressure is dissipated by a spiral duct within the head and the trickle discharge is 2 to 8 litres/hour according to the dripper head selected.

Another system, which is commercially available in the USA, uses a double walled pipe. For each perforation in the inner tube there are four perforations in the outer tube equally spaced at 200 mm centers. A system developed in Hawaii uses trickle heads through which pressure is reduced to 1/3 atmosphere at a discharge nozzle. The small jet from the nozzle is broken by a cup shaped deflector.

The main advantage of trickle over other types of irrigation is the excellent control of water application which it provides. Water is applied daily at a rate as close as possible to the rate of consumption by this plant. Evaporation from the soil surface is minimal and deep percolation can be almost entirely avoided.

Soil moisture deficit is kept to a very low level by daily irrigation but soil aeration is maintained. By inclusion of fertilizer in the water, nutrients are supplied directly to the plant roots and, being in the water, it is readily available to the plant. These two effects combine to provide an environment highly favourable to plant growth and improvements in yield and quality, whilst discouraging weed proliferation.

Field experiments on tomatoes in Israel have shown yields per hectare 65% greater than obtained by furrow and sprinkler irrigation, but these were with saline water. However, the quantitative increase depends on all the conditions of soil, crop, climate and cultivation and in general it can be said that only the trickle or drip irrigation system can be expected to give significantly better results than the other methods. The other advantage is in its operation. It is convenient, simple to use once set up, and has a low labour requirement. Unfortunately, the capital cost for trickle or drip irrigation equipment is considerably higher than that of sprinkler or gravity irrigation, and the problem of blockage of the outlets does not appear to have been completely solved, hence the maintenance cost too is high.

b) <u>The design of Sprinkler Irrigation System</u>

The items required in the design are:

1. The lay out of the system
2. Selection of the sprinkler and nozzle
3. The design of the sprinkler lateral and number required
4. Design of the main pipe line.

c) Planning of the system

The system chosen should be the most economic which performs to design requirements.

Factors to be considered are :

1. The crop to be irrigated must be worth the expense of sprinkler irrigation. If sprinkler system is appropriate then the availability of skilled personnel to service the equipment must be assured.

2. The amount and rate of water application, bearing in mind the possibility of crop rotation.

3. The availability and cost of labour compared with that required for the type of scheme being considered. (i.e. portable, solid set or mechanised)

4. The appropriate method of driving pumps. If electricity is available at site. a choice can be made between electrical or diesel power, or occasionally the use of a spare tractor with a adaptable shaft.

d) Selection of Sprinkler, Spacing and Crop

By considering the type of crop, the soil and climatic conditions, the general type of sprinkler to be used can be chosen. The problem is to decide on the particular combination of nozzle, operating pressure, spacing along the lateral and lateral shift distance.

The following table will be applicable for most field applications.

Type of Sprinkler	Pressure Range	Wetted diameter	Discharge	Equivalent rain fall	Comment
Medium Pressure	30-70psi (2-5kg/cm2)	70-140ft (20-45M)	2-20 gpm (0.55-5.5) m3/h	0.13-1.8in/h (3.3-45mm/h)	Good to Very good uniformity. Suitable for most application

Source : Irrigation design and practice by Bruce Withers & Stanley Vipond p.50 - 1980.

This type of irrigation may be good and economical for flat and large orchards, particularly where labour is expensive and scarce, sandy soils, high evaporation rates and crops of high value. Aluminium pipes with couplers is the best for mains and laterals.

No matter which sprinkler system you select it will consist of four basic units. They are as follows:

- pumping unit
- main line pipe unit
- lateral pipe unit and
- sprinkler unit.

However, the fact that it has become an established practice in many countries suggest that these demerits can be outweighed by the many advantages.

Another possibility is that, even though there is a strong justification for using surface irrigation for most of the growing season and then introducing frequent light irrigation by portable sprinkler units at times of critical moisture periods could still give the desired results. In Britain 25 mm of water applied at a critical stage of growth can have an effect as 100 mm applied uniformly through the irrigation season. [Source : Crop responses to water at different stages of growth, Research Review No.2, Commonwealth Agricultural Bureaux.

e) Selection of Irrigation Methods for High Value Crops

Selection of an irrigation method is based on technical feasibility and economics. Surface methods are generally the cheapest to install, and where conditions are suitable there is little point in considering other methods.

However, where high value cash crops are to be grown there may be economic justification for considering other types of irrigation, especially where conditions are not ideal or costly amendments are required for surface irrigation.

The sprinklers are three types (1) rotating or rotary sprinkler (2) spray type nozzles and (3) Perforated pipes.

The rotary sprinkler is the most popular of the three types. Spray type nozzles do not rotate. They produce a fixed spray pattern ranging from 90° to a circle, depending on the field application. Perforated pipe is a pipe with holes in it through which water sprays out over a limited area. The rotary sprinkler rotates by the force of water action usually against a spring loaded lever. It strikes one side of the sprinkler with enough impact to cause it to turn slightly. As this action is repeated, the sprinkler continues to rotate thereby making complete revolutions.

There are many different types of sprinkler systems but they are generally classified under these categories :

a) multi-sprinkler b) single sprinkler c) Boom sprinkler

In the multi system you get five general types, they are :

(1) Permanent (2) hand moved (3) tractor moved (4) self moved and (5) self propelled.

In the single sprinkler system a large gun type sprinkler is operated under pressure to irrigate a large area approximately 1 to 6 ha.(2.5 to 15 Acres.)

The single sprinkler will be classified as (1). hand moved or tractor moved and (2) self propelled types.

The hand moved type is so called because the laterals and sprinkler are moved by hand/tractor from one position to another. Usually aluminium pipes and couplers are used for easy handling. The self propelled type moves continuously from one end of the field to the other while sprinkling. This unit has a flexible hose lateral which is rolled on a pulley along the field by the same power that propels the sprinkler. The power is generated by a water driven turbine. a steel cable anchored at the opposite end of the field, guides the sprinkler as it moves. Flexible hoses 2.5 to 5 inches (6 to 13 cm) are generally used.

i) <u>Boom Sprinkler System</u>

This is sometimes called the rotating boom. This consists of a long sublateral (boom) with several nozzles spaced on the boom so as to provide even water distribution. This too has two types the 1) tractor moved 2) self propelled and operated in the same manner as for single sprinkler system. This is not commonly used due to its cost, and requirement of good field surface condition for the operation of the tractor with the boom and the lane required for the boom and bore even when self propelled.

The approximate cost of installing the sprinkler systems are given below:

ii) <u>Multi Sprinkler</u>

Permanent - will cost anything between Rs.180,000 to 540,000 per acre.

iii) <u>Hand moved</u>

Portable set will cost anything between Rs.36,000 to 144,000 per acre. Tractor moved will cost anything between Rs.72,000 to 144,000/acre.

iv) Single Sprinkler

Hand moved will cost between Rs.45,000 to 90,000/acre

Tractor moved will cost Rs.90,000 to 180,000/acre.

v) Boom Sprinkler

Tractor moved will cost Rs.90,000 to 180,000/acre Self propelled will cost Rs.90,000 to 180,000/acre.

These costs depends on the slope of the land, the water application rate, the shape of fields, sub surface conditions, the maximum height of crop, the labour required and the size of a single system varying from about 0.4 to 20 ha. (1 to 50 Acres). But does not include the cost of the pump, the power unit, machine and cost of water.

vi) Trickle or drip Irrigation

The approximate cost of installing drip or trickle irrigation systems are given below :

In Flat land - Point source emitters for orchards and vineyards Rs.10,800 to 16,200/acre.

Line source emitters for row or bedded crops - same as above.

All these above rates are based on the slope of the land, water intake rate in soils, slope of field and labour required. This does not include cost of water, pump and power unit and emitters.

[Source : Planning for Irrigation System - J.H. Turner-p. 76-93- 1980 and the US$ converted at Rs.45/=].

vii) Existing Installations

According to information gathered from Hayleys Agro Section, it was stated that the sprinkler irrigation system they constructed at Hingurane Farm for Sugar cane, about six years ago for a 10 acre block was around Rs. 800,000/-. Today, if they were to do the same project, it will approximately cost Rs. 1,000,000/-. This is for pump, PVC pipes and pumped from a reservoir.

On information obtained from official at the Sugar Cane Farm at Pelwatte, it transpired that they had imported direct and installed 10 (ten) Rotary sprinkler units and irrigate an extent of 115 ha. Each Unit with Wright Rain pumping unit has 22 sprinklers. Sprinklers are 2 meters high and each unit irrigates 15 Ha. This is equal to 35 mm of rainfall in 12 hours. Each unit works on two shifts of 8 to 12 hours irrigating 1.5 Ha at a time on a rotation of 10 to 12 days. Each unit complete, will today cost approximately Rs. 1,000,000 for installation, he said. The approximate operation cost to operate the 10 units will be around Rs.2450/- per day based on the following: 5.5 litres of diesel per shift per unit. Wages of 1 Pump operator and 1 Semi skilled Labour. These two could handle 3 units per shift.

The maintenance cost will be only when replacements are necessary for the Pumping unit, sprinklers and the portable pipes and couplers. The general maintenance is the servicing of the pumping units which is approximately about Rs.5000/= per month. Based on these figures the O & M cost will be round Rs. 55,000 to 60,000/- per month for all 10 units.

