A COMPARATIVE STUDY ON THE ECONOMIC EFFICIENCY OF DIFFERENT SOURCES OF IRRIGATION IN CHITTUR DEVELOPMENT BLOCK

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "A Comparative Study on the Economic Efficiency of Different Sources of Irrigation in Chittur Development Block" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any University or Society.

Vellanikkara,
26-2-1990

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CERTIFICATE

Certified that this thesis entitled "A Comprative Study on the Economic Efficiency of Different Sources of Irrigation in Chittur Development Block" is a record of research work done independently by Shri. S. Kalyana Krishnan, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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To my Parents

and

Teacher

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Introduction

INTRODUCTION

The presence of moisture in soil is essential for plant growth. The most important source of moisture is rainfall. Though annual rainfall in India is fairly high, it is mostly seasonal and in many parts of the country, it is also irregular, besides being inadequate. Therefore, agricultural activities depending entirely on annual precipitation, were almost impossible even during the ancient times when population was very much lesser than what it is today. Irrigation which means artificial application of water to soil to assist growth of plants, was practised from ancient times as even Vedas make mention of wells, canals, reservoirs and dams.

The importance of irrigation was well recognized by the rulers of India resulting in the building of irrigation systems appropriate to topographical and other physical conditions. Thus storage tanks in South India and canals in the North were provided by the rulers even before the dawn of Christian Era.

The country has accumulated a good deal of irrigation resources and technology of irrigation over the years. However, much of these were scattered attempts. During recent times, the recommendations of the different Famine Commissions and the Irrigation Commission of 1903 appointed by the British resulted

in somewhat more organised attempts to provide irrigation.

By the dawn of independence, undivided India had 28.2 M.ha. of irrigated area out of a net sown area of 116.8 M.ha. At the time of partition, a net sown area of 18.3 M.ha with an irrigated area of 8.8 M.ha ceded to Pakistan. India's share of irrigated area was only 19.4 M.ha. out of the net sown area of 98.5 M.ha.(around 20%). As rightly pointed out by the National Commission on Agriculture, it therefore, called for tremendous effort to make up the leeway and meet the requirements of the growing population through irrigated agriculture.

Post Independence Period

Irrigation development was given high priority in the Five Year Plans. The public spending on major, medium and minor irrigation projects was 18.7% of the total plan outlay for public sector in the first plan. In the subsequent Five Year Plan also, the outlay for irrigation stood around 10 to 11%. The third plan saw a marked shift of emphasis from major and medium irrigation projects to minor irrigation works and till date, minor irrigation has also been given an important share in the investment spending. Besides the feeling that all available sources of irrigation should be made use of in a conjunctive manner, this shift can be attributed to the realisation of the facts that:

a) Lesser cost is involved in per hectare investment on minor irrigation works

b) Lower gestation period between the beginning of the project work and its completion

c) Lower maintainance cost of the minor irrigation investments

d) Absence of any significant adverse influences on environment.

An estimated investment of Rs. 160 billion has been made on irrigation works by the Central and State Governments between 1950 and 1984. This represents almost one tenth of the total public investment during this period (Vaidhyanathan, 1987). According to the Seventh Five Year Plan document, by the end of Sixth Plan period, a total irrigation potential of 68 million hectares has been created in the country, making India one among the nations in the forefront with respect to irrigation facilities.

As far as the state of Kerala is concerned, till the end of March 1987, an area of 3.81 lakhs hectares (net) has been brought under irrigation through major, medium and minor irrigation schemes with an investment of Rs. 655 crores.

Irrigation water use

Taken the world over, fresh water forms only 2.7% of all available water and 77.2% of this is in the form of ice caps and glaciers. Of the remaining 22.8%, 11.2% is in the form of ground water which lies 750 metres below the surface and 0.04% is in gaseous state in the atmosphere. If we assume that half of the remaining amount of fresh water is available for irrigation, it will constitute only 0.156% of the total water available in earth's surface (United Nations Report, 1977). This amply points out to the need for a careful utilisation of whatever fresh water that is available to mankind.

In India, as mentioned earlier, irrigation has been made available to the farmer at a high cost and with much difficulty. Therefore, rational use of this precious resource is all the more necessary. This means making the best use of this limited resource. The National Commission on Agriculture (1976) expressed its views on the subject thus "Irrigation as at present followed in the country is extravagant in the use of water. In view of the inadequacy of water resources to meet requirements, there is a need for great deal of efficiency and economy in water use . . . The flexibility available in choice of crops in irrigated areas must be utilised to adjust cropping patterns in a balanced manner in conjunction with production in unirrigated areas".

Irrigation water being a resource whose supply cannot be augmented in the short run, its opportunity cost has to be taken into account while making use of it. Crops such as rice, sugarcane etc., whose water requirements are very high, ought to be included in crop plans only in areas where water availability is relatively better. In areas like Kerala, water availability during the post monsoon period, which is major part of the year, is highly inadequate. The need is to optimise the available irrigation water rather than optimise production from the existing crops some of which happen to be such as requiring relatively more water like rice and sugarcane. In Kerala, though the average size of holding is the lowest in the country, even this limited land is not sufficiently intensively cultivated for want of soil moisture.

In this context, it will be worthwile to quote the observations made by the Kerala State Planning Board in an evaluation study done in 1975. It says that " . . . . It is interesting to note that the selected cultivators seem to ignore the use of irrigation water for alternate crops either through ignorance or negligence. Left to themselves, they tend to grow rice only although its water requirement is much higher than that of other crops" (State Planning Board, 1975). It also goes on to add that " . . . . most of the beneficiary

cultivators in the selected sample have very little awareness about the efficiency of water use. They are under the notion that more water they use, the better the crop".

It has also been pointed out that development of irrigation in Kerala has neither made any significant contribution nor had any stabilisation effect in the yield of rice (Nair and Narayana, 1983, George and Mukherjee, 1986).

To sum it up and put it this way, the source and quantity of water available for irrigation are found to influence the decision of the farmers in making crop plans and use of associated inputs. It has also been demonstrated that there is considerable wastage of water resource which states like Kerala can ill afford. Optimum utilisation of water demands the maximum coverage from existing water resources as well as their timely use in profit maximising crop combinations. Studies on comparative efficiencies of irrigation systems vis-a-vis their productivities from both individual farmers point of view as well as aggregate agricultural output have pointed to the scope in the improvement in use of irrigation water. The broad objective of the present study is to examine the existing pattern of use of irrigation water and to suggest optimal plans for

the use of this scarce input, in an area where it is relatively scarce, but at the same time, having a flexibility in cropping pattern.

The specific objectives of the study are given below:

1) To compare the principal sources of irrigation with respect to their adequacy and influence over cropping pattern

2) To estimate the cost and technical co-efficients in farms

3) To develop optimal plans for farms differing with respect to source of irrigation

4) To suggest means for optimal use of irrigation water

The various sources that were studied include canal, well, canal + well, spout fed well and rainfed cultivation. Chittur Development Block in Palghat district was purposively selected for the study since it has different sources of irrigation and also flexibility available in changing cropping patterns.

Plan of the study

The study is presented in five chapters, including the present one. Chapter two contains a brief review of

research studies connected with economics of irrigation. A brief profile of the study area and the methodology of the study have been described in chapter three. The results of the study have been presented in chapter four alongwith discussions thereon. Summary of the main findings of the study is presented in the fifth and the final chapter.

Review of Literature

REVIEW OF LITERATURE

Economics of irrigation has received considerable attention of research workers and a large number and variety of papers have been published on this topic. The literature reviewed here are presented under the following headings:

a) Impact of irrigation

b) Source of irrigation vs. degree of flexibility and reliability

c) Rationality in use of irrigation input and

d) Optimal allocation of irrigation water and other inputs

a) Impact of irrigation

Irrigation, as is well known, is the artificial application of water to crops for their growth and development. It being a concious effort on the part of man to increase crop production, the resultant impact of irrigation is worth examining.

Mann (1958) used the data on average national yield per acre of rice, wheat, gram, jowar and cotton, pertaining to 1946-'47 and observed that there is an almost doubling of income due to irrigation, for crops.

Yeswanth (1965) made a case study of six villages in

Ramanathapuram district in Tamil Nadu and observed that the intensity of cropping in the district was 100 per cent in rainfed farms, whereas it was 168 per cent in case of pumpset owners, indicating a positive relationship between intensity of cropping and irrigation.

Garg and Singh (1971) made a study on the income disparity between dry land and irrigated farms in Kanpur district of Utter Pradesh by taking 100 cultivators each representing the two categories. They reported that the per hectare cost of inputs in irrigated farms was Rs. 1,393.39 whereas it was only Rs. 503.57 in dry farms. Net income per hectare was Rs. 1,971.17 in irrigated farms and Rs. 413.77 in dry farms. Input-output relationship was also reported to be more favourable in irrigated farms compared to dry land farms.

Singh et al. (1971) have concluded after a study of benefit cost ratio and productivity on dry and irrigated farms in 50 randomly selected cultivators holdings in Unnao district that the use of inputs like fertilizers, human labour and bullock labour per hectare was higher on irrigated farms as against dry farms.

Kahlon et al. (1971) examined the relative economics of irrigated and dry farming by taking 70 sample farms through multi stage stratified random sampling in Ferozpur district of Punjab and reported that there was significant difference in cropping pattern between these two types of

farms. Cropping intensity, cost of cultivation, yield per hectare and gross income per hectare of major crops were more in irrigated farms as compared to those in unirrigated farms.

Bharara (1974) reported that irrigation brought about beneficial changes in occupational structure, land use pattern, land distribution pattern, size of holding, area sown, yield of crops, input use and labour employed in a hitherto unirrigated land region. A gradual commercialisation of agriculture was also observed.

Bagi (1981) attempted to empirically estimate the economic contribution of irrigation to crop production in Haryana. The results indicated higher technical efficiency in irrigated farms. Such farms were found to use larger quantities of variable inputs with improved relative allocation efficiency.

Patel (1981) made an attempt to study the impact of irrigation on employment at farm level in the command areas of some of the irrigation projects in Gujarat. Absolute difference between the per hectare number of labour days for the irrigated and rainfed farms varied from 27 to 82 in Saurashtra region and from 12 to 92 in Gujarat region respectively. Thus the results indicate an increase in employment by virtue of irrigation.

Rejeena (1982) made a study to assess the impact of

bank finance for minor irrigation in Trichur district and observed that the area under perinneal crops, cropping intensity and use of chemical fertilizers increased in beneficiary farms who availed irrigation facilities. However, the employment of hired human and bullock labour declined significantly.

Nair and Narayana (1983) analysed the impact of irrigation in stabilizing and increasing the yield of paddy crop in Kerala. For this they used the data on yields taken from the crop cutting surveys conducted by the directorate of Economics and Statistics, in irrigated as well as unirrigated area. They concluded that the impact of irrigation in terms of stabilizing productivity of paddy lands and increasing it over time is seen to be only marginal in the state.

Nair (1984) in a study made on the impact of coconut rehabilitation programme of "SADU" in Trivandrum district of Kerala has found that the utilisation of loans in unirrigated category was low (50.18%) compared to irrigated category (122.43%).

It has also been observed in the above study that the productivity rise in coconut in irrigated farms was 47% compared to only 20% in unirrigated farms.

Palanisami (1984) made a study on the pattern of water allocation, use and management in Lower Bhavani

Project command area in Coimbatore and concluded that:

1) Fertilizer application was directly related to water availability.

2) Yields of crops were directly influenced by water availability and fertilizer application.

Patel and Patel (1984) after a study of 144 sample farms in Dantiwada Irrigation Project of Gujarat observed that the cropping pattern and input use structure in irrigated farms are distinctly different from those observed in rainfed farms. Per hectare income in irrigated farms was found to be higher by Rs. 896.00 over rainfed farms.

Employment of human labour in irrigated farms was found to be higher by 34 mandays per hectare or by 61% over the one used in rainfed farms.

Vaidhyanathan (1987) points out the difficulty in precisely estimating the magnitude of the impact of irrigation. He attributes it to the effect of irrigation on crops yields directly and also via its influence on the scope for using other inputs and the efficiency with which they are used. Nevertheless, he has suggested that since there is strong complementary relationship between water and other inputs, the difference in land productivity between irrigated and unirrigated farms can be legitimately taken as as measure of the overall impact of irrigation.

b) Source of irrigation vs. degree of flexibility and reliability

Rao (1963) has opined that in general, minor irrigation schemes are largely preferred to medium and major irrigation schemes because of their limited capital requirements, manageable size, short gestation period, vicinity of the service area and greater use of local talents and resources in their development.

A study conducted by the Programme Evaluation Organization of the Planning Commission (1969) has observed that minor and smaller irrigation sources are performing better than the major canal irrigation systems in effective water distribution and management. A farmer has complete control on his private source of irrigation and hence can apply water according to his crop's need.

Moorthi and Mellor (1972) after a study on different sources of irrigation in Utter Pradesh concluded that farmers with private tubewells have better control of water supply in terms of timely availability in adequate quantity. This resulted in higher cropping intensity, yield, higher crop income and cultivation of high yielding crops in such farms. This was attributed to the flexibility factors in quantity and timing available in those farms.

Vohra (1972) while pondering on the policy implications on ground water observed that the high yielding varieties and

multiple cropping systems demand more water than anything else, that too at the right time and right quantity. This requirement, according to him, can be met only be a source of irrigation that is completely under the farmers own control. No surface irrigation system can even remotly hope to compete with ground water in this respect.

Chambers (1974) after a detailed analysis on agrarian change in rice growing areas of Tamil Nadu observed that insecurity of water deliveries to individual farmers have been shown to cause farmers to select crops which are more drought resistant. They adhere to the traditional types of crops and crop variations for fear of risk and thereby loose the higher possible yields and profits that some of the more water dependent crops may afford.

Palanisami (1984) reported that as the field distance from irrigation channels increased, the number of wells increased mainly to supplement the supply of canal water. Type of crops grown and water availability were directly related.

Sankhyan and Singh (1984) made a comparitive study of the impact of surface and lift irrigation systems by analysing the data of 200 sample farms and have reported differences in cropping pattern between the systems. But no significant difference in the distribution of incomes and economic efficiency was indicated in the model that was used.

Sidhu et al. (1984) observed that there was positive relationship between the degree of water supply flexibility and reliability (represented by source of irrigation) and other variable inputs. Owing to high use of inputs which was the result of increase in the degree of water supply flexibility and reliability, the yield and economic returns were also higher at flexible source of irrigation.

Thakur and Kumar (1984) made a comparative study of economic efficiency of different systems of irrigation in Western Uttar Pradesh and have concluded that private tube wells in comparison with state tube wells and canal irrigation helped more in increasing the income of farmers due to possibility of better water management.

Dhawan (1986) observed that from the view point of timeliness in irrigation operation, public irrigation works compare quite unfavourably with the ones owned by the farmers individually, especially tubewells and dugwells fitted with pumpsets.

c) Rationality in use of irrigation water input

A study conducted by the evaluation division of the State Planning Board (1975) revealed that the minor irrigation beneficiaries have very little awareness about the efficiency of water use. The farmers were found to be under the notion that the more water they use, the better the crop. It was noted that the cultivators seems to ignore

the use of irrigation water for alternative crops either through ignorance or negligence. Left to themselves, they tend to grow rice only although its water requirement was much higher than that of other crops.

National Commission on Agriculture (1976) opined that irrigation as at present practiced in the country is extravagant in the use of water. In view of the inadequacy of water resources to meet requirements, there is need for a greater deal of efficiency and economy in water use.

Making a mention on the predominance of rice in Indian cropping system, NCA pointed out that rice crop grown in non rainy season or low rainfall areas consumes disproportionately more water than the production it gives. Under these water paucity conditions, rice should be grown only if the available irrigation supplies cannot be put to better use for other crops.

Mangalabhanu (1977) in his report on command area development has advocated a change in the present cropping pattern being followed in Kerala, for better utilisation of available water and thereby to maximise production.

Levine's (1977) study conducted in Phillipines, Taiwan and other parts of Asia revealed that irrigation system in developing countries were often inefficient, both in water use and in cropping effectiveness.

Nair and Narayana (1983) after making a critical

assessment of the impact of irrigation on agricultural production in the state of Kerala concluded that the lack of any significant influence of irrigation on crop yields is due to the poor management of irrigation water.

Palanisami (1984) reported that excess irrigation was observed at the head reach farms and deficient irrigation at the tail reach farms, in the Lower Bhavani irrigation project.

Patel and Patel (1984) observed that the overall distribution of benefits of irrigation remains unbalanced in the Dantiwada Canal Irrigation Project in Gujarat. Allocation of water among crops is not efficient and hence there is a need for reallocation of water from low paying crops to high paying ones.

Singh and Saraswat (1984) have stated that the existing cropping patterns in the valleys of Himachal Pradesh are suboptimal, indicating thereby that even without bringing additional lands under cultivation, agricultural production can be substantially increased by adopting optimum crop plans with the existing resource base and irrigational facilities.

Ashturkar (1986) made a study on the irrigation water management in Maharashtra and reported that jowar, bajra, paddy and cotton based cropping systems are equally profitable compared to sugarcane. The water requirements of these crops are very less when compared to sugarcane

and hence if the area under sugarcane is restricted, large areas of such crops can be brought under irrigation, which ultimately will increase and stabilise the production and productivity of major cereals, pulses and oilseed crops in the state.

Panda's (1986) study in a canal irrigation system revealed that inspite of the working of agencies like CADA, there exists gross inequality in the use of canal irrigation water for different crops at different locations.

Rath and Mitra (1986) pointed out that it is inapprop priate to go in for a sugarcane centered cropping system where irrigation water is not plentiful. In Maharashtra, it is an anomaly that the sugarcane crops which accounts for about one nineth of the gross irrigated crop area used around 60 per cent of the total irrigation water.

d) Optimal allocation of irrigation water and other inputs

Having understood the importance of irrigation and the irrational use of the scarce input, it will only be proper to review studies aimed at understanding optimum use of the said input.

Hiremath (1973) tried to optimise crop returns for each canal for different periods in the Krishnarajasagar Project under existing situations. Crop and water returns were maximised through temporal and spatial allocation of the net impoundable inflows into the reservoir.

Newton (1977) used a regional farm linear programming model in a study of water resource planning in Santa Maria Valley, California. It provided a valuable tool in water resource planning because of its ability to reflect agricultural adjustments to a dynamic water situation.

Sharma and Sirohi (1977) tried to allocate available water of the Tomaria reservoir in Uttar Pradesh optimally among the major irrigated crops in each period under conditions of weather uncertainity. The study indicated that the gross returns in the command area could be increased by 20 per cent by adopting optimal decision rules and adjusting area under the crops.

Maji and Heady (1978) attempted to evolve an optimal cropping pattern and reservoir management policy for the Mayurakshi Irrigation Project under conditions of average as well as variable monthly inflows. The results indicated that there is scope for maximising net return to the project area by changing existing cropping pattern and reservoir management policy.

Sumayao (1979) estimated that optimum allocation of available water increased efficiency of an irrigation system by saving water to the extent of 60 per cent.

Selvarajan and Subramanian (1981) have pointed out that there exists ample scope for increasing farm incomes and employment through resource use optimisation and water

augmentation in the Parambikulam Aliyar Project Command of Tamil Nadu.

Sivanandam (1983) has shown that there is substantial scope for increasing aggregate farm income of the Periyar-Vaigai project area through inter regional and inter months reallocation of available water supply.

Palanisami (1984) has reported that the result of linear programming analysis taken up to optimise the water use at farm level under canal with well and canal irrigation (along) has indicated an increase in income under optimum plans over the existing plan.

Satpute and Rajmane (1986) have studied the water allocation in the command area of Jayakwadi Project of Maharashtra and have emphasised the need to revise the existing pattern of water distribution policy so as to maximise the efficiency of available water.

Chhikara and Singh's (1986) study in Haryana has revealed that there exists the possibility of increasing net returns at farm level through optimisation of land and water resources at both existing level and improved levels of technology.

Verma and Banga (1986) have concluded after a study of Jai Samand Dam Project in Rajastan that the existing use of reservoir water was far from optimal. The results of

the study indicated that a change in existing cropping pattern and reservoir management policy is desirable and consistent with the maximisation of net returns.

Profile of the study area and Methodology

PROFILE OF THE STUDY AREA AND METHODOLOGY

The present study was an attempt to compare the economic efficiencies of different sources of irrigation. This essentially involved an in depth analysis of costs and benefits of the different systems that are in vogue in the study area. It should also throw light on the utilisational aspects of irrigation that is presently followed. For the study to be of any practical use, the selected area should have two basic requisites. The first is that, it should have a variety of irrigation sources, the second being the possibility of flexibility in cropping pattern to allow necessary adjustments, if the analysis of the study calls for it. Chittur Development Block in Palghat district of Kerala suits well to these requirements and hence it was taken as the study area.

