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FEASIBILITY STUDY ON YEAR ROUND CULTIVATION IN SYSTEM B

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CHAPTER ONE

1.1 INTRODUCTION AND BACK GROUND

The system B Maduru Oya Irrigation Project is a part of the accelerated Mahaweli Program and is the largest of the development areas encompassing a gross area of 136,000 Ha. The total irrigable land is about 38,200 Ha of which 24,000 Ha lie on the left bank (NEDECO 1987). Right bank is not yet developed. The general layout plan is shown in Figure 1. The climate is tropical and project area is principally in the dry zone. The rainfall is seasonal with south west monsoon (Yala) from May to August and North East monsoon (Maha) from October to March. Approximately 75% of rainfall is received during the Maha season. The average rainfall is about 1700 mm per annum and it is almost unit model. It falls in the dry zone low country "DL2"(Fig 2). Fig 3 gives the average monthly rainfall regimes and it shows that the system B project area falls in 1500-2000mm regimes.

However the Maduru Oya drainage alone does not yield sufficient water to meet the full needs of the project. The reservoir storage is augmented by Mahaweli water diverted at Minipe anicut.

According to the Mahaweli Act. each farmer in a settlement is allocated 1 Ha. of low land. Irrigation facilities are available and farmers are allowed to cultivate either paddy or other field crops according to their wish.

Water from the Maduru oya reservoir is conveyed through the Main, Branch, D canal and finally gets into the turn out through the Field Canal. MEA is responsible for operation and maintenance of all structures and canals up to Field canal Turn Out (FTO). Within the Turn Out the operation and maintenance is done by the farmer organizations. Continuous irrigation is recommended in the O & M manual for cultivation of paddy during the land soaking and land preparation stages. During the crop establishment period and the crop development period intermittent irrigation is recommended.

However irrigation systems designed for paddy requires several modifications to encourage crop diversification. If the same irrigation system is used to provide the flexibility and optimum root zone environment practices recommended for OFCs, the land development pattern has to be changed to facilitate the OFCs cultivation. At present, land below the turn out is prepared in such away as to have very little slope, (less than 0.25) so that the water table can be easily brought to the ground level. This is ideal for land allocated for paddy but for OFC, it creates numerous problems such as drainage etc.(Gunawardane,1991).

In System B Mahaweli project about 99% of soils are suited for OFC in Yala, provided the water table is below the root zone level and sufficient irrigation water is available. About 15% of the soils of the net irrigable area are suited for OFC during Maha season. It is identified that additional 77% are suited to OFC if drainage practices such as raised beds, interceptive drains or subsurface drainages are applied. The remaining 8% is not acceptable to drain out because of flooding or alkaline conditions. The realistic cropping goal during Maha season is 65% OFC, 27% paddy and 8% grass or fallow (Caulley,1991).

Countries in Asia, including Sri Lanka are in the tropical zone where soil and climate are actually more favourable for year round cultivation. Year round crop production is possible with irrigation, due to temperature and unlimited solar radiations(Bredfield, 1971). The farmers in the tropics could produce four times as much as dry matter per unit area as their counterparts in the temperate zones.(Bredfield, 1972).

The best returns to land and water resources in irrigation schemes could be achieved by growing crops suited to various land classes. Most of the non rice crops require less irrigation water than rice. In irrigation schemes normally the upper catena of the well drained soils are good for cultivation of Other Field Crops (OFC). But, most of the farmers in irrigation schemes prefer to grow rice under puddled condition in the upper catena of paddy field where well drained soils are available. The main reason for this situation may be due to easy marketing and storing facilities (Dimantha, 1987). Hence, it is necessary to schedule production of OFC taking into account market opportunities available to obtain higher prices and to minimise post harvest losses. Off-season planting is, therefore, required to get the higher price for agricultural products prevailing in the market during off-season. To promote off-season cultivation, irrigation water should be made available to farmers to match their cropping calendar.

Farmers of system B will have the opportunity to increase cropping intensity and produce food according to market opportunities since the Mahaweli Authority has taken a decision to provide irrigation water on year round basis. It is therefore necessary to study the agronomical and water management constraints associated with year around irrigation. This report presents results of a study conducted in Mahadamana Unit to promote off season cultivation with year round irrigation.

1.2 OBJECTIVES

The purpose of this study is three fold. First is to estimate the total quantity of water needed to irrigate a turn out when both OFC and paddy are cultivated in the turn out with full flexibility of water issues. Second is to determine actual quantity of water needed to irrigate a turn out when proper and equitable distribution of water is ensured among farmers. Third purpose is to determine the crop combinations and sequences which are agronomically appropriate to practice with year round irrigation.

The objectives of this study are;

a. To understand and determine the variation of on-farm water use when both OFC and paddy are simultaneously cultivated in the same farm.

b. To estimate the project water duty and suggestions recommended to practice year round irrigation issues.

c. To identify the minimum capital needed to maximize the profits when growing different types of crops.

d. To study the use of family labour and hired labour and their distribution over time during a cropping season.

e. To find suitable crop combinations and sequences to achieve optimal production when irrigation water is available year around.

CHAPTER TWO

METHODOLOGY

2.1 THE AREA OF STUDY

The research was carried out in the Turnout No. 66, Mahadamana Unit of Ellewewa Block in System B. The field canal 66 in Mahadamana unit is fed by the distributary canal SD5/D1/101 which receive water from the Jayanthi Wewa. Jayanthi wewa is fed by the LB L1 canal. (Fig 4)

The study area was selected considering the following reasons.

a. Research Turn out area has a facility of issuing water during the off season as it is fed by a tank and it is independent from the main canal net work.

b. Selected turnout area has easy access from the Aralaganwila Research station. When both OFC and Paddy are grown simultaneously numerous agronomic problems may arise. Hence it is easier for research officers to visit the field and give technical advice to farmers if and when necessary.

c. There are 25 soil series identified in the project area. They are grouped into six major soil groups. They are classified as Reddish Brown Earth, Low Humic Gley soils, Non calcic Brown soils, old Alluvial soils, Recent Alluvials. Study area consisted of Alluvial soils in the head end of the canal and NCB deposits in the tail end of the canal.

d. The study area has a moderate gradient upto the end of liyadde so that upper catena is suitable for OFC.

e. Farmers prepared to take up the challenge and agreeable to cultivate their liyaddes on year round irrigation basis according to our programme.

The study commenced in April 1991 with the Yala cultivation. Turn out consisted of 11 lots. However 10 farmers participated in the programme as one had leased out his liyadde at the beginning of the programme without our knowledge.

2.2 WATER REQUIREMENT

During the land preparation stage water issues are required continuously for paddy cultivation but for cultivation of OFC a very minimal quantity of water (Probably one water issue) is required. This is to wet the land for preparation of raised beds and ridges.

When rotational water issues are done the total flow of 28 lts/sec is divided and issued to two farm lots at a time for a period of 12 hrs at the rate of 14 lts/sec. This rotation is ideal for paddy cultivation as the water table has to be brought to the ground level within a short time.

When OFC and paddy are simultaneously cultivated in a farm the water distribution will be much complicated and this needs some study as to how the farmers respond to this type of situation. On the other hand farmers may not respond to rotational schedules laid down by the MEA officials and they may prefer to have a rotation on their own to suit their conditions and requirements.

Hence in the study it was important to provide 28 lts/s discharge at the head of the canal and give flexibility to farmers in the T.O areas to decide a rotation to suit their OFCs. The farmers were trained on how to distribute and when to issue water among themselves and thereby correct water issues were assured to each crop.

The following measurements were taken with regard to the flow into the F-canals and the flow into the farmer's plots. Water table elevation too was taken into consideration.

At the head of the FC 66 there is a measuring weir. This weir was calibrated with a pygmy current meter. The calibrated data was used to develop a rating curve.

Flows into the farmers' plots were measured using long threaded flumes. Flumes too were calibrated with a pygmy current meter and rating curves were made.

Daily water table fluctuations were monitored by using measuring wells and farmers were given a training to operate the gates when they notice the water table was dropped down.

Studies were carried out from the beginning of the land soaking to the end of the crop maturing stage.

Meteorological data such as Rainfall, Pan evaporation, Sun Shine hours etc. were collected from the Agro Meteorological Station established at Regional Agricultural Research Centre Aralaganwila.

Water issue records of the project were taken from the water management section of the Project.

2.3 DESCRIPTION OF CULTIVATION

2.3.1 Cropping Patterns

In order to obtain maximum benefit from 1 Ha. farm lots and also to minimize the water usage during the 1991 Yala season crops were chosen carefully with due regard to their water requirements, labour needs, yields and marketability at attractive prices. Experiences on cropping patterns published by Dr. Jane Gleason was also taken into account in determining the cropping pattern. The crop combinations selected for this season were B'onions, Red Onions, Soyabeans, Green Grams, Chillies and Paddy.

BIG ONIONS

B'onion is a very important item in the households as it gives flavour to curries. Hence there is a ready market for B'onions. As seeds are not available locally, all our requirement has to be imported from else where. (In system C Mahaweli Project there is a project to produce B'onion seeds but it is still at the initial stages.) Two varieties of seeds Poona Red and Pusha Red were distributed among farmers. There was a problem of single leaf formation in some of the nursery beds inspite of the nurseries being laid under research officers instructions.

Each farmer in the T.O prepared 10-12 beds of 10ft*3ft*4in separated by one foot wide drains. The beds were properly burnt with straw to get rid of fungus problem. Before seeding a basal dressing prepared by the Corporation was spread. Thereafter seeds were planted in shallow drills 6-4 inches apart and covered with straw. It was observed that the germination took place within seven to nine days. In addition to the straw mulching seed beds were covered with polythene

hut erected 1 1/2 ft above the beds. This cover was used during the night and specially during the rainy season to protect nurseries.

Field preparation and planting is very important in B'onion cultivation, as seedlings were sensitive to poor drainage and water logging. Hence they were planted in raised flat beds (10'*2'). Cow dung was mixed with the soil to improve fertility of soils. Seedlings were planted at 6 inches apart with only one seedling at each location. The Basal mixture was used before planting the seedlings.

Vegetative Growth

Seedlings were transplanted after 6-7 weeks and at that time good plants were about 8-11 inches in height. The weeds germinated in between rows was removed manually during the crop establishment and maturity period. It was observed that the bulbs of the B'Onion seedlings were not formed at correct period for planting. The Agronomist's advice was sought after. Their decision was that the farmers had planted B'Onion seedlings in deep drills. Farmers were advised to expose the roots to enable formation of bulbs. This could not be practised as deep rooting had to be done to prevent damage to stalks due to the heavy wind blowing.

Irrigation

Beds were wetted before planting of Seedlings. Daily hand irrigation was done during the first week till seedlings were established. Thereafter 3-4 day flood irrigation was performed.

Again daily watering by using a sprinkler bucket was done during the bulbs forming stage. At the tail end of the cultivation, irrigation was stopped and bulbs were allowed to dry out before harvesting the crop.

Insect and Diseases

As a result of fungus living in the soil some of the seedlings were subject to damping-off disease. It was noticed that the affected plants discoloured, wilted and died. Fungicide such as Captan Solution (One Ounce in 3 gals.) was used to overcome this problem.

Harvesting

Harvesting of B'onions was done after 100 to 110 days after transplanting. After harvesting the crop was dried for few days under shade and hung by the leaves in airy spaces of their cottages.

RED ONIONS

First the farmers ploughed their liyaddes, then the weeds and residuals were turned over for decomposing. Cow dung was mixed with the soil for a successful onion cultivation. Raised beds of 2 ft wide, 4-6 inches high and 10 feet length beds were formed for red onion planting. Beds were separated with a 1 feet wide drains as directed by Research Officers. It was found that 1800 Kgs. of red onion seed bulbs are required to plant in one acre and recommended spacing of each plant was 2 inches. Shallow planting of seed bulbs was recommended.

As per recommendations of the Dept. Agriculture basal dressing before planting and two top dressings at 3-4 weeks and 6 week after planting was done.

Farmers were advised to loosen the earth and weed around onion bulbs and to keep them exposed at the surface for better yields from the cultivation. Some farmers in the turn out had experience in onion cultivation and they strictly followed

the instructions given and periodically remove the soil from around the developing bulbs.