In system B a nursery is being maintained by MASL efficiently using sprinklers, micro sprinkler (mist) and drip irrigation. The nursery is for Pineapples and various fruit trees.

viii) Gravity Irrigation

The approximate cost of laying out the canal system for a new project without cost of head works will be between Rs.75,000 to 100,000 per ha. depending on the soil and slope of land. The O & M costs is approximately Rs.500 to 700 per Ha.

5.8 Year Round Irrigation in other Countries

Consultant visited the experimental one hectare block under drip irrigation for ground nuts in the Anna University, water resources engineering, field experiment center in Madras. This was a surface drip project, with water from an overhead tank.

The work in the project consisted of ground nut drip irrigation by flexible pipe with 3 mm nozzles the pipes are connected to a fixed pipeline laid at the highest elevation and the flexible pipe manually lifted and put in the line of the ground-nut plants after 3 hours of irrigation. This method is highly labour intensive and can be undertaken only with highly motivated research persons.

Due to intense application to manual labour the cost of O & M will be dominated by wages of O & M manual labour.

5.9 Possibility of Using Ground Water for Year Round Irrigation

An investor of high value crops who is prepared to invest a big sum of money should be reasonably sure of the availability of water year round. He should be assured of the daily availability and should be able to utilise the water when ever he requires it. Therefore, the customary rotational practices may not be a suitable solution to the water requirements of his crops.

The only difficulty of obtaining a year round irrigation water in the mahaweli system is that these systems have been designed to provide irrigation water for paddy on a seasonal and rotational basis. This probably will facilitate the cultivation of certain variety of short term high value crops during the two seasons every year. Since soils suitable for crops like Gherkins, Baby Corn, Sweet Corn, Tomatoes, Melons, are present in the Mahaweli Systems, there should be no difficulty in the successfully growing of selected crops.

Then there are the drought resisting permanent crops like cashew, mangoes, pine apples, bananas and several other varieties of fruits which could be grown with minimal irrigation water. These could be irrigated from agro-wells or deep tube wells when gravity irrigation is not available. This could augment the year-round supply of water under lift irrigation by using pumps for furrow, drip or sprinkler irrigation. By these methods the moisture content in the soil around the plants could be maintained.

In fact these methods of lift irrigation viz, furrow, drip or sprinkler have not been adopted in the Mahaweli Systems except as sprinkler irrigation pilot projects in System B. Uda Walawe and the Hingurana and Palwatte Sugar Farms, due to its high cost of installation and maintenance.

These applications however, has its advantages, in that crops that require adequate on farm irrigation could be successfully grown and that even shallow dug wells or deep tube wells could be used for this purpose.

In any case the question of switching over to lift irrigation under furrow, drip or sprinkler will be mainly confined to the resourceful entrepreneurs and big firms. The small farmers will be able to enter into this only as outgrowers. In this study the consultants have not examined the hydrological feasibility of deep wells and the availability or non-availability of ground water in the Mahaweli Systems. This study will involve in the assessment of the yield from each well and duration of recharge as well as the total water potential available, its period and the repercussions it will have on the existing irrigation system.

It was however, possible to gather some information in Uda Walawe, of a Dutch entrepreneur who had dug some trial tube wells in his 20 Ha. block and found that the discharge was only 2 liters/Sec, and in another block of 20 Ha, the tube well had yielded 5 liters per sec. The trials had cost him approximately Rs.125,000/- in each block.

It was found that Private investors were reluctant to spend large sums of money even on site specific feasibility studies unless they are clear in their minds that water is available throughout the year and that they are consulted during the operation of the system.

Since investors will not have access to Mahaweli irrigation water and that they will have to find their own source of supply, it will be useful if the MASL or EIED could dig a few trial tube wells and run some pump tests to determine recovery rates in the large extents of lands to be leased and provide the drill log details and water table data to potential investors. This will indicate the probable water table in the area and will serve as an incentive to private investors.

6. MACHINERY AND EQUIPMENT FOR MAINTENANCE

6.1 Maintenance of Head Works and Canals

The O & M programme for round the year irrigation will be limited to head reaches of main canals and head and mid reaches of distributaries in the area. It is presumed the tail sections of the D canals and the main and branch canals will continue under paddy. Where drip irrigation is proposed, the command area will depend on the overhead tank capacities and their replenishment. For sprinkler Irrigation the command area will depend on the number of sprinkler units installed and the source will either be the canal or dug wells. In both cases maintenance of the pumps, nozzles and emitters will have to be periodically done.

Daily canal maintenance will be limited to removal of weeds or floating debris. Canal repairs after heavy rainstorms etc will be more frequent than desilting, because in the lined section there is little chance of bank erosion.

Maintenance work can be classified under the following categories.

i) routine
ii) seasonal or annual
iii) emergency

i) Routine maintenance will be clearing, desilting and weeding of field canals and D. Canals. FOO now handle the FCC and the MEA the D. Canals. This work should be on a routine programme prepared for the year.

ii) The seasonal or annual maintenance will be based on the findings after inspection of the canal and structures during the canal closures. Priorities will be attached to each work depending on the gravity of the repair needed, the location and the availability of funds. This work could be undertaken by the maintenance gang attached to the block office and will be minor repairs to gates and structures.

iii) Emergency maintenance will be for eg. like a badly leaking bund or structure that may suddenly breach or collapse causing a complete failure of the supply as against a repair that is unlikely to fail completely although it may restrict the supply of water. This work must be undertaken immediately by the block office and funds obtained if necessary from the RPMS Office. Provision for this type of work must be provided for in the annual maintenance estimate.

Maintenance of drainage canals too should not be neglected, specially in low lying areas where salinity could be a problem. Desilting and removal of weeds from drains should be included in the annual programme of maintenance activities. This maintenance work could be attended to once in two years after taking levels along the bed of the drains and identifying badly blocked areas to be taken up for maintenance on a priority basis. This work could be done by a back-hoe and or manually and in some instances a motor grader too could be used.

Maintenance of Roads in the system too should be annually attended to. This work will also have to be on a priority basis depending on funds. A motor grader will be useful for regrading roads, and in some cases in clearing drainage lines as well.

The present organigram of the MEA is shown in figure 1.

The actual operation and maintenance of the project comes under the purview of the Block Manager. The officer named IE Block is responsible to the Block manager for the proper functioning of the sub area canals, gates and control managements will be under this officers' jurisdiction. The I.E. Block is assisted by 2(EA) Engineering Assistants, whist each EA will be supported by 2 technical officers. In the proposed year round irrigation programme it is essential that operation and maintenance should be up-graded to such an extent that it merits special attention.

It is therefore proposed to have a unit exclusively for the day to day operation, maintenance & monitoring. The functions of this unit will be concentrated on monitoring flows as well as canal losses in addition to the normal operation & maintenance. This is illustrated in Figure 2 where IE maintenance will oversee the additional functions of monitoring and data collection. It has to be emphasised that success of pressure irrigation depends on reducing losses as conveyance and providing only crop water requirements.

6.2 Maintenance Functions

E.S.I. (Essential Structural Improvements) for structures necessary for control of flow has to be carried out, where such repair cannot be accomplished in the canal closure period of a maximum of five days, such work may have to be done by the unit, armed with rubber dams and pumps, to isolate such structures needing attention.

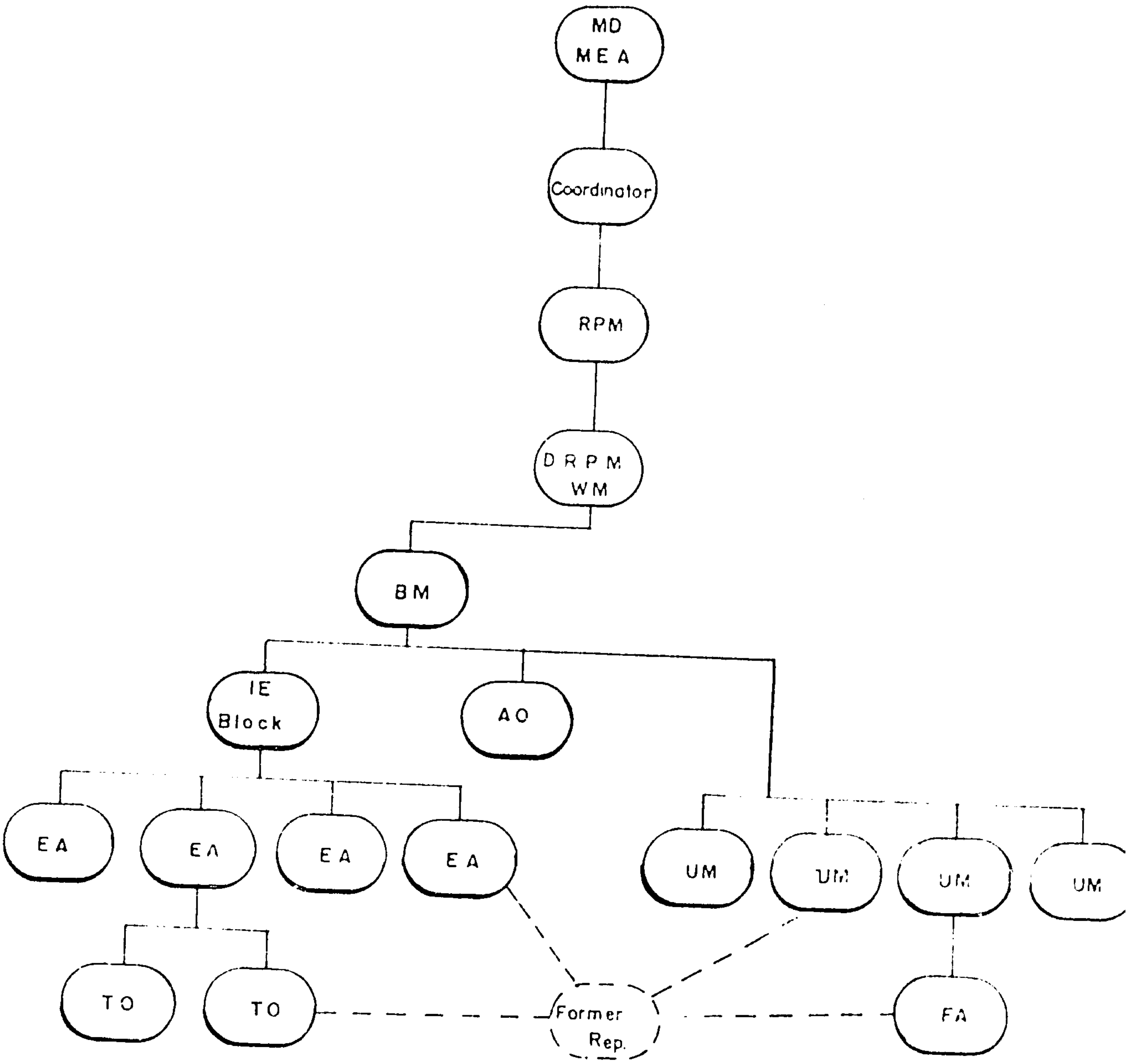
The round the year irrigation projected also means greater focus on the day to day repair and operation of gates and measurement of flows.