Before going into the details of methodology as such, it is felt that a general information about Chittur Block would serve as a useful backdrop to the study.

Profile of the study area

Chittur Community Development Block forms part of the Palghat District which lies between 10° 20' and 11° 14' North latitudes and 76° 02' and 76° 54' East longitudes. The Block is bound on the North and East by Coimbatore district of Tamil Nadu and on the South

and West by Kollengode Community Development Block. Area of the block is 261.23 square Kms. spanning 19 villages in 6 panchayats. Three of the Eastern panchayats adjascent to Tamil Nadu have characteristics of soil, climate and land use pattern some what similar to that of Tamil Nadu.

Soil and topography

Topographically, the block is more or less plain with scattered hills falling mostly in the midland category. Almost the entire area is covered by stream courses draining off into the irrigation system under the Chitturpuzha Project.

Soil is mostly red loam with the Eastern parts having black cotton soil in addition.

Climate and rainfall

The block enjoys a tropical climate getting the benefit of both Southwest and Northeast monsoons. Average rainfall of the block is slightly less than the average rainfall of Palghat. This can be seen from the table given below:

Table 3.1 Monthly rainfall of Chittur and Palghat

Month	Rainfall in mm (1986)		Rainfall in mm (1987)	
	Chittur*	Palghat£	Chittur*	Palghat£
January	5.0	2.8	0.0	0.0
February	13.3	0.0	0.0	0.0
March	0.0	0.0	54.0	11.0
April	41.3	30.6	16.5	0.0
May	48.4	75.9	133.2	100.6
June	385.3	469.9	196.3	189.6
July	279.8	268.6	293.4	69.0
August	383.0	342.4	177.2	238.4
September	39.2	71.6	62.2	111.6
October	102.7	118.6	82.7	238.3
November	68.6	67.4	84.7	90.6
December	16.2	10.0	89.2	226.9
Total	1382.8	1457.8	1189.4	1276.0

* Source: C.D. Block Office, Chittur

£ Source: State Seed Farm, Kunnannur, Palghat

Land utilisation and cropping pattern

Details of land utilisation pattern are given below:

Table 3.2 Chittur Block: Land utilisation pattern (1980 - '81)

Sl. No.	Classification	Area in acres	Percentage to total geographical area
1.	Land put to non agricultural use	9266	13.72
2.	Barren and uncultivable land	1055	5.56
3.	Pastures and grazing land	49	0.07
4.	Area under miscellaneous crop trees	362	0.54
5.	Cultivable waste	3027	4.48
6.	Current fallows	1815	2.69
7.	Other fallows	911	1.35
8.	Net area sown	51034	75.59
	Total	67519	100.00

Source: Comprehensive development plan for scheduled castes in Chittur Block, Agricultural Finance Corporation, Bombay, 1984

It can be seen from the table that some amount of increase in the cropped area can be brought about by bringing the cultivable waste of 3027 acres under plough.

Data relating to cropping pattern is given in Table 3.3.

Table 3.3 Cropping pattern in Chittur Block (1980-'81)

Sl. No.	Crop	Area in acres	Percentage to total cropped area
1.	Paddy	35341	51.40
2.	Jowar	947	1.38
3.	Ragi	500	0.73
4.	Pulses	752	1.09
5.	Other cereals	846	1.23
6.	Sugarcane	7601	11.06
7.	Palmyrah	2189	3.18
8.	Vegetables	835	1.21
9.	Groundnut	7431	10.81
10.	Coconut	3121	4.54
11.	Sesamum	30	0.04
12.	Other oil seeds	589	0.86
13.	Cotton	2389	3.47
14.	Arecanut	242	0.35
15.	Condiments & Spices	33	0.05
16.	Fruit crops	5506	8.01
17.	Cocoa	21	0.03
18.	Fodder crops	23	0.03
19.	Others	361	0.53
	Total cropped area	68756	100.00

Source: Comprehensive development plan for Scheduled Caste in Chittur Block, AFC, Bombay, 1984.

It is clear from the table that there is a wide diversity of crops being grown in the study area. Among the seasonals and annuals, paddy, sugarcane, groundnut and cotton occupy considerable areas under cultivation. Minor cereals and millets, pulses, vegetables and other oilseed crops are also cultivated, though to a lesser extent.

It has to be taken note that in spite of Chittur Block being a low rainfall region, the major part of the cropped area is devoted to those crops which require large quantity of water, like paddy and sugarcane (62.46%).

Irrigation

Chitturpuzha Project is the main source of irrigation throughout the block. Out of the total irrigated area of 28517 acres (1980-'81 figures) 55%, i.e. 15798 acres is covered by this canal. Apart from this, tanks and wells put together also constitute a major source of irrigation with a share of 44%.

Table 3.4 Chittur block: Area under different sources of irrigation (1980-'81)

Sl. No.	Source	Area in acres	Percentage
1.	Canal	15798	55.40
2.	Tanks	5411	18.90
3.	Wells	7267	25.48
4.	Minor/lift irrigation	4	0.01
5.	Rivers/lakes	37	0.13
	Total	28517	100.00

Source: Comprehensive development plan for Scheduled Caste in Chittur Block, AFC, Bombay, 1984.

The figures shown in the above table were deceptive to a certain extent. A reconnoitoring study of the block indicated that within the command of the irrigation canal, many of the farmers were having wells, mainly for supplementing the canal water source. Thus the areas so irrigated cannot be strictly taken as either canal irrigated or well irrigated. Similarly, for the benefit of farmers who are owning their lands in the upper reaches of the canal, water is being provided to wells dug in their lands, through a spout pipe (subject to certain conditions and an agreement being executed between the farmer and the irrigation department) from the canal. Eventhough ferms so irrigated also broadly come under the canal source of irrigation, they are significantly different from normal

canal irrigated farms. Such a source of irrigation has been designated as "spout fed well" for identification. Farms irrigated from the spout fed wells have advantages of water availability as well as flexibility in the use of water.

Thus, for the purpose of the present study, the following sources of irrigation were identified:

	Source	Abbreviation used
1.	Canal	CFF
2.	Well	WFF
3.	Canal + well	CWF
4.	Spout fed well	SWF
5.	Rainfed as control	RFF

Note:

1. Farms under the CFF group derived irrigation water exclusively from canals.

2. Farms under the WFF group derived irrigation water exclusively from well source.

3. Farms under the CWF group were those which (a)derived water from canal for irrigation of more than 80% of the net sown area and (b) had atleast one well each to supplement the irrigation water received from canal.

4. Farms under the SWF group derived irrigation water exclusively from wells, to which canal water was fed by providing a spout pipe.

5. Farms under the RFF group were those which had no irrigation water source at all. In other words they were purely rainfed farms.

METHODOLOGY

When the profile of the villagewise land utilisation pattern was examined (Table 3.5), it was seen that Kunnamkathupathy Village is having an almost uniformly distributed irrigated area under canal and well, which was lacking in any of the other villages. Morover, Kunnamkathupathy is also having dryland (rainfed) cultivation in practice, as can be seen from the percentage irrigated area figures (50.88%). It was observed that this village had considerable area under irrigation from spout fed wells also. Thus, it was decided that Kunnamkathupathy was the best choice among the villages for data collection. The location of the study area and sample village is shown in Fig. I.

Sampling procedure

Stratified random sampling technique was used for the study. The details of canal irrigated farms were readily available with the village office since canal water tax is being collected through them. Similarly, a separate list of farmers is being kept there for whom water is supplied to their wells, from canals. With the active support of the village office staff and the agricultural demonstrator

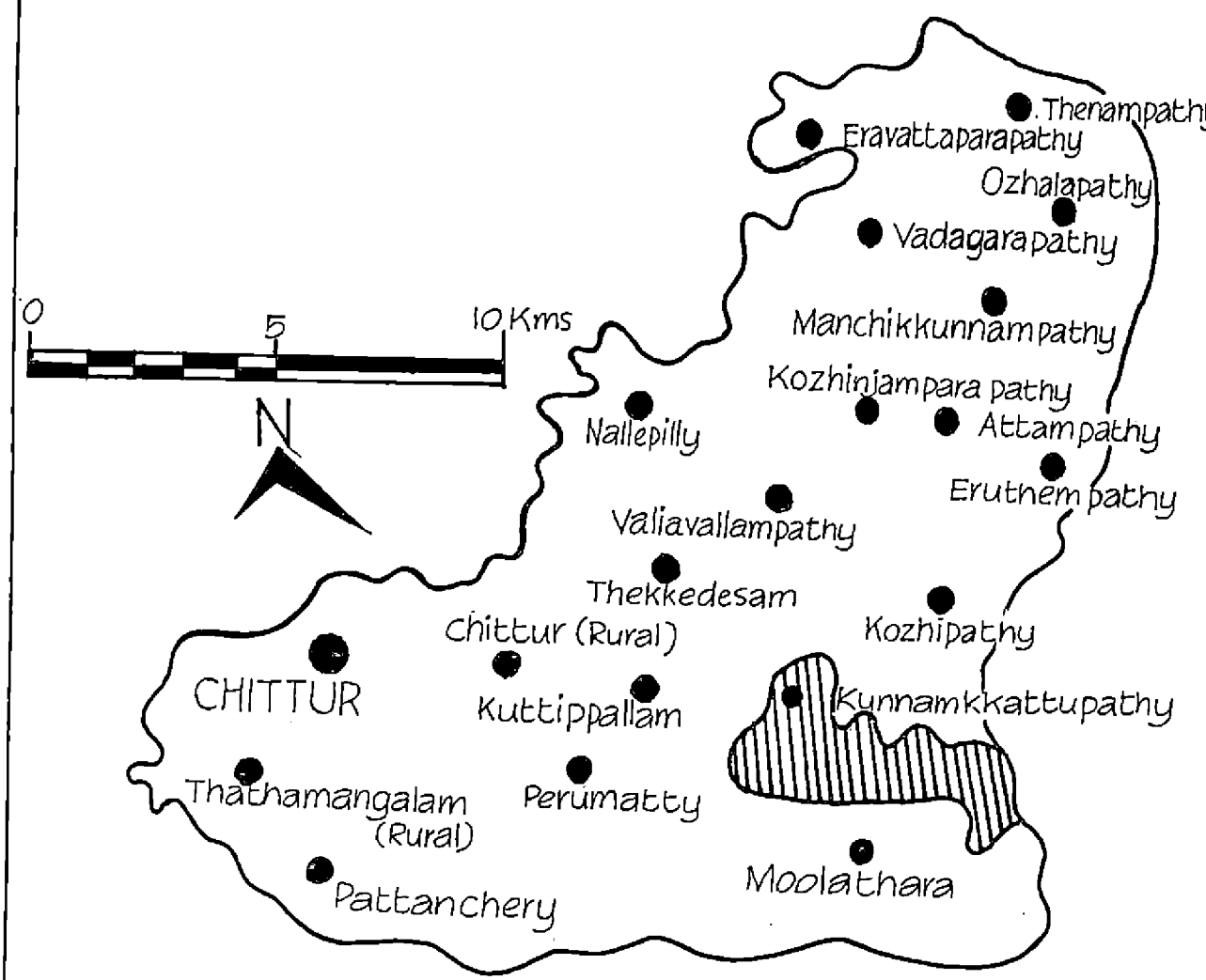
Table 3.5 Chittur Block: Villagewise land utilisation and irrigation pattern (Area in acres)

Sl. No.	Name of village	Geographical area	Net sown area	Total irrigated area	Source of irrigation			
					Canal	Tanks	Wells	Others
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	Eravattapparapathy	1315	949	206 (21.70)	1	31	174	-
2.	Vadakarapathy	5180	4347	1513 (34.80)	2	841	661	9
3.	Thenampathy	1660	1298	763 (58.78)	15	748	-	-
4.	Ozhalapathy	2879	2386	1226 (51.38)	-	1226	-	-
5.	Attempathy	1206	1010	405 (40.09)	-	20	385	-
6.	Manchikunnampathy	2688	2189	1060 (48.42)	-	1010	35	15
7.	Eruthempathy	2173	1740	1531 (87.98)	57	-	1468	6
8.	Kozhipathy	4254	2493	874 (35.05)	-	799	75	-
9.	Kunnamkattupathy	3209	2313	1177 (50.88)	554	68	555	-
10.	Valiyavallampathy	4890	3696	3145 (85.09)	1557	242	1346	-
11.	Kozhinjampara	2100	1207	201 (16.65)	-	3	198	-
12.	Nalleppilly	2961	2266	1772 (78.19)	1368	52	349	3
13.	Thekkedesom	2795	2274	1778 (78.18)	1694	8	76	-
14.	Kuttippallam	2212	1702	1523 (89.48)	957	69	497	-
15.	Chittur (Rural)	3759	2713	2201 (81.12)	2168	5	28	-
16.	Thathamangalam (Rural)	3577	2707	2242 (82.82)	2115	-	127	-
17.	Perumatty	8545	6314	1364 (21.60)	1148	18	198	-
18.	Moolathara	6486	5215	2381 (45.65)	1281	95	1001	4
19.	Pattamchery	5630	4215	3155 (74.85)	2881	176	94	4

Note: Figures in parenthesis in column 5 indicate percentage irrigated area with respect to net sown area in that village.

Source: Comprehensive development plan for Scheduled Castes in Chittur Block, AFC, Bombay (1984).

FIG. 1 : CHITTUR DEVELOPMENT BLOCK
LOCATION OF VILLAGES



LEGEND : ▨ Sample village.

of the local "Krishi Bhavan", separate lists of farmers (i) having exclusively well as the source of irrigation (ii) those having canal and well, and (iii) farmers who have no water source at all (rainfed) were prepared. On the basis of these lists and the village office records, five strata comprising of (1) canal fed farms (CFF) (2) well fed farms (WFF) (3) canal + well fed farms (CWF) (4) spout fed well irrigated farms (SWF) and (5) rainfed farms (RFF) were formed. Care was taken to exclude farms having an area of less than two acres since it was felt that such farms would in general be marginal in nature without much potential to invest on irrigation. Also, the choice of crops will be limited in such farms.

Twenty farms each were selected from canal fed, well fed and rainfed groups. As already mentioned, the canal with well and spout fed well sources or irrigation were also found to be in vouge, though in a lesser scale than the canal and well sources. Hence, to represent these also in the study, fifteen farms each were selected randomly from the canal with well and spoutfed well source groups.

Data

Primary data were collected from the selected sample farmers in January and February 1988, using a well structured and pre tested interview schedule (Appendix I). The method of personal interview was adopted to elicit

data from the respondents,which pertained to crop year 1986-'87 i.e. from May 1986 to April 1987, as sowing commences in the month of May in the study area.

The various aspects that were covered include,

1) General economic and social condition of the sample farmers
2) Land use pattern and type of tenure
3) Seasonwise cropping pattern
4) Investment and use of irrigation structures and equipments
5) Operational expenses of machines including irrigation related ones
6) Details of canal sources of irrigation
7) Crop wise irrigation details
8) Details of loan obtained
9) Cost of cultivation of various crops and
10) Crop output and returns

Apart from collection of primary data from sample farmers, details of climatological variables were also collected from Block Development Office, Chittur and Integrated Seed Development Farm at Eruthempathy.

Farmers of the sample area were mostly of low education level. But since farming was their main occupation, their responses to questions were satisfactory.

Tools of analysis

As mentioned earlier, farms having an area of two or more acres only were selected for the study.

Irrigation vs.cropping pattern, input use etc.

Before we proceed further, it is felt that the definition of irrigation and irrigated area has to be explicitly mentioned.

The Directorate of Economics and Statistics, Government of Kerala defines irrigation as "the process of letting in water for the benefit of crops grown, which involves some artificial or mechanical or manual effort for at least one wetting". This definition of irrigation has been adopted in the present study.

A crop which received watering at least once during its life time has been included under irrigated area.

The farms in the sample area were classified on the basis of irrigation source, with respect to crops grown, cropping intensity, use of inputs like manures, fertilizers, plant protection chemicals etc. Comparison was also made on the basis of output obtained.

Adequacy of the irrigation water available was ascertained from the respondent farmers as 'adequate'/ 'partially adequate'/'inadequate'. These responses were accordingly grouped and tables formed.

Percentage analysis was done for the above mentioned data.

Cost of cultivation and cost of irrigation

Cost of cultivation was worked out for each of the crops as per the standard concepts of cost A, cost B and cost C, the details of which are given elsewhere in the chapter. Operation wise cost of cultivation was also worked out and compared.

Details pertaining to investment on irrigation was calculated for different investments like well, pumpset, pipeline, pumphouse, spout pipe etc. and comparison done among the investments under different sources of irrigation on the basis of capital value net of depreciation.

Analysis of variance

Friedman two-way analysis of variance by ranks was the test used in this study, in order to compare the sample observations under the various categories of farms. For this test, the data has been cast into a two way table taking the observations under each of the categories in a column. The number of conditions that were compared, were taken in rows. Thus, for each analysis, there would be R columns and N rows. The test determines whether there is significant difference between the different columns (categories). The values under the different categories in a row are ranked, in ascending order. Sum of these ranks taken columnwise, formed the rank of

columns (Rj values). If there is no difference between the various observations under study, the rank totals (Rj's) would be uniform. In order to test wether the ranks differ significantly, the value of the test statistic χ_r^2 was found out using the following formula

$$\chi_r^2 = \frac{12}{NK(K+1)} \sum_{j=1}^{K} (Rj)^2 - 3N(K+1)$$

with degree of freedom K-1,

where N = No. of rows,

K = No. of columns

Rj = Sum of ranks in the j^{th} column

Irrigation water optimisation

The most important part of the methodology was to analyse whether the available water was being utilised properly and if not, how to optimise use of the available irrigation water input. Several researchers like Singh and Sirohi (1977), Kaushik and Gangwar (1980) Elumali (1982), Palanisami (1984), Singh and Jain (1985) etc. have used linear programming as a tool in their studies, to optimise the use of irrigation water. This technique was used in the present study also.

Linear programming involves the maximisation (or minimisation) of a linear function of variables subject to linear inequalities and the variables involved must assume non-negative values (Kahlon and Singh, 1980).

The following form of linear programming model was used in the study

Maximise $Z = C'X$

Subject to $AX \leq B$ and $X \geq 0$

$X = (x_1\ x_2 - - - x_p)'$ where
x_i is the area under crop i

$C' = (c_1\ c_2 - - - c_p)'$ where
c_i is the net income from unit area of the crop i

$B = (b_1\ b_2 - - - b_p)'$ where
b_i is the maximum input available for the i^{th} activity

$A = (aij)_{n \times p}$ where aij is the level of i^{th} input required for unit area under crop j

Net income has been considered over Cost B less rental value of land since it had the least amount of imputed values.

Monthly irrigation requirement of crop formed the input per unit activity and the total (monthly)available water was taken as the input availability. Both these have been arrived at, after a series of calculation involving actual climatological parametres pertaining to the reference crop year.

Apart from trying to optimise monthly available water, optimisation was also attempted for different levels of water availability (from the existing level) at -10% and +10%. This procedure resulted in evolution of appropriate

cropping patterns suitable to water stress as well as excess water situations.

Estimation of irrigation water requirement of crops

Since there was no way to physically measure the actual quantity of irrigation water utilised by the crops comming under the study, irrigation water requirement estimated climatologically, was used as a proxy for it.

Before going into the details of estimation, it would be of help to know some of the terms and definitions used in this regard.

1. $E.T_o$

The reference crop evapotranspiration (ET_o) is defined as the rate of evopotranspiration from an extensive surface of 8 to 15 cm tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water (Food and Agriculatural Organisation, U.N.).

2. Crop water requirement

Crop water requirement is defined as "the depth of water needed to meet the water loss through evopotranspiration (ET crop) of a disease free crop growing in large fields under non restricting soil conditions including soil, water and fertility and achieving full production potential under the given growing environment" (FAO).

ET crop can be obtained by multiplying ET_o with a factor called K_c (which varies from crop to crop, found out experimentally for each crop).

$$ET \text{ crop} = K_c \times ET_o$$

Irrigation water requirement

$$\text{Irrigation water requirement} = \text{Crop water requirement} - \text{Effective rainfall}$$

Effective rainfall

Effective rainfall is that part of the rainfall which is possible for the crop to be effectively utilised, for its maintainance and growth.