Irrigation

Beds were wetted before planting of seed bulbs. Daily hand irrigation was done during the first week till the seed bulbs were established. Thereafter 3-4 day flood irrigation was performed till the bulbs formed and matured depending on the weather condition. At the tail end of the cultivation, irrigation was stopped and bulbs were allowed to dry out before uprooting crop.

Pest and Diseases Problem

At the early stages there were symptoms of damping-off, (as in the B'onion plantations) due to fungus problem and the diseases was kept under control by spraying Caftan solution as described earlier. Caterpillar problem was observed and it was suppressed by applying lanate and Methamidiphos.

Harvesting

After 85-95 days of planting red onions seeds bulbs, the crop were ready for harvesting. Onion bulbs were dried in the shade hung in every available space in the farmer's houses.

SOYABEAN

Ploughing for soyabean cultivation was done in liyaddes and proper land preparation was very important as weeds would become competitive to the growth of Red Onions. In order to inoculate the seeds, they were immersed in Nitrogen "s" solution. The planting of seeds was done on ridges at 6 inches intervals. Farmers were instructed to do the weeding in the second and third weeks after planting to get rid of weed problem.

Irrigation

Flooding was done in 3-5 day intervals upto 14 days, i.e till the germination was over. After that flood irrigation was done upto three months in 12-14 days intervals.

Application of Fertilizers

Basel dressing was applied at the rate of 275 Kg/Ha. The mixture was prepared at the rate of Urea 5: T.S.P. 15: M.O.P 7.5 ratio. Top dressing of Urea 100 Kg./Ha. was done at the flowering stage.

Controlling of Pests

At the early stages leaf eating caterpillars damaged a few plants. Pod borer damage was observed at the ripening stage. But both attacks were not at epidemic level, so no pesticide was used.

Harvesting

The crop was harvested 85 days after planting. As the ripening was uniform plants were cut at the collar region and stubble was left in the field. Harvest was dried on the threshing floor for 4 days, and threshing was done manually. If an extensive area is grown with soya, it may be necessary to hire a four wheel tractor to thresh the crop.

GREEN GRAMS

Planting of green gram seeds was done in mid May in the trials.

The selected variety was MI-4. seeds were planted under irrigated conditions, after ploughing, harrowing and formation of ridges. Interval between consecutive ridges was 9". Seeds were planted on ridges in shallow drills and irrigation was done in 3-4 days upto 10 days and after that 1-1 1/2 weeks intervals, water was diverted along the furrows.

Application of Fertilizer

A basal dressing of 3.5 Urea: 14 T.S.P: 7.5 M.O.P was applied at the rate of 250 Kg. per Ha. Top dressing of urea 30 Kegs. was applied at the flowering stage.

Pest Control and Agronomic Problems

Leaf eating caterpillars damaged the crop in a few isolated places but the damage was not severe. Hence no pesticides were applied. Symptoms of leaf mossaic disease was also observed in the field.

Harvesting

First harvesting was done after 75 days of planting. Picking the harvest was done 3-5 times and the harvest was done under sun light and the seeds were separated manually.

CHILLIES

Land preparation was done mainly by iron plough with animal power and some farmers used mole board with 2 wheel tractors followed by harrowing. Raised beds of 3'* 10' were prepared in the fields.

MI -2 seedlings were brought from the Mahaweli seed farm and planted at 2 ft. by 1 ft. with two seedlings at each point.

Irrigation

Hand watering was done each day upto 14 days and thereafter furrowed basins were flooded 4-5 days for the first three months after transplanting there after the irrigation intervals were increased upto 7 days.

Fertilizer Application

Basal dressing was of 250 Kegs./Ha. at the ratio of Ammonium Sulphate 2 : T.S.P 2 : M.O.P 1. Two weeks after planting first top dressing of Ammonium Sulphate of 100 Kegs. per Hectare was applied. Second top dressing of 200 Kg./Ha. was applied 4 weeks after planting. Again after 6 to 8 weeks 100 Kegs/ Ha. of Ammonium sulphate was applied.

Agronomic and Pest Problems

Controlling of weeds at the initial stages was done by applying weedicide called "Lasso" one day after transplanting and manual weeding was done again 4-5 weeks later when the weeds began to appear.

Narrow leaf curl (NLD) and Collar rot were observed in the plantation. Anthracnose caused chilly pods to rot and to overcome this problem copper fungicide such as Antrocole was used. Rapid spread of thrips attack was controlled by application of "Lebicide". However the attack controlled did have a bearing on the yield. the pod bores attack being mild did not call attention.

Harvesting

Picking of pods began about 75 days after transplanting. Ripened pods were harvested and kept under shade until the bulk gets red in colour and dried under different intensities of sunlight to prepare dried chillies.

PADDY

Fields were soaked well and ploughing was practised with animal power and few liyaddes with, four wheel tractors. Harrowing followed by levelling and land preparation was completed within 15 days. The selected paddy was of 3.5 months old variety. In some paddy fields farmers did the transplanting and in other fields broadcasting of paddy was done.

Irrigation

Irrigation began with land soaking and continuous irrigation was practised during this period. Land preparation and soaking was completed in three weeks.Until the crop establishment period was over, continuous irrigation was practised. After that rotational irrigation in five day intervals was practised.

Fertilizer Application

Two basel dressing were applied, but first top dressing of urea was applied at the tillering stage. Farmers did not apply the Ag. Dept. recommended dosage. TDM was applied at the stage of panicle initiation.

Pest and Agronomic Problems

Stem borer attack was a severe problem in the field. Farmers applied Cabofuran to overcome this problem. Wind damage was also identified in the field.

Harvesting

Harvesting was done manually. Cutting drying and stacking was followed by threshing by four wheel tractors and winnowing was done with two wheel tractor mounted fan.

2.4 LINEAR PROGRAMMING

In order to analyze economic benefits of the cropping pattern linear programming was used. In this case the objective function was optimized and solved subjecting to a set of constraints, which are also linear functions. The objective function could be expressed in mathematical term as follows.

Max. $Y = R_1X_1 + R_2X_2 + R_3X_3 + \ldots\ldots\ldots\ldots\ldots\ldots + R_nX_n$

Subjected to $A_{1J}X_1 + A_{2J}X_2 + A_{3J}X_3 + \ldots\ldots\ldots\ldots + AX_{4nJ} <= B_J$

Where Y = Variable to be maximized, usually revenue or profit in Rupees.

R_i = Net revenue of crop i, in rupees/ Per Hectare.

X_i = Crop area in Hectares.

A_{ij} = Technical coefficient, indicating the amount of resource B_j needed to produce one Ha. of X_i.

B_j = Constraint (maximum supply) level of resources.

Data Requirement

In the case of Lp technique the collection of actual and accurate data is very important as it will finally reflect the end results.

The objective function needs input cost, yields of each crop and prices to analyze the revenue of each crop separately.

Yields

The yield values given below are from Other Field Crop (OFC) and paddy trials had in Mahadamana unit in Ellewewa Block in Yala 1991. The average yield of each crop is given in the following table. Yield results are given in the Annex D.

PADDY	CHILLY	B'ONION	R'ONION	G'GRAM	SOYA.
4846 Kg./Ha	1189 Kg./ha.	7340 Kg./Ha.	10476.2 Kg./Ha.	1358 Kg./Ha.	1708 Kg./Ha.

PRICE OF INDIVIDUAL CROPS

Prices of crops are highly variable and fluctuate seasonally. In most cases prices decline with increases in supply of production. As there is no developed marketing system mostly the market prices of subsidiary food crops are subject to fluctuation. Only paddy has a guaranteed price but the price of paddy also goes down during the harvesting period, specially in paddy producing areas such as system B.

In the case of OFCs farmers have to generally sell their produce at the closest village fairs unless some other means is arranged to transport their produce to distant marketing centres such as Colombo Tripoli where they can sell their produce at higher prices.

Following values were the average prices farmers obtained during the season.

CROP	PADDY	CHILLY	B'ONION	RED ONION	GREEN GRAM	SOYA
MARKET PRICE in Rs./Kg.	6.50	90	20	21	25	18

Gross Income

This represents the average income taken by the farmers of Mahadamana trials in the Yala 1991. The average income shown in the following table.

Income = Yield of each crop * price of 1Kg. of each crop

Crop	Paddy	Chilly	B'Onion	R'onion	G'Gram	Soya
Income/Ha.	31500	107000	146800	220000	33950	30750

Input Cost

This is the expense for seed/planting materials, crop production (weedicide, fungicide and insecticide) and farming equipment. The average cash expenditure for the proposed crop combination is given in the following table.

CROP	PADDY Rs.	CHILLY Rs.	B'ONION Rs.	R'ONION Rs.	GREEN GRAM Rs	SOYA Rs.
INPUT COST Rs./Kg.	17300	39500	49200	85000	12700	8985

Return

This is the net average income taken for each crop. These variables were fitted as the dependent variables in the model.

Return (R_{is}) = yield of each crop * price of 1 Kg. of each crop - input cost.

CROP	PADDY	CHILLY	B'ONION	RED ONION	GREEN GRAM	SOYA
RETURN /Ha.	14200	67500	97600	135000	21250	21800

Constraint sets: Data needed for technical coefficient for profitable cropping pattern

This is to determine the availability of resources such as labour, land, water etc. The data collected from Mahadamana trials were used in this analysis.

Labour

It is found that the most profitable cropping patterns needed correspondingly high labour use. Data for weekly labour usage in the field for a season for each crop is given in the annex E. According to the data obtained from Mahadamana Trials labour utilization for Chilly needed highest labour of 376.00 where as soya needed only 105.0 m/days.

Irrigation Water Supply

This will be a major constraint specially for yala cultivation when the project area is fully developed and cultivated. Irrigating low land by efficiently using water, coupled with the drought resistant crops, will increase cropping intensity in yala. On farm water management recommendations and net irrigation requirements for the selected crop combination was taken from the guidelines given by (Gunawardane,1990).

CHAPTER THREE

3.0 RESULTS AND DISCUSSION

Water balance in a rice based system where paddy and OFC are grown simultaneously

The major constituents of crop water requirement for paddy are evapo-transpiration, seepage and percolation (S&P), and operational losses. In fact the actual water requirement for crop growth in paddy as well as in non rice crops is the

evapotranspiration. But in the case of paddy when supplying water to achieve desired saturation and flooding some seepage and percolation is unavoidable.

On the contrary for OFCs where the cultivable field starts without a crop canopy, actual ET is composed only of evaporation from the surface initially. Actual ET increases slowly at first and then rapidly with more extensive crop canopy cover. In general the crop coefficient, which is the ratio between actual and potential ET, varies from less than one to little more than one at full canopy state. In this paper for calculation purposes 1.1 was assumed as the crop coefficient. (FAO 24, 1997). As flooded environment is not needed, S&P is not to be considered for OFC cultivation.

3.1 EVAPOTRANSPIRATION (ET)

Crop Evapotranspiration was found by using the Pan evaporation method (class A pan). Pan coefficient was taken as 0.85 for short crop area under moderate condition. Table 19 (FAO,1977). Transpiration varies greatly with the crop growth stage and tends to increase as leaves grow. Under usual cultivation it is small at the beginning of the cultivation and becomes larger towards tillering stage and reaches its peak at about the flowering stage and then decreases gradually during the ripening stage. This relationship is illustrated in the table below. In the beginning of the season the mean monthly evapotranspiration was 3.9 mm/day. With the canopy development it increased to 5.97 mm/day in June and reduced gradually with the ripening of the crop.

Main contributory factors for evapotranspiration are the effect of radiation, wind, temperature and humidity on evaporation. Annex A gives the table of metrological data from April to August. It shows that the Evapotranspiration varies with the climatological environment in the area from month to month.

Month	Mean Epan mm/day	Mean ET^0=Epan*Kp(0.85) mm/day
April	4.6	3.9
May	4.3	4.3
June	5.97	5.97
July	5.24	5.24
August	5.33	5.30

Source: Research Station . A'wila. Table 3.1

3.2 PERCOLATION

In general percolation is divided into two types, namely horizontal and vertical. The percolation rates are governed by many factors such as texture of soil depth of top soil ground water table, elevation etc. Horizontal percolation predominates in terraced paddy fields where the elevation of each field differs considerably. However much of the water lost in horizontal percolation is available for reuse because it is either collected in the drainage canal or flows into the adjacent fields. This was noticed when cultivating paddy simultaneously with OFC and water table was up and well with in the root zone for most of the crops. The table of mean monthly values of depth of ground water table is given in the Annex B. The vertical percolation is the most critical to determine the amount of water requirement in each paddy field.