The measurements of discharges in main Canals, Distribution canals and field canals need to be carried out 3 times a day eg. 6 am, noon and 6 pm. to determine if the scheduled flows are delivered or not.

These measurements done by taking gauge heights and reading off a rating curve should be checked once in day by actual current metering as rating curves give in-accuracies with physical variations eg. canal roughness, sedimentation etc.

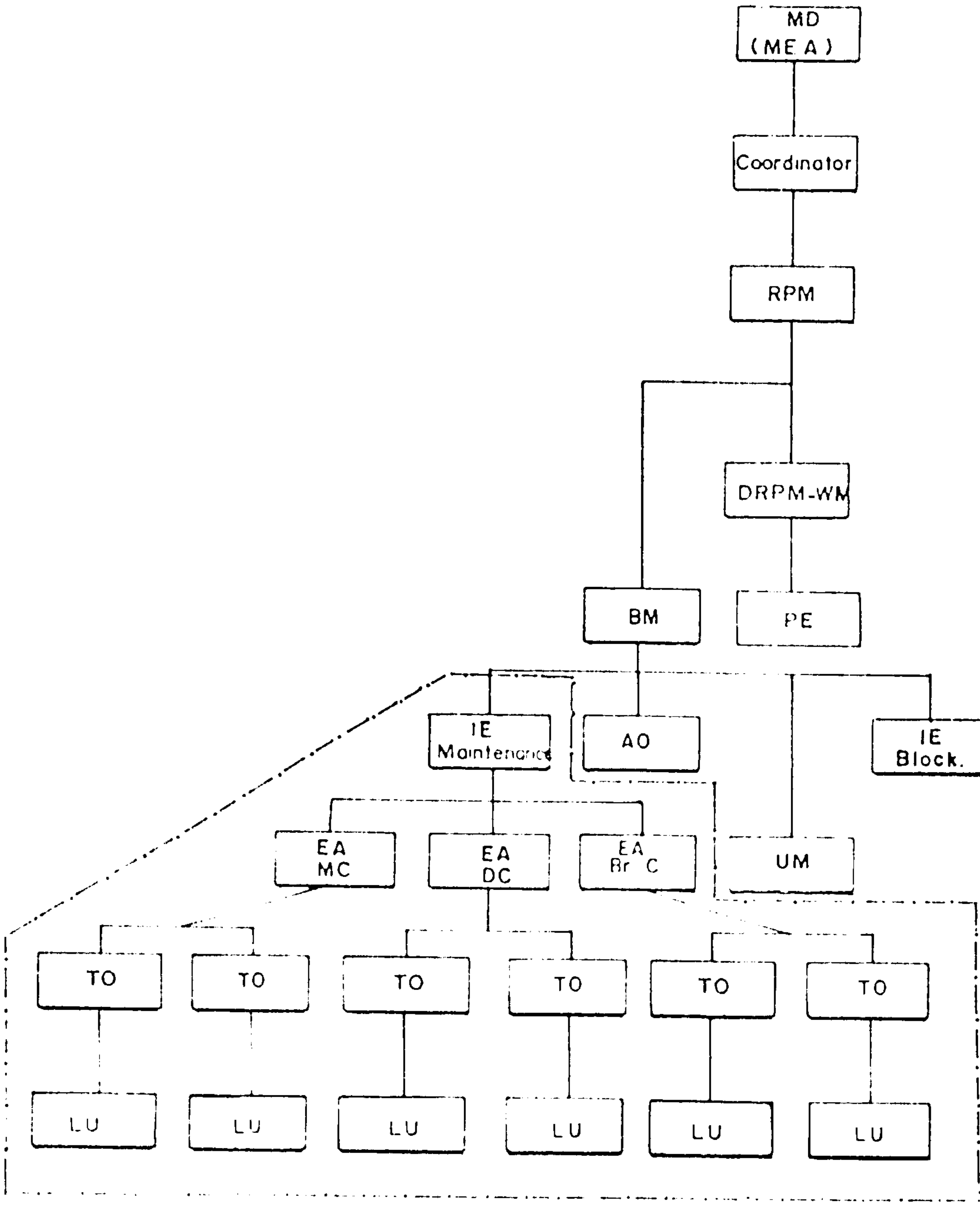
The I.E. maintenance will be expected to inspect all the D canals in addition to Main and branch canals daily or once in 2 days by jeep and walk on canal type surveys.

All data pertaining to flows, gauge height, rainfalls, canal losses wind speeds have to be collected daily and supplied to the I.E. maintenance who will maintain data banks for each canal.



PRESENT ORGANIGRAM - MEA

Fig. 1.



PROPOSED ORGANIGRAM
FOR YEAR ROUND IRRIGATION

Fig. 2.

6.3 Annual Maintenance Report

The reports submitted by the various officers could be studied and discussed at a monthly meeting in the Block Office so that remedial action could be taken. All these reports will be useful for the preparation of an annual maintenance report by the Block Irrigation Engineer. This will list all canals, structures and drains and indicate the maintenance repairs to be carried out for the year and the repairs attended to during the year.

6.4 Annual Maintenance Estimate

The above mentioned reports will identify the maintenance necessary for the next year. Based on this the annual maintenance estimate will include the programme of work proposed for the next year. In keeping with this estimate the maintenance programme could be prepared for the year.

6.5 Maintenance Programme

Project Manager should in consultation with F.O.O. declare at least 2 weeks before, that certain D canals or Branch canals will be closed for repair. The period of closure should not exceed the rotation period. During closure, desilting can be done either manually or with back hoe in case of earthen canals or tyre mounted excavator.

Machinery for weed cutting could be utilised even when the canal is flowing. For structure repairs, there should be a mobile unit that can be rapidly deployed. They will isolate a structure with sand bags and pump out the water and proceed with concreting that needs attention. The earth work can then be backfilled and consolidated with pneumatic tampers.

The Main Canal can be closed for one day on short stretches during Intermediate season and desilting in predetermined sections based on levels taken could be done during that period by machinery and or manually. Weeding and clearing of secondary growth can be done even while water issues are on. All RPM should prepare a calendar for the above maintenance in order to ensure smooth execution. Sequence of activities in operation and maintenance process is given in Figure 3.

6.6 Dewatering plan for accumulated maintenance work

The Main canals, Br. Canals and D. canals should be surveyed and levelled once in 2 year cycle so that the desilting of canals and restoring bunds and bund roads could be carried out.

Where cross regulators are present on the canals within one kilo meter length, they could be closed and the canal emptied by operating turn outs within that length and by use of pumps.