Effective rainfall has been computed for crops other than paddy, by following the method suggested by USDA Soil Conservation Service (1969). In the case of paddy, 75% of actual rainfall has been taken as effective rainfall (Sasidharan, 1982).

According to the FAO, the choice of method (for estimation of crop water requirement), must be based on the type of climatic data available and on the accuracy required in determining water needs.

There are four commonly used methods of estimation, the climatic data needs of which are as follows:

Method	Temperature	Humidity	Wind	Sunshine	Radiation	Evaporation	Environment
Blaney criddle	*	0	0	0			0
Radiation	*	0	0	*	(*)		0
Penman	*	*	*	*	(*)		0
Pan evaporation		0	0			*	*

* Measured data; 0 Estimated data (*) If available but not essential

Source: "Guidelines for predicting crop water requirements" FAO, Rome, 1984.

According to the FAO, method wise, the following is the descending order of accuracy.

1) Penman method
2) Pan evaporation
3) Radiation method
4) Blaney - Criddle method

Of the various methods, with the available data on pan evaporation and environment (obtained from Chittur Block Development Office, Nattukal, the observatory nearest to the study area), it was decided that pan evaporation method would be the best.

Data on daily pan evaporation and rainfall were obtained from the B.D.O.'s office. K_c values for the different crops, for the different growth periods were taken from the FAO guidlines and the dissertation submitted by Sashidharan (1982).

The following step wise procedure was adopted and the steps followed are made clear with the sample of Groundnut 2nd crop.

$\underline{ET_o}$

Reference crop evapotranspiration was obtained as follows:

$$ET_o = K_p \times E \text{ pan}$$

Where E_{pan} = Pan evaporation in mm/day and represents the mean daily value of the period considered

K_p = Pan co-efficient (FAO Guidelines, 1984)

Values of K_p were obtained from standard tables provided by FAO (see Appendix II) for different humidity and wind conditions and pan environment. Wind velocity and relative humidity data were collected from Integrated Seed Development Farm, Eruthempathy (see Appendix III).

The planting/sowing date for different crops were ascertained from the farmers.

Example of irrigation requirement calculation in case of Groundnut IInd crop

Sowing date - 11th September

Duration - 110 days

	Stage of crop	Length of stage	K_c value
1.	Initial stage*	25 days	0.5
2.	Crop development stage*	30 days	0.5 - 0.95
3.	Mid season stage*	30 days	0.95
4.	Late stage*	25 days	0.95 - 0.55

* FAO Guidelines/Sasidharan, 1982

Step 1

ET_o calculation

Month	Epan	K_p	ET_o ($E_{pan} \times K_p$)
September '86	7.44	0.65	4.83
October '86	5.70	0.75	4.28
November '86	5.23	0.75	3.92
December '86	5.48	0.60	3.29

Step 2

ET crop calculation Crop: G.N. IInd crop.
Sowing: 11th September

Month	No.of days	ET_o	K_c	ET crop mm/day	ET crop total for the month
September '86	20	4.83	0.5	2.42	48.4
October '86	31	4.28	0.7	2.996	92.9
November '86	30	3.92	0.95	3.724	111.7
December '86	29	3.29	0.8	3.29	76.3

Thus the monthly crop water requirement of the Groundnut IInd crop has been arrived at.

Irrigation water need = Crop water need + soil water need - effective rainfall

The rainfall data pertaining to the appropriate periods were summed up and the effective rainfall calculated using the chart given by USDA.

Further on, the step followed by Sasidharan (1982), which is a slight improvement over USDA's method has been adopted. It is quoted as follows:

"After calculating the effective rainfall, the net irrigation requirement for each month is worked out and for this, it is assumed that soil holds 100mm of available water within the root zone and 50% of this can be depleted by plants without suffering any detrimental effect. For the purpose of calculation, the soil moisture level is not permitted to go below 50% of the moisture available between field capacity and wilting point, that is, only 50 mm out of 100 mm available water in the root zone is used. In the case of crops planted during months having high rainfall, soil moisture usable in the root zone is at field capacity. In other cases, soil moisture usable in the root zone at the time of planting is taken as 25 mm i.e. soils holds 75% of the moisture available at field capacity.

Soil-moisture balance at the end of the month is also taken as 25 mm in all the months except during the critical months during which irrigation can be avoided by using a part or whole of the 25 mm water.

In the assessment of effective rainfall, a modification of the USDA method has been done in the months in which rainfall far exceeds the crop water needs. In such months, the effective rainfall is estimated for total water need (crop + soil). During other months, only crop water need is taken for estimating the effective rainfall".

Calculation of available water in the root zone of crops has been done for Valiyavallampathy (adjascent village to the study area, Kunnamkattupathy) soils, for which primary research data are available. The details are given in Appendix V. Since data for Kunnamkattupathy are not available, the data for Valiyavallampathy have been used as proxy.

Step 3

Calculation of irrigation requirement (Contd.)
(Groundnut IInd crop)

With the aforesaid background, irrigation water requirement for groundnut IInd crop was estimated as follows:

(All figures in mm)

Month	ET crop total	Soil water need	Total water need	Rain-fall	Effec-tive rain-fall	Ante-cedent soil mois-ture	Total avail-able mois-ture	Irrig-ation requi-rement
September	48.4	25.0	73.4	39.2	24.0	25.0	49.0	24.4
October	92.9	25.0	117.9	109.1	71.0	25.0	96.0	21.9
November	111.7	25.0	136.7	68.6	49.0	25.0	74.0	62.7
December	76.3	25.0	101.3	16.2	11.0	25.0	36.0	65.3
Total								174.3

Likewise, the irrigation water requirement has been computed for the various crops. For those crops for which K_c values are not readily available, the values of closely related crops have been used.

Exception in calculation of irrigation requirement for paddy

1) Paddy is a crop which requires standing water. Due to this reason, percolation losses are sure to occur, the quantum of loss being dependent on the type of soil. For the clay loam soils of the area, a mean percolation of 5 mm/day has been considered.

2) For transplated rice crop, a good amount of water is required for the initial land preparation of the paddy field. This puddling water requirement is taken as 150 mm for both the 1st and 2nd crop seasons.

Thus, in the calculation of irrigation requirement for paddy, both the above factors have been additionally considered, following the steps of Sasidharan.

The working sheet for calculation of irrigation requirement of various crops is given as Appendix VI.

The irrigation water requirement so arrived at, actually pertains to a crop grown under ideal conditions. In the present study, this irrigation water requirement is supposed to have been provided for the crop, the yield of which is maximum among the different source groups.

For example, following is the yields of groundnut under the different irrigation sources:

Crop	---	Groundnut 2nd crop			
Source of irrigation	---	Canal + well	Canal Well	SF well	Rainfed
Yield (Kg/acre)	---	1024.8	968.8	946.4	1013.6	526.8

The irrigation water requirement calculated above is presumed to have been utilised for raising one acre of groundnut under canal + well and spoutfed well farms, in the second crop season.

For estimation of irrigation water requirement of crops under the other irrigation source groups, a "scaling down" technique was used (with suitable modifications) following the steps of Palanisami (1984).

To quote the method adopted by him, "the water requirement of these crops (like paddy, groundnut etc., the water requirements of which have been fully met) by soil type and season were obtained from the Agricultural Research Station located in the Lower Bhavani Project Command area. These research station estimates were then adjusted downward according to the reduced yields which farmers achieved, relative to the maximum yields recorded in the Research station. It is thus assumed that fertilizer applications are also due only to water availability. Hence, the farmer who obtained maximum

yield had a water supply equal to the research station water requirements data; the water supply estimates for farmers with lower yields were scaled down proportionately . . . .". Example to illustrate this, quoted by Palanisami, is given in Appendix VII.

Vaidhyanathan (1987) pointing out the difficulty in estimating the precise magnitude of irrigation has also observed that "since there is a strong complementarity between water and the inputs, the differences in land productivity between irrigated and unirrigated farming can be legitimately taken as a measure of overall impact of irrigation".

A slight improvement has, however, been made from the technique used by Palanisami, in the present study. According to FAO, "When the full crop water requirements are not met, water deficits in the plant can develop to a point where crop growth and yield are affected and the manner in which water deficit affects crop growth and yield varies with the crop species and crop growth period. To evaluate the effect of plant water stress on yield decrease through the quantification of relative evapotranspiration (ET_a/ET_m), an analysis of research results shows that it is possible to determine relative yield losses if information is available on actural yield (Y_a) in relation to maximum yield (Y_m) under different water supply regimes .. . In order to quantify the effect of water stress, it is necessary to derive the relationship between relative yield decrease

and relative evaptranspiration deficit given by empirically derived yield response factor (K_y), or;

$$\left(1 - \frac{Y_a}{Y_m}\right) = K_y \left(1 - \frac{ET_a}{ET_m}\right)$$

where Y_a = actual harvested yield

Y_m = maximum harvested yield

K_y = yield response factor

ET_a = actual evapotranspiration

ET_m = maximum evapotranspiration

Ref: Yield response to water: FAO, Rome, 1979.

For the present study, the same formula is used as follows:

Y_a = actual yield (the reduced yield)

Y_m = maximum yield (the one for which, the calculated irrigation water requirement is persumed to hold good)

K_y = yield response factor (standard)

ET_a = irrigation water use corresponding to the reduced yield (to be estimated)

ET_m = calculated irrigation water use corresponding to the maximum yield

$$ET_a = \left\{ \frac{\left(1 - \frac{Y_a}{Y_m}\right)}{K_y} - 1 \right\} \times ET_m$$

The value of K_y for different crops has been taken from the tables provided by FAO (see Appendix VIII). Values of related crops K_y have been taken for those crops for which K_y values are not available.

Working it out for the 2nd crop groundnut, we have the following details:

Step 4

$$Y_a = \frac{968.8 + 946.4}{2} = 957.6$$ (average of lower yields of negligible difference)

$$Y_m = \frac{1024.8 + 1013.6}{2} = 1019.2$$ (average of Max.yields of negligible difference)

K_y = 0.7 (obtained from FAO tables, for groundnut crop)

ET_m = 174.3 mm (calculated by the PEP method)

$$ET_a = \left\{ \frac{1 - \frac{947.6}{1019.2}}{0.7} - 1 \right\} \times - 174.3$$

= 159.3 mm

This much water is persumed to have been used by the Groundnut 2nd crop in canal irrigated and well irrigated strata.

Thus, in a similar manner, the water supply estimates for irrigation source groups (irrigation strata) with lower crop yields, were scaled down and found out.

Water stress is assumed to be uniform throughout the crop's life and based on this assumption, the monthly irrigation water use of crops (with reduced yields) was also found out.

Step 5

Groundnut 2nd crop

Month	Monthly water requirement of the groups with Max.crop yield(mm)	Monthly water requirement of lower yield groups of crops (mm)
September '86	24.4	24.4 x 159.3/174.3 = 22.30
October '86	21.9	21.9 x 159.3/174.3 = 20.02
November '86	62.7	62.7 x 159.3/174.3 = 57.30
December '86	65.3	65.3 x 159.3/174.3 = 59.70
	174.3	159.30

In this way, the net monthly irrigation (estimated) requirement of all crops under all the categories of irrigations was worked out, which formed the input per unit activity, for the L.P. application.

With the information collected on the acreage of each crop under each source of irrigation, it was possible to estimate the total monthly requirements of the various crops under any particular source group.

$$TMR\ I_1 = a_1 mr_1 + a_2 mr_2 \ldots\ldots a_n mr_n$$

Where $TMR\ I_1$ = Total monthly irrigation (estimated) requirement of the various crops under irrigation source group I

$a_1, a_2 \ldots a_n$ = Acreage of various crops comming under the irrigation source group I

$mr_1, mr_2\ mr_n$ = The monthly (estimated) requirement of irrigation water for each of the crops

The total monthly irrigation (estimated) requirements was worked out for the different months of the reference crop year 1986-'87 and these formed "input availabilities" for the L.P. Model.

The net acreage under annual crops formed the land constraint, for the L.P. model.

Labour requirement, working capital etc. were not considered constraints for selection of crops, by the farmers. Hence these have not been included in the programming.

Alternative crops like banana, sesamum, mulberry etc., which are grown in the sample village, but have not come in the semple, have also been considered in the linear programming model.

In the case of mulberry, the economic life of the plant extends over 15 to 20 years. The mulberry plant as such doesn't yield any income unless the leaf from the crop is utilised for the production of coccoons from mulberry silk worm. The equipments needed for rearing the silk worms have a life span of about four years. Thus, the net returns or cost for any particular year cannot be considered as pertaining to that year alone. In the first year and the years which require replacement of permanent investments (for example the 5th, 9th and 13th year needs replacement of rearing equipments), the cost will be more than the other years.

This problem was overcome by following the method adopted by Jayachandran (1985) as indicated below:

The cost and net margins of mulberry were discounted to the 0th year (i.e. the start of the enterprise activity) by the net present worth (NPW) method and the NPW was amortized for the number of years of life of the investment using the interest rate as same for the calculation of NPW

Net present worth of returns,

$$NPWR = \sum_{i=1}^{n} \frac{R_i}{(1+r)^i}$$

Net present worth of costs

$$NPWC = \sum_{i=1}^{n} \frac{C_i}{(1+r)^i}$$

Where n = Economic life period (taken as 16 years for mulberry)

C_i = Gross cost for the i^{th} year

R_i = Gross returns for the i^{th} year

r = Discount rate - taken as 15%

(The minimum rate of return prescribed by NABARD for agricultural project investments)

Both the cost and returns were then amortized for the number of years of life (16 years in this case) using the formula

$$\text{Amortized returns} = \frac{NPWR \times r\ (1+r)^n}{(1+r)^n - 1}$$

$$\text{Amortized cost} = \frac{NPWC \times r\ (1+r)^n}{(1+r)^n - 1}$$

Where r and n are the same as mentioned earlier.

The cost and returns calculated for the alternative crops (included in L.P.) has been worked out and are given in Appendix IX.

Water requirement of mulberry was calculated based on the recommendations of the Central Silk Board and for the other crops, the pan evapouration method was used.

The different crop combinations tried in the programming are given in Appendix X.

Other concepts and definitions

Cropping intensity

Cropping intensity is the ratio of gross cropped area to net cropped area expressed as a percentage:

$$\text{Cropping intensity} = \frac{\text{Gross cropped area}}{\text{Net cropped area}} \times 100$$

Cost of cultivation

Cost of cultivation refers to the total expenses involved in cultivating unit area of a crop.

In the present study, the standard cost concepts used in Farm Management Studies have been adopted, with suitable modifications.

There was no case of "leasing-in" of land in the sample farms and hence the terms cost A was used to denote the following items:

a) Cost A

1) Value of hired human labour
2) Value of owned and hired bullock labour
3) Tractor/tiller charges
4) Value of seeds (farm produced and purchased)
5) Value of manures (owned and purchased)
6) Value of fertilizers
7) Value of plant protection chemicals
8) Irrigation (fuel) charges
9) Canal water charges
10) Land revenue, taxes etc.
11) Owned and hired machinery charges
12) Depreciation and maintainance on farm buildings, machinery and equipments
13) Depreciation and maintainance on irrigation structures, machinery and equipments
14) Interest on working capital

b) Cost B includes Cost A plus

15) Imputed rental value of owned land
16) Imputed interest on fixed capital of irrigation structure and equipments
17) Imputed interest on fixed capital of others

c) Cost C includes Cost B plus

18) Imputed value of family labour

Note: Depreciation and maintainance as well as imputed interest on fixed capital has been accounted separately for irrigation investments and investments on other items, in order to quantify the "irrigation related expenses".

Values of owned bullock labour was imputed on the basis of the prevailing market rate for a pair of hired bullocks.

Farm produced seeds and farm owned manure were also valued at the prevailing village prices.

Owned and hired machinery charges mainly accounted for the charge paid for the use of hired sprayers and other equipments and the expenses involved in use of owned machinery.

Land revenue, taxes, depreciation, interest charges etc.

Land revenue, taxes, depreciation and maintainance charges on farm buildings, machinery and equipments and imputed interest on fixed capital of others, have been apportioned to the various crops based on the area cultivated under each crop.

Straight line method of depreciation has been adopted over life period of the various investments.

Irrigation related expenses

Irrigation (fuel) charges include the fuel/electricity expenses incurred in operating the pumpsets. Maintenance and repair costs of the pumpsets alone have been included under this head.

Canal water charges refers to the payments made to the revenue department, for the use of canal water.

Straight line method has been adopted in calculating depreciation, over the life period of the investments. Maintenance refers to the cost of maintainance, repairs etc., incurred on the capital items like well, pipeline, pumpshed etc.

Interest on the capital value net of depreciation of irrigation structures and equipments was calculated taking the long term lending rate of banks. In the present study, an uniform rate of 10% has been considered.

The fermers were not able to give a correct idea of the quantity of water supplied to the various crops. Given the fact that different crops require irrigation water in different amounts, it would not be justifiable if the irrigation related expenses are apportioned without giving due consideration to the irrigation requirement of the crops.

The irrigation (estimated) requirement of various crops, estimated through pan evapouration method was used for this purpose. The irrigation expenses except canal water charges, were apportioned between the various crops giving due weightage to their irrigation requirement. The canal water charges were apportioned based on the ayacut area occupied by the various crops.

Interest on working capital

Interest on working capital was calculated at the rate of 11.5% for small farmers and 12.5% for large farmers i.e. the actual rate at which bank finance is being provided. The same criterion was followed in the present study also.

Family labour charges

The actual duration of work put in by the family members has been assessed and valued at market rates for hired labour for similar activities.

Harvesting charges

In case of crops like paddy, harvesting charges are made as payments in kind. The value of such payments in kind has been imputed at prevailing market prices and accounted as harvesting charges. The physical quantity of the payments in kind has been added with the yield (which, the farmers respond as net of harvesting charges, made in kind).

Rental value of land

Leasing in/out of land was not a practice in the study area. Therefore, land rent could not be considered. However, a nominal rent of 1/10th of the value of gross produce (both main product and bye-product) is included under rental value of land.

Operation wise cost of cultivation

Operation wise cost of cultivation gives a picture of cost of cultivation of crops at different stages, for various operations. This has been worked out for all the crops.

Income

Gross farm income includes value of main product as well as bye product, both consumed as well as disposed of by the farmer, calculated at farm gate prices prevailing during the reference crop year 1986-'87.

Net farm incomes were calculated over (a) cost C and (b) over (cost B - rental value of land). However, the latter has alone been used in the linear programming application.

Net margin over cost C gives an idea of the profits if the farming is considered as a "business", i.e. returns to management. Net margin over (cost B - rental value of land) gives an idea of the actual returns that the farmer obtains from the farm, i.e., returns to labour and management excluding the rental value of land.

Results and Discussion

RESULTS AND DISCUSSION

4.1 General background of sample farms

A very brief account of the general background of the sample farms is given in this section.

4.1.1 Area owned

As already mentioned, sample farms with minimum two acres area were alone selected. No further groupings have been done for the individual strata. Table 4.1.1 shows the land holding pattern of the selected sample.

The total area under all the categories put together came to 543.4 acres, with an average area of 6.04 acres per farm. The average area under spout fed well group was the highest, at 8.18 acres, and the lowest was that of the canal fed group, at 3.59 acres. Average area under canal + well, well fed and rainfed farm categories were 5.78, 7.20 and 5.91 acres respectively.

Leasing out and leasing in of land was totally absent. Hence, there was no distinction between area owned and area operated.

4.1.2 Family size

The overall average size of family was 5.87 and the majority of families, i.e. 64.44% had a family size of 4 to 6. Almost all the categories had maximum family size group of 4 to 6.

While canal fed farm category had the smallest average family size of 5.2 members, canal + well fed group had the biggest average family size at 6.6 members, as can be seen from Table 4.1.2.

4.1.3 Educational status

No family in the sample had illiterate members. Most of the families (45.66%) had members of highest educational status in the group of "upto SSLC". There were one each of farm families in the various strata with education upto P.D.C. level and there was one graduate each in the canal + well fed and well fed farm groups. Details can be seen from Table 4.1.3. On the whole, educational status could be said to be moderate.

4.1.4 Soil type

Distribution of sample based on soil type indicated that 53.3% of the farms had black loam soil and 46.7% had red loam soil. Table 4.1.4 indicates this sort of a balance between the two soil types in all the categories of farms.

Fragmentation of holdings was in general absent. Due to this reason, the soil type in any particular farm was almost exclusive, without much of mixture.