Observations during Maha 1985-86 that the site percolation rates (within individual liyaddes) range from a high of 24 mm/day to a low of -4 mm/day. The standard deviation for the 34 observations is nearly 6mm/days. Observations were carried out only in Damminna Blocks (O&M Manual, 1987).

In the project area there are six soil groups. This is sub divided into 25 soil series. Unlike in Damminna Area most part of the project area soils are in sandy nature. On the other hand substantial area of the project is underlain by a impervious subsoil horizon.

In irrigation planning the amount of vertical percolation is presumed constant through out the period. i.e the seasonal change of water requirement in depth was determined by taking into consideration only seasonal change of evapotranspiration. Through my experience in system B, in actual practice the amount of vertical percolation itself shows certain changes. Hence water requirement in depth is affected by percolation and evapotranspiration except in the case of ill-drained soils.

Hence it is important to carry out seepage rate study to determine the percolation rate and there by correct estimate of irrigation water requirement is possible. In the absence of accurate data on the hydraulic characteristics of soils, the average seepage and percolation rate is assumed to be 7 mm/day.

3.3 Calculation of theoretical field water requirement in an area where OFC and Paddy are simultaneously grown

Calculation of field water requirement for OFC

Assumptions

Crop coefficient Kc = 1.1 (FAO 24. ,1977)

Application Efficiency = 60% (O & M manual.)

Seepage and Percolation = 7 mm/day (O&M Report No.08.)

Month	April	May	June	July	August
ET^0	3.9 mm/day	4.3 mm/day	5.97 mm-/day	5.24 mm-/day	5.3 mm-/day
ET^0*Kc	3.9*1.1=4.29mm/d	4.3*1.1=4.73mm/d	5.97*1.1=6.5mm/d	5.24*1.1=5.7mm/d	5.3*1.1=5.83mm/d
Field water= req.	4.29/0.6=7.1mm/d	4.73/0.6=7.8mm/d	6.5/0.6=10.8mm/d	5.7/0.6=9.6mm/d	5.83/0.6=9.7mm/d

Average field water req. = 9.03 mm/day.

Calculation of field water requirement for paddy

Month	April	May	June	July	August
ET^0	3.9 mm/d	4.3 mm/d	5.97mm/d	5.25mm/d	5.3mm/d
ET^0 * Kc	4.29mm/d	4.73mm/d	6.5 mm/d	5.7mm/d	5.83mm/d
Sepage & Percolation	7.0mm/d	7mm/d	7mm/d	7mm/d	7mm/d
Crop Water Req.	11.29 mm/d	11.73 mm/d	13.5 mm/d	12.7 mm/d	12.83 mm/d
Field water Req.	18.81 mm/d	19.55 mm/d	22.5 mm/d	21.16 mm/d	21.38mm/d

Average field water Req. = 20.68 mm/day

Average Field water Requirement when growing 0.7 Ha. of paddy and 0.3 Ha.of OFC simultaneously in rice based system.

Field water Requirement $= 9.03*0.3*10^{-3} + 20.68*0.7*10^{-3}$ m/Ha.

-do- $= 17.18*10^{-3}$ m/Ha.

Discharge of water need to satisfy above Req. $= 17.18*10^{-3}*10^{4}/24*3600$ m^3

$= 2.00*10^{-3}$ m^3

= 2.00 l/sec.

At present during the rotational water issues, the total flow in a field canal that is about 28 lts./sec (one cusec.) is divided and issue water to two farm lots at a time for a period of 12 Hrs. at the rate of 14 lts/sec.

But it is interesting to note that according to the above calculation to irrigate one Ha. lots of paddy and OFC cultivation need only 2.00 l/sec discharge for a period of 24 Hrs. or 4.00 l/sec discharge for 12 Hrs. Hence in a day 14 Nos of 1 Ha. lots could be irrigated. Through the experience gained by working in the field the farmers do not like to practice night irrigation. On the other hand Irrigation in the OFC areas have to be accomplished during the day time as farmers presence is needed to divert water along on farm ditches etc. Hence night irrigation could be used for areas where paddy is cultivated.

Water needed for Irrigation in OFC grown Areas under raised beds

In the trial area eight beds were selected and water was issued and discharge was found by using long threaded flume. The results are indicated below.

Total no of beds taken for conside ation = 08 Nos.

Total area covered by six beds = 864 ft^2

= $864/(3.281)^2$

= 80.26 m^2

Discharge through the calibrated flume. = 1.7 l/sec.

Duration of irrigation is determined by the irrigation requirement to wet the root zone, irrigation application efficiency, basin size, and the stream size. Depth of irrigation recommended for System 'B' as 15 mm and 35 mm for the highest and lowest frequency was based on the irrigation requirement to wet the root zone. (Gunawardena, 1990).

The duration of irrigation is given from the following equation.

$$T = A * D / 60 * Q$$

Where,

Duration pe irrigation in minutes = T

Area of the basin in m^2 = A (80.26 m^2)

Depth of irrigation in mm = D (20 mm)

Stream size in l/s = Q (1.7 lts/s)

$$T = A * D / 60 * Q$$

$$= 80.26 * 20 / 60 * 1.7$$

$$= 15.7 \text{ min}$$

Hence time taken to irrigate the area considered = 16 Min.

Total Volume needed to irrigate the area = 1.7*16*60/1000 m^3

-do- = 1.632 m^3

Total Volume of water needed to irrigate 1 Ha. of OFC cultivation = 1.632* 100,00*$(3.281)^2$/864

-do- = 203.3 m^3

Time taken to irrigate 1.0 Ha. of OFC cultivation = 16* 100,00* $(3.281)^2$/864

= 1993.5 Min

= 33.2 Hrs.

If the discharge is treble then time needed to irrigate 1 Ha. of OFC cultivation = 33.2/3 Hrs.

= 11.06 Hrs.

Discharge = 1.7*3 lts/sec.

= 5.1 lts./sec.

No. of lots could be irrigated if 1 cusec is sent in a field canal = 28/5.1

= 5.4 lots

This shows that at a time 5 lots could be irrigated in a turn out in a 11.06 Hour duration. Hence in a day 10 lots could be irrigated if 1 cusec (28 lts./sec) discharge is released through the field canal.

Rainfall Utilization

Rainfall during the season was very poor. South West Monsoon which is normally experience from May to August had no significant effect in the rainfall of system B. Comparison of rainfall and the crop water requirement is shown in the table below. Only in May there was a considerable rainfall of 9.6mm. When analyzing the rainfall pattern it is found that 7.8 mm of 9.6 mm(MAY rainfall) was experienced in one day in the third week of May. Hence this yala was a fairly a dry spell and farmers had to totally depend on irrigation water.

Month	Total Crop water Req't (mm)	Supply from rain (mm)	Supply from irrigation (mm).
April	16.29 (100)	5.3 (32.5)	10.99(67.5)
May	16.73 (100)	9.6(57.27)	7.13 (42.7)
June	18.50 (100)	1.11(5.9)	17.36(94.0)
July	17.7 (100)	0.08(0.045)	17.62(99.5)
August	17.83 (100)	7.6(43.9)	10.23(57.73)

Parentheses indicate percentages.

3.4 WATER REQUIREMENT IN DEPTH

Water requirement varies with the stage of cultivation. For instance for paddy cultivation there are four stages and water requirement varies accordingly.

- Land Soaking Stage
- Land Preparation Stage.
- Crop Establishment to Maturity (CEM).

Land Soaking Stage

In this case continuous water supply is needed to saturate the soil in order to create a conducive environment for ploughing and harrowing operations. During the land soaking operation considerable quantity of water is lost through seepage.

In general it is observed that there is a inequality of water distribution and head enders get more water than the tail enders and consequently water is not

sufficient for all farmers to continuously and simultaneously soak liyaddes. (Silva, 1990).

Hence farmers were trained on proper water management and water issues in the T.O 66 Mahadamana were entrusted to the farmer organization. In order to regulate and to ensure uniform distribution of water in the T.O wooden planks were distributed (to divert water into their lots) among all the farmers. On the contrary it is observed that water is not needed for the areas where OFC is planed to be grown. Because, in the case of OFC cultivation soil saturation is not necessary as in paddy cultivation. Hence if the full extent of the paddy liyadde is cultivated with OFC, requirement of water for land soaking could be saved.

Land Preparation

The purpose of land preparation is to form a conducive soil environment in which the land is ready for planting of paddy and it's growth. This includes the time needed for vegetative decomposition of weeds etc. Normally this process takes 2-3 weeks. During the land preparation period water is utilised for evapotranspiration and seepage requirements. In the case of cultivation a little quantity of water is needed for land preparation.

Crop Establishment to Maturity Stage

During this period water was given to the farmers in a five days rotation. According to the (FAO 24, 1977) the crop water requirement during this period vary with the growth stage. Specially during the heading, flowering and milking stage reliable water supply should be assured in order to get a good yield.

As per the Mahadammana trials qty. of water used at different stages

Cultural Prac--tices	Ave. total Volume m^3.	Average Height m.	Remarks.
Land Soaking.	1000	0.1000	Results from RARC
Land Preparation	5000	0.5000	Results from RARC.
C.E.M Period.			
1st Month	3452.88	0.3452	Results from Mahadamana Trials
2nd Month	3812.4	0.3812	-do-
3rd Month	2873.52	0.2873	-do-
Total	16138.8	1.6137	

3.5 ACTUAL WATER DUTY IN SYSTEM B IN YALA 1991

Before irrigation water reaches a cultivated field, it passes through many stages of regulating, operating, distributing and conveyance. Considerable quantity of water is lost at each stage by evaporation from the open water surface, seepage, outflows, and run off losses. The magnitude of the water losses is clearly seen when comparing the duty of the system B yala 1991 with the duty calculated from the Mahadamana Trials. In the Mahadamana trials the water duty was about 1.613 M. whereas Project duty was about 2.48m. See table below. The magnitude of these losses depend on a number of factors such as soils, climate, errors in

irrigation system designs, inefficient water management practices, agricultural practices, experience and cooperation of farmers, and social conditions.

Block	Area	Volume	Duty.
	Ha.	Ha.m.	m.
Damminna	1071.6	2625.4	2.45
Wijayabapura	1915.0	4289.6	2.24
Ellewewa	1995.0	5346.6	2.68
Dimbulagala	1792.31	5568.73	2.56
Sevanapitiya	1905.80	4587.52	2.46
Senapura	1384.4	3474.84	2.51
Total	10028.14	28663.38	2.48

3.6 TIMING OF THE CULTIVATION

This is one of the serious problems that the Project management faces very frequently. Although the farmers agree upon to stick to the cultivation program decided at the cultivation meeting, normally the farmers are not ready to start cultivation according to the cultivation calender. This was significant in the Mahadamana Trials also. Consequently water issues had to be extended upto end of August 1991 whereas the due date for closing the water issues was 15 August. That means the canals conveyed water for a longer period than was envisaged and thereby increased conveyance and seepage losses.

One major constraint for not cultivating, according to the cultivation program was the lack of draft power. In the project area the amount of draft power available, both buffalos and tractors are limited. This contributed in large measures to the absence of timely cultivation operations in the Mahadamana unit also.

Cropping Pattern

Nine farmers in the Mahadamana unit participated in the program and they cultivated six crops. The following crop combination was selected and the extent of cultivation is given below.

TYPE OF CROPS	TOTAL EXTENT CULTI-VATED	Percentage of Extent of Cul.
B'onion	6500 m^2	7.3%
Red Onion	2500 m^2	2.8%
Soyabean	4150 m^2	4.68%
Green Gram	6250 m_2	7.3%
Chillies	7750 m^2	8.74%
Paddy	61450 m_2	69.7%
Total	88600 m^2	

The percentage of crop diversification was abou 0%. The most popular OFC among farmers was B'onions and Chillies. Their per tage of cultivation was about 7.3% and 8.7% consequently. As there was a olem in the sustainability of B'onions seedlings in the nurseries some b'oni eedlings, were bought from the nearby nursery and some seedlings were borrow ith the curtsey of Mr. Martin West (MARD Project). Because of this reason nt of B'onion cultivation was restricted. Some of the farmers in Mahadamana had a bad experience in chili cultivation and they could not get a good har in the previous season due to narrow leaf disorder and therefore they were reluctant to grow chillies, though it was a cash crop. Finally they agreed upon to grow 8.7% of the total extent of chillies. The total percentage of red onions cultivation was just 2.8% as there was a problem of getting seed bulbs. Red onions seed bulbs were purchased with the assistance of MARD Officials.