OPERATION AND MAINTENANCE PROCESS

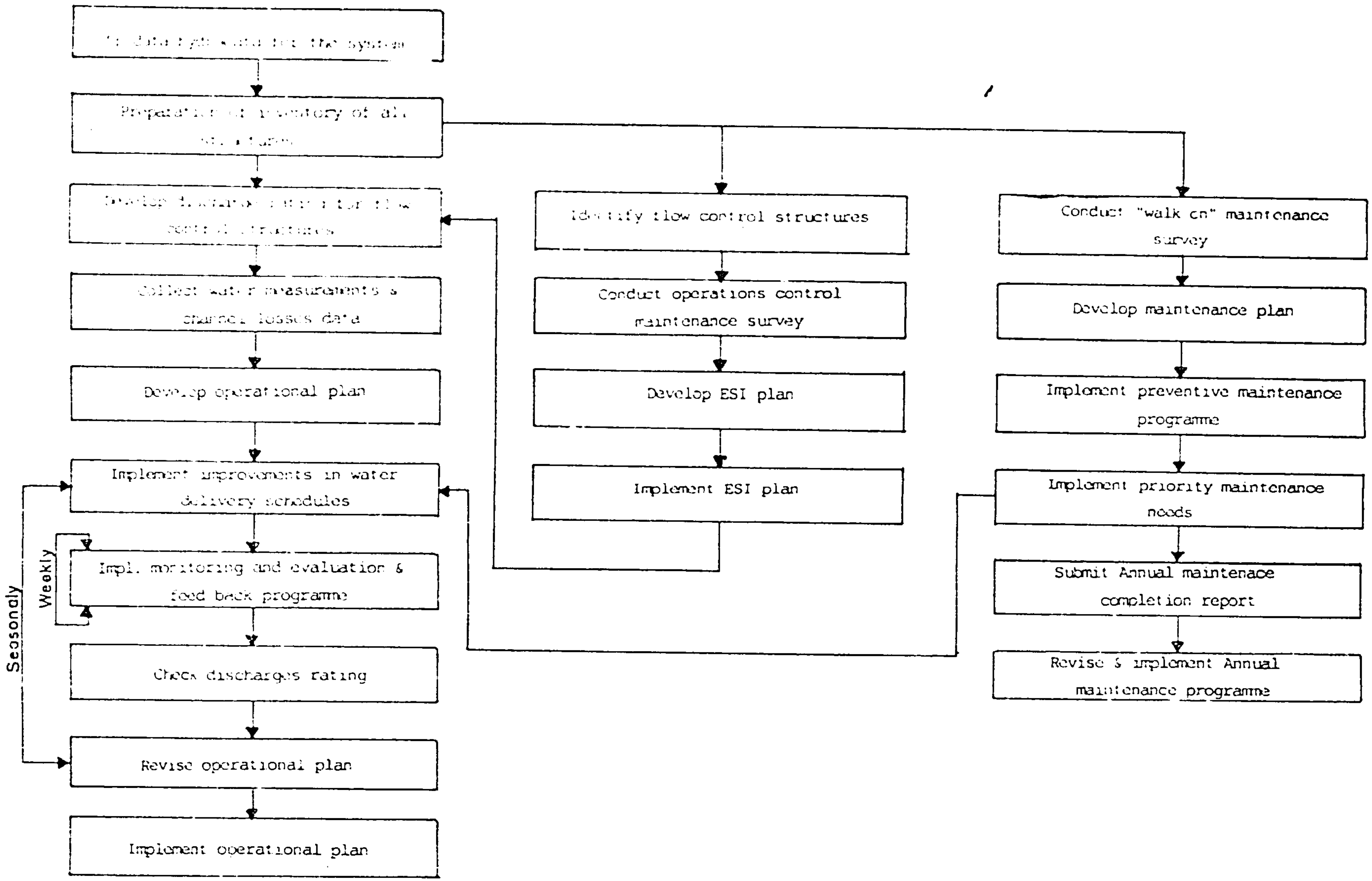


Fig. 3

If no regulators are present, sizable sections say 500m long could be isolated by sand bags and pumping out the water. For this type of work pumps of 5 to 10 cusecs capacity with low head say 15 feet would suffice.

Pumps are needed only to remove the excess water speedily. Inflatable rubber dams could also be used in conjunction with sand bags and suitable anchoring to isolate sections of canals for dewatering and subsequent desilting and repairs to structure. Desilting can be manually or by use of back hoe and farm tractor trailers.

Retaining walls could be built on curves in canals to prevent erosion if a long close season was available. Such long close season cannot be expected if round the year irrigation is practised. Steel sheet piling can be adopted for such sections as they can be driven without interrupting water issues.

6.7 Machinery & Equipment

Back hoe and weed cutting attachment is the most versatile and could be used even with water flow in channels where regulators are present, canal sections could be easily isolated and even pumped dry. Where regulators are located too far apart say over 1 km away inflatable rubber dams could be used with sand bags on ballast. Desilting is possible by back hoe or manually.

The following machinery and equipment may be necessary for each RPM's office. They could be deployed on maintenance work as mentioned in this report in the relevant paragraphs.

1.	Hydraulic Back hoe (rubber tyred) with weed cutting attachments	1 No.
2.	Tractor Trailers (0.75 Cu. trailer capacity)	4 Nos.
3.	4" dia low lift mobile pumps	3 Nos.
4.	Pneumatic tampers	6 Nos.
5.	Motor grader with adjustable blade for regrading Bund roads	1 No.
6.	Inflatable rubber dams 20 to 40 feet in length with air compressor	2 Nos.
7.	Canvas dams	2 Nos.
8.	Motorised rubber tyred crane-Capacity 1 to 2 ton	1 No.
9.	Pneumatic Hammers	2 Nos.
10.	Sheet piles steel 10 feet long	60 Nos.
11.	Sand blasting equipment with rotary brushes and sprayguns with air compressor	1 No.
12.	Front End Loader	1 No.
13.	2 KW Generator with 2 set of flood lights	1 Unit
14.	Tents	2 Nos.
15.	Plate vibrators	2 Nos.
16.	Monkey grubber	2 Nos.
17.	Timber piles for coffer dams	40 Nos.
18.	Gunny bags	500 Nos.

The following equipment will be necessary to set up a meteorological station in each RPM's unit.

1.	Rain guage	1 No
2.	Sunshine recorder	1 No
3.	Anemometer	1 No
4.	Current meter over 50 cusec	1 No
5.	" " 25 to 50 cusec	1 No
6.	" " 1 to 25 cusec	1 No
7.	" " upto 1 cusec	1 No
8.	Evaporation pan	1 No
9.	Soil moisture probes (portable)	10 Nos.

7. MONITORING AND PROGRESS CONTROL

7.1 Inspection Programme

Regular inspections of all canals, structures and drains, linked to a planned programme of maintenance is a prerequisite for every system. A system can only be operated efficiently if it is in good physical condition and will depend on timely and accurate measurement, reporting and processing of data with necessary adjustments made to canal discharges.

The first step should be to prepare an upto date hydro-data of every system. This should include the Issue Tree showing details of location of turn outs from Main, Br and D. Canals, The Canal capacities , the command area under each of these canals and their lengths. Secondly, the preparation of an inventory of all structures in the system with all details and a condition report of each structure as at present.

The main and Branch Canals should be inspected by the Chief Irrigation Engineer twice a year, once during canal closure and once when the canals are carrying its maximum discharge. A condition report of the structures and canals inspected should be submitted to the project office. This will assist in the preparation of the next years maintenance estimate and also help to decide the mode of execution of maintenance and assign priorities as to how, when and by whom the work should be carried out during the year.

The D.R.P.M. (W.M) should inspect all D Canals and structures serving more than 25 ha. monthly and a condition report of the structures and canal bunds should be submitted to the project office.

The Block Irrigation Engineer and the Engineering Assistants should inspect all D canals and structures once a week and submit their reports on the above basis to the project office.

The Unit Manager and Technical Officers should inspect all canals and structures in their respective sections atleast three times a week and submit their report on the above basis to the project office.

Field Assistants and Gate Operators should do a routine inspection daily and bring to the Irrigation Engineers notice any damages to canals, bunds or structures.

Whenever an emergency repair is deemed necessary, The inspecting officer should bring this to the immediate notice of the Block Irrigation Engineer and D.R.P.M Water Management, so that action could be taken to have the work inspected and funds released for necessary repairs.

7.2 Monitoring Operations

In order to ascertain operation efficiency of the system, all off takes from Main and Branch canals and long D canals should be made as measuring points by installing Parshall flumes or broad crested weirs and gauges.

Once the project gets on stream, it is advisable for closer monitoring to install rain gauges in tracts up to 400 ha. (1000 acres) so that spatial variation of precipitation within a project area are also recorded. Canal losses in conveyance can be established and sections that are contributing to heavy seepage loss can be remedied by lining or geo textile use.

As drip and sprinkler irrigation are planned, measurements of sunshine hours, humidity, wind speed, evaporation and soil permeability should be carried out at least at one location in each sub project. The equipment necessary for such an unit is given in para 6.7.

7.3 Progress Monitoring

As mentioned earlier, the efficiency of an irrigation system will depend on timely and accurate reporting of data necessary for both adjustments in the water management of the system to suit demands as well as help in planning future operations and checking the efficiency of the operation.

The following indicators will give valuable data and will be useful for future planning.

i) Cropping pattern - This will cover the actual crop areas by Field Canals.

ii) Monitoring of actual water issues. This will include water levels in canals from gauges in D.and F. Canals actual discharges and rotations.

iii) Daily rainfall - record of daily rainfall figures will help adjust water issues and decide canal closures.

iv) Condition reports of Canals and Structures to identify maintenance requirements.

v) Maintenance work planned for the year and carried out during the year.

vi) Cropped data - This will give the area cultivated against the area harvested and yields obtained.

vii) Daily tank water levels - this will show the end storage available after water issues.

viii) Data on Evaporation, Temperature, Relative humidity, wind velocity and sun-shine hours will help in the selection of crops and project its relative yield in each system.

8. INSTITUTIONAL DEVELOPMENT

Institutional Development in the Mahaweli Systems was not given the required priority when the first settlements started in system H in 1976. A Resident Project Manager (RPM) was appointed to attend to the activities connected with the production programme including water issues. He had very little say in the settlement of the families in the system. A Deputy General Manager (Settlements) was solely responsible for settlement functions. The support services of the Land Commissioners Department were available to the Deputy General Manager. It was not a simple process to develop institutional setup in a newly built Irrigation Project as system H of the Mahaweli Development Board (MDB) was responsible for Management of Mahaweli River Basin Projects, till the Mahaweli Authority of Sri Lanka was established in 1979. The RPM was assisted by three Deputy Resident Project Managers, one for Water Management another one for Agriculture and the other for Community Development.