Table 4.1.1 Total and average size of land holdings of sample farms

Category	CWF N=15	CFF N=20	WFF N=20	SWF N=15	RFF N=20	Total N=90
Total area (acres)	86.75	71.82	143.93	122.65	118.25	543.4
Average area (acres)	5.78	5.39	7.20	8.18	5.91	6.04

CWF - Canal + well irrigated farms

CFF - Canal irrigated farms

WFF - Well irrigated farms

SWF - Spout fed well irrigated farms

RFF - Rainfed farms

Table 4.1.2 Distribution of sample farms based on farm family size

Size of family	Category					
	CWF N=15	CFF N=20	WFF N=20	SWF N=15	RFF N=20	Total N=90
1 - 3	-	2 (10.0)	-	4 (26.7)	1 (5.0)	7 (7.8)
4 - 6	9 (60.0)	14 (70.0)	14 (70.0)	6 (40.0)	15 (75.0)	58 (64.4)
7 - 9	3 (20.0)	3 (15.0)	3 (15.0)	3 (20.0)	3 (15.0)	15 (16.7)
Above 9	3 (20.0)	1 (5.0)	3 (15.0)	2 (13.3)	1 (0.50)	10 (11.1)
Average size of family	6.60	5.20	5.85	6.27	5.70	5.87

Figures in parantheses are percentages to total

Table 4.1.3 Distribution of sample farms based on the highest educational status of farm family members

Educational status	Category					
	CWF N=15	CFF N=20	WFF N=20	SWF N=15	RFF N=20	Total N=90
Upto 4th Std.	1 (6.7)	1 (5.0)	2 (10.0)	2 (13.3)	4 (20.0)	10 (11.1)
Upto 7th Std.	4 (26.6)	9 (45.0)	7 (35.0)	4 (26.7)	8 (40.0)	32 (35.6)
Upto SSLC	8 (53.3)	9 (45.0)	9 (45.0)	8 (53.3)	7 (35.0)	41 (45.6)
P.D.C.	1 (6.7)	1 (5.0)	1 (5.0)	1 (6.7)	1 (5.0)	5 (5.5)
Graduates	1 (6.7)	-	1 (5.0)	-	-	2 (2.2)
Post-graduates	-	-	-	-	-	-
Illiterates	-	-	-	-	-	-

Figures in parentheses indicate percentages to total

Table 4.1.4 Distribution of sample farms based on soil type

Soil type	Category					
	CWF N=15	CFF N=20	WFF N=20	SWF N=15	RFF N=20	Total N=90
Black loam	8 (53.3)	11 (55.0)	10 (50.0)	8 (53.3)	11 (55.0)	48 (53.3)
Red loam	7 (46.7)	9 (45.0)	10 (50.0)	7 (46.7)	9 (45.0)	42 (46.7)

Figures in parentheses are percentages to total

4.2 Irrigation Vs. cropping pattern, input use etc.

The sample farms deriving benefits from canal (both directly and indirectly) mostly came under the head and middle reaches of the Chitturpuzha canal irrigation system. Farms under the rainfed category were out of the purview of the irrigation canal ayacut in the same village.

4.2.1 Cropping pattern

Table 4.2.1 gives the status of the various crops in the cropping pattern of the different strata. In general, it was seen that there is a predominance of paddy (40.56%) in the irrigated farm groups, whereas groundnut was the leading crop in the rainfed category. The exception to this general rule in irrigated farms was well fed (WFF) category, in which the dominant crop was groundnut (46.16%) Among the irrigated farm groups, canal fed category had the maximum percentage area under paddy and spout-fed well category had the minimum area (percentage wise) under it. Only 11.01% of the cropped area was under paddy in the rainfed farms.

If sugarcane is also taken into consideration, the overall area allotted to high water using crops came to 45.71% in the irrigated farms.

Oil seed crops also constitute a major group having a share of 34.8% aree in the irrigated farms. However, it may be more appropriate to say as groundnut crop rather

than 'oil seed crops' since only this oilseed was seen cultivated by the irrigated farms. In the case of rainfed category, apart from groundnut, sesamum was also seen cultivated though to a lesser extent of 4.25 acres (i.e. 2.18%).

The overall share of sorghum and minor millets in the irrigated farms came to 12.74% while in the rainfed farms, the share was 32.9%. Similarly, in case of pulses, it was 3.95% and 13.95% respectively. This clearly indicated the predominance of low water requiring crops in the rainfed farms compared to irrigated farms.

Coconut was seen cultivated in the spout fed well irrigated farms (9.73%) and well fed farms (5.71%), to some extent. For canal + well fed category, the proportion was 3.03% of the cropped area. In the case of canal fed farms, a very negligible 0.37% of area, mainly the bunds of paddy and other fields have been planted with coconut.

Tapioca, cotton and vegetables were also cultivated to small extent.

Among the irrigated farms, though not very distinct, a slight similarity was seen in the cropping patterns of canal fed and canal with well fed farms in one side and, well fed and spout fed well irrigated farms on the other side. Perinneal crop coconut and annual crop sugarcane, both of which require water round the year, were seen cultivated more in the latter group.

4.2.2 Season-wise cropped area

If the season wise cropped area details given in Table 4.2.2 are examined, it can be seen that cent percent of the farms in irrigated categories and 70% farms in the rainfed category cultivate paddy in the first crop season. Groundnut was seen cultivated by 57.14% of the irrigated farms in the first crop while it was 95% in the case of rainfed group.

In the second crop season, paddy and groundnut were cultivated by 45.71% and 80% respectively of the sample farms in the irrigated farm group. In the rainfed farms there was no case of cultivation of paddy in second crop while 30% of the farms cultivated groundnut.

Taken area wise, in the irrigated farms, first crop paddy lead the race by occupying 26.99% of gross cropped area under annuals followed by 20.72% in the case of second crop groundnut. The next in this line was first crop of groundnut. Thus it is clear that taken overall, the irrigated farms followed the general pattern of first crop paddy and second crop groundnut. Apart from this, the trend observed in irrigated farms was to move towards more water requiring crops like paddy sugarcane etc.

In the case of rainfed farms, groundnut occupied 30.57% of gross cropped area in the first crop while the share of first crop paddy was only 11.68%. Pulses and millets taken together, occupied 20.65% of gross cropped area in first crop season. In the second crop season, pulses and millets

Table 4.2.1 Cropping pattern - Irrigation strata wise

(Area in acres)

Sl. No.	Crops	Gross cropped area					
		CWF N=5	CFF N=20	WFF N=20	SWF N=15	Overall@ n=70	RFF N=20
1.	Paddy	63.30 (44.53)	95.70 (69.88)	53.75 (22.48)	78.50 (39.28)	291.25 (40.56)	21.50 (11.01)
2.	Groundnut	47.30 (33.27)	31.75 (23.18)	110.35 (46.16)	60.50 (30.28)	249.90 (34.80)	69.75 (35.71)
3.	Sorghum	2.50 (1.76)	4.25 (3.10)	18.00 (7.53)	14.50 (7.26)	39.25 (5.48)	32.00 (16.39)
4.	Sugarcane	10.50 (7.39)	0.00 -	14.50 (6.06)	12.00 (6.00)	37.00 (5.15)	0.00 -
5.	Pulses	4.00 (2.81)	3.75 (2.74)	13.00 (5.44)	7.60 (3.80)	28.35 (3.95)	27.25 (13.95)
6.	Minor millets	3.50 (2.46)	0.00 -	7.80 (3.26)	4.50 (2.25)	15.80 (2.20)	32.25 (16.51)
7.	Cotton	3.00 (2.11)	1.00 (0.73)	7.00 (2.93)	0.00 -	11.00 (1.53)	7.00 (3.58)
8.	Tapioca	3.75 (2.64)	0.00 -	0.00 -	2.00 (1.00)	5.75 (0.80)	0.00 -
9.	Vegetables	0.00 -	0.00 -	1.00 (0.42)	0.80 (0.40)	1.80 (0.25)	0.00 -
10.	Sesamum	0.00 -	0.00 -	0.00 -	0.00 -	0.00 -	4.25 (2.18)
11.	Coconut	4.30 (3.03)	0.50 (0.37)	13.65 (5.71)	19.45 (9.73)	37.90 (5.28)	1.30 (0.67)
	Total	142.15 (100.00)	136.95 (100.00)	239.05 (100.00)	199.85 (100.00)	718.00 (100.00)	195.30 (100.00)

1. @ Overall indicates summation of irrigated strata

2. Figures in parentheses are percentages to total area

Table 4.2.2 Distribution of gross cropped area based on season

(Area in acres)

Sl. No.	Season wise cropped area	Category					
		CWF N=15	CFF N=20	WFF N=20	SWF N=15	Overall@ N=70	RFF N=20
1.	Paddy 1st crop	41.05 (15)	56.85 (20)	45.75 (20)	63.00 (15)	206.65 (70)	21.50 (14)
2.	Paddy 2nd crop	22.25 (8)	38.85 (14)	8.00 (3)	15.50 (7)	84.60 (32)	0.00 -
3.	Groundnut 1st crop	17.50 (10)	8.25 (5)	49.05 (17)	13.00 (8)	87.80 (40)	56.25 (19)
4.	Groundnut 2nd crop	26.30 (11)	23.50 (11)	61.30 (20)	47.50 (14)	158.60 (56)	13.50 (6)
5.	Groundnut 3rd crop	3.50 (2)	-	-	-	3.50 (2)	-
6.	Sugarcane (New planting)	6.50 (4)	-	14.50 (7)	4.00 (3)	25.00 (14)	-
7.	Sugarcane (Ratoon)	4.00 (2)	-	-	8.00 (4)	12.00 (6)	-
8.	Tapioca	3.75 (2)	-	-	2.00 (1)	5.75 (3)	-
9.	Sorghum 1st crop	1.50 (1)	0.50 (1)	3.00 (2)	4.50 (3)	9.50 (7)	14.75 (11)
10.	Sorghum 2nd crop	1.00 (1)	3.75 (3)	15.00 (6)	10.00 (5)	29.75 (15)	17.25 (9)
11.	Cotton 2nd crop	3.00 (2)	1.00 (1)	7.00 (4)	-	11.00 (7)	7.00 (6)
12.	Ragi 1st crop	1.00 (1)	-	1.30 (2)	1.50 (2)	3.80 (5)	-
13.	Ragi 2nd crop	0.50 (1)	-	-	-	0.50 (1)	4.50 (3)
14.	Chama (little millet) 1st crop	-	-	3.50 (3)	-	3.50 (3)	11.00 (5)
15.	Chama 2nd crop	2.00 (1)	-	3.00 (2)	3.00 (1)	8.00 (4)	16.15 (8)
16.	Black gram 1st crop	1.50 (1)	1.00 (1)	2.50 (2)	4.00 (2)	9.00 (6)	4.00 (3)
17.	Black gram 2nd crop	0.50 (1)	0.75 (1)	3.00 (3)	2.30 (2)	6.55 (7)	2.50 (3)
18.	Horsegram 1st crop	-	-	-	-	-	7.75 (5)
19.	Horsegram 2nd crop	2.00 (1)	-	5.00 (2)	1.00 (1)	8.00 (4)	9.50 (8)
20.	Cowpea 1st crop	-	2.00 (2)	2.00 (2)	0.30 (1)	4.30 (5)	0.50 (1)
21.	Cowpea 2nd crop	-	-	0.50 (1)	-	0.50 (1)	3.00 (2)
22.	Sesamum 2nd crop	-	-	-	-	-	4.25 (3)
23.	Tomato 2nd crop	-	-	1.0 (1)	0.80 (2)	1.80 (3)	-
	Gross cropped area(annuals)	137.85 (64)	136.45 (59)	225.40 (97)	180.40 (71)	680.10 (291)	184.00 (106)
24.	Coconut	4.30 (11)	0.50 (2)	13.65 (13)	19.45 (9)	37.90 (35)	1.30 (2)
25.	Gross cropped area (annuals + perennials)	142.15	136.95	239.05	199.85	718.00	185.30
26.	Average gross cropped area (annuals)	9.19	6.82	11.27	12.03	9.72	9.20
27.	Average gross cropped area (annuals + perinnials)	9.48	6.85	11.95	13.32	10.26	9.27

1. @ Overall indicates the summation of irrigated strata

2. Figures in parentheses indicate number of farms cultivating the respective crops.

were the major group of crops (29.07%) followed by groundnut (7.34%). The general trend in the rainfed farms was, therefore, to move away from paddy and centre around crops like groundnut, millets and pulses, which had comparatively low water requirement.

4.2.3 Cropping intensity

Cropping intensity for the irrigated categories taken together was 177.2% compared to 158.31% for rainfed farms. Among the irrigated farms, canal fed farm group had maximum cropping intensity at 198.19% and the spout fed well category had the lowest at 166.9%. This low figure was partly because of the fact that the index for intensity of cropping considers both seasonal and perinneal crops at par, while spout fed well irrigated farms had the maximum of perinneals. Canal + well fed group and well fed group of farms had cropping intensities of 175.28% and 176.75% respectively. Data from Table 4.2.3 reveals to some extent the contribution of irrigation in increasing the intensity of cropping.

4.2.4 Irrigation water adequacy

Result of the response of farmers to the question of adequacy or not of irrigation water is given in Table 4.2.4.

Taken overall, majority of the farmers responded that the water that is made available is adequate for their cultivation practices. While 54.3% responded so, 42.8% of farmers indicated that water is only partially adequate and for 2.9%, water was inadequate.

In between the various categories, the spout fed well farmers were the most satisfied, giving a response of adequate for 86.7%. Only 20% of the well fed farm owners said that water was adequate and 75% of them indicated that water available to them was only partially adequate.

In the case of canal fed farms, no farmer felt water to be inadequate. Sixty per cent of them were of the opinion that water was adequate and 40% said that water was only partially adequate.

Sixty per cent of canal + well fed farm owners felt that water was adequate, while 33.3% felt that water was only partially adequate and one farmer in the group (6.7%) felt that water was inadequate.

From the responses, it can be concluded that majority of farmers deriving benefit from canal water (directly or indirectly) felt that their water requirement is met adequately while majority of the farmers in the well fed category feel that their water requirement is met only partially.

Table 4.2.3 Cropping intensity of sample farms (area in acres)

Cropped area	Category					
	CWF	CFF	WFF	SWF	Overall@	RFF
1. Gross cropped area	142.15	136.95	239.05	199.85	718.00	185.30
2. Net cropped area	81.10	79.10	135.25	119.75	405.20	117.05
3. Cropping intensity	175.28	198.19	176.75	166.90	177.20	158.31

@ Overall indicates summation of irrigated strata

Table 4.2.4 Distribution of sample farms based on responses to question on adequacy of irrigation water

Adequacy	Responses of various categories				
	CWF N=15	CFF N=20	WFF N=20	SWF N=15	Overall@ N=70
Adequate	9 (60.0)	12 (60.0)	4 (20.0)	13 (86.7)	38 (54.3)
Partially aadequate	5 (33.3)	8 (40.0)	15 (75.0)	2 (13.3)	30 (42.8)
Inadequate	1 (6.7)	-	1 (5.0)	-	2 (2.9)

Figures in parentheses are percentages to total

4.2.5 Input use

Various research studies have pointed out substantial rise in use of inputs consequent to assured irrigation. An attempt is made here also, to examine the use of various inputs and compare the sample farms under various categories of irrigation in this respect.

Except in the case of paddy, for all other crops, the variety of crop sown was almost same for the various strata. In the case of paddy, rainfed farms sowed 'Modan' (local) varieties which do not require transplantation. However, those farms adopted such a practice since irrigation was not available. Therefore, watever differences in input use was there, can genuinely be taken as differences due to impact of irrigation. These differences have been quantified and estimated in the cost of cultivation of the appropriate crops.

While studying the use of inputs, attempt has been made to compare the use of physical quantities of input. Wherever it was felt to be difficult to do so, the value of the input used, has been made use of. Friendman's two way analysis of variance has been used to make comparison of the sample farms under various irrigated categories.

4.2.5(a) Use of seed

Table 4.2.5(a) gives comparison of the various sample farms based on value of seed input used. In majority of the crops, the value of seed input was higher for irrigated farms than the rainfed farms. Except in the case of paddy, there was no varietal difference between the seeds used in rainfed and irrigated farms. Among the irrigated farm categories, even though canal fed and well fed groups' seed use based on value of the input seems to be slightly more, there isn't much of statistical difference between the groups, with regard to this. The calculated value of X_r^2 (5.55) is lower than the table value of X_r^2 at both 5% and 10% levels of significance.

Use of physical quantity of seeds by the various groups for different crops, is being compared subsequently in this chapter.

4.2.5(b) Use of plant protection chemicals

Plant protection chemicals were used only for a few crops like paddy, groundnut, cotton, sugarcane and tomato.

Of these, only those crops, which were being cultivated commonly by almost all the categories were taken, for sake of comparison.

Table 4.2.5(b) gives a comparative picture of the sample farm groups' use of P.P. Chemicals, based on its value. There was no significant difference between the irrigated categories, as can be inferred by the X_r^2 value of 2.1. For all the crops shown, the use of P.P.Chemicals was seen to be lower for the rainfed category than the irrigated categories.

4.2.5(c) Use of manures and fertilizers

Table 4.2.5(c) gives a comparison of sample farms based on use of physical quantities of manures and fertilizers. It can be seen that rainfed farms used definitely lower amounts of the various fertilizers and manure when compared to the average under irrigated farms. There was no significant difference in use of this input, among the various irrigated categories.

Crop wise use of manures and fertilizers is being compared subsequently

4.2.5(d) Use of tractor, tiller/bullock labour

Bullock labour was used mainly for preparatory cultivation. Tractor and tillers were used increasingly to do this tillage work. Other than paddy, but for the sorghum

1st crop, the irrigated farms were found to use more of this input, than the rainfed farms. Figures in Table 4.2.5(d) gives us an idea that among the irrigated farms, there is no indication that any particular category used more of this input, as evidenced by the X_r^2, value of 3.15.

4.2.5(e) Use of hired human labour

Table 4.2.5(e) gives a comparison of sample farms based on use of hired human labour. Use of this input by the rainfed farms was definitely lower than that of the irrigated categories, taken together. Calculated value of X_r^2 was 9.45, indicating that there is considerable difference between the various irrigated categories with regard to use of hired human labour. Well fed farms used least amount of hired human labour and spout fed well farms used the highest amount of it.

4.2.5(f) Use of family labour

Use of family labour for some of the crops in different irrigation categories has been given as a Table 4.2.5(f). From the table, it is clear that rainfed farms, except in the case of blackgram 1st crop, used more of family labour than the irrigated farms. Since the calculated value of X_r^2 is 7.95, which is significant at 5% level, it can be inferred that there is considerable difference among the irrigated categories themselves with regard to use of this

input. The canal with well farms used more of this input and the well fed farms used least of it.

When the proportion of family labour charges to total cost of cultivation was analysed (please see Table 4.2.5(g)), it was seen that in almost all crops in which comparison was made, this proportion was very much higher for the rainfed farms than the irrigated ones. This indicates that the rainfed farms used family labour intensively.

4.2.5(g) Capacity of pumps used

It is worth noting that 100% of the irrigated sample farms except of course, the canal fed farms, used pumpsets for lifting water. It is also worth mentioning that only one farmer used an additional diesel pumpset along with electric pumpset and all the rest of pumpsets used were electrically operated.

Table 4.2.5(h) examines the capacity of pumpset used. It can be seen that majority of the farmers used 5 hp pumpsets (68.3%) and 7.5 hp pumpsets were used by 23.53% of farmers. 5.88% of farmers used 10 hp pumpsets. Higher horsepower pumpsets were used more by the farms of spout fed well irrigated and well irrigated categories. This is in line with the average area of farms (see Table 4.1). The canal with well fed farms had a lesser average area and similarly, they were seen to use more of the medium type 5 hp pumpsets (i.e. 86.7% of the total).

4.2.5(h) Short term credit

Fifty farms in the irrigated category and nine farms in the rainfed category had availed of short term credit facilities. Comparison of sample farms based on use of short term credit, given in Table 4.2.5(i) indicates that the irrigated categories used more of this input both on per farm basis as well as on per acre basis. Average amount of loan availed of per farm was the highest for spout fed well irrigated category and the lowest for canal fed farm category. This average amount is in symmetry with the average size of farms under different categories, given in Table 4.1. The higher the farm size, the more was the amount of loan availed per farm and vice versa.

Comparisons based on average credit per acre of gross cropped area indicated that canal with well irrigated farms availed of the highest loan per acre of Rs. 623. This was followed by spout fed well irrigated farms and canal fed farms at Rs. 607 and Rs.556 respectively. The well fed farms had availed of least amount of loan per acre at only Rs. 503.