All the farmers were keen to cultivate more paddy and finally 69.7% was cultivated with paddy.

3.7 ECONOMIC BENEFITS

ECONOMIC BENEFITS

Six linear programming models were considered for system B Mahaweli Project to decide the optimal cropping pattern. It is found that the majority of the farmers have no sufficient capital to hire tractors to be used in farm production and also to use agro chemicals in time. Hence agricultural credit might be important at the initial stages till they are self-sufficient to adopt high technology in farms and also to grow OFC with higher net returns. Hence six models depending on the capital and also the extent of OFC cultivated area was considered and optimal cropping pattern was considered. In the first case cultivation of 50% paddy and 50% OFC was considered by using capital of Rs.20,000/= and in the second case 100% cultivation of OFC was considered by using the capital of Rs.20,000/=. Similarly Optimum cropping pattern was analyzed for the capital of Rs. 30,000/= and Rs. 40,000/= and also with 50% extent of paddy or 100% extent of OFC grown in the project area.

Family labour per week was assumed as 9 labour days/week. Which include 6 male days and 3 female days. In a house hold female cannot spend much time in the field as they have to maintain their homes, involve in cooking and looking after children etc.

Model 1

Resources Constraints

Capital	= Rs. 20,000/=
Family labour per week	= 9 days/week.
Total extent of OFC cultivation	= 0.5 Ha.

Results

Total return expected from 1 Ha. liyadde	= Rs. 30,886.00
Shadow value of labour	= Rs. 27.5
Shadow value of land	= Rs. 3,864.85
Shadow value of capital	= Rs. 1.75

Cropping Pattern

Paddy	= 0.5 Ha.
B'onion	= 0.17 Ha.
Soya	= 0.33 Ha.

Model 2

Resources Constraints

Capital	= Rs. 20,000/=
Family labour	= 9 days
Total extent of OFC cultivation	= 1 Ha.

Results

Total return	= Rs. 42,754.00
Shadow value of labour	= Rs. 27.5
Shadow value of land	= Rs. 3,542.27
Shadow value of capital	= Rs. 1.75

Cropping Pattern

B'Onion	= 0.275 Ha.
Soya	= 0.725 Ha.

Model 3

Resources Constraints

Capital	= Rs. 30,000.00
Family labour	= 9 labour/week
Total extent of OFC cultivation	= 0.5 Ha.

Results

Total Return	= Rs. 49,794.00
shadow value of land	= Rs. 3,878.19
Shadow value of labour	= Rs. 27.4
Shadow value of capital	= Rs. 1.74

Cropping Pattern

Paddy	= 0.5 Ha.
B'Onion	= 0.42 Ha.
Soya	= 0.08 Ha.

Model 4

Resource Constraint

Capital	= Rs. 30,000/=
Total extent of OFC	= 1 Ha.
Family labour	= 9 days/week.

Results

Total return	= Rs. 61,595.00
Shadow value of labour	= Rs. 27.46
Shadow value of land	= Rs. 3,603.5
Shadow value of capital	= Rs. 1.74

Cropping Pattern

B'Onion	= 0.52 Ha.
Soya	= 0.48 Ha.

Model 5

Resources Constraint

Capital	= Rs. 40,000/=
Family labour	= 9 labour days/week
Total extent of OFC	= 0.5 Ha.

Results

Total return	= Rs. 62,508/=
Shadow value of labour	= Rs. 20.6
Shadow value of land	= Rs. 3902.80
Shadow value of capital	= Rs. 1.66

Cropping Pattern

Paddy	= 0.5 Ha.
R'Onion	= 0.17 Ha.
B'Onion	= 0.33 Ha.

Model 6

Resources constraints

Capital	= Rs. 40,000/=

Family labour	= 9 days./week.
Total OFC extent	= 1.0 Ha.
Results	
Total Return	= Rs. 80,164.00
Shadow value of labour	= Rs. 27.46
Shadow value of land	= Rs. 3,603.5
Shadow value of capital	= Rs. 1.74
Cropping Pattern	
B'Onion	= 0.77 Ha.
Soya	= 0.23 Ha.

A. Labour Utility

Labour is a very important commodity to manage a farm efficiently. In a project where diversified crops are introduced the farmers cannot totally depended on family labour and in this case 9 labour days (6 male and 3 female labour day per week) were considered. Because in a farmer family both male and female cannot spend full time in the field. Specially females have to look after their children and attend to their domestic work. The distribution of labour in each week for a proposed crop combination when the profit was maximized is given in the annex F,G,H,I,J,K.

Shadow value of labour for model 1, 2, 3, 4 & 6 was around of Rs. 27.5. But in the case of model 5 it was reduced to Rs.20.6/=. This means if the labour constraint was increased by one labour unit, the return will be increased by Rs.27.5/= in the case of model 1, 2, 3, 4 & 6. But in the case of model 5 the increase of return was Rs.20.5/=.

In order to increase the net return by a remarkable amount it is very important to increase the labour. In each case it is observed that the labour usage was maximum during the land preparation, sowing, harvesting period. Labour during the balance period of a cultivation season was not so critical. In most of the cases 2-3 labour days was sufficient during the period of weeding, fertilizing, pest controlling and protecting their crops. It appeared that the labour usage was increased in planting and harvesting period with the increase of capital. The maximum number of hired labour (65 labour days for a week) was needed for a capital of Rs. 40,000/= where b'onion and Soya was in the final solution. On the other hand with the increase of OFC grown area the labour utility increases accordingly.

B. Availability of Capital, Cost of cultivation and Increase in Income

Agriculture in system B has become significantly more costly than in the past. Results of Linear Programming indicate that farmers would find it difficult to cultivate one Hectare of any crop with less than Rs. 10,000/=. Increased costs of fertilizer, general inflation in the country are contributing factors in increasing production cost. The higher production cost may hamper the production of growing OFC in paddy fields hence providing credit facilities to the prospective farmers are important. (Gleason, et.al.1989/1990).

It is a pleasure to state that the Banks agreed to pay maximum amount of Rs.20,000/= as cultivation loans and it has become a great relief to the

farmers. In order to save them from unscrupulous mudalali's those who give them loans at high interest rate. Hence in this case of study for model 1 minimum capital of Rs.20,000/= was considered as cultivation loan. In the case of other models of this study capital of Rs. 30,000/= and Rs. 40,000/= was considered for analyzing a cropping pattern.

According to the LP programming results the capital was a major contributing factor for increasing of income. Net return in respect of the capital invested by an individual is indicated in the following tables.

Proposed Capital	Rs.20,000/=	Rs. 30,000/=	Rs.40,000/=
OFC extent	50%	50%	50%
Net Return	Rs.30,886.0	Rs.49,794.0	Rs.62,530.0

Proposed Capital	Rs.20,000/=	Rs.30,000/=	Rs.40,000/=
OFC extent	100%	100%	100%
Net Return	Rs.42,754.0	Rs.61,595.0	Rs.80,164.0

As per the above results obtained from the LP model the net return of farmers vary according to the extent of OFC cultivation. Net return of 1 Ha. of paddy cultivation was about Rs. 14,200/= as per the results obtained from the field. This can slightly vary depending on the yield and the market price of paddy. On the contrary a farmer who could invest a capital of Rs.40,000/= could get a net return of Rs.80,164/=. This shows that a farmer who could invest capital of Rs.40,000/= and carefully manage a farm of 1.0 Ha. could increase his income by 5.6 times than a net return of 1 Ha. of paddy lot. Hence cultivation of OFC is a profitable venture than growing paddy.

According to the income gained from each crop it was found that Red onion got a good gross return of Rs.220,000/=. But the capital investment on growing 1 Ha. of Red Onion was very high and it was about Rs.85,000/=. Similarly B'Onion the next crop which farmers have taken high return needed initial investment of Rs.49,200/= to cultivate 1.0 Ha. The third crop which take high return was the chilly and it was about Rs.107,000/= and it's initial investment was Rs.39,500/=. The lowest gross return was Rs. 31,500/= for growing of paddy and it's initial investment was about Rs. 17,300/=. Hence it is clearly shown that the capital in a farm management crop diversification programme play an important role in the rate of return. Red Onion and B' Onion are perishable varieties. Hence cultivating onions at the correct period is very important to get high incomes. The farmers should be promoted to store their produce in dry places to sell them when the prices goes up.

Under the year around cultivation concept, at least a three season cultivation could be expected. Hence it is interesting to note that in model 1 a farmer can get a monthly income of Rs. 7721.50/= which is equivalent to the middle level Govt. staff grade salary. In the case of model 6 where percentage of growing OFC was 100% and initial investment was Rs.40,000/= could get a monthly income of Rs.20,041/=. This is very much higher than a Govt. senior staff grade salary. This indicate that the monthly income is dependable on the extent of OFC cultivation and the amount of initial investment.

The shadow value of capital was around Rs.1.76/=. This means that if the capital is increased by one unit the net return could be increased by 1.76. On the other

hand if the unit increase is Rs.1/= the increase of return which could be expected is about Rs.1.76/=.

C. Cropping Pattern

In the case of model 1 to achieve the optimal return the farmers are recommended to grow 0.5 Ha. of paddy, 0.17 Ha. of B'onion and 0.33 Ha. of Soya in his 1.0 Ha. lot. In the second case types of crops to be grown to obtain a optimal solution was to grow 0.275 Ha. of Soya and 0.725 Ha. of Soya. The cropping pattern for optimal solution in the third case is to grow 0.5 Ha. of paddy, B'Onions 0.42 and Soya 0.08 Ha. In the fourth model is to grow B'Onion 0.52 Ha. and Soya 0.48 Ha. In the case of fifth case is to grow Paddy 0.5 Ha., 0.17 Ha. of R'onion and 0.33 Ha. of B'onions. In the last case analyses indicated to grow 0.77 Ha. B'Onion and 0.23 Ha. of Soya to achieve a maximum return.

But it is interesting to note that in macro level farming is considered the total extent of the project area is not suitable for OFC cultivation. Because there are ill drained areas, water logged areas and rocky areas etc. found in the project area. Hence selection of suitable areas for OFC cultivation is of prime importance, if this program is to be successful in a big way.

D. Land

Each farmer is given 1 Ha. of irrigable land and 1/2 Ac. of homestead for his existence under Mahaweli scheme. It is the responsibility of farmers to make use of land and get a maximum return out of it. MEA agriculture officers in each block to assist them to achieve this objective.

The shadow value of land in the model 1 is Rs. 3564.85/=. This indicate that if the land constraint is increased by one unit (1.0 Ha.) in the first case the net return could be increased by Rs. 3,564.85/=. Similarly for model 2, 3, 4, 5 and 6 the shadow values are Rs. 3542.27/=, Rs. 3878.19/=, Rs. 3603.5/=, Rs. 3902.8/= and Rs.3603.5/= respectively. This shows by just increasing only the land extent will not bear much return unless other constraints such as labour and capital is increased.

Sensitivity Limits and Stability of the solutions

Sensitivity limits is a important tool in **Linear Programming** analyses to indicate the stability of a solution. Sensitivity limits indicate the details on the degree to which the assigned values of all variables can change without significantly modifying the optimal solution. If a model is sensitive, small changes in the value of the variables will dramatically change the value of optimal solution. In a farm management **Linear Programming** model all variables such as prices, yields, costs, wages, levels of resources such as land, labour and capital gives sensitivity limits. (Gleason, et.al 1988/90).

Sensitivity Limits of Crop return

<u>Model 1</u>

Resource level

Capital	= Rs. 20,000/=
Family Labour	= 9 days./week.
Farm size	= 1.0 Ha.