In place of Mahaweli Development Board, Mahaweli Authority of Sri Lanka was established under a special act of Parliament in 1979. Under this Authority two main agencies were created namely Mahaweli Economic Agency (MEA) and Mahaweli Engineering and Construction Agency (MECA) MEA is responsible for Post Construction, Implementation of Settlement, On Farm Development, Water Management, Agricultural Production, Community Development, Supply of Agricultural inputs and other connected activities for the welfare of the settler families the systems.

The Settlement Division of the Mahaweli Authority was establish in 1980. Unit and Block are demarcated for administrative purposes with a Unit Manager/Block Manager incharge of respective Areas. A Unit Manager is given approximately hundred families under his care to attend to all activities connected with post settlement and the Block Manager is responsible for about 20 units consisting of 2000 to 2800 Ha. There are a host of senior staff to assist the Block Manager through the Unit Manager such as Irrigation Engineer, Agricultural Officer, Land Officer, Community Development Officer, Marketing Officer and Administrative Officer.

At the Headquarters in Colombo a Water Management Secretariat (WMS) was setup. The WMS is to advice the Water Management Panel (WMP) which is responsible for the release of water for Irrigation & Power Generation from the Mahaweli Reservoirs and other diversion systems. The Members of this panel include the heads of the organisations which use the Mahaweli Waters, Director of Irrigation, Director of Agriculture, Secretaries to the Ministries connected with Land Development, Members of Parliament representing areas under the Mahaweli and the Government Agents of the respective Districts.

The seasonal water issue plan refereed to as the Seasonal Operational Plan (SOP) is prepared by the Water Management Secretariat (WMS) and approved by the Water Management Panel. The following factors are considered in finalising the annual water issues from the Mahaweli Systems.

1 Inflows to the Mahaweli System
2 Effective Rainfall
3 Crops to be cultivated and the cropping pattern

4 Losses of water in the way of evaporation, percolation and conveyance
5 Water requirement for each crop planned to be established for the season.

8.1 Establishment of Farmer Organisations in Mahaweli Systems

Since the settlement in the Mahaweli Systems first started in system H, there had been various kinds of organisations established within the system with different objectives. The most common organisations are Rural Development Societies, Death Donations Societies, Youth Organisations, Religious Organisations and Community Development Societies. These organisations came up to achieve certain social objectives which were not perhaps related to water management and agricultural production. However, the necessity to involve farmers in irrigation matters specially in the maintenance of field canals and distributory canals was felt by the authorities outside the Mahaweli Systems, as the major irrigation schemes outside Mahaweli had from time to time experimented in getting farmers involved in the management of the irrigation systems. In Mahaweli this aspect was not given the required emphasis at the beginning. This could be explained due to the fact that newly appointed officials to attend to various problems of the farmers were available at Unit, Block and Project level. These officers attended to activities connected with settlement, or agricultural extension, supply of inputs, health and other needs of the farmers. However, it should be noted that these services were made available only upto a limited period until the settlers were properly established to run their agricultural pursuits on their own.

With the opening up of systems B,C,G and taking over of Uda Walawe Special Project under Mahaweli Authority it became necessary that farmers be consulted at various stages of designs, construction operation and maintenance of the systems with some emphasis on water management. As done in the major irrigation schemes outside the Mahaweli Systems, farmers are expected to do the maintenance of their field canals on their own. It became necessary that farmers had to be mobilized into groups for a common purpose of operation and maintenance of their field canals regularly. Farmers were expected to concentrate on the distribution of water among them-selves within the field canals and timely maintenance of same for the cultivation of crops according to the cultivation calendar decided by the Agency. Attendance to the minor repairs to structures and canals also came under their duties. It is noted that in Mahaweli Systems farmers have the habit of depending on the officials of the agency whether it was for irrigation water, agricultural inputs or credit. This dependency syndrome may have delayed the establishment of Farmer Organisations or Turn Out Groups at the field canal levels. It is also noted that various type of farmer organisations have been tried out at different periods in several Mahaweli Systems during the last decade.

At present in System H & Uda Walawe, have some farmer organisation with the main objective of getting the farmers together only for water management & maintenance at the field canal levels System G & C also have formed the turn out groups and selected farmer leaders to represent at the Unit Level where Unit Manager presides over the committee meetings. It is also noted the there is no uniform system of organising farmers as done in the Integrated Management of Irrigation Schemes (INMAS) projects coming within the purview of the Irrigation Management Division (IMD) of the Ministry of Lands, Irrigation and Mahaweli Development.

It is not possible to follow the INMAS hierarchy in setting up of farmer organisations in Mahaweli Systems. But INMAS principles could be adopted in the functioning of the water users associations. At present there are some organisations established at field canal level and D canal level. But there is no uniformity in the system management. Therefore, it is suggested that before a Year Round Irrigation Project is launched in the selected systems as proposed by the consultants, a sustainable, viable and self reliant farmer organisations have to be established and the farmer participation at planning design and implementation stages have to be ensured.

It is very encouraging to note that Mahaweli Economic Agency (MEA) has issued instruction to all Mahaweli Systems under the Mahaweli Authority of Sri Lanka giving a policy frame work on the management of Irrigation Systems by the irrigation agencies and farmer organisations jointly based on a mutually agreed programme for sharing responsibilities of managing the affairs of the irrigation systems from Field Canal Level to Project Level.

8.2 Farmer Participation in Management of Irrigation Systems

Under the INMAS Programme about 40 major irrigation schemes have set up farmer organisation at three levels -Field canal level (informal groups) D Canal level and the Project level. The involvement of farmer in the affairs of the irrigation systems became imperative with the completion of construction of Major Irrigation Schemes mainly in the dry zone for the purpose of settling farmers. However, the need for infrastructure development gradually became of secondary importance and the emphasis was directed towards production, so that the farmers who are beneficiaries of the Major Irrigation Schemes would be able to optimise the benefits accrued from the massive investments made by the respective governments. The same argument holds good in the case of Mahaweli Systems too. The construction phase has already come to an end and the development process has started to achieve the maximum benefits from the systems.

It is common knowledge that the Major Irrigation Schemes outside Mahaweli Systems deteriorated due to negligence and inadequate operation and maintenance. This has led to early rehabilitation. It is time that Mahaweli Systems will have to be maintained properly on time to avoid such calamities where maximum benefits will not be achieved if the systems do not have a proper maintenance programme. The main factors that could be attributed to the delayed maintenance are that the funds required are not provided regularly and non involvement of farmers in activities connected with the irrigation system.

The experience gained in the last 10-15 years in the field of Irrigation Management would help to build sustainable farmer organisations in the Mahaweli Systems in order to get farmer involvement in Water Management and O & M in particular.

The proposed plan for organisation of farmers in the Mahaweli System will have a uniform system of operation and maintenance with the participation of farmers themselves by giving them a greater responsibility and promoting self reliance within the communities. The Mahaweli farmers will also get a feeling of ownership of the irrigation system. This will in turn encourage greater participation in activities connected with the irrigation system, in order to keep it at the maximum level of production. The government may not be in a position to continue providing necessary funds for maintenance as done in the past. In the Major Irrigation Projects coming within the perview of the INMAS, farmer organisations have taken over the Distributory Canals and Field Canals for operation, maintenance and management. This has relieved the government of the burden of providing financial resources annually for O & M.

Providing Year Round Irrigation for crop production will need officials to have closer relationship with the farmers in all activities in the management of the system. Their cooperation and participation are prerequisites for smooth functioning of the water distribution and timely maintenance of the system. As done in the INMAS irrigation systems, the Mahaweli farmers will have to take over the Field canals and the D canals for maintenance. With this objective in view it is necessary to establish viable and sustainable farmer organisation with legal recognition to attend to system maintenance and production to achieve high productivity and diversification. Their activities need not be confined to operation and maintenance of the system only.

To start with, priority should be given to O & M of the system to avoid the deterioration of the irrigation project over time with a consequence that rehabilitation becomes necessary much earlier than expected. it is common knowledge that major irrigation systems out side Mahaweli have faced this situation and foreign donors who assisted rehabilitation of some selected major schemes have been concerned about poor and inadequate maintenance even after rehabilitation.

8.3 The proposed Farmer Organisation in Mahaweli Systems

The Farmer Organisation should be set up in Mahaweli on the same principles as done in the Major Irrigation Schemes under the INMAS programme. The government has accepted as a matter of policy, the setting up of farmer organisations in Major Irrigation Systems including Mahaweli Systems. As stated by D. M. Ariyaratne, Director Irrigation Management Division in his paper presented at the work shop held at Kandy 22nd to 24th February 1990 on Resource Mobilisation for Sustainable Management - (IIMI) the new policies are given as follows.

1. Adoption of Management Principles of village tanks in larger systems in the turnout areas and the distributory channels respectively.

2. Development of village level institutions to provide for active farmer participation and involvement.

3. Encouraging farmers to manage the operation and maintenance of the distributory system by contributing their labour and other resources. The development is expected to enable the exemption of farmers from payment of O & M fees.