While making these discussions, it has to be remembered that 20 farms out of 70 under the irrigated categories (28.57%) and eleven out of 20 (55%) under the rainfed category did not avail of any short term credit.

Table 4.2.5(a) Comparison of sample farms based on use of seeds

Crop	Value of seed input used (Rs. per acre)					
	CWF	CFF	WFF	SWF	Overall@	RFF
Paddy 1st crop	135.2 (6.26)	161.6 (5.43)	149.1 (6.70)	133.9 (11.60)	145.1 (5.71)	100.2 (6.81)
Paddy 2nd crop	134.1 (9.19)	163.2 (11.24)	166.9 (8.92)	151.6 (9.92)	153.8 (9.23)	-
Groundnut 1st crop	427.5 (24.02)	539.4 (28.78)	338.4 (24.41)	439.0 (7.36)	389.9 (18.54)	404.1 (15.42)
Groundnut 2nd crop	464.2 (27.86)	407.5 (14.41)	487.9 (22.16)	389.1 (27.10)	442.5 (20.73)	391.5 (19.47)
Sorghum 1st crop	21.0 (0.0)	24.0 (0.0)	24.6 (5.00)	22.4 (3.72)	23.0 (2.30)	20.2 (1.31)
Sorghum 2nd crop	20.1 (0.0)	19.2 (2.76)	18.9 (1.48)	18.4 (2.35)	18.8 (1.53)	22.9 (1.48)
Black gram 1st crop	64.0 (0.0)	56.0 (0.0)	40.0 (2.50)	48.6 (3.00)	49.6 (2.65)	30.0 (1.44)
Black gram 2nd crop	32.0 (0.0)	53.3 (0.0)	53.7 (4.36)	45.2 (5.40)	49.0 (3.99)	24.0 (2.41)
R_j values	18	25	23	14	-	-

X_r^2 value = 5.55 Table value of X_r^2 : 5% level of significance - 7.82
10% level of significance - 6.25

@ Overall indicates average of rainfed categories

Figures in parentheses indicate standard error

Table 4.2.5(b) Comparison of sample farms based on use of plant protection chemicals

Crop	Value of seed input used (Rs. per acre)					
	CWF	CFF	WFF	SWF	Overall@	RFF
Paddy 1st crop	47.20 (2.78)	46.40 (2.24)	39.50 (2.28)	43.20 (2.79)	44.07 (2.69)	23.00 (1.49)
Paddy 2nd crop	76.60 (3.66)	82.10 (4.09)	61.80 (5.98)	81.00 (6.57)	78.53 (6.41)	-
Groundnut 1st crop	16.00 (1.53)	0.00 -	25.00 (1.92)	29.40 (3.51)	21.51 (3.72)	11.10 (0.86)
Groundnut 2nd crop	26.40 (2.13)	11.50 (1.04)	26.90 (1.32)	31.60 (1.75)	25.94 (1.34)	9.40 (0.49)
R_j values	10	9	8	13	-	-

@ Overall indicates average of irrigated categories

Figures in parentheses indicate standard errors

X_r^2 value was found to be not significant

Table 4.2.5(c) Comparison of sample farms based on use of manures and fertilizers

(Figures in Kg/acre)

Sl. No.	Crop	Input*	Manure/fertilizer used					
			CWF	CFF	WFF	SWF	Overall@	RFF
1.	Paddy 1st crop	O.M.	3435.00	1920.00	3201.00	3699.00	3048.00	3600.00
		N	48.00	37.72	33.37	42.02	40.11	16.00
		P	11.90	13.45	9.60	11.43	11.67	6.80
		K	27.31	34.70	26.15	36.03	31.74	6.80
2.	Paddy 2nd crop	N	44.12	43.37	33.06	52.47	44.26	-
		P	11.32	16.29	10.63	11.71	13.61	-
		K	31.65	34.39	31.63	42.94	34.98	-
3.	Groundnut 1st crop	O.M.	2724.00	2073.00	2697.00	3576.00	2774.00	2562.00
		N	6.31	7.73	5.89	5.12	6.03	2.13
		P	7.60	7.73	8.54	5.58	7.84	2.13
		K	7.91	7.73	8.75	3.27	7.68	2.13
		Gy	117.14	151.50	146.80	119.23	137.25	44.10
4.	Groundnut 2nd crop	O.M.	399.00	0.00	0.00	0.00	66.20	0.00
		N	7.06	8.52	8.19	8.72	8.21	1.42
		P	8.26	8.52	9.38	10.32	9.35	1.42
		K	7.37	8.52	8.58	8.38	8.31	1.42
		Gy	135.00	151.10	154.20	133.70	144.42	64.20
5.	Sorghum 1st & 2nd crops	O.M.	1200.60	563.80	800.00	621.00	733.80	719.10
		N	4.32	3.97	3.62	7.93	5.29	2.90
		P	1.72	0.00	0.48	2.97	1.42	0.00
		K	1.72	0.00	0.48	2.97	1.42	0.43
6.	Black gram 1st & 2nd crops	O.M.	1200.00	1713.00	1227.00	951.00	1166.40	453.00
		N	2.84	4.86	0.00	4.05	2.55	0.71
		P	2.84	4.86	1.82	5.48	3.78	0.71
		K	2.84	4.86	0.00	4.05	2.55	0.71
	R_j values		61	66	52	71		

@ Overall indicates average of irrigated farms
X_r^2 value was found to be not significant

* Abbreviations used in input column

O.M. - Organic manure
N. - Nitrogen
P. - Phosphorus
K. - Potassium
Gy. - Gypsum

Table 4.2.5(d) Comparison of sample farms based on use of tractor, tiller/bullock labour

Crop	Bullock labour/tractor, tiller charges (Rs. per acre)					
	CWF	CFF	WFF	SWF	Overall@	RFF
Paddy 1st crop	246.9 (8.18)	281.4 (7.87)	191.8 (7.09)	244.4 (8.51)	243.4 (8.14)	187.0 (6.13)
Paddy 2nd crop	239.7 (10.96)	207.4 (10.26)	200.0 (6.03)	219.3 (7.41)	217.4 (5.38)	-
Groundnut 1st crop	202.8 (8.84)	204.8 (8.00)	189.6 (6.70)	215.4 (7.14)	197.7 (6.59)	153.4 (4.36)
Groundnut 2nd crop	203.4 (8.53)	208.9 (9.90)	216.8 (7.69)	214.8 (8.66)	212.8 (5.86)	175.0 (5.42)
Sorghum 1st crop	100.0 (0.00)	120.0 (0.00)	133.3 (5.50)	122.2 (6.89)	122.1 (3.26)	184.8 (2.39)
Sorghum 2nd crop	100.0 (0.00)	76.4 (5.95)	90.0 (6.15)	110.0 (4.00)	95.3 (3.34)	82.1 (4.51)
Blackgram 1st crop	100.0 (0.00)	100.0 (0.00)	100.0 (0.00)	112.5 (4.50)	105.6 (4.16)	90.0 (3.21)
Blackgram 2nd crop	192.0 (0.00)	200.0 (0.00)	100.0 (0.00)	152.2 (8.33)	136.8 (15.32)	90.0 (2.89)
R_j values	19	20	16	25		

@ Overall indicates average of irrigated farms

Figures in parentheses indicate standard error

X_r^2 value was found to be no significant

Table 4.2.5(e) Comparison of sample farms based on use of hired human labour

Crop	Hired human labour charges (Rs. per acre)					
	CWF	CFF	WFF	SWF	Overall@	RFF
Paddy 1st crop	933.1 (36.08)	1023.9 (55.99)	850.0 (41.82)	1076.9 (26.89)	983.5	360.0
Paddy 2nd crop	877.8 (28.42)	1009.9 (60.91)	758.9 (40.64)	355.8 (33.80)	831.6	-
Groundnut 1st crop	405.4 (11.08)	366.2 (28.48)	347.7 (12.59)	457.4 (26.54)	377.2	270.0
Groundnut 2nd crop	468.1 (33.07)	465.2 (27.55)	426.0 (20.61)	463.1 (29.50)	449.9	187.0
Sorghum 1st crop	76.7 (0.00)	30.0 (0.00)	76.0 (6.00)	188.9 (42.79)	127.2 (27.51)	40.3
Sorghum 2nd crop	130.0 (0.00)	10.7 (7.35)	55.9 (4.15)	206.0 (24.02)	103.1 (21.63)	20.8
Black gram 1st crop	136.7 (0.00)	70.0 (0.00)	51.2 (32.00)	140.2 (12.25)	107.1 (20.47)	24.0
Black gram 2nd crop	150.0 (0.00)	266.7 (0.00)	85.0 (52.02)	170.3 (12.50)	140.7 (27.87)	26.2
R_j values	23	20	11	26		

@ Overall indicates average of irrigated farms

Figures in parentheses indicate standard error

X_r^2 value = 9.45 - Significant at 5% level

Table 4.2.5(@) Comparison of sample farms based on use of family labour

Crop	Inputed value of family labour (Rs. per acre)					
	CHF	CFF	WFF	SWF	Overall@	RFF
Paddy 1st crop	190.0	128.5	140.8	129.5	142.7	173.4
Paddy 2nd crop	188.7	115.1	132.0	169.7	149.7	-
Groundnut 1st crop	101.8	91.3	40.4	106.8	70.6	85.2
Groundnut 2nd crop	99.5	81.7	55.5	73.2	72.0	128.6
Sorghum 1st crop	103.3	60.0	29.3	10.0	33.5	74.2
Sorghum 2nd crop	44.0	54.4	29.6	42.0	37.4	49.6
Blackgram 1st crop	93.3	95.0	32.0	118.8	87.8	74.0
Blackgram 2nd crop	110.0	0.0	26.7	54.3	30.7	78.2
R_j values	27	18	13	22	-	-

@ Overall indicates average of irrigated farms

X_r^2 value = 7.95 - Significant at 5% level

Table 4.2.5(g) Proportion of family labour charges to total cost of cultivation

Crop	Imputed value of family labour as proportion to total cost of cultivation (%)	
	Irrigated farms	Rainfed farms
Paddy 1st crop	4.93	12.16
Groundnut 1st crop	4.42	6.55
Groundnut 2nd crop	3.72	11.14
Sorghum 1st crop	5.58	14.14
Sorghum 2nd crop	5.65	17.13
Cotton 2nd crop	6.81	11.88
Little millet 2nd crop	4.98	15.78
Blackgram 1st crop	12.08	20.72
Blackgram 2nd crop	5.87	22.65

Table 4.2.5(h) Comparison of sample farms based on capacity of pumps used

HP of pumpset	Distribution among categories			
	CWF N=15	WFF N=20	SWF N=15	Overall N=50
3	-	-	1 (6.25)	1 (1.96)
5	13 (86.70)	14 (70.00)	8 (50.00)	35 (68.63)
7.5	2 (13.30)	5 (25.00)	5 (31.25)	12 (23.53)
10	-	1 (5.00)	2 (12.50)	3 (5.88)
Total	15	20	16*	51

Figures in parentheses are percentages to total

* There were two pumpsets in a particular farm

Table 4.2.5(i) Comparison of sample farms based on short term credit availed

Sl. No.	Item	Category					
		CWF	CFF	WFF	SWF	Overall@	RFF
1.	Total quantum of credit availed	88500	51100	113000	114000	366600	34500
2.	Number of beneficiaries	15	13	18	14	50	9
3.	Average amount availed per farm	5900	3931	6278	8143	7332	3833
4.	Gross cropped area (acres)*	142.15	91.95	224.80	187.85	646.75	103.53
5.	Average credit per acre of GCA*	623	556	503	607	567	333

@ Overall indicates average of irrigated farms

* Gross cropped area of S.T. credit beneficiary farms

4.3 Production and productivity

In the earlier section we have tried to see whether there was any significant difference in the input use, taking each one of it into consideration. We know that output is a biological activity and is the result of an interaction of a variety of inputs and other factors including environment. However, seeds, manures and fertilizers constitute the basic and most important of all inputs. In this section, an attempt is first made to compare the outputs of various crops and then, compare the output of each crop with the use of the basic inputs, under different categories.

4.3.1 Output obtained

Table 4.3.1 gives a comparison of sample farms based on productivity of the principal crops that are cultivated commonly in all the categories. It can be seen that the overall average of all irrigated farm was higher than the output under rainfed farms, for each of the the crop compared. Analysis of variance of the different categories of irrigation indicate that there is significant difference in the output obtained in sample farms. In general, output was seen to be high for the spout fed well irrigated farms and low for the well fed farms. Difference in source of irrigation would have affected the use of inputs, resulting in differences in the output produced.

4.3.1(a) Paddy 1st crop

Table 4.3.1(a) gives a comparison of sample farms based on use of seeds, manures and fertilizers.

It can be seen that all the categories of irrigation have used more than the recommended quantity of seeds. Rainfed farms are however, seen to use marginally lower quantity of seeds than recommended. Among the irrigated categories spout fed well irrigated farms were seen to use the lowest quantity of seeds (48.9 kg/acre) while canal fed farms were using the highest (55.2 kg/acre). In the case of organic manure, almost all farms, including the rainfed category, were seen to use higher quantities than the recommended level. Canal fed farms are however, an exemption to this.

Both Nitrogen and Potash were seen to be used in excess of the recommended dosages by most of the irrigated farms. Nitrogen is being used as per the recommended dose and Potash is being used marginally less (than the recommended dose) by the rainfed farms. The least amount of use of both N & K was exhibited by the well fed farms, among the irrigated farm groups. While canal with well farms used maximum of Nitrogen, the spout well fed farms used maximum of Potash.

Phosphate was seen to be used by all the categories of farms, including the rainfed farms, in lower quantity

than the recommended dose. Here also, among the irrigated categories, the well fed farms used least amount of this input and the canal fed farms used maximum of it (9.6 Kg/ acre and 13.45 Kg/acre respectively).

Output-wise, spout fed well farms had the highest of paddy yield, at 1914 Kg per acre. While the output was 1764 Kg per acre for both canal with well fed farms and canal fed farms, it was least for the well fed farms, with only 1350 Kg/acre. This is seen some what in line with use of fertilizer input under different categories. In the case of well fed farms, fertilizer use was the lowest and the yield was also the lowest among the irrigated farms. However, statistically there seems to be not much of difference between the various categories with regard to use of inputs.

4.3.1(b) Paddy 2nd crop

Second crop of paddy was seen cultivated only by the irrigated farms. As in the case of paddy 1st crop, most of the various categories of farms were seen to use higher quantities of seeds, N and K, than the recommended standard dose per acre (Table 4.3.1(b)). While organic manure was not at all used, Phosphate use was very much lower than the recommended dose.

If the input use for the first crop and second crop of paddy are examined, it can be seen that all the inputs

except, of course organic manure, are being used higher for the second crop than the first.

Analysis of variance of use of inputs indicate that X_r^2 value is 6.9, which is significant at 10% level. It gives an idea that the use of inputs was not uniform, and that differences exist in the inputs used under the various categories. R_j values indicate that input use was maximum in the case of spout fed well irrigated farms and input use was minimum under well fed farms. The effect of this was seen clearly in the output under the respective categories. It was the highest (among the irrigated farms) for spout fed well farms at 1380 Kgs per acre and the lowest for well fed farms at 900 Kgs per acre.

Eventhough the R_j value is seen to be more for canal fed farms than the canal with well fed ones, the yield is seen to be less for the former than the latter. Water availability would have been a factor here since paddy is a crop which requires copious irrigation. Existence of well in the canal with well farms would have played a role in supplementing the availability of water for the crop.

A surprising factor that was noticed is that, even though the use of seeds, manures and fertilizer inputs was higher for the second crop of paddy, the yield of the first crop of paddy was significantly higher than that of the second crop. Water availability would have played a role in this regard. As is known well, there is very chance

of shortage of water in the second crop season, when compared to first crop.

4.3.1(c) Groundnut 1st crop

Table 4.3.1(c) gives an idea of the use of major inputs for the first crop of groundnut. Seeds, manure and nitrogen was seen to be used in excess than the recommended doses in the irrigated farms. But P, K and Gypsum were used less than the standard recommended dosages. In case of rainfed farms also, seeds and organic manure were used in excess while, N, P, K and Gypsum were used deficiently.

Comparison of sample irrigated farms does not indicate any significant difference in the use of inputs, as seen from the low X_r^2 value of 2.6. Even though the R_j values are high for canal fed and well fed farms in comparison with rest of the two categories, their yield of groundnut was lower at 795.2 Kg per acre and 789.6 Kg per acre respectively, compared to 985.6 Kg per acre for spout fed well irrigated farms and 927.9 Kg per acre for canal with well irrigated farms. In general, there doesn't seem to be any direct relation between the use of inputs and output of crops.

4.3.1(d) Groundnut 2nd crop

Comparison of input use of sample crops for groundnut 2nd crop given in Table 4.3.1(d) doesn't indicate any significant difference ($X_r^2 = 3.4$) between the various categories with respect to use of inputs. As in the first

crop, seed and nitrogen were seen to be used in excess of recommended doses. Generally, organic manure was not used in the second crop. Gypsum, P and K were used in lower quantities than the recommended levels. Rainfed farms were seen to use all inputs shown, except for seeds, in lower quantities than the recommended doses.

Among the irrigated categories, the well fed farms were seen to use maximum of seeds, gypsum and potash. However, the yield was minimum for this category, at 946.40 Kg per acre, among the irrigated farm groups. Canal with well fed farms, having an R_j value of 11, which is least of all the other groups, had the highest output among irrigated farms, with 1024.80 Kg per acre. As in the groundnut 1st crop, here also, there doesn't seem to be any direct relation between input used and output obtained. Water availability would have been the major factor governing the output for groundnut 2nd crop.

4.3.1(e) Cotton 2nd crop

Cotton was cultivated in the sample farms, in the second crop season. Input use for this crop is given in Table 4.3.1(e). While nitrogen was used marginally in excess of the recommended dose, potassic fertilizers were used almost double the recommended dose, in irrigated farms. Seeds, organic manure and phosphatic fertilizers were used less than the doses recommended. Rainfed farms used all the given inputs in lower amounts.

There is a significant difference seen with respect to use of inputs, among the various irrigated categories. Canal with well fed farms used the highest amounts of all inputs. The yield under this category was the highest, at 563.3 Kg per acre. Even though the R_j value of well fed farm group was only 6 (compared to 9.5 for canal fed farms) which indicates low amount of use of inputs, the yield of cotton for this category was higher than that of canal fed farm group. This might have been due to the fact that water availability was flexible (in usage of timeliness) in the case of well fed farms than the canal fed farms. In any case, this result cannot be taken conclusively since there is only one time data.

4.3.1(f) Sugarcane (new planting)

Sugarcane being an annual crop, was seen cultivated in farm groups having an assured source of irrigation almost around the year. Canal water was available only for 9 to 10 months in the year (except peak summer months) and hence farmers did not cultivate sugarcane under this category.

Table 4.3.1(f) gives an idea of input use of the various sample groups cultivating sugarcane. All the inputs except nitrogen was seen to be used in excess than the recommended levels. Nitrogen was seen used lesser by 3 Kgs than the recommended dosage of 90 Kg per acre.

Among the various categories, spout fed well irrigated farms were seen to use maximum of organic manure and nitrogen

while phosphatic and potassic fertilizers were used maximum by the canal with well fed farms. Even though this was the case, the output of the well fed farms was higher (32.5 tons per acre) than that of the canal with well fed farms (31.07 tons per acre). Output was highest for the spout fed well irrigated farms at 36.5 tons per acre. There doesn't seem to exist any direct relationship between output obtained and the manure and fertilizer inputs used.

4.3.1(g) Sugarcane (Ratoon) crop

Farmers in general prefered to take ratoon crop of sugarcane since the costly operation of preparatory cultivation can be avoided to a large extent. In the study period, only the canal with well irrigated farms and the spout fed well irrigated farms were seen to cultivate sugarcane as a ratoon crop.

Table 4.3.1(g) gives an idea of input used for the sugarcane ratoon crop. It can be seen that the input use was significantly higher than the recommended doses and also higher than some of the inputs used for newly planted crop (Table 4.2.6) It was seen that there existed a paradox with respect to output obtained and input used, for the two different irrigation categories. While the use of N, P and K was significantly on the higher side by the spout fed well irrigated farms, the output was lower than that of the canal with well fed farms (23.9 tons per acre and 27.5 tons per acre respectively). This is most glaring when we consider

the fact that in both the cases crops in the sample farms belong to the first ratoon (of the two to three ratoons that are usually taken).