Crop	Optimal Allocation	Return/Ha.	Minimum	Maximum	Range as % of Return
Chilly	0.00	67500.00	None	77251.8	None
B'onion	0.17	97600.00	84448.30	none	
R'onion	0.00	135000.00	None	159231.8	
G'gram	0.00	21250.00	none	28168.2	
Soya	0.33	21800.00	14217.7	50402.2	165.9

Table 3.1

In the analyses sensitivity limits for paddy did not appear as extent of paddy was fixed at 0.5 Ha. In the optimal solution chilly did not appear as it 's net return was not sufficient to enter in the final solution and at least Rs. 77251.00/= to be obtained to enter in the final solution. Hence there was no sensitivity limit. In the case of Big Onion the sensitivity limits were very high. Red Onion was not in the final solution as it's net return was not sufficient. Net return of Red onion should reach at least Rs.159231.00/= to appear in the optimal solution.

In order to appear G'gram in the optimal solution net return should reach at least Rs. 28168.2. Hence there was no sensitivity limits. In the case of Soya the sensitivity limits was 165.9% and it indicate that it was a stabler crop.

Model 2

Resource level
Capital = Rs. 20,000/=
Family labour = 9 days/ week.
Farm size = 1 Ha.

Crop	Optimal Alloca-tion/Ha.	Return/Ha. (Rs.)	Minimum (Rs.)	Maximum (Rs.)	Range as% of Return /Ha.
Paddy	0.00	14200.00	None	35617.7	
Chilly	0.00	67500.00	None	77856.40	
B'Onion	0.275	97600.00	85118.00	None	No limit
Red Onion	0.00	135000.00	None	157912.29	-
G'gram	0.00	21250.00	None	28417.87	-
Soya	0.725	21800.00	13925.4	49214.4	161.8%

Table 3.2

Paddy was not in the optimal solution as it's net return was not sufficient. The upper limit of paddy was about Rs.35617.7/=. Similarly chilly was not in the optimal solution as it's upper limit was Rs. 77856.5/=. B'onion shows a very high sensitivity limit and there is no upper limit. Hence B'onion is a stable crop. Red onion was not in the optimal solution and it's upper limit was Rs. 157912.97/=. Green gram was not in the optimal solution and it's upper limit was Rs. 28417.8/=. In the case of soya the sensitivity range was 161.8% and it shows

it's stability. In the same time Return/ Ha. is also very high. Hence this crop combination is quite suitable for farmers who owns a 1 Ha extent of land.

Model 3

Resource Level
Capital = Rs. 30,000/=
Family labour = 9 days/week.
Farm size = 1 Ha.

Crop	Optimal Allocation Ha.	Return/Ha.	Minimum	Maximum	Range as % of Return
Paddy	0.5	14200.00	None	None	None
Chilly	0.00	67500.00	None	77294.13	-
B'onion	0.42	97600.00	84522.37	None	infinite
Red onion	0.00	135000.00	None	159147.4	None
G'gram	0.00	21250.00	None	28153.6	None
Soya	0.08	21800.00	14234.5	50326.9	165.5

Table 3.3

In the case for paddy there was no sensitivity limits as the extent paddy was fixed at 0.5Ha. B'Onion gives a very high return per Ha. and it sensitivity level was very broad. There was no upper limit. Soya return per Ha is not so attractive as B'onion but its sensitivity limits is fairly broad. Other three crops such as Chilly, Red onion, and green gram was not in the optimal solution and there upper limit was Rs. 77294.14/=, Rs.159147.6/=, and Rs.28153.8/=.

Model 4

Resource Level.
Capital = Rs.30,000/=
Family Labour = 9 l.days/week.
Farm Extent = 1.0 Ha.

Crop	Optimal Allocation Ha.	Return/Ha.	Minimum	Maximum	Range as of Return/Ha.
Paddy	0.00	14200.00	None	36209.8	-
Chilly	0.00	76500.00	None	78118.04	-
B'onion	0.52	97600.00	84523.79	None	infinite
Red Onion	0.00	135000.00	None	159147.60	-
G'Gram	0.00	21250.00	None	28428.43	-
Soya	0.48	21800.00	13913.00	50326.98	167.0

Table 3.4

In this case also B'Onion gives high Return/ Ha. and also broad range of sensitive limits. Although the return per Ha for soya is very low, the crop has a fairly broad sensitive limits. Crops such as Paddy, chilly, Red onion and G'gram does not appear in the optimal solution as the return per Ha. was not attractive. There are upper limits for these crops and they are Rs. 36209.0/=, Rs.78118.04/=, Rs.159147.00/= and Rs. 28428.43/= respectively.

Model 5

Resource Level
Capital = Rs.40,000/=
Family Labour = 9 days/week
Farm Extent = 1.0 Ha.

Crop	Optimal Alloca--tion/Ha	Return/Ha	Minimum Rs.	Maximum Rs.	Range as % of return
Paddy	0.5	14200.00	None	None	-
Chilly	0.00	67500.00	None	84602.15	-
B'onion	0.33	97600.00	84522.37	135657.25	52.4%
Red Onion	0.17	135000.00	96942.75	159147.6	46.0%
G'gram	0.00	21500.00	None	54186.03	-
Soya	0.00	21800.00	None	50326.98	-

Table 3.5

As extent of paddy was fixed at 0.50 Ha. there was no sensitivity limit. In this case B'Onion and R'Onion gives high return per Ha. and it has a fairly broad sensitive limit. Hence R'Onion and B'Onion are again a reliable crop to be grown. Other three crops such as chilly, Red onion and G'gram was not in the final solution.

Model 6

Resource Level
Capital = Rs.40,000/=
Family Labour = 9 days/week
Farm extent = 1.0 Ha.

Crop	Optimal Allocation Ha.	Return/ Ha.	Minimum	Maximum	Range of Return
Paddy	0.00	14200.00	None	36098.3	-
Chilly	0.00	67500.00	None	78118.0	-
B'onion	0.77	97600.00	84522.37	None	infinite
Red onion	0.00	135000.00	None	159147.00	-
Greengram	0.00	21250.00	None	28428.43	-
Soya	0.23	21800.00	13913.0	50326.98	167%

Table 3.6

In this case B'onion and soya was in the optimal solution and their sensitivity limits were fairly broad. Hence this a stable crop combination for a capital of Rs. 40,000/=. Other crops such as paddy, chilly, R'onion, G'gram and soya were not in the optimal solution. They have maximum limits of Rs. 36,2098.00/=, Rs.78118.0/=, Rs.159,147/= and Rs. 28428.4/= respectively. Unless the return for these crops reach to these limits they will not appear in the optimal solution.

CHAPTER 4

SUMMARY AND RECOMMENDATIONS

The water consumption in the system B project area is fairly high. In the Yala 1991 the project water duty was about 2.48 m where as in Mahadamana unit duty was maintained at 1.613m. This proves that sizable quantity of water was not properly utilized. The magnitude of these losses depended on a number of factors such as soils, climate, errors in irrigation system designs a inefficient water management practices of the farmers. As we have cultivated only 1/3 of the total project extent there is no water problem at present. When the full extent is cultivated there will be a problem, if water is not correctly utilized. System B farmers prefer grow paddy in their liyaddes' mainly due to the marketing problems during the glut period if OFC are grown. Paddy is a crop which needs more water as it needs ponding of water in different stages from land preparation to harvesting. For instance paddy needs more than 1.5 m hight of water, where as OFC such as Green gram needs only 0.34m for a season. Hence water duty will be very high if paddy is grown compared to the areas where OFC are grown.

On the other hand the average income of a farmer family in system B is very low and most of them are doing subsistence type of farming with marginal profit, because they cultivate mainly paddy in their fields. Paddy is a crop which could get only a marginal profit and in yala the Mahadamana farmers could get average net income of Rs. 14,200/= per Ha. Hence it is high time to train farmers to engage in crop combinations where farmers' income could be increased with less use of water. Simultaneously relevant authorities should pay a serious concern about the prices of OFC and fix guaranteed prices for OFC there by the farmers will be motivated to grow OFC in future.

The cultivation of OFC in paddy liyaddes under irrigation during yala is proved to be a means of reducing water consumption in the dry seasons. There are substantial differences in field irrigation requirements between rice and non-rice crops. Under no rainfall conditions, the field irrigation requirement of paddy (20.68 mm/day) is almost two times than that of OFC cultivation (9.03mm/day).

It is interesting to note that the present rotational water issues ie. to issue two lots at a time for a period of 12 Hrs. at the rate of 14 lts/sec. is not so realistic and leads to wastage of water and where as issue of water to 5 lots at a time for a period of 12 Hrs. at the rate of 5.32 lts/sec. is more appropriate for farmers. Further water needed for irrigation in OFC grown areas under raised beds were experimented in the field and found that the 5.1 lts./sec. discharge for a period of 11.06 Hrs. was needed. This justify that the present rotation is very inefficient and considerable quantity of water could be saved if a proper rotation of water is introduced in the field. This gives an added advantage of preserving and increasing the fertilizer application efficiency.

As this is a considerably small discharge soil erosion in the liyaddes could also be avoided. On the contrary the farmers prefer to use more irrigation water to flood their fields to reduce weed growth. When all the farm outlets are open "Head enders" get more water than the 'Tail enders'. (Silva, 1990). It is observed that the farm inlets are to be operated in a fully open position or a

fully closed position as there is no gatted arrangement. In order to ensure equity of water distribution regulation among farmers is very important. Hence farmers should be trained to get water to their respective fields when it is really needed. This situation can only be achieved if farmers are given training on water distribution at Turn Out level. In this respect farmer organizations can play a important role. This was proved in Mahadamana Unit by giving farmers a training on proper water distribution and the water usage could be brought down to 1.61 m. where the project water duty was about 2.46 m. This situation could be achieved only if farmers use wooden planks for regulation of water at farm gate and provide them a device and knowledge when water is required to their fields. Hence farmers should be trained to bury perforated bamboo pieces in fields (where OFC is grown) so that farmers could simply determine the depth of watering the respective fields and decide when to send water to their fields.

Irrigation in the OFC areas are to be accomplished during the day time and night irrigation could be used for areas where paddy is grown. Water requirement varies with the type of crop and the stage of cultivation. If the full extent of paddy liyadda is cultivated with OFC water requirement for land soaking could be saved. But in the case of land preparation at least one issue of water is needed for preparation of beds for cultivation of OFC. On the contrary, water issues of two to three weeks are needed for paddy cultivation.

It is found that during land preparation and land soaking stage loss of water is wasted when cultivating paddy due to inefficient application of water. Further some farmers take 1-1.5 months for land preparation. One major constraint for not cultivating according to the cultivation program was the lack of draft power. Hence it is proposed to irrigate the whole turn out and complete the land preparation in a limited period of time by centralizing machinery and to measure water which could be saved by timely cultivacion in the next season.

During the period from crop establishment to maturity period five day rotation could be introduced instead of three and half day rotation. But it is observed that the farmers in general, did not practice rotational irrigation during the CEM stage and considerable quantity of water was wasted. Hence farmers must be given proper training to save water by adhering to the rotations and they must be taught when the water is to be assured for a plant to bear a good harvest that is the heading, flowering and milking stage.

It is found by the study carried out at Mahadamana a considerable quantity of water can easily be saved if the farmers are given adequate training in operations in the field canal.

The effects of growing OFC were studied in respect of a few selected crops such as B'onions, Red Onions, Soyabeans Greengram, chillies along with paddy which were grown successfully in paddy fields during this yala season.

To determine the optimum cropping pattern for low lands to evaluate correct allocation of resources, Linear Programming was used in the analyses.

It was impracticable to corporate soil characteristics into the analyses, as it differ from place to place. Irrigation water supply was included in the Linear Programming and land added through encroachments and/or illegal leases, may affect the final results.

According to the results obtained by the analyses there is a strong possibility of diversification of crops in the project. But most essential is farmers to maximize the use of their land, labour and capital resources. In the current season nearly 30% of cultivable extent of the Turn Out was grown OFC against 6% crop diversification in the project.