4. Continuation of government allocation to maintain and manage the main system (Head Works and Main canals) approximately 50% of the total cost of operation and maintenance

5. Provision of a legal frame work to recognise the rights and obligations of farmers' organisation through amendments to the Irrigation Ordinance and the Agrarian Services Act as required.

6. Enactment of legislation to transfer over a period of time, the ownership of the irrigation network below the D Channel level to farmers' organisations, when they are found to be ready to take on that responsibilities.

The government policy is centred round the maintenance and operation of irrigation systems giving the farmers a share of the responsibility for management. To achieve the policy objectives of participatory management of Mahaweli Irrigation Systems efforts should be made to organize the farmers on a firm footing, so that such organisation would be sustainable over a period of time. It is, therefore, necessary that the farmers be organized before the Year Round Irrigation Programme is implemented in the selected Mahaweli areas.

It is suggested that an uniform system of farmer organisation be established in all the systems selected for the programme.

Consultants are of the opinion that farmers should be organized through a catalyst to form turn out groups and D Canal water users associations with the turnout group leaders. The Unit Managers should organise the Unit Level Project Management Committee. Similarly at the level of the Block Manager, a committee can be established. The introduction of such a participatory management system will involve some changes of the attitudes of the agency officials as well as the farmers. The proposed reorganisation of the farmers at FC level and DC level will take some time. However, as suggested by the MEA, employment of Institutional Organiser as an intermediary will be most useful. As done in the MIRP and ISMP systems in Anuradhapura and Polonnarwa districts out side Mahaweli area, the Institutional Organiser will be able to have personal contacts with the individual farmers through house to house visits. The Institutional Organiser may not be employed for an indefinite period. Once the farmer organisations are well established so that they could manage their affairs the IO should withdraw from the scene.

8.4 Process of Organisations

The farmer organisations at turnout level and D Canal level must function well before crop production under Year Round Irrigation is introduced. The involvement of farmers in the water management and water distributory programme and the introduction of new crops, production of such crops as out growers should take place through well established farmer groups. MEA's proposals to a uniform system of farmer organisation at field canal level and D' Canal level is welcome. In a Year Round Irrigation Project, farmers may be expected to cultivate short term crop using bare minimum of water to go through at least three seasons cultivations for a year. The farmers cooperation and agreement on a common agriculture programme is, therefore, very essential. This could only be achieved by getting the farmers together for a common objective. These organisations arranged on the basis of hydrological boundaries bring together, say 20-30 farmers at the field canal level with a common cause, being the equitable sharing of the water supply available to them.

In the Mahaweli System in general, some sort of farmer organisations are in existence. It was evident from the records available at the Resident Project Managers (RPM) offices that farmer organisations are there in system C,H and G and also in the Uda Walawe special project area. But these organisations are not set up to take up the challenge to face a new crop-production system with new innovations and export oriented objectives.

In a Year Round Irrigation and production of high value crops mainly for export will need an organisation to guarantee a reasonable price to the producer with efficient marketing system. It is suggested that a special sub committee of the Project Management Committee on Production and Marketing of other field crops be set up at the Block Managers' level. This committee will have to provide the farmers through D'Canal level farmer organisations the necessary technical advice and extension services, including the support of inputs. The farmers who will be outgrowers in an agricultural production project to grow high value crop for exports need support services. This has to be organised with the support of the farmer organisations.

At the MEA head office level a special unit for the management of Farmer Organisations has to be setup. This unit will give all encouragement and support to the farmer organisation through RPM, Block Manager and Unit Manager. Special Subject Matter Officers at all these levels must be recruited to advise the farmers on crop production, processing, packing, storage and marketing. It is necessary to get the farmer involvement in all these aspects. It is evident that the management of the Mahaweli systems with the existing set up such as Mahaweli Economic Agency with a Resident Project Manager at the system level and DRPMS to support him in Water Management, Agriculture Production and Community Development, works satisfactorily at present. However, it is noted that farmer organisation and farmer involvement in day to day activities is lacking to a certain degree.

With the new participatory Management concept being practised in Mahaweli System, farmer involvement in water management and crop production in particular should have to be given priority specially when the year round irrigation is provided for intensive production of high value crops.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The major challenge facing Sri Lankan agricultural policy, is how to encourage the development of a more efficient and diversified agricultural sector, which has the capacity to respond to changing market conditions.

Sri Lanka is well placed to respond to this challenge. It has all the necessary resources like land, soil, climatic conditions and the potential to grow a wide range of crops.

The realisation of this potential will however, depend partly upon how domestic policies are adopted to the current environment. Policies will have to be changed to create the conditions for our farmers to exploit their production potential. The main strategy should be the need to introduce efficiency in productivity in the domestic agricultural sector to meet import needs and to make the agricultural sector export oriented. Any export strategy should have a domestic base and agri-business will ensure that. The thrust however, should be to increase yield in the Mahaweli Systems.

The study revealed that the land and climatic factors in the four systems are almost similar, except that in System C, rainfall has been more and wind velocity has been minimal. However, water availability was a problem only in System H.

In the four systems (inspite of water shortage in system H), three seasons can be introduced with judicious water use and by controlling the extent under paddy. Existing seasons will not be changed (ie. the normal periods for wet and dry seasons) and the new season (intermediate season) could be from June-July to September (between the dry and wet seasons).

In determining the crop mix, it is advisable to follow a combination of mono-cropping, crop rotation and field rotation, taking into account the importance of legumes and avoidance of crop family members in crop combinations. The commodities screened for cultivation should match with the crop recommendation of the Department of Agriculture. Any new commodities should be cultivated only with extensive experimentation and with buy back arrangements.

This study examined the following indicators with a view to making its recommendations.

a. develop a cropping calendar in keeping with availability of water, soil characteristics and plant water use. Farmers to be allowed a greater latitude to choose their cropping pattern in response to market needs.

b. develop a water management operational plan in consultation with the farmers.

c. create the institutional infrastructure for the O & M of the system.

d. evolve easy credit facilities and strengthen cost recovery.

e. increase support for agricultural research, extension and rural infrastructure.

f. encourage private sector participation in agricultural production, processing and marketing by promoting investment policies.

g. strengthen institutional arrangements for monitoring and evaluating production, marketing and strengthening the accuracy and timeliness on the agricultural data base.

h. improve inter-agency coordination for achieving progress in the above areas.

9.2 Recommendations

Issue	Constraints	Solutions
1. Farmers are not making use of the water distributed to them efficiently.	**1.1** Farmers do not attend to the maintenance of the canal network on a regular basis. It was observed that maintenance work by farmers is attended to only before the commencement of the cultivation season.	**1.1** Draw up O&M plan in consultation with the FOO for removal of floating debris daily from main branch and distributory canals. Close or isolate sections of canals for desilting in consultation with FOO. The period of closure should not exceed the rotation period (3 days for paddy, 7 days for OFC). These sections should be 1/2 km for main and 1 km for branch and D. canals.
	1.2 Farmers are not capable of deciding on water distribu-tion and usage due to lack of training and knowledge.	**1.2** Organize training programmes for farmers in Water Management and O&M.
	1.3 There were no O&M plans prepared in consultation with FOO for main, branch or Distributory Canals.	**1.3** Prepare the O&M plans in consultation with FOO.
	1.4 Biennial levelling of the canal network had not been carried out regularly to help identify and plan out action for urgent maintenance.	**1.4** Ensure that biennial levelling is carried out regularly.

Issue	Constraints	Solutions
	1.5 There were no regular maintenance units under Block Managers. (BM)	**1.5** Make available to each BM a minimum maintenance gang of at least 6 men to attend to urgent repairs etc.
	1.6 Essential machinery units to attend to emergency maintenance were not available at Block Levels.	**1.6** Make available to each BM a mobile machinery unit with necessary equipment for emergency maintenance.
	1.7 There were no skilled personnel to handle maintenance units at Block Level.	**1.7** Make available to each BM a maintenance gang skilled and capable of handling urgent maintenance work and its machinery. These personnel could be gradually withdrawn once FOO are capable of handling these works.
2. Farmer Training in Water Management is inadequate	**2.1** No Farm Water Management training to farmers at field level to obtain optimum use of water	**2.1** Train farmers in the knowledge of soil productivity, erosion control, and on farm water management for increasing cropping intensity and the possibility of year round irrigation for three cultivation seasons
	2.2 Meteorological stations in each system had not been setup and hence data were not available	**2.2** Establish Meteorological stations in each project area to collect data for the above unit and make data readily available

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	2.2 Meteorological stations in each system had not been setup and hence data were not available	**2.2** Establish Meteorological stations in each project area to collect data for the above unit and make data readily available

Issue	Constraints	Solutions
3. Crop production were not based on an efficient cropping calendar depending on the availability of water	**3.1** There was a lack of technical knowledge to develop cropping calendar for 3 seasons	**3.1** Establish a Water Management Panel with FO Representatives under each RPM to develop suitable cropping calendars and to decide on the patterns of production and marketing of crops
4. Necessary data regarding the available land was lacking	**4.1** Trial tube wells not undertaken by MASL	**4.1** Drill trial tube wells in land ear-marked for investors
	4.2 Investors not provided with basic information on water availability, soil type, climatic conditions and crop suitability	**4.2** Provide investors with details of drill logs, ground water table, recharge rates and water quality together with advice on soil conditions and type of crop to be grown