4.3.2 Value of output

Comparison of sample farms based on value of output derived is given in Table 4.3.2. The values were higher for the irrigated farms when compared to the rainfed farms.

Analysis of sample farms indicate that there is significant difference between the groups with respect to value of output obtained. The X_r^2 value was found to be 11.55 which was highly significant at 5% level of significance. It can be inferred that the value of output obtained was low for the well fed farm category and was generally higher for the spout well fed category of farms.

Weighted average of value of output per acre of gross cropped area was Rs.2,934.9 for irrigated farms whereas it was only Rs.879.6 for rainfed farms. Among the irrigated categories, this value was the highest for the canal with well irrigated farms (Rs.3,377.20) and the lowest for the well fed farms (Rs.2,422.30).

From the foregoing analysis of production and productivity of crops, the following results have come to light.

1. Use of fertilizer and seed inputs have been mostly irrational, in the sense that they were eigher being used

in excess or being used lower than the recommended dosages. Seeds were used in excess than the recommended quantities, in the case of paddy and groundnut. This applied true for the irrigated farms and the groundnut crop in rainfed farms.

Nitrogen was seen used in excess than recommended dosage in almost all crops. At the same time, phosphorous was used lower in crops except that a sugarcane. Potash was used in excess in all crops except groundnut. Agronomically speaking excess of Potash leads to luxury consumption and excess of nitrogen will be lost by leaching. Therefore, both these are undesirable from the economic point of view.

2. Rainfed farms used low amount of all inputs in general. This indicated the marginal nature of dry land farms. Low use of inputs also got reflected in the low amount of ouput that was obtained.

3. In general, higher output that was obtained in spout fed well irrigated farms and canal + well irrigated farms, and lower output in well fed farms was seen to be in line with the use of inputs in these categories.

Table 4.3.1 Comparison of sample farms based on productivity of the principal crops

(Figures in Kg/acre)

Sl. No.	Crop	Product*	Output obtained					
			CWF	CFF	WFF	SWF	Overall@	RFF
1.	Paddy 1st crop	M.P.	1764.0 (60.21)	1764.0 (60.21)	1350.0 (48.62)	1914.0 (56.56)	1718.1 (45.92)	601.8 (31.49)
2.	Groundnut 1st crop	M.P.	927.9 (26.24)	795.2 (41.42)	789.6 (25.21)	985.6 (23.46)	846.7 (23.32)	631.7 (26.87)
3.	Groundnut 2nd crop	M.P.	1024.8 (20.51)	968.8 (24.96)	946.4 (25.89)	1013.6 (28.42)	982.9 (10.14)	526.8 (15.43)
4.	Sorghum 1st crop	M.P.	80.0 (0.00)	Negli-gible	83.3 (12.10)	159.2 (14.84)	114.3 (18.95)	26.7 (2.98)
	- do -	B.P.	600.0 (0.00)	750.0 (0.00)	651.0 (25.00)	600.0 (24.84)	624.0 (24.23)	501.0 (16.44)
5.	Sorghum 2nd crop	M.P.	180.0 (0.00)	130.0 (15.98)	160.0 (11.32)	210.0 (22.30)	173.7 (12.92)	44.3 (6.89)
	- do -	B.P.	600.0 (0.00)	519.0 (18.03)	465.0 (18.08)	480.0 (20.81)	481.4 (36.24)	423.0 (21.65)
6.	Blackgram 1st & 2nd crop	M.P.	187.5 (25.00)	200.0 (0.00)	126.4 (9.67)	172.2 (15.43)	161.1 (15.31)	87.7 (10.43)
	R_j values		23	19.5	13	24.5		

1. * M.P. denotes main product and B.P. denotes bye product
2. @ Overall indicates average of irrigated farms

In case of sorghum, both the grain as well as straw was felt to be of equal importance and it was difficult to differentiate as to which was the main product and which was the bye product. However, since conventionaly the grain part is taken as the main product, the same nomenclature has been adopted here also. For the purpose of analysis, both have been considered on par.

3. Figures in parentheses indicate standard error

X_r^2 value = 8.1 - Significant at 5% level

Table 4.3.1(a) Quantities of major inputs used in sample farms for paddy 1st crop

(Figures in Kg/acre)

Items	Recommended input dose (Kg/acre)	Category					
		CWF	CFF	WFF	SWF	Overall	RFF
Seed	36 (36)*	51.20	55.20	54.60	48.90	52.38	33.40
Organic manure	2000 (2000)*	3435.00	1920.00	3201.00	3699.00	3048.00	3600.00
Nitrogen (N)	36 (16)*	48.0	37.72	33.37	42.02	40.11	16.00
Phosphorous (P)	18 (8)*	11.90	13.45	9.60	11.43	11.67	6.80
Potassium (K)	18 (8)*	27.31	34.70	26.15	36.03	31.74	6.80
R_j values	-	14	14	8	14	-	-
Output (Kg/acre)@	-	1764.0	1764.0	1350.0	1914.0	1718.1	601.8

* Figures in parentheses are recommended doses for rainfed cultivation

@ Main product considered as output

X_r^2 value = 3.24 - Insignificant

Table 4.3.1(b) Quantities of major inputs used in sample farms for paddy 2nd crop

(Figures in Kg/acre)

Items	Recommended input dose (Kg/acre)	Category					
		CWF	CFF	WFF	SWF	Overall@	RFF
Seed	36.0	51.15	52.41	56.25	56.80	53.25	-
N	36.0	44.12	43.37	33.06	52.47	44.26	-
P	18.0	11.32	16.29	10.63	11.71	13.61	-
K	18.0	31.65	34.39	31.63	42.94	34.98	-
Organic manure	2000.0	0.00	0.00	0.00	0.00	0.00	-
R_j values	-	8	11	6	15	-	-
Output*	-	1326.00	1230.0	900.0	1380.0	1251.50	-

* Main product alone considered in output

@ Overall indicates average of irrigated strata

X_r^2 value = 6.9 - Significant at 10% level

Table 4.3.1(c) Quantities of major inputs used in sample farms for groundnut 1st crop

(Figures in Kg/acre)

Items	Recommended input dose (Kg/acre)	Category					
		CWF	CFF	WFF	SWF	Overall@	RFF
Seed	40.00	54.46	64.24	55.72	57.15	56.48	47.30
Organic manure	800.00	2724.00	2073.00	2697.00	3576.00	2774.00	2562.00
N	4.00	6.31	7.73	5.89	5.12	6.03	2.13
P	30.00	7.60	7.73	8.54	5.58	7.84	2.13
K	30.00	7.91	7.73	8.75	3.27	7.68	2.13
Gypsum	200.00	117.14	151.50	146.80	119.23	137.25	44.10
R_j values	-	13	18	17	12		
Output	-	927.90	795.20	789.60	985.6	846.7	631.70

@ Overall indicates average of irrigated strata

* Main product alone considered in output

X_r^2 value = 2.6 - Insignificant

Table 4.3.1(d) Quantities of major inputs used in sample farms for groundnut 2nd crop

(Figures in Kg/acre)

Items	Recommended input dose (Kg/acre)	Category					
		CWF	CFF	WFF	SWF	Overall@	RFF
Seeds	40.00	54.56	55.10	55.80	52.40	54.47	52.20
Organic manure	800.00	399.00	0.00	0.00	0.00	66.20	0.00
N	4.00	7.06	8.52	8.19	8.72	8.21	1.42
P	30.00	8.26	8.52	9.38	10.32	9.35	1.42
K	30.00	7.37	8.52	8.58	8.38	8.31	1.42
Gypsum	200.00	135.00	151.10	154.20	133.70	144.40	64.20
R_j values	-	11	16	19	14	-	-
Output*	-	1024.80	968.80	946.40	1013.60	982.90	526.80

@ Overall indicates average of irrigated farms

* Main product alone considered in output

X_r^2 value = 3.4 - Insignificant

Table 4.3.1(e) Quantities of major inputs used in sample farms for cotton 2nd crop

(Figures in Kg/acre)

Items	Recommended input dose (Kg/acre)	Category					
		CWF	CFF	WFF	SWF	Overall@	RFF
Seeds	4.80	3.25	3.00	2.60	-	2.81	2.50
Organic manure	8000.00	6810.00	4500.00	3930.00	-	4767.30	4350.00
N	28.00	43.00	31.50	24.70	-	30.31	15.75
P	14.00	8.50	8.50	7.30	-	7.74	4.25
K	14.00	36.50	18.50	23.30	-	26.46	4.25
R_j values	-	13.50	9.50	6.00	-	-	-
Output	-	563.30	325.00	407.10	-	442.20	287.10

@ Overall indicates average of irrigated farms cultivating the crop

X_r^2 value = 7.3 - Significant at 5% level

Table 4.3.1(f) Quantities of major inputs used in sample farms for sugarcane(new planting)

(Figures in Kg/acre)

Items	Recommended input dose (Kg/acre)	Category					
		CWF	CFF	WFF	SWF	Overall@	RFF
Organic manure	4000.00	6240.00	-	5688.00	7500.00	6121.40	-
N	90.00	63.00	-	88.21	121.60	87.00	-
P	30.00	54.40	-	39.79	40.60	42.72	-
K	30.00	63.50	-	36.62	38.10	43.85	-
R_j values	-	9	-	5	10	-	-
Outpur (tons/acre)	-	31.07	-	32.50	36.50	32.77	-

@ Overall indicates average of irrigated farms cultivating the crop

X_r^2 value = 3.5 - Insignificant

Table 4.3.1(g) Quantities of major inputs used in sample farms for sugarcane(Ratoon crop)

(Figures in Kg/acre)

Items	Recommended input doze (Kg/acre)	Category					
		CWF	CFF	WFF	SWF	Overall@	RFF
Organic manure	4000.0	0.0	-	-	0.0	0.0	-
N	90.0	109.5	-	-	126.5	120.8	-
P	30.0	30.6	-	-	51.5	44.6	-
K	30.0	70.0	-	-	106.5	94.3	-
Output (Tons/acre)	-	27.5	-	-	23.9	25.1	-

@ Overall indicates average of irrigated farms cultivating the crop

Table 4.3.2 Comparison of sample farms based on value of output derived

(Amount in Rs/acre)

Crop	Categorywise value of output$ derived					
	CWF	CFF	WFF	SWF	Overall@	RFF
Paddy I*	3980.9	3967.1	3125.1	4216.3	3859.4	1425.8
Paddy II*	2969.8	3042.4	2231.3	2990.7	2937.1	-
Groundnut I*	1916.0	1801.2	1736.1	2019.2	1820.0	1223.8
Groundnut II*	2363.2	2253.8	2195.9	2358.1	2280.8	1237.0
Groundnut III	2457.1	-	-	-	2457.1	-
Sugarcane (N.P.)	8241.5	-	8417.9	9709.0	8578.6	-
Sugarcane (Rat.)	7725.0	-	-	7232.5	7396.7	-
Tapioca	5540.0	-	-	5115.0	5392.2	-
Sorghum I*	433.3	450.0	497.0	586.7	527.0	320.5
Sorghum II*	642.5	522.7	521.4	667.3	574.7	354.5
Cotton II	3366.7	2250.0	2935.7	-	2990.9	814.6
Ragi I	683.0	-	669.2	743.3	702.1	-
Ragi II	860.0	-	-	-	860.0	387.8
Chama (little millet) I	-	-	722.8	-	722.8	377.6
Chama II	685.0	-	540.0	670.0	625.0	377.8
Blackgram I*	680.0	650.0	406.0	609.5	569.2	278.0
Blackgram II*	507.0	680.0	452.3	517.4	505.4	305.0
Horsegram I	-	-	-	-	-	280.0
Horsegram II	625.0	-	540.0	600.0	568.8	312.5
Cowpea I	-	660.0	405.0	-	532.5	300.0
Cowpea II	-	-	656.0	-	656.0	350.0
Sesamum II	-	-	-	-	-	146.7
Tomato II	-	-	2250.0	2875.0	2527.8	-
R_j values*	22	21	10	27	-	-
Weighted average of output per acre of gross cropped area	3377.2	3066.8	2422.3	3193.6	2934.9	879.6

* These crops alone considered for analysis

@ Overall indicates average of irrigated farms

$ By output is meant the main product and bye product taken together

X_r^2 value =11.55 (Significant) Table value: 5% level - 7.82

10% level - 6.25

4.4.1 Investment on irrigation

Amounts spent on one or more items that help derive the benefit of irrigation for the sample farms has been taken as investment made on irrigation. This includes investment on irrigation structures like well, pump shed, and spout pipe or machinery and equipments like pumpset and pipeline. But before going into the investment as such, it would be of help if we get an idea of the life of investments already put in by them. Table 4.41(a) gives the average present life of irrigation infrastructures. It can be seen that well and pipeline were the oldest in the case of spout fed well category. Pumpshed and pumpset were the oldest in the canal with well fed farm category. In general, the well fed farms had the newest structures.

Investments in canal fed farms were of the nature of land development in the form of terracing, levelling etc., to make irrigation water available to the fields, at the time when the irrigation canal system was laid down. The value of investments made at that time have already been amortized and hence it is not taken into account now.

Table 4.4.1(b) gives an idea of the on farm investments on irrigation. Capital value net of depreciation for irrigation structures, machinery and equipments was highest for spout fed well irrigated farms (Rs. 1,18,600) and lowest for canal with well irrigated farms (Rs.50,600).

Average of capital value net of depreciation per acre of water, per acre of net sown area and per acre of gross irrigated area was the highest for spout fed well irrigated farms and lowest for canal with well fed farms. This high figure in the spout fed well irrigated farms is due to the presence of more number of higher HP pumpsets and the longer distribution system that is needed in such farms.

4.4.2 Farm investments other than irrigation investments

Details of investment on farm buildings, machinery and implements have been summed up and are given in Table 4.4.2. The capital value of investment net of depreciation per acre of net sown area for irrigated farms (Rs. 329.90 per acre) was almost three times that of the rainfed farms.

Within the irrigated farms, investment per acre of net sown area was highest for canal fed farms (Rs. 437.00) and lowest for well fed farms (Rs. 218.40). This might be due to the fact that the canal fed farms had relatively more investible resources to invest on farm buildings, machinery implements etc., as compared to the other categories, since they did not need any on-farm investments for irrigation.

4.5.1 Cost of irrigation

Cost of irrigation per acre, in sample farms is given in Table 4.5.1(a). All expenses other than human labour related to irrigation have been taken into account. Cost per

acre cm of water for the irrigated farms was Rs. 12.73. Among the various categories, canal fed farms had the lowest cost per acre cm (only Rs. 0.30), while well fed farms had the highest cost at Rs. 14.41 per acre cm.

Of the overall average cost of irrigation for sample farms of Rs. 12.73 per acre cm, the most important item was fuel/electricity charges (Rs. 5.63 per acre cm) and the least important was canal water charges (Rs. 0.34 per acre cm), otherwise called water cess.

Table 4.5.1(b) shows the irrigation related expenses of some crops. This includes labour expenses on irrigation also. Even though there is no significant difference between the various categories (other than the canal fed farm category), the R_j values indicate that spout fed well irrigated farms had the highest irrigation related expenses and canal with well irrigated farms had the lowest expenses per acre.

Among the various crops, the expenses for irrigation was highest for sugarcane, followed by second crop of paddy. Black gram 2nd crop had the lowest expense per acre.

4.5.2 Percentage cost of irrigation

Table 4.5.2 gives a comparison of sample farms based on percentage cost of irrigation. The comparative analysis indicate that there is significant difference between the various categories (canal fed farms excluded) with regard to

percentage cost of irrigation. While irrigation related expenses as percentage to total cost of cultivation was highest for the well fed farm category, it was lowest for canal with well irrigated farms.

The cost of irrigation as percentage to total cost of cultivation was negligible for the canal fed farms since they did not need any on farm investment. Whatever amount that was expended was mainly for the labour charges that was paid to oversee the flow of water farm canal to the field.

Taken crop wise, millets and pulses and paddy 2nd crop had high percentage cost of irrigation when compared to paddy 1st crop, groundnut 2nd crop, or even sugarcane. In general, it can be said that irrigation related expenses formed almost 1/6th to 1/5th of the total cost of cultivation for majority of crops.

For crops other than those mentioned in Table 4.2.7 irrigation related expenses as percentage to total cost of cultivation is given in the table on respective crops' operation wise cost of cultivation (Table 4.7.1 to 4.7.20).

Table 4.4.1(a) Average present life of irrigation investments

Investment	Category wise life (in years			
	CWF	WFF	SWF	Overall
Well*	9.00 (1.76)	7.65 (1.22)	9.67 (1.73)	8.66 (1.57)
Pump shed*	7.73 (1.25)	6.70 (0.98)	6.73 (0.91)	7.02 (0.89)
Pump set*	8.60 (1.22)	6.75 (0.97)	6.87 (0.87)	7.34 (1.18)
Pipeline*	6.14 (1.19)	6.70 (1.16)	6.73 (0.91)	6.54 (0.63)
Spout pipe*	-	-	6.87 0.85	6.87 0.85

Figures in parentheses indicates standard error

* Life of investments (1) Well - 50 years
(2) Pupp shed - 9 years
(3) Pump set - 9 years
(4) Pipeline - 9 years
(5) Spout pipe - 25 years

(Based on views of experts in the field of Agricultural Engineering)

Table 4.4.1(b) On farm investment on irrigation in sample farms

(Amount in Rs.)

Sl. No.	Items	Category			
		CWF	WFF	SWF	Overall
1.	Capital value net of depreciation for irrigation structures, machinery and equipments	50600.00	91040.00	118600.00	260240.00
2.	Total irrigation water available (in acre cms)	4892.50	4925.30	6258.20	16076.00
3.	Capital value net of depreciation per acre cm of water	10.34	18.48	18.95	16.19
4.	Net sown area (in acres)	81.10	135.25	119.75	336.10
5.	Capital value net of depreciation per acre of net sown area	623.92	673.12	990.40	774.29
6.	Gross irrigated area (in acres)	116.35	164.05	157.10	437.50
7.	Capital value net of depreciation per acre of gross irrigated area	434.90	555.00	755.00	594.83

Table 4.4.2 Farm investments other than on irrigation, on sample farms

(Amount in Rs.)

Sl. No.	Depreciation	Category					
		CWF	CFF	WFF	SWF	Overall@	RFF
1.	Capital value net of depreciation for farm buildings, machinery and implements	28154.00	30199.00	29540.00	45801.50	133694.50	13771.00
2.	Net sown area (acres)	81.10	69.10	135.25	119.75	405.20	117.05
3.	Investment per acre of net sown area (1)/(2)	347.20	437.00	218.40	382.50	329.90	117.70

@ Overall indicates summation of irrigated farms

Table 4.5.1(a) Cost of irrigation per acre, in sample farms

(Amount in Rs.)

Sl. No.	Items of cost	Category				
		CWF	CFF	WFF	SWF	Overall
1.	Total amount of water available for irrigation (acre/cms)	4892.50	5357.26	4925.33	6258.21	21433.30
2.	Depreciation and maintenance on irrigation structures, machinery and equipments	19888.50	-	32398.00	30283.10	82569.60
2(a)	Cost per acre cm of items (2)	4.06	-	6.58	4.84	5.14
3.	Fuel/electricity charges and pumpset maintenance	26398.00	-	29456.00	34666.00	90520.00
3(a)	Cost per acre cm of item (3)	5.40	-	5.98	5.54	5.63
4.	Interest charges on fixed capital of irrigation investments	5060.00	-	9104.00	11860.00	26024.00
4(a)	Cost per acre cm of item (4)	1.03	-	1.85	1.90	1.62
5.	Canal water charges	1596.50	1590.05	-	2400.00	5586.55
5(a)	Cost per acre cm of item (5)	0.33	0.30	-	0.38	0.34
6.	Overall cost per acre cm of irrigation water	10.82	0.30	14.41	12.66	12.73

Table 4.5.1(b) Irrigation related expenses of some crops

(Amount in Rs.)

Sl. No.	Crop	Categorywise expenses/acre				
		CFF	CWF	WFF	SWF	Overall
1.	Paddy 1st crop	113.88	432.73	456.26	506.67	372.76
2.	Paddy 2nd crop	143.10	995.70	990.76	1158.10	633.46
3.	Groundnut 2nd crop	57.51	228.62	262.26	258.45	225.19
4.	Sugarcane (new planting)	-	928.95	1232.20	1233.10	1149.49
5.	Sorghum 2nd crop	18.14	198.86	241.36	292.93	224.09
6.	Blackgram 2nd crop	32.67	128.03	150.77	144.24	133.21
7.	Horsegram 2nd crop	-	174.60	153.90	146.28	158.13
8.	Chama 2nd crop	-	150.19	138.61	188.94	160.39
	R_j values *	-	12	16	20	

* Canal fed farms excluded from analysis

X_r^2 value = 4 (insignificant) Table value : 5% level - 5.00
10% level - 4.60

Table 4.5.2 Comparison of percentage cost of irrigation for selected crops

(Amount in Rs.)