Though different types of crop combination was analyzed only paddy, Red Onion and B'Onion was in the Optimal solution. In the six models analyzed above shows that

different extent of R'Onion, B'Onion and paddy was in the final solution. Because B'Onion and R'Onion cultivation in the Mahadamana unit was very successful in this season and their net return per Ha. was higher than other crops. In this season another cash crop such as Chilly could not meet expected results. With regards to B'Onion and R'Onion cultivation main problem which farmers are confronting is the marketing problems. B'Onions and R'onions are two perishable crops where harvest cannot be kept longer, (till the glut period is over) unless it is kept in dry places in racks. It is observed that most of the farmers have no such facilities and they are tempted to sell their harvest even at a lower price to dispose them quickly as they are perishable. Mahadamana farmers were lucky enough to sell their produce at a higher price to a certain extent. Hence in the optimal solutions in the each case analyses it is observed that Red Onion and B'Onion were appeared even though the input cost was higher than most of other crops. Chilly plants suffered narrow leaf disease, collor rot and Anthocnose. Hence Chilly yield was very low. The NLD problem was observed in most of Chilly plantations in the project area during the yala season. Hence return was not satisfactory compared to the input cost. Although chilly was not in the optimal solution compared to B'onion and Red Onion harvest can be kept for a longer period than the above crops and in the off season the harvest could be sold at a very high price. In the case of G'gram and Soya net return was very low hence it does not appear in the final solution.

When input cost was considered Red Onion needs the highest input cost where as soya was the lowest. Hence one who needs to get a high return for his liyadde it is very important to make a high initial investment. For growing of OFC such as Red Onion, B'Onion one needs some experience and knowledge to achieve high yield, better price by keeping them in dry places and sell them at a high price. Farmers who are experienced; confident and have capital to invest can grow Red Onions and B'onions. Main problem in respect of Red onion is the market price, during the glut it goes down very badly. It is found that some farmers can not sell their Red onion or B'onion yield even at Rs. 10/= a Kg. in the last season. It is observed that soon after the glut prices rise to high levels. Hence the post harvesting techniques not only for Red Onion but for other crops too, are to be introduced and monitored through our extension officers.

Selection of the crop combination depends on the topography of the terrain, drainability, soil characteristics, availability of capital and experience to achieve the successful return.

It was hypothised that the profitability is the most important criteria for making a decision to select a cropping pattern. Production and market risks associated with profitable crops such as Chillies, Red Onions and Big Onion have an impact on the selection of the cropping pattern. Untimely cultivation, Untimely availability of inputs supply and draft power, technical know how together with declining prices during the glut, may affect the final results.

In order to curtail the Government contribution for maintenance of irrigation net work, collection of O & M fee is important. In this case O & M fee of Rs. 500/= was taken into consideration. The present practice of collecting Rs. 250/= in the first year and gradually increase year by year upto Rs.500/=, is not realistic, because their is no way of controlling the water consumption of individual farmer. Hence water fee should be based on water consumption of individual farmers; there by farmers will be concerned about their usage in fields in future. Hence instead of flat rate, the charges on water should be based on quantity of water used by the individual farmers. To implement this; separate metering devices should be installed at each farm gate. This will help to reduce unnecessary wastage of water in the field.

In order to collect O&M fee the farmers should be given a proper understanding and knowledge through our extension officers. If this drive is successful millions of Rupees now spent on O&M activities out of public funds could be used for future projects. There is no doubt that this could be achieved only through

the consent of the farmers. Opening up of new projects will help to reduce the unemployment problem among younger generation in the country.

LIMITATION OF THE STUDY

This study was greatly hampered by lack of data on the timing and quantity of water delivered to and used by individual farmers and also the variations in the selling prices of their produce. Also one season's data collection was used in the analysis therefore trends can't be generalized. However within these limitations the suggestions made should go a long way to improve the water use efficiency of farmers and to decide a good cropping pattern for yala season. This will also reduce the unnecessary wastage of water by the individual farmers.

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ANNEX A

MONTH	MEAN SUN SHINE Hrs.	WIND	TEMP. Max	TEMP. Min	HUMIDITY.
APRIL	7.92	3.68	34.5	23.4	65.57
MAY	8.59	4.74	30.3	23.4	76.42
JUNE	5.67	9.33	35.1	24.3	69.8
JULY	6.47	7.79	34.7	23.3	61.3
AUGUST	4.8	7.6	35.2	23.5	65.86

Source: Agriculture Research Station -A'wila.

ANNEX B

Month	June	July	August
Farm Plot No.	Ground water	Elevations	in cms.
Fc66-01	30.0	27.5	35.1
Fc66-02	34.8	40.7	45.2
Fc66-03	32.8	37.5	40.4
Fc66-04	33.0	34.0	38.0
Fc66-05	24.4	34.6	38.7
Fc66-06	35.1	38.1	43.1
FC66-07	36.2	28.0	42.5
Fc66-08	30.5	24.5	39.5
Fc66-09	33.5	28.7	36.7
Fc66-10	32.5	31.0	38.5
Mean	32.16	32.47	38.95

ANNEX C

Lot No.	Paddy Kg./Ha.	Chilly Kg./Ha.	R'onion Kg./Ha.	B'onion Kg./Ha.	G'gram Kg./Ha.	Soya Kg./Ha
1	4695	1287	7910	12883.0	1410	1550
2	4950	1207	7020	9633.0	1370	1770
3	4500	1293	7815	11933.0	1436	1695
4	4910	1127	5986	10750.3	1310	1555
5	4750	1017	8904	9723.0	1510	1750
6	4644	1157	7815	8958.3	1335	1760
7	4825	1272	7285	9829.3	1475	1860
8	5251	1202	6775	10201.3	1255	1740
9	5090	1139	6550	10346.0	1139	1710
Ave.	4846	1300	7340.	10476.2	1358	1710

ANNEX D

Data for labour usage in the Mahadamana Trials.

Week No.	Paddy	Chilli	B'onion	Red Onion	G'Gram	Soya.
1	4.0	8.0	50.0	2.0	2.0	2.0
2	12.0	4.0	4.0	2.0	10.0	10.0
3	27.0	60.0	65.0	65.00	25.0	25.0
4	2.0	25.0		80.0	15.0	15.0
5	2.0	2.0	80.0	2.0	2.0	2.0
36	2.0	25.0.	2.0	2.0	1.0	1.0
7	2.0	2.0	2.0	2.0	1.0	1.0
8	2.0	2.0	3.0	2.0	1.0	2.0
9	2.0	2.00	3.0	2.0	2.0	2.0
10	2.0	2.0	2.0	2.0	2.0	1.0
11	2.0	2.0	2.0	2.0	1.0	1.0
12	2.0	2.0	2.0	2.0	2.0	1.0
13	2.0	2.0	2.0	2.0	2.0	1.0
14	2.0	2.0	2.0	2.0	2.0	1.0
15	2.0	2.0	2.0	2.0	1.0	2.0
16	2.0	2.0	2.0	2.0	2.0	1.0
17	2.0	20.0	2.0	2.0	1.0	1.0
18	2.0	40.0	10.0	10.0	2.0	1.0
19	3.0	50.0	90.0	90.0	50.0	30.0
20	3.0	40.0	10.0	10.0	30.0	10.0
21	47.0	20.0	31.5	1.0	20.0	10.0
Total	126.0	376.0	303.0	227.0	147.0	105.0

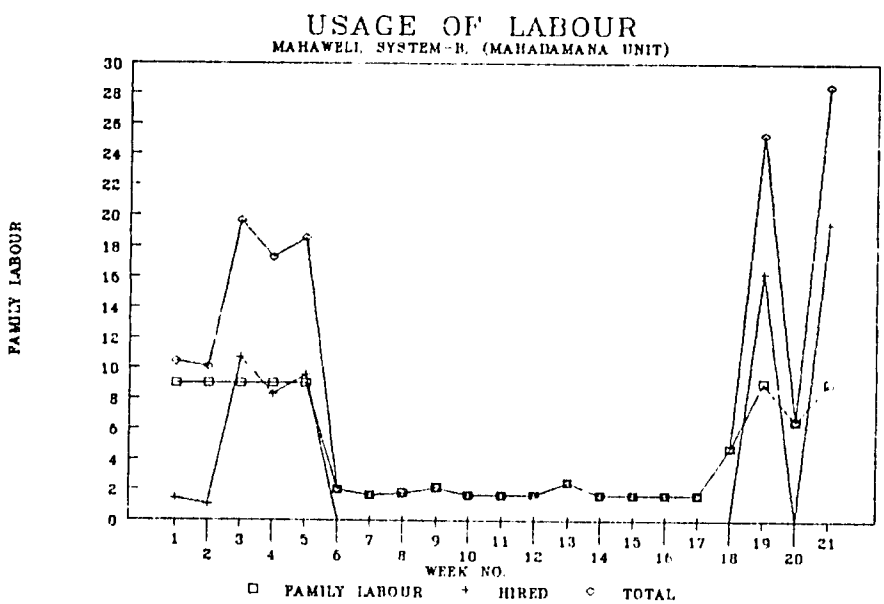
USAGE OF LABOUR

MODEL 1

Capital 20,000/- Return 54,410.90

Extent of OFC cultivation 50%

Week No.	Family Labour	Hired	Total
1	9.00	1.41	10.41
2	9.00	1.07	10.07
3	9.00	10.68	19.68
4	9.00	8.28	17.28
5	9.00	9.54	18.54
6	2.00	-	2.00
7	1.65	-	1.65
8	1.80	-	1.80
9	2.15	-	2.15
10	1.65	-	1.65
11	1.65	-	1.65
12	1.65	-	1.65
13	2.50	-	2.50
14	1.65	-	1.65
15	1.65	-	1.65
16	1.65	-	1.65
17	1.65	-	1.65
18	4.76	-	4.76
19	9.00	16.27	25.27
20	6.50	-	6.50
21	9.00	19.50	28.50



ANNEX-E

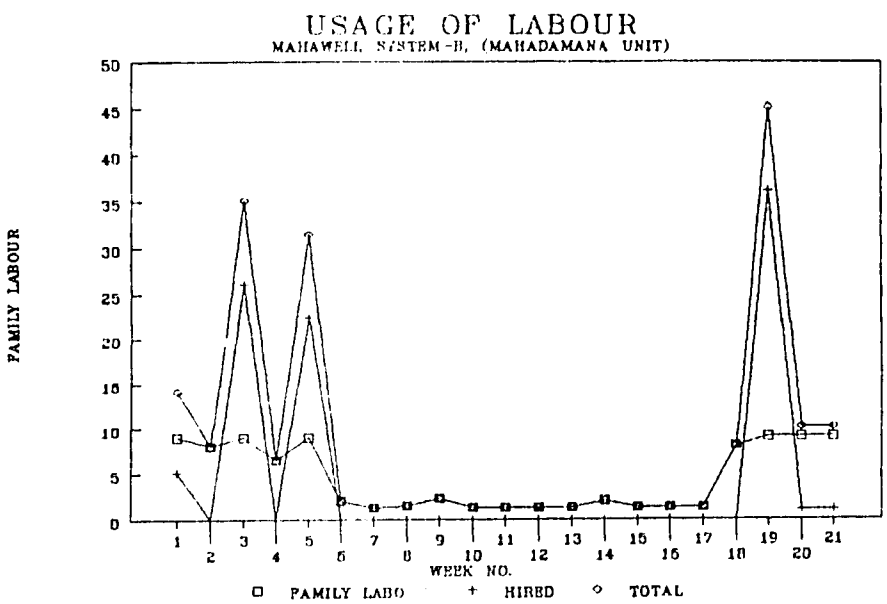
USAGE OF LABOUR

MODEL 2

Capital 20,000/- Return 90585.65

Extent of OFC cultivation 100%

Week No.	Family Labour	Hired	Total
1	9.00	5.14	14.14
2	8.00	-	8.00
3	9.00	26.10	35.10
4	6.50	-	6.50
5	9.00	22.48	31.48
6	2.00	-	2.00
7	1.25	-	1.25
8	1.50	-	1.50
9	2.25	-	2.25
10	1.25	-	1.25
11	1.25	-	1.25
12	1.25	-	1.25
13	1.25	-	1.25
14	2.00	-	2.00
15	1.25	-	1.25
16	1.25		1.25
17	1.25	-	1.25
18	7.97	-	7.97
19	9.00	36.17	45.17
20	9.00	1.00	10.00
21	9.00	1.00	10.00