Issue	Constraints	Solutions
5. Farmer Organisations and Institutional Development	**5.1** Performance of FOO not monitored.	**5.1** Develop indicators to have feed backs on the performance of FOs.
	5.2 Farmer Organisation still not given a free hand in the on farm water management of the water available to them.	**5.2** Make FOO responsible to handle on farm water management under guidance of RPM till such time they can handle on their own.
	5.3 Lack of rehabilitation in some systems.	**5.3** To rehabilitate systems that have not been rehabilitated on a plan drawn up in consultation with FOO before handing over
	5.4 Strengthening of weak FOO	**5.4** Appoint an Institutional Organiser or Project Manager to act as a catalyst to form and strengthen Farmer Organisations with the ultimate view of turning over such systems to the FOO once it is efficiently functioning, while simultaneously implementing the recommendations in 2.1 and 5.2 of this repo[illegible]

Issue	Constraints	Solutions
6. Weak extension service was clearly evident	**6.1** Crop production had not been supported with strong extension facilities	**6.1** Appoint the existing Institutional Organisers (IO) introduced under INMAS who are 'A' Level qualified educated youths of the area and have gained considerable knowledge in Irrigation and Agriculture, as Agricultural Extension Officers in addition to the duties now performed as IOO

ANNEXES

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ANNEX I

CURRENT DUTIES OF PADDY IN METERS USED IN COMPUTATIONS

1. System H (Maha)

Kalawewa				Kandalama	Dambulu Oya
Year	Duty(M)			Duty(M)	Duty(M)
	R.B	Yoda	Ela	L.B	
1986/87	1.82	1.74	1.34	1.07*	1.48
1987/88	1.64	1.40	1.12	0.90*	0.86*
1988/89	2.36	1.27	1.79	1.25	1.44
1989/90	1.75	1.61	1.54	1.24	1.24
1990/90	1.94	1.78	1.81	1.30	1.26
1991/92	1.78	1.64	1.51	1.25	1.37
Average	1.88	1.57	1.52	1.26	1.36

2) System G (Maha)

Year	1987/88	88/89	89/90	90/91	91/92	Average
Duty(M)	1.85	0.75*	2.03	2.64	2.22	2.3

3) Udawalawe

Maha Duty (1985/86) = 1.75m
Yala (1986) = 2.19m

[Ref. JICA report on feasibility study on LB extension, Mahaweli authority has stated that the period 1983 - 1986 has been operated in a efficient manner. The highest duty reported during this period is in 1985 & 1986.]

4) System C (Maha)

Year	1986/87	87/88	88/89	89/90	90/91	91/92	Average
Duty(M)	2.45	1.57	2.18	N/A	1.66	2.30	2.03

* Values are unreliable and not considered.

5) Duty of paddy in Maha & Yala as per the Field Research study done by NIPPON KOEI Co Ltd., July 1992. in System C.

Maha (120 days)

Water requirement per day	= 12.3mm
Field water Requirement (FWR)	= 120 X 12.3 = 1476mm
Land preparation (LP)	= 300 mm (assumed)
Total	= 1776 mm
Sluice duty assuming 70% canal efficiency	= 2.54 m

Yala (90 days)

Water requirement per day	= 14.5 mm
FWR = 90 X 14.5	= 1305 mm
LP	= 450 mm (assumed)
Total	= 1755 mm
Sluice duty assuming 70% canal eff.	= 2.19 m

DUTIES OF PADDY ASSUMING 190 MM OF WATER FOR LAND PREPARATION

Water requirement for Paddy maha & Yala assuming 178mm of water for land preparation & application efficiency 55% and conveyance efficiency 70%

Maha (120 days)

Evapotranspiration	= 520mm
Water requirement at the farm =520/.55	= 945.5mm
Add for Land preparation	= 178.0mm
Total	= 1123.5mm
Main sluice duty	= 1.6m

Yala (90 days)

Evapotranspiration	= 670 mm*
Water requirement at farm	= 1218 mm
Add for Land Preparation	= 178 mm
Total	= 1396mm
Main sluice duty	= 2.0m

DUTIES OF OTHER FIELD CROPS
(CHILLI & RED ONION)

1. Chillies (green - 120 days)

Total irrigation required as per annex iv	= 1219mm
For green chilli assume only 1000 mm	
Duty at sluice assuming 70% conveyance efficiency	= 1.41m

2. Red Onion (105 days)

Total irrigation requirement as per annex v	= 850 mm
Duty at sluice assuming 70% conveyance efficiency	= 1.21 m

* Source Dept. of Agriculture Annex V

CROP WATER REQUIREMENT - OTHER FIELD CROPS IRRIGATION FREQUENCY

1. Pulses

	Groundnut	Soyabean', Cowpea, Greengram, Blackgram
Crop duration	105 days	85 - 90 days
Frequency		
a) 0-1 month	7 - 8 days	4 - 7 days
b) later stages	7 - 14 days	7 - 14 days
Irrigated moisture depletion	75%	50 - 75%
Average no, irrigations	13	12
Total consumption	39.00 cm	39.00 cm
Total field loss	32.00 cm	35.00 cm
Total irrigation requirements	70.00 cm	71.00 cm
Consumption between irrigations	4.00 cm	4.00 cm
Peale consumption	0.61 cm	0.71
Field loss per application	2.60 cm	2.90 cm
Water applied per irrigation	6.8 cm	7.00
Application efficiency		
a) Ridge and furrow	60%	60%
b) Basin	50 - 80%	50 - 80%

Drainage: When needed, by surface drainage or lowering the water table.

' Soyabean is the only crop suitable for a lower drainage member.

2. Coarse Grains - Maize

Crop duration	115 days
Soil moisture depletion at irrigation	50%
Frequency	
0-1 month	4 days
Later stages	7 - 14 days
Total number of irrigations	20
Total consumption	615 mm
Total moisture loss	391 mm
Total irrigation requirement	1600 mm
Application efficiency	60%

3. Onion

Crop duration	90 days
Soil moisture depletion at irrigation	50%
Total number of irrigations	23
Frequency	3 days
Total water consumption	385 mm
Total moisture loss	280 mm
Total irrigation requirement	665 mm
Water application efficiency	60%

4. Big onion

a) Nursery beds - daily irrigation morning and evening for the first week. For the next month, irrigate every 3 - 7 days.

b) After transplanting, irrigate every 3 - 7 days until 2 weeks before harvest.

5. Red onion

Early stage, irrigate once every 3 - 4 days. After that, apply once a week until 2 weeks before harvest.

6. Chillie

a) Nursery - apply 1 gallon water per 10'x3' bed morning and evening (2 gals/day)

b) For 2 weeks after transplanting apply 51 mm of water once a week, then apply 64 mm once a week until final harvest

Crop duration	150 days
Soil moisture depletion at irrigation	50%
Frequency	4 days
Total no. of irrigation	762 mm
Total water consumption	457 mm
Total irrigation requirement	48"
Water application efficiency	60%

7. Gingerly

a) Apply 40 mm of water per application every 14 days, if needed, depending on rainfall and soil moisture level.

8. Other crops

a) Brinjal - daily for 1 week after planting, then once every 4 days

b) Bandakka, Luffa cucumber - daily until germination, then every 3 - 4 days

c) Pathola - daily until germination, then every 3 days

d) Pole bean, bush bean · daily until germination, then once every 2 - 3 days. Adequate moisture during flowering and pod-filling stages is very important

e) Beet - daily until full establishment, then once every 2 days for 2 weeks and once every 4 days thereafter

f) Knon-khol - daily until 4 days after plowing and then once every 2 days. Irrigate every 4 days after crop is well established

g) Carrot - daily until germination, then once every 4 days

h) Radish - daily for the first 4 - 5 days and once every 3-4 days thereafter

i) Cabbage - daily until full establishment, then every 2 days for 2 weeks, and every 4 days thereafter

j) Cauliflower - daily for 4 days after planting, then every 2 days for 2 weeks, and every 4 days thereafter

k) Leek - daily for 4 days after planting and once every 3-4 days thereafter

l) Gotukola, Mukunuwenna - twice daily until crop os established, then every 2 days.

Source: Department of Agriculture, Sri Lanka

A N N E X - V

CROP WATER REQUIREMENTS

Crop	Age (days)	Frequency of Irrigation (days)		Evapotranspiration (mm)		Seepage & Percollation Lossess (mm)		Land Preparation (mm)		Total Water Requirement (mm)	
		Establishment	Growth Reproductive Stage	Maha	Yala	Maha	Yala	Maha	Yala	Maha	Yala
Rice - WDSS	90	Two weeks	5	460	670	960	1160	300	300	1720	2130
	120	Continuous	5	520	770	1320	1600	300	300	2140	2670
Rice - WDSS	90	Two weeks	5	460	670	560	760	150	150	1170	1580
	120	Continuous	5	520	770	770	1050	150	150	1440	1970
Chillie	120	3 - 4	6 - 7		600	-	370	-	150	-	1120
Chillie	135	3 - 4	6 - 7	-	680	-	420	-	150	-	1250
Chillie	150	3 - 4	6 - 7	-	750	-	470	-	150	-	1370
Onion	105	3 - 4	3 - 4	-	440	-	260	-	150	-	850
Soybean	90	6 - 7	6 - 7	-	380	-	240	-	150	-	770
Pulses	55	6 - 7	6 - 7	-	230	-	150	-	150	-	530
	65	6 - 7	6 - 7	-	280	-	170	-	150	-	600
	75	6 - 7	6 - 7	-	320	--	200	-	150	-	670
	85	6 - 7	6 - 7	-	360	-	220	-	150	-	730
	95	6 - 7	6 - 7	-	400	-	240	-	150	-	790

Source: Department of Agriculture

EFFECTIVE RAINFALL (Pe)

Pe = 0.67 (R-1)

Where R = monthly rainfall in inches subject to a maximum value of 9 inches and zero when R in inch or lower

Effective rainfall for each system was calculated using the above formula for Maha season. (Five year average was taken for 1986 to 1991 for Yala season it was assumed that there is no contribution from rainfall. For OFC cultivation in Maha 50% of the effective rainfall is considered.