Sl. No.	Crop	Irrigation related expenses as proportion to total cost of cultivation (%)				
		CFF	CWF	WFF	SWF	Overall
1.	Paddy 1st crop	4.18	13.73	16.48	15.39	12.46
2.	Paddy 2nd crop	5.50	29.56	33.32	37.66	21.65
3.	Groundnut 2nd crop	3.25	11.07	12.88	12.89	11.30
4.	Sugarcane (New planting)	-	11.67	14.65	13.78	13.72
5.	Sorghum 2nd crop	4.57	28.20	38.96	32.80	32.60
6.	Blackgram 2nd crop	3.59	15.10	26.69	17.66	18.65
7.	Horsegram 2nd crop	-	23.35	29.08	20.56	26.07
8.	Chama (little millet) 2nd crop	-	16.44	21.26	24.25	20.96
	R_j values*	-	9	21	18	

Canal fed farms excluded from analysis

X_r^2 value = 9.75 - Significant

4.6 Cost of cultivation and net margins

Cost of cultivation and net margins over cost C for important crops are given in Table 4.6.

4.6.1 Paddy

It can be seen from the table that the overall average of cost of cultivation for paddy was only slightly higher for the first crop than the second crop. But the net margins i.e. profit over cost (C) were higher for the former than the latter.

Category wise, cost of cultivation of paddy (both crops) was lowest for the canal fed farms. As already explained, it is mainly due to the low irrigation related expenses under this category. Cost was highest in spout fed well irrigated farms for the first crop and the canal with well irrigated farms for the second.

The net margins for both the first and second crops were highest for the canal fed farm category. It was seen that for all categories of farms other than the canal fed ones, the net margins for the second crop over cost C, was very low. However, if the rental value of land and family labour charges are not taken into account in the cost, the profit for paddy 2nd crop would be Rs. 86.30 per acre for canal with well irrigated farms, Rs.858.60 per acre for canal fed farms, Rs. 404.60 per acre for spout fed well irrigated farms and Rs. 387.10 per acre for well fed farms. One inference that can be drawn is that cultivation of paddy in the second crop season is much less remunerative than the crop in first crop season. In the rainfed farms only the first crop was being taken and the margin was Rs. 172.70 per acre.

4.6.2 Groundnut

As in the case of paddy, in general, only the first and second crop were seen cultivated by most of the categories. In the canal with well irrigated farms category, a third crop of groundnut was also seen taken by some farms.

The overall cost of cultivation for the irrigated crops was Rs. 1,717.60 for the first crop and Rs.1,992.10 for the second crop. Unlike paddy, the cost of cultivation of second crop was higher here, than the first crop. Net margin was also higher for the second crop than the first. The third crop's cost was the highest and so also, the profit per acre was also highest for this crop.

Category wise, the cost of cultivation was the highest for the spout fed well irrigated farms in the first crop season and the cost was the highest for the canal with well irrigated farms in the second crop season. Cost was the lowest for well fed farms during the first crop and the canal fed farms during second crop.

Net margin over cost C was negative (-Rs.49.80) for the canal fed farms in the first crop and at the same time, net margin was the highest for this group (Rs. 484.60) among the various categories, for the second crop.

For the rainfed farms, the cost was higher and net margin negative during the first crop season compared to a relatively lower cost and a positive net margin for the

second crop.

From the foregoing analysis, it is clear that even though the cost may be a bit more, the returns are more remunerative in the second crop season, for the groundnut crop.

4.6.3 Sugarcane

Sugarcane was cultivated both as new planted crop and ratoon crop. It requires round the year (except the rainy months) irrigation. Canal fed farms were not in a position to cultivate sugarcane since canal water will be available only for about nine to ten months.

The overall average cost of cultivation of newly planted sugarcane was Rs. 8,379.70 per acre compared to the cost of Rs. 5,309.60 per acre for the ratoon crop. Category wise, the cost of cultivation of sugarcane (new planting) was the highest for spout fed well irrigated farms (Rs. 8,948.50 per acre) and it was the lowest for canal with well irrigated farms (Rs. 7,959.20 per acre). In the case of ratoon crop also, the cost was higher for the spout fed well irrigated farms (Rs. 5,430.20) than the canal with well irrigated farms (Rs. 5,062.30).

If the net margin from sugarcane crop is examined, it can be seen that ratoon crop of sugarcane is more remunerative than the new planted crop. (Net margin of Rs. 2,089.10 per acre and Rs. 199.00 per acre respectively). Thus it can

be clearly concluded that taking a ratoon crop after a newly planted crop will be more paying than undertaking fresh planting every year.

4.6.4 Tapioca

The canal with well irrigated farms and spout fed well irrigated farms were the two categories which were found to cultivate tapioca. The overall cost of cultivation of this crop was Rs. 4,755.10 per acre. Cost of cultivation in canal with well irrigated farms was Rs. 5050.60, with a net margin of Rs. 489.40 per acre. The cost in spout fed well irrigated farms came to Rs. 4,291.00 per acre, with a net profit of Rs. 914.00 per acre.

4.6.5 Cotton

Cotton was cultivated in all the sample categories except the spout fed well irrigated farms. Cost of cultivation in irrigated farms, taken overall, came to Rs. 3,014.80 per acre, while that in rainfed farms came to Rs. 1,641.70 per acre. The profit (net margin) over cost C was negative for the former (Rs. 24.20) while it was Rs. 172.90 for the latter.

Among the irrigated categories, there was a wide variation in the cost of cultivation, ranging from Rs. 1,968.60 per acre for the canal fed farms to Rs.3,641.10 per acre for the canal with well irrigated farms. The net margins also varied from Rs. 281.40 per acre for the former to Rs. 274.40 per acre for the latter.

4.6.6 Other crops

Details of cost of cultivation and net margins of other crops can be seen from Table 4.6. It can be seen that for crops other than those mentioned earlier, net margins were mostly negative indicating lack of profitability over cost C.

The foregoing analysis of cost of cultivation under different categories indicates that there is significant difference between the various categories with respect to cost of cultivation of crops. If the R_j values are any indication, the cost of cultivation was lowest for the canal fed and well fed farm categories and was highest for rest of the two irrigated categories. While the cost in canal fed farms was less due to the low irrigation cost, that in well fed farms was less due to low level of use of almost all inputs. Cost of cultivation was naturally higher in irrigated farms compared to rainfed farms.

Net margins were generally high for paddy 1st crop, sugarcane, tapioca and groundnut 2nd and 3rd crops.

4.7 Operation-wise cost of cultivation

Operation-wise cost of cultivation gives a picture of cost of cultivation of crops at different stages, for various operations.

Tables 4.7.1 to 4.7.20 give an idea of the operation-wise cost of cultivation of various crops, that are being cultivated in the sample farms.

Since the cost of cultivation has already been discussed, it is felt that an elaborate repetition is unnecessary. The tables have been presented for reference, from the academic point of view.

Table 4.6 Comparison of cost of cultivation (Cost C) and net margins of crops

(Amount in Rs/acre)

Crop	Cost of cultivation and net margins per acre					
	CWF	CFF	WFF	SWF	Overall	RFF
Paddy I*	3151.5 (+829.4)	2722.7 (+1244.4)	2669.2 (+355.9)	3292.0 (+924.3)	2991.3 (+867.7)	1426.5 (+172.7)
Paddy II*	3369.1 (-399.3)	2603.1 (+439.3)	2973.5 (-742.2)	3074.8 (-84.1)	2926.0 (+11.1)	-
Groundnut I*	1843.2 (+72.8)	1851.0 (-49.8)	1575.5 (+160.6)	2002.7 (+16.5)	1717.6 (+102.0)	1301.5 (-77.7)
Groundnut II*	2065.0 (+297.2)	1769.2 (+484.6)	2036.9 (+159.0)	2004.3 (+353.8)	1992.1 (+288.5)	1154.8 (+82.2)
Groundnut III	2322.0 (+469.4)	-	-	-	2322.0 (+469.4)	-
Sugarcane (N.P.)	7959.2 (+282.3)	-	8411.2 (+6.7)	8948.5 (+760.5)	8379.7 (+199.0)	-
Sugarcane (Rat)	5062.3 (+2662.7)	-	-	5430.2 (+1802.3)	5307.6 (+2089.1)	-
Tapioca	5050.6 (+489.4)	-	-	4201.0 (+914.0)	4755.1 (+637.1)	-
Sorghum I*	622.8 (-189.5)	500.4 (-50.4)	553.0 (-56.0)	760.6 (-173.9)	659.6 (-132.6)	524.9 (-204.4)
Sorghum II*	705.0 (-62.5)	397.1 (+125.6)	619.5 (-98.1)	893.1 (-225.8)	687.4 (-111.63)	289.5 (+65.0)
Cotton II	3641.1 (-274.4)	1968.6 (+281.4)	2896.4 (+39.3)	-	3014.8 (-24.2)	1641.7 (+172.9)
Ragi I	954.2 (-271.2)	-	711.9 (-42.7)	874.0 (-131.0)	839.7 (-137.7)	-
Ragi II	1263.6 (-403.6)	-	-	-	1263.6 (-403.6)	450.7 (-62.9)
Chama I	-	-	688.5 (+34.3)	-	688.5 (+34.3)	471.7 (-94.1)
Chama II	913.7 (-228.7)	-	652.0 (-112.0)	779.2 (-109.2)	765.1 (-140.1)	382.8 (-5.0)
Black gram I*	804.8 (-124.8)	668.4 (-18.4)	492.5 (-86.5)	799.2 (-189.7)	700.8 (-131.2)	357.2 (-79.2)
Black gram II*	847.8 (-340.8)	909.3 (-229.3)	564.8 (-112.5)	816.7 (-299.3)	714.3 (-208.9)	345.3 (-40.3)
Horse gram I	-	-	-	-	-	341.6 (-60.8)
Horse gram II	747.7 (-122.7)	-	529.2 (+10.8)	711.6 (-111.6)	606.6 (-37.9)	370.9 (-58.4)
Cowpea I	-	833.7 (-173.7)	369.7 (+35.3)	-	601.7 (-69.2)	355.4 (-55.4)
Cowpea II	-	-	673.1 (-17.1)	-	673.1 (-17.1)	312.5 (+37.5)
Sesamum II	-	-	-	-	-	445.9 (+0.8)
Tomato II	-	-	2356.0 (-286.3)	3124.3 (-249.3)	2797.5 (-269.7)	-
R_j values	26	14	14	26		

* These crops alone considered for analysis

Figures in paranthesis indicate net margins over cost C

X^2_r value + 10.8 (significant) Table value : 5% level - 7.82
10% level - 6.25

Table 4.7.1 Operation wise cost of cultivation of PADDY IST CROP

(Amount in Rs./acre)

Sl. No.	Item	Cost of cultivation and net margins per acre					
		CWF N=15	CFF N=20	WFF N=20	SWF N=15	Overall* N=70	RFF N=14
1.	Preparatory cultivation	290.97 (9.23)	239.09 (8.78)	241.22 (8.71)	261.69 (7.95)	256.75 (8.58)	209.26 (14.67)
2.	Seeds & Sowing	159.26 (5.05)	183.43 (6.74)	178.31 (6.44)	153.32 (4.66)	168.31 (5.63)	114.40 (8.02)
3.	Nursery raising & maintainance						
4.	Transplantation	192.90 (6.12)	241.29 (8.86)	204.57 (7.39)	232.38 (7.05)	220.83 (7.38)	-
5.	Manures & Manuring	673.31 (21.36)	514.32 (18.89)	507.32 (18.32)	650.39 (19.76)	585.84 (19.58)	334.96 (23.48)
6.	Plant protection	82.65 (2.62)	76.47 (2.81)	69.42 (2.51)	62.62 (1.90)	71.91 (2.40)	36.65 (2.57)
7.	Weeding & intercultivation	201.87 (6.41)	185.03 (6.80)	179.85 (6.49)	181.18 (5.50)	186.05 (13.30)	189.76 (6.22)
8.	Harvesting	406.31 (12.89)	458.95 (16.86)	350.10 (12.64)	492.93 (14.97)	434.75 (14.53)	215.50 (15.11)
9.	Post harvest expenses	69.00 (2.19)	75.25 (2.76)	52.05 (1.88)	71.62 (2.18)	67.76 (2.27)	56.45 (3.96)
10.	Land revenue & taxes	4.00 (0.13)	4.00 (0.15)	4.00 (0.14)	4.00 (0.12)	4.00 (0.13)	4.00 (0.28)
11.	Owned & hired machinery charges	17.90 (0.58)	18.60 (0.68)	18.50 (0.67)	24.00 (0.73)	19.67 (0.66)	15.20 (1.07)
12.	Depreciation and maintainance on farm buildings, machinery & equipments	111.30 (3.53)	108.60 (3.99)	102.50 (3.70)	110.20 (3.35)	108.20 (3.62)	50.70 (3.55)
13.	Interest on fixed capital of other capital investments	16.80 (0.53)	22.60 (0.83)	10.90 (0.39)	18.60 (0.57)	17.64 (0.59)	7.60 (0.53)
14.	Interest on working capital	94.50 (3.00)	84.50 (3.10)	81.70 (2.95)	100.80 (3.06)	90.84 (3.04)	49.40 (3.46)
15.	Irrigation labour charges	96.63 (3.03)	101.88 (3.74)	103.10 (3.73)	86.77 (2.64)	96.51 (3.23)	0.00
16.	Irrigation fuel charges	166.80 (5.29)	0.00	146.60 (5.29)	183.80 (5.58)	121.62 (4.07)	0.00
17.	Canal water charges	12.10 (0.38)	12.00 (0.44)	0.00	12.60 (0.38)	9.55 (0.32)	-
18.	Depreciation & maintainance on irrigation structures, machinery & equipments	125.40 (3.97)	0.00	161.20 (5.83)	160.60 (4.88)	0.00	109.56 (3.66)
19.	Interest on fixed capital of irrigation equipments	31.80 (1.01)	0.00 (1.64)	45.30 (1.91)	62.90 (1.19)	35.52	0.00
20.	Rental value of land	398.00 (12.53)	396.70 (14.57)	312.50 (11.28)	421.60 (12.81)	385.90 (12.90)	142.60 (10.00)
21.	Others						
22.	Total expenses	3151.50 (100.00)	2722.70 (100.00)	2769.20 (100.00)	3292.00 (100.00)	2991.28 (100.00)	1426.50 (100.00)
23.	Irrigation related expenses as percentage to total	(13.73)	(4.18)	(16.48)	(15.39)	(12.46)	(0.00)

* Overall indicates average of irrigated strata

Figures in paranthesis are percentage to total

Table 4.7.2 Operationwise cost of cultivation of PADDY IIND CROP

(Amount in Rs./acre)

Sl. No.	Item	CWF N=8	CFF N=14	WFF N=3	SWF N=7	Overall* N=32	RFF N=0
1.	Preparatory cultivation	286.61 (8.51)	238.81 (9.70)	210.62 (7.08)	234.50 (7.63)	247.92 (8.47)	
2.	Seeds & sowing	150.66 (4.48)	184.84 (7.10)	184.66 (6.27)	159.50 (5.19)	171.21 (5.85)	
3.	Nursery raising & maintainance						
4.	Transplantation	213.05 (6.33)	194.80 (7.48)	126.75 (4.26)	102.32 (3.33)	176.22 (6.02)	
5.	Manures & manuring	474.76 (14.09)	451.38 (17.34)	356.39 (11.99)	465.60 (15.14)	451.15 (15.42)	
6.	Plant protection	123.47 (3.66)	124.32 (4.18)	97.92 (3.29)	90.24 (2.93)	115.36 (3.94)	
7.	Weeding & intercultivation	196.82 (5.84)	232.56 (8.93)	242.56 (8.16)	83.42 (2.71)	196.78 (6.73)	
8.	Harvesting	316.54 (9.40)	398.08 (15.29)	280.59 (9.44)	179.45 (5.84)	325.47 (11.12)	
9.	Post harvest expenses	41.60 (1.23)	59.36 (2.28)	42.25 (1.42)	37.17 (1.21)	49.01 (1.67)	
10.	Land revenue & taxes	4.00 (0.12)	4.00 (0.15)	4.00 (0.13)	4.00 (0.13)	4.00 (0.14)	
11.	Owned & hired machinery charges	39.90 (1.18)	35.50 (1.36)	27.50 (0.92)	20.30 (0.66)	33.12 (1.13)	
12.	Depreciation and maintainance on farm buildings,machinery & equipments	111.30 (3.30)	108.70 (4.18)	102.50 (3.45)	110.20 (3.58)	109.07 (3.73)	N I L
13.	Interest on fixed capital of other capital investments	16.80 (0.50)	22.60 (0.87)	10.90 (0.37)	18.60 (0.60)	19.24 (0.66)	
14.	Interest on working capital	101.00 (3.00)	100.80 (3.87)	73.00 (2.45)	112.40 (3.66)	100.35 (3.43)	
15.	Irrigation labour charges	131.90 (3.91)	129.90 (5.00)	124.26 (4.18)	80.70 (2.63)	120.88 (4.13)	
16.	Irrigation fuel charges	438.00 (13.00)	0.00 (0.00)	359.70 (12.10)	480.70 (15.63)	237.28 (8.11)	
17.	Canal water charges	13.00 (0.39)	13.20 (0.50)	0.00 -	12.40 (0.40)	11.75 (0.40)	
18.	Depreciation & maintainance on irrigation structures,machinery & equipments	329.30 (9.78)	0.00 -	395.60 (13.30)	419.90 (13.65)	200.95 (6.87)	
19.	Interest on fixed capital of irrigation equipments	83.50 (2.48)	0.00 -	111.20 (3.74)	164.40 (5.35)	62.60 (2.14)	
20.	Rental value of land	296.90 (8.81)	304.20 (11.69)	223.10 (7.50)	299.00 (9.72)	293.66 (10.04)	
21.	Others	-	-	-	-	-	
22.	Total expenses	3369.10 (100.00)	2603.10 (100.00)	2973.50 (100.00)	3074.80 (100.00)	2926.02 (100.00)	
23.	Irrigation related expenses as percentage to total	(29.56)	(5.50)	(33.32)	(37.66)	(21.65)	

* Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Table 4.7.3 Operationwise cost of cultivation of GROUNDNUT IST CROP

(Amount in Rs./acre)

Sl. No.	Item	CWF N =10	CPF N=5	WFF N=17	SWF N=8	Overall* N=40	RFF N=19
1.	Preparatory cultivation	184.03 (9.98)	216.31 (11.69)	154.38 (9.80)	198.92 (9.93)	172.70 (10.05)	125.68 (9.66)
2.	Seeds & sowing	480.50 (26.07)	601.78 (32.51)	450.89 (28.61)	502.74 (25.10)	478.64 (27.87)	476.70 (36.62)
3.	Nursery raising & maintainance	-	-	-	-	-	-
4.	Transplantation	-	-	-	-	-	-
5.	Manures & manuring	359.01 (19.48)	319.16 (17.24)	300.20 (19.05)	382.90 (19.12)	325.95 (18.98)	168.86 (12.98)
6.	Plant protection	23.33 (1.27)	0.00	33.31 (2.10)	43.15 (2.15)	29.65 (1.73)	21.02 (1.62)
7.	Weeding & intercultivation	186.36 (10.11)	122.23 (6.60)	112.63 (7.15)	174.00 (8.69)	137.31 (7.99)	102.20 (7.85)
8.	Harvesting	216.64 (11.75)	216.69 (11.71)	174.07 (11.05)	286.50 (14.31)	203.21 (11.83)	169.20 (13.00)
9.	Post harvest expenses	23.33 (1.27)	19.14 (1.03)	12.72 (0.81)	18.80 (0.94)	16.34 (0.95)	15.14 (1.16)
10.	Land revenue & taxes	4.00 (0.22)	4.00 (0.22)	4.00 (0.25)	4.00 (0.20)	4.00 (0.23)	4.00 (0.31)
11.	Owned & hired machinery charges	5.40 (0.29)	0.00	8.80 (6.56)	13.60 (0.68)	8.01 (0.47)	4.40 (0.34)
12.	Depreciation and maintainance on farm buildings,machinery & equipments	98.90	96.50	91.00	98.00	94.13	45.10
13.	Interest on fixed capital of other capital investments	14.90 (0.81)	20.10 (1.09)	9.70 (0.62)	16.60 (0.83)	12.34 (0.72)	6.70 (0.51)
14.	Interest on working capital	55.20 (2.99)	55.00 (2.97)	50.20 (3.19)	61.60 (3.08)	53.34 (3.11)	40.10 (3.08)
15.	Irrigation labour charges	0.00	0.00	0.00	0.00	0.00	0.00
16.	Irrigation fuel charges	0.00	0.00	0.00	0.00	0.00	0.00
17.	Canal water charges	0.00	0.00	0.00	0.00	0.00	0.00
18.	Depreciation & maintainance on irrigation structures,machinery & equipments	0.00	0.00	0.00	0.00	0.00	0.00
19.	Interest on fixed capital of irrigation equipments	0.00	0.00	0.00	0.00	0.00	0.00
20.	Rental value of land	191.60 (10.39)	180.10 (9.73)	173.60 (11.02)	201.90 (10.08)	182.00 (10.60)	122.40 (9.40)
21.	Others	-	-	-	-	-	-
22.	Total expenses	1843.20 (100.00)	1851.00 (100.00)	1575.50 (100.00)	2002.70 (100.00)	1717.60 (100.00)	1301.50 (100.00)
23.	Irrigation related expenses as percentage to total	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Table 4.7.4 Operationwise cost of cultivation of GROUNDNUT IIND CROP