ANNEX-E

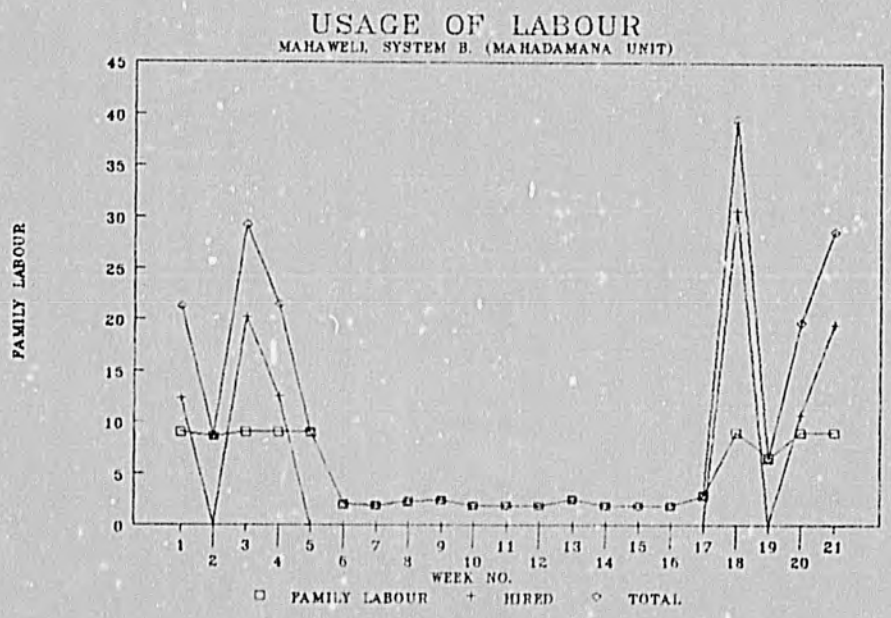
USAGE OF LABOUR

MODEL 3

Capital 30,000/- Return Rs.59454.10

Extent of OFC cultivation 50%

Week No.	Family Labour	Hired	Total
1	9.00	12.30	21.30
2	8.60	-	8.60
3	9.00	20.19	29.19
4	9.00	12.50	21.50
5	9.00	-	9.00
6	2.00	-	2.00
7	1.89	-	1.89
8	2.28	-	2.28
9	2.39	-	2.39
10	1.89	-	1.89
11	1.89	-	1.89
12	1.89	-	1.89
13	2.50	-	2.50
14	1.89	-	1.89
15	1.89	-	1.89
16	1.89	-	1.89
17	2.86	-	2.86
18	9.00	30.57	39.57
19	6.50	-	6.50
20	9.00	10.70	19.70
21	9.00	19.50	28.50



ANNEX-G

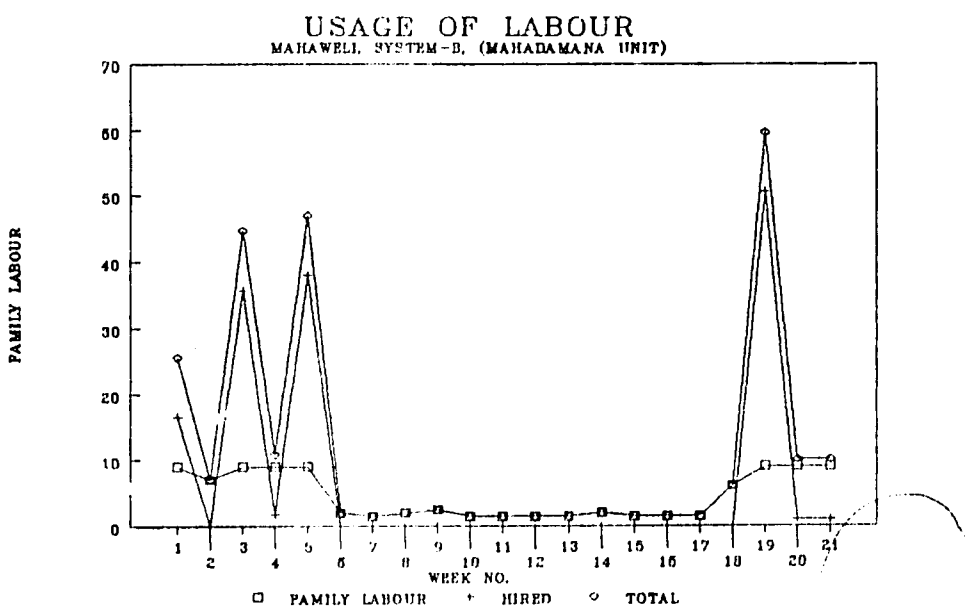
USAGE OF LABOUR

MODEL 4

Capital 30,000/- Return Rs.98121.50

Extent of OFC cultivation 100%

Week No.	Family Labour	Hired	Total
1	9.00	16.57	25.57
2	7.05	-	7.05
3	9.00	35.64	44.64
4	9.00	1.84	10.84
5	9.00	37.92	46.92
6	2.00	-	2.00
7	1.49	-	1.49
8	1.98	-	1.98
9	2.49	-	2.49
10	1.49	-	1.49
11	1.49	-	1.49
12	1.49	-	1.49
13	1.49	-	1.49
14	2.00	-	2.00
15	1.49	-	1.49
16	1.49	-	1.49
17	1.49	-	1.49
18	6.07	-	6.07
19	9.00	50.47	59.47
20	9.00	1.00	10.00
21	9.00	1.00	10.00



ANNEX-H

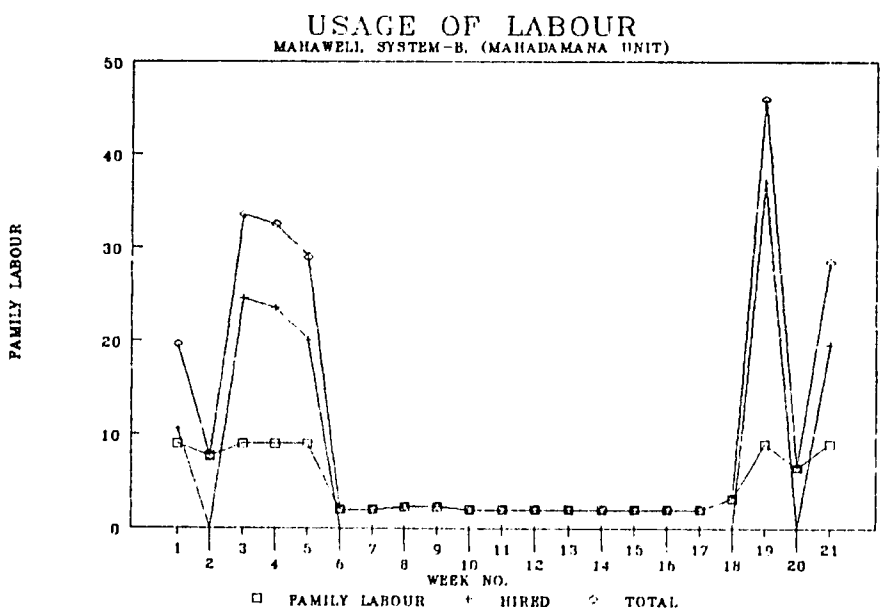
USAGE OF LABOUR

MODEL 5

Capital 40,000/=

Extent of OFC cultivation 50%

Week No.	Family Labour	Hired	Total
1	9.00	10.62	19.62
2	7.69	-	7.69
3	9.00	24.50	33.50
4	9.00	23.50	32.50
5	9.00	20.00	29.00
6	2.00	-	2.00
7	2.00	-	2.00
8	2.34	-	2.34
9	2.34	-	2.34
10	2.00	-	2.00
11	2.00	-	2.00
12	2.00	-	2.00
13	2.00	-	2.00
14	2.00	-	2.00
15	2.00	-	2.00
16	2.00	-	2.00
17	2.00	-	2.00
18	3.20	-	3.20
19	9.00	37.00	46.00
20	6.50	-	6.50
21	9.00	19.50	28.50



ANNEX-I

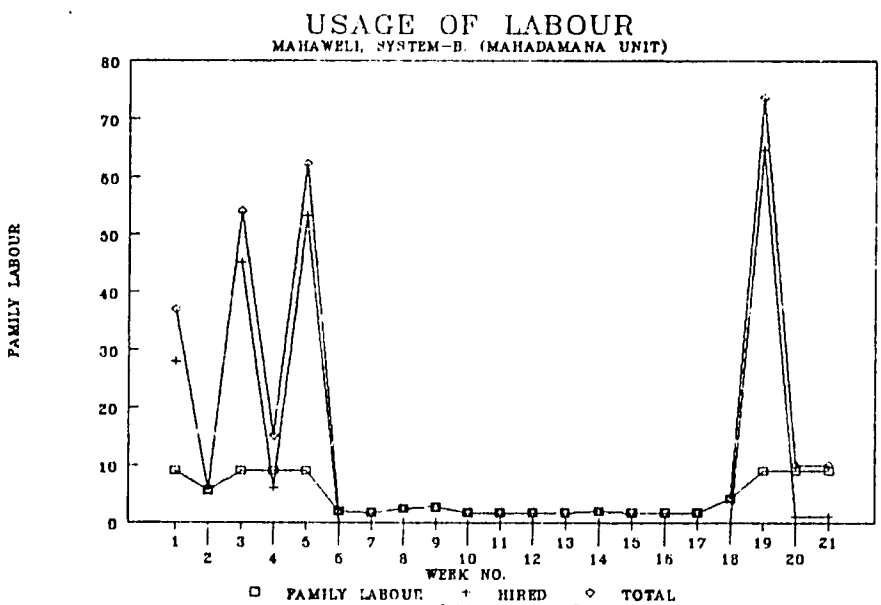
USAGE OF LABOUR

MODEL 6

Capital 40,000/= Return Rs.103145.00

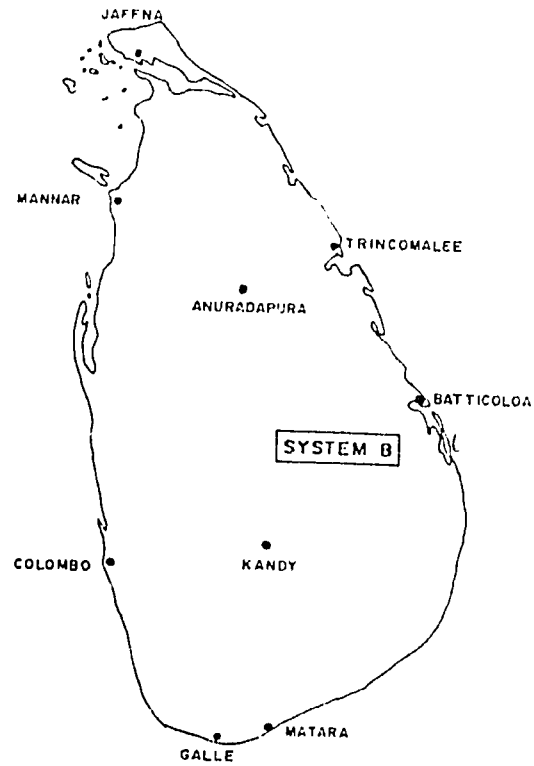
Extent of OFC cultivation 100%

Week No.	Family Labour	Hired	Total
1	9.00	27.98	36.98
2	5.62	-	5.62
3	9.00	45.15	54.15
4	9.00	6.11	15.11
5	9.00	53.37	62.37
6	2.00	-	2.00
7	1.72	-	1.72
8	2.45	-	2.45
9	2.72	-	2.72
10	1.72	-	1.72
11	1.72	-	1.72
12	1.72	-	1.72
13	1.72	-	1.72
14	2.00	-	2.00
15	1.72	-	1.72
16	1.72	-	1.72
17	1.72	-	1.72
18	4.16	-	4.16
19	9.00	64.73	73.73
20	9.00	1.00	10.00
21	9.00	1.00	10.00



ANNEX J

LOCATION MAP OF SYSTEM 'B' PROJECT



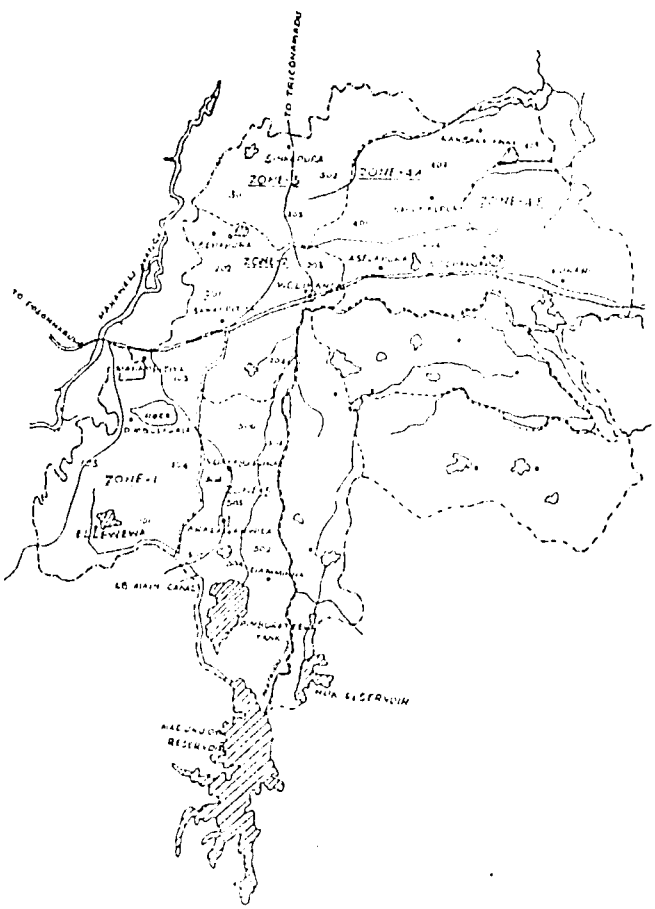


FIG. I.