Effective rain fall from October - March

System	Pe (m)
H (Kandalama)	0.4
H (Dambulu Oya)	0.4
H (Kalawewa)	0.34
C	0.48
G	0.56
Uda Walawe	0.4

REFERENCE

1. **Agricola** - Handbook for the Ceylon Farmer (a studio Times Publication)

2. **Common Wealth Secretariat,** Guidelines for Exporters of select fruit and vegetable to the UK and the Germany markets

3. **Department of Agriculture,** Peradeniya 1990 - Crop Recommendations for adoption in Grama Niladari Divisions of Sri Lanka

4. **Department of Agriculture,** Peradeniya 1990.Crop Production Guidlines - Technoguide

5. **Department of Agriculture,** Crop Enterprise Budgets May 1992.

6. **Common Wealth - Agriculture Bureau** - Crop responses to water at different stages of growth, Research Review No.2 .

7. **Daines S.R.**of SRD Research Group, USA Export marketing Strategies by (Study undertaken for the EIED Division of MASL).

8. **Henry, Frederich E.** Packing house and Cold Chain Requirements by MARD/MDS Projects, March 1991.

9. **International Trade Centre,** Tropical and off-season Fresh Fruits and Vegetables - A study of selected European Markets, Switzerland 1987.

10. **International Trade Centre, Switzerland** - Market News Services' for fruits and vegetables, (weekly nes bulletin).

11. **JICA** - Feasibility study on Walawe Irrigation upgrading and Extension Project (Left Bank) - Progress Report II August 1992.

12. **Kelegama S and Wignaraja G** Examination of Priority Export Products and Identification of New Export Products for Development and Promotion in Sri Lanka (Study undertaken for the Sri Lanka Export Development board, January 1992).

13. **Mahaweli Enterprise Development Project,** Market Intelligence Briefs, prepared under EIED, MASL.

14. **Market Research Department** - Trends Import of Fresh Fruit and Vegetables in the Netherlands, Den. Haag, Netherlands, January 1990.

15. **Nippon Koei Co. Ltd.** Field Research on Field Water Requirement of Lowland paddy. July 1992

16. **Nippon Koei Co. Ltd.** Field Research on Soil Three phase Analysis - July 1992

17. **Ponrajah A.J.P.** - Technical guidelines for Irrigation Works.

18. **Sir M. McDonald and Partners** - Walawe Irrigation Improvement Project - Soil Data Tables

19. **Sri Lanka Export Development Board** - Labour Absorption and Import Intensity of the Sri Lanka Export Sector (an ad-hoc study).

20. **Turner J.H.** Planning for Irrigation Systems - 1980.

21. **Brece Wtihers & Stanley Vipond** Irrigation design and practice by - 1980.

MED/EIED PUBLICATIONS AVAILABLE

Local Market for Pickled Products (December 1990)

Non Farm Small Scale Enterprise Credit on Selected Mahaweli Systems, Geoffrey Peters and M.W. Panditha (December 1990)

Crop Profiles - Spices, Herbs and Aromatics, L. Denzil Phillips (July 1991)

Study of the Tourism Development in the Uda Walawe (July 1991)

Potential for Silver Skin Onions in the Mahaweli, Walter Nueberg (August 1991)

Nursery Development of Papaya and Mango, Papaya Growers' Guide and Technical Notes for Business Plan for Mixed Fruit Cultivation Investment, Ben Hatfield (November 1991)

Dehydrated Fruit Processing Opportunities and Trends in Sri Lanka, Wanchai Somchit, (November 1991)

An Evaluation of the Entrepreneur Development Programmes, Dr. Susan Exo and Hina Shah, (December 1991)

Aromatics PIP Interim Report on Trials Establishment, Dr Thomas Davies (December 1991)

Agro-Business Financing Review, Dennis De Santis (December 1991)

Integrated Fruit Drying, juicing, Pulping project - Prep Feasibility Study, Michael Smedley, Ben Hatfield and Wanchai Somchit (December 1991)

Cold Chain Requirements for Uda Walawe, Fredrick E. Henry (March 1992)

Field Manual for Processing Tomatoes, Peter Florance (March 1992)

Processing Tomato Trials in Mahaweli System H, Peter Florance (March 1992)

Processing Tomato Trials in Mahaweli System C, Peter Florance (March 1992)

Dried Fruit Processing in the Mahaweli, Dr. Kamal Hyder (September 1992)

Feasibility Study on Commercial Potential of Snake Venoms in Mahaweli Systems, Anslem de Silva, (January 1993)

Census of Mahaweli Enterprises and Employment (January 1993)

Most publications are priced at Rs.100/-. The publications are available at the MED Office at 8th Floor, Unity Plaza, Colombo 4. (inquiries, Ph. 508682-4)

An EIED publication entitled - "Information Available for the Mahaweli Investor", is also available at the MED Office.

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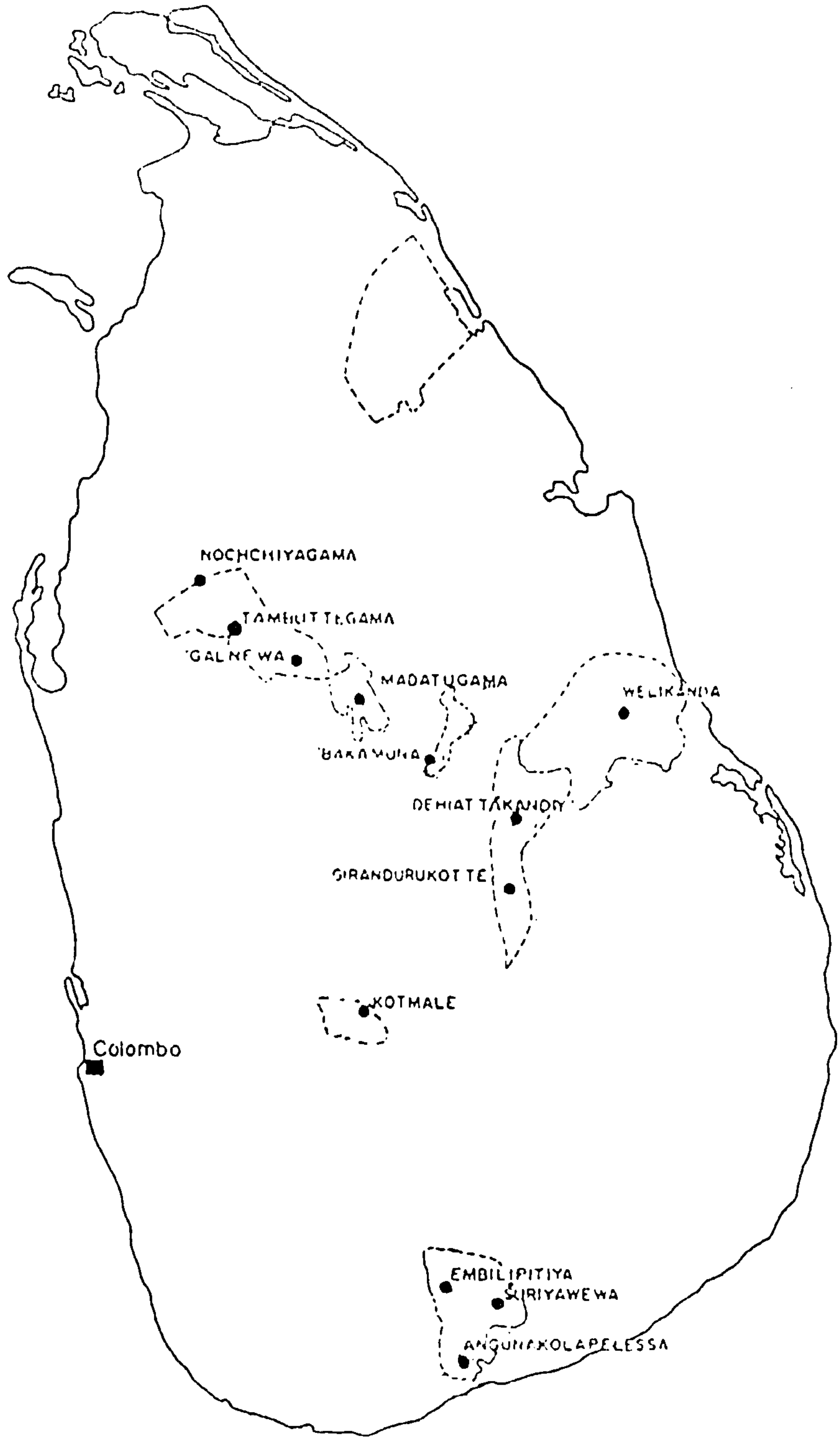

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