AGROECOLOGICAL REGIONS OF SRILANKA

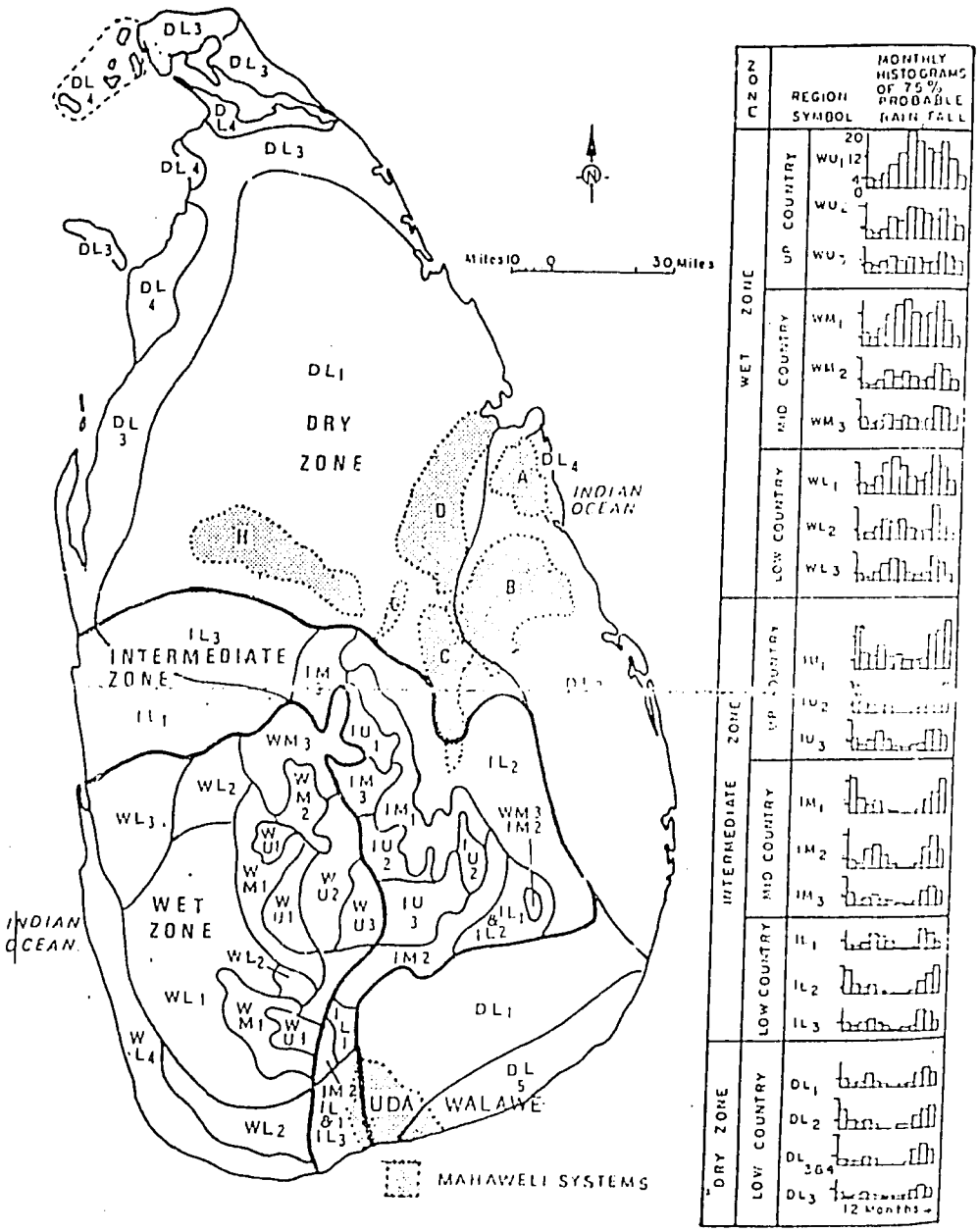


FIG. 2

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SURFACE WATER & RAINFALL

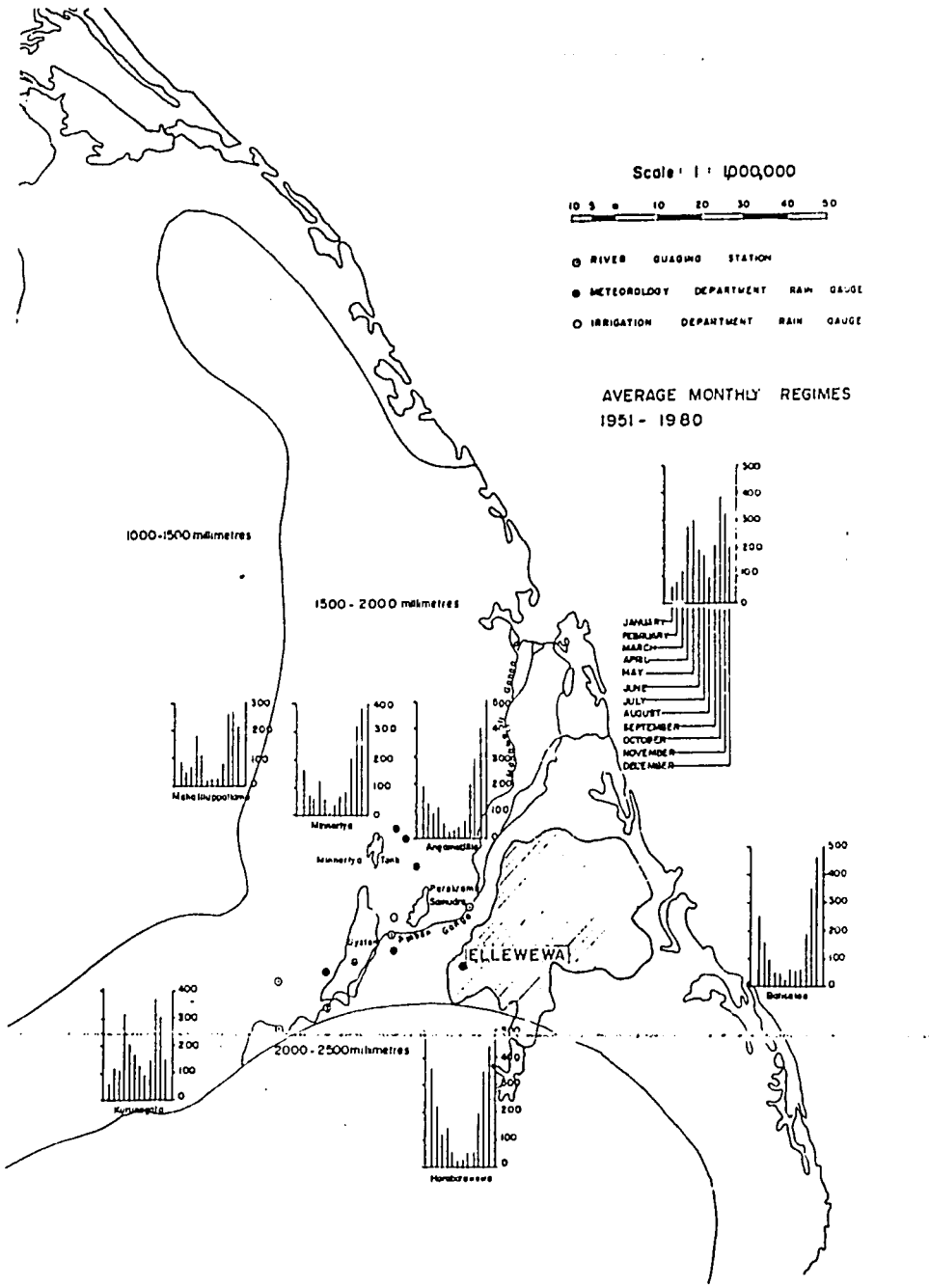
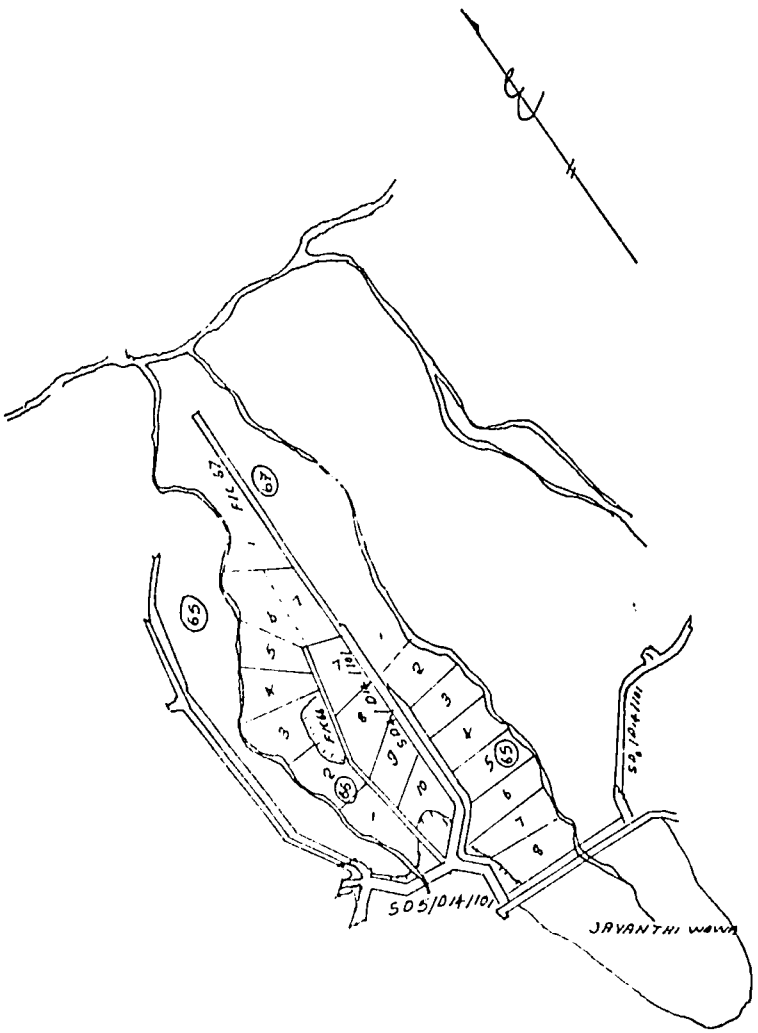


FIG. 3.

44

LOCATION PLAN OF TURNOUT NO. 66 OF MAHADAMANA UNIT ELLEWEWA BLOCK



SCALE 16 CHAINS TO AN INCH

FIG. 4.

45