(Amount in Rs./acre)

Sl. No.	Item	CWF N=11	CFF N=11	WFF N=20	SWF N=14	Overall* N=56	RFF N=6
1.	Preparatory cultivation	170.85 (8.27)	177.09 (10.00)	184.31 (9.04)	195.26 (9.74)	184.29 (9.25)	161.92 (14.02)
2.	Seeds & sowing	503.27 (24.38)	500.92 (28.30)	540.89 (26.55)	429.55 (21.43)	495.38 (24.87)	531.63 (46.04)
3.	Nursery raising & maintainance	-	-	-	-	-	-
4.	Transplantation	-	-	-	-	-	-
5.	Manures & Manuring	228.88 (11.08)	212.64 (12.02)	210.67 (10.34)	201.96 (10.08)	211.37 (10.61)	52.92 (4.58)
6.	Plant protection	33.99 (1.65)	16.58 (0.94)	44.90 (2.20)	46.00 (2.36)	39.22 (1.97)	14.62 (1.27)
7.	Weeding & intercultivation	189.16 (9.16)	141.66 (8.01)	149.76 (7.35)	166.60 (8.29)	160.00 (8.03)	73.11 (6.33)
8.	Harvesting	280.43 (13.58)	242.16 (13.69)	240.27 (11.80)	273.18 (13.63)	257.00 (12.90)	88.80 (7.69)
9.	Post harvest expenses	20.10 (0.07)	26.04 (1.47)	14.14 (0.69)	19.74 (0.98)	18.57 (0.93)	12.50 (1.08)
10.	Land revenue & taxes	4.00 (0.19)	4.00 (0.23)	4.00 (0.20)	4.00 (0.20)	4.00 (0.20)	4.00 (0.35)
11.	Owned & hired machinery charges	7.80 (0.38)	4.70 (0.27)	10.70 (0.53)	13.40 (0.67)	10.13 (0.51)	5.00 (0.43)
12.	Depreciation and maintainance on farm buildings, machinery & equipments	98.90 (4.79)	96.60 (5.46)	91.00 (4.47)	98.00 (4.89)	95.24 (4.78)	45.00 (3.90)
13.	Interest on fixed capital of other capital investments	14.90 (0.72)	20.10 (1.14)	9.70 (0.48)	16.60 (0.83)	14.17 (0.71)	6.70 (0.58)
14.	Interest on working capital	48.00 (2.32)	43.80 (2.48)	54.70 (2.69)	46.20 (2.31)	49.42 (2.48)	34.90 (3.02)
15.	Irrigation labour charges	33.62 (1.63)	44.51 (2.52)	32.76 (1.61)	32.95 (1.64)	84.70 (1.74)	0.00
16.	Irrigation fuel charges	94.10 (4.56)	0.00	95.30 (4.68)	96.60 (4.82)	81.37 (4.08)	0.00
17.	Canal water charges	12.20 (0.59)	13.00 (0.73)	0.00	11.60 (0.58)	7.41 (0.37)	0.00
18.	Depreciation & maintainance on irrigation structures,machinery & equipments	70.70 (3.42)	0.00	104.80	84.30	77.48 (3.89)	0.00
19.	Interest on fixed capital of irrigation equipments	18.00 (0.87)	0.00	29.40 (1.44)	33.00 (1.65)	24.23 (1.22)	0.00
20.	Rental value of land	236.30 (11.44)	225.40 (12.74)	219.60 (10.78)	235.80 (11.76)	228.08 (11.45)	123.70 (10.71)
21.	Others	-	-	-	-	-	-
22.	Total expenses	2065.00 (100.00)	1769.20 (100.00)	2036.90 (100.00)	2004.30 (100.00)	1992.13 (100.00)	1154.80 (100.00)
23.	Irrigation related expenses as percentage to total	(11.07)	(3.25)	(12.88)	(12.89)	(11.30)	

* Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Table 4.7.5. Operationwise cost of cultivation of GROUNDNUT IIIRD CROP, SESAMUM IIND CROP and HORSEGRAM IST CROP

(Amount in Rs./acre)

Sl. No.	Item	Groundnut IIIrd crop	Sesamum IInd crop	Horsegram Ist crop
		CWF N=2	RFF N=3	RFF N=5
1.	Preparatory cultivation	169.34 (17.29)	175.60 (39.38)	134.00 (39.23)
2.	Seeds & sowing	479.00 (20.64)	-	-
3.	Nursery raising & maintainance	-	-	-
4.	Transplantation	-	-	-
5.	Manures & manuring	226.68 (9.76)	52.10 (11.69)	38.00 (11.12)
6.	Plant protection	43.69 (1.88)	0.00	-
7.	Weeding & intercultivation	167.49 (7.21)	-	-
8.	Harvesting	277.95 (11.97)	-	-
9.	Post harvest expenses	19.92 (0.86)	108.00 (24.22)	78.40 (22.95)
10.	Land revenue & taxes	2.70 (0.12)	4.00 (0.90)	4.00 (1.17)
11.	Owned & hired machinery charges	14.30 (0.62)	-	-
12.	Depreciation and maintainance on farm building machinery & equipments	98.90 (4.26)	45.10 (10.11)	45.10 (13.20)
13.	Interest on fixed capital of other capital investments	14.90 (0.64)	6.80 (1.53)	6.80 (1.99)
14.	Interest on working capital	50.50 (2.17)	9.60 (2.15)	7.30 (2.14)
15.	Irrigation labour charges	63.33 (2.73)	-	-
16.	Irrigation fuel charges	224.80 (9.68)	-	-
17.	Canal water charges	10.80 (0.47)	-	-
18.	Depreciation & maintainance on irrigation structures, machinery & equipments	169.10 (7.28)	-	-
19.	Interest on fixed capital of irrigation equipments	42.90 (1.84)	-	-
20.	Rental value of land	245.70 (10.54)	44.70 (10.02)	28.00 (8.20)
21.	Others	-	-	-
22.	Total expenses	2322.00 (100.00)	445.90 (100.00)	341.60 (100.00)
23.	Irrigation related expenses as percentage to total	22.00	-	-

Figures in paranthesis are percentages to total

Table 4.7.6 Operation wise cost of cultivation of SUGARCANE (NEW PLANTING)

(Amount in Rs./acre)

Sl. No.	Item	CWF N=4	WFF N=7	SWF N=3	Overall*
1.	Preparatory cultivation	477.69 (6.00)	541.36 (6.44)	602.24 (6.75)	534.87 (6.38)
2.	Seeds & sowing	1756.15 (22.06)	1870.17 (22.23)	1828.19 (20.43)	1833.81 (21.88)
3.	Nursery raising & maintainance	-	-	-	-
4.	Transplantation	-	-	-	-
5.	Manures & manuring	1605.23	1476.81	1796.23	1561.31
6.	Plant protection	26.46 (0.34)	28.26 (0.34)	0.00	23.27 (0.28)
7.	Weeding & intercultivation	213.84 (2.69)	266.60 (3.17)	219.72 (2.46)	245.38 (2.93)
8.	Harvesting	1127.68 (14.17)	1166.00 (13.86)	1223.45 (13.67)	1165.23 (13.91)
9.	Post harvest expenses	-	-	-	-
10.	Land revenue & taxes	8.00 (0.10)	8.00 (0.10)	8.00 (0.09)	8.00 (0.09)
11.	Owned & hired machinery charges	0.00	5.00 (0.06)	0.00	2.90 (0.03)
12.	Depreciation and maintainance on farm building, machinery & equipments	296.70 (3.73)	273.40 (3.25)	294.00 (3.29)	282.75 (3.37)
13.	Interest on fixed capital of other capital investments	44.80	29.00	49.70	36.42
14.	Interest on working capital	649.60 (8.16)	672.60 (8.00)	721.00 (8.06)	674.36 (8.04)
15.	Irrigation labour charges	196.15 (2.46)	222.30 (2.64)	262.17 (2.93)	221.88 (2.65)
16.	Irrigation fuel charges	364.90 (4.59)	419.20 (4.98)	427.40 (4.78)	406.39 (4.85)
17.	Canal water charges	24.00 (0.30)	0.00	24.00 (0.27)	10.08 (0.12)
18.	Depreciation and maintainance on irrigation structure machinery and equipments	274.30 (3.45)	461.10 (5.48)	373.30 (4.17)	398.48 (4.76)
19.	Interest on fixed capital of irrigation equipment	69.60 (0.87)	129.60 (1.54)	146.20 (1.63)	116.66 (1.39)
20.	Rental value of land	824.10 (10.35)	841.80 (10.01)	970.90 (10.85)	857.85 (10.24)
21.	Others	-	-	-	-
22.	Total expenses	7959.20 (100.00)	8411.20 (100.00)	8948.50 (100.00)	8379.65 (100.00)
23.	Irrigation related expenses as percentage to total	(11.67)	(14.65)	(13.78)	(13.72)

* Overall indicates average of irrigated strata

Figures in paranthesis are percentage to total

Table 4.7.7 Operation wise cost of cultivation of SUGARCANE (RATOON)

(Amount in Rs/acre)

Sl. No.	Item	CWF N=2	SWF N=4	Overall* N=6
1.	Preparatory cultivation	236.86 (4.68)	267.66 (4.93)	257.39 (4.85)
2.	Seeds & sowing	-	-	-
3.	Nursery raising & maintainance	-	-	-
4.	Transplantation	-	-	-
5.	Manures & manuring	1153.27 (22.78)	1399.36 (25.77)	1317.33 (24.82)
6.	Plant protection	137.05 (2.70)	0.00	45.68 (0.86)
7.	Weeding & intercultivation	212.53 (4.20)	277.56 (5.12)	255.88 (4.82)
8.	Harvesting	881.40 (17.41)	936.76 (17.26)	918.31 (17.30)
9.	Post harvest expenses	-	-	-
10.	Land revenue & taxes	8.00 (0.16)	8.00 (0.15)	8.00 (0.15)
11.	Owned & hired machinery charges	19.50 (0.39)	0.00	6.50 (0.12)
12.	Depreciation & maintainance on farm building, machinery & equipments	230.10 (4.55)	293.90 (5.41)	272.63 (5.14)
13.	Interest on fixed capital of other capital investments	42.50 (0.84)	49.70 (0.92)	47.30 (0.89)
14.	Interest on working capital	344.10 (6.80)	386.00 (7.11)	372.03 (7.01)
15.	Irrigation labour charges	191.18 (3.78)	220.56 (4.06)	210.77 (3.97)
16.	Irrigation fuel charges	416.60 (8.23)	380.70 (7.01)	392.67 (7.40)
17.	Canal water charges	24.00 (0.47)	24.00 (0.44)	24.00 (0.45)
18.	Depreciation and maintainance on irrigation structures, machinery and equipments	312.20 (6.18)	332.60 (6.12)	326.13 (6.14)
19.	Interest on fixed capital of irrigation equipments	79.50 (1.57)	130.20 (2.40)	113.30 (2.13)
20.	Rental value of land	772.50 (15.26	723.20) (13.32)	739.63 (13.94)
21.	Others	-	-	-
22.	Total expenses	5062.30 (100.00	5430.20 (100.00)	5307.55 (100.00)
23.	Irrigation related expenses on percentage to total	20.24	20.04	20.10

* Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Table 4.7.8 Operation wise cost of cultivation of TAPIOCA

(Amount in Rs./acre)

Sl. No.	Item	CWF N=2	SWF N=1	Overall* N=3
1.	Preparatory cultivation	416.00 (8.29)	417.92 (9.95)	416.67 (8,76)
2.	Seeds & sowing	553.33 (10.98)	509.67 (12.13)	538.14 (11.32)
3.	Nursery raising & maintainance	-	-	-
4.	Transplantation	-	-	-
5.	Manures & manuring	1051.27 (20.81)	1148.28 (27.33)	1085.01 (22.82)
6.	Plant protection	65.33 (1.29)	0.00	42.61 (0.90)
7.	Weeding & intercultivation	576.00 (11.40)	0.00	375.65 (7.90)
8.	Harvesting	640.00 (12.67)	496.92 (11.83)	590.23 (12.11)
9.	Post harvest expenses	-	-	-
10.	Land revenue & taxes	8.00 (0.16)	8.00 (0.19)	8.00 (0.17)
11.	Owned & hired machinery charges	5.30 (0.10)	0.00	3.46 (0.07)
12.	Depreciation & maintainance on farm buildings, machinery & equipments	296.70 (5.87)	293.80 (6.99)	295.70 (6.22)
13.	Interest on fixed capital of other capital investments	44.80 (0.89)	49.70 (1.18)	46.50 (0.95)
14.	Interest on working capital	398.60 (7.89)	353.20 (8.41)	382.81 (8.05)
15.	Irrigation labour charges	106.67 (2.11)	63.71 (1.52)	91,73 (1.93)
16.	Irrigation fuel charges	159.90 (3.17)	146.30 (3.48)	155.17 (3.26)
17.	Canal water charges	24.00 (0.48)	24.00 (0.57)	24.00 (0.50)
18.	Depreciation and maintainance on irrigation structures, machinery and equipments	120.20 (2.38)	127.90 (3.04)	122.88 (2.58)
19.	Interest on fixed capital of irrigation equipments	30.50 (0.60)	50.00 (1.19)	37.28 (0.78)
20.	Rental value of land	554.60 (10.97)	511.50 (12.18)	539.21 (11.34)
21.	Others	-	-	-
22.	Total expenses	5050.60 (100.00)	4201.00 (100.00)	4755.05 (100.00)
23.	Irrigation related expenses as percentage to total	8.74	9.80	9.07

* Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Table 4.7.9 Operationwise cost of cultivation of SORGHUM IST CROP

(Amount in Rs./acre)

Sl. No.	Item	CWF N=1	CFF N=1	WFF N=2	SWF N=3	Overall* N=7	RFF N=11
1.	Preparatory cultivation	177.33 (28.47)	170.00 (33.98)	180.83 (32.70)	194.02 (25.60)	185.96 (28.20)	225.80 (43.01)
2.	Seeds & sowing	-	-	-	-	-	-
3.	Nursery raising & maintainance	-	-	-	-	-	-
4.	Transplantation	-	-	-	-	-	-
5.	Manures & manuring	179.53 (28.83)	93.20 (12.63)	127.63 (23.68)	226.32 (29.76)	180.76 (27.40)	126.87 (24.17)
6.	Plant protection	0.00	0.00	0.00	0.00	0.00	0.00
7.	Weeding & intercultivation	0.00	0.00	0.00	0.00	0.00	0.00
8.	Harvesting	88.40 (14.15)	60.00 (11.99)	63.71 (11.52)	97.12 (12.11)	107.69 (16.32)	71.74 (13.67)
9.	Post harvest expenses			11.03 (0.99)	44.34 (5.83)		
10.	Land revenue & taxes	4.00 (0.64)	4.00 (0.80)	4.00 (0.72)	4.00 (0.53)	4.00 (0.61)	4.00 (0.76)
11.	Owned & hired machinery charges	0.00	0.00	0.00	0.00	0.00	0.00
12.	Depreciation and maintainance on farm building machinery & equipments	98.90 (15.88)	96.60 (19.30)	91.10 (16.47)	98.00 (12.88)	95.90 (14.54)	45.10 (8.59)
13.	Interest on fixed capital of other capital investments	14.90 (2.40)	19.90 (3.98)	9.70 (1.75)	16.60 (2.18)	14.33 (2.17)	6.70 (1.28)
14.	Interest on working capital	16.70 (2.68)	11.70 (2.30)	15.30 (2.70)	21.50 (2.83)	18.27 (2.77)	12.60 (2.40)
15.	Irrigation labour charges	0.00	0.00	0.00	0.00	0.00	0.00
16.	Irrigation fuel charges	0.00	0.00	0.00	0.00	0.00	0.00
17.	Canal water charges	0.00	0.00	0.00	0.00	0.00	0.00
18.	Depreciation and maintainance on irrigation structures, machinery and equipments	0.00	0.00	0.00	0.00	0.00	0.00
19.	Interest on fixed capital of irrigation equipments	0.00	0.00	0.00	0.00	0.00	0.00
20.	Rental value of land	43.30 (6.95)	45.00 (8.99)	49.70 (8.99)	58.70 (7.72)	52.71 (7.99)	32.10 (6.12)
21.	Others	-	-	-	-	-	-
22.	Total expenses	622.80 (100.00)	500.80 (100.00)	553.40 (100.00)	760.60 (100.00)	659.62 (100.00)	524.90 (100.00)
23.	Irrigation related expenses as percentage to total	0.00	0.00	0.00	0.00	0.00	0.00

* Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Table 4.7.10 Operationwise cost of cultivation of SORGHUM IIND CROP

(Amount in Rs./acre)

Sl. No.	Item	CWF N=1	CFF N=3	WFF N=6	SWF N=5	Overall* N=15	RFF N=9
1.	Preparatory cultivation	139.05 (19.72)	118.45 (29.83)	123.46 (19.94)	149.38 (16.73)	132.07 (19.21)	121.43 (40.94)
2.	Seeds & sowing						
3.	Nursery raising & maintainance	-	-	-	-	-	-
4.	Transplantation	-	-	-	-	-	-
5.	Manures & manuring	42.90 (6.09)	45.02 (11.39)	36.51 (5.89)	63.63 (7.13)	46.91 (6.82)	20.31 (7.03)
6.	Plant protection	0.00	0.00	0.00	0.00	0.00	0.00
7.	Weeding & intercultivation	0.00	0.00	0.00	27.71	9.31	0.00
8.	Harvesting	127.79 (18.12)	43.49 (10.95)	53.17 (8.58)	174.15 (19.50)	95.12 (13.84)	49.16 (16.93)
9.	Post harvest expenses						
10.	Land revenue & taxes	4.00 (0.57)	4.00 (1.01)	4.00 (0.64)	4.00 (0.45)	4.00 (0.58)	4.00 (1.38)
11.	Owned & hired machinery charges	0.00	0.00	0.00	0.00	0.00	0.00
12.	Depreciation and maintainance on farm building machinery & equipments	98.90 (14.03)	96.50 (24.30)	91.10 (14.71)	98.00 (10.97)	94.36 (13.73)	45.10 (15.52)
13.	Interest on fixed capital of other capital investments	14.90 (2.11)	20.10 (5.06)	9.70 (1.57)	16.60 (1.86)	13.50 (1.96)	6.70 (2.31)
14.	Interest on working capital	14.40 (2.04)	8.00 (2.01)	8.10 (1.31)	15.00 (1.68)	10.62 (1.54)	7.40 (2.56)
15.	Irrigation labour charges	18.26 (2.59)	6.14 (1.55)	9.86 (1.59)	15.83 (1.77)	11.68 (1.70)	0.00
16.	Irrigation fuel charges	86.80 (12.31)	0.00	96.10 (15.51)	112.90 (12.64)	89.32 (13.00)	0.00
17.	Canal water charges	12.00 (1.70)	12.00 (3.02)	0.00	12.00 (1.34)	5.95 (0.87)	0.00
18.	Depreciation and maintainance on irrigation structures, machinery and equipments	65.20 (9.25)	0.00	105.70 (17.06)	98.60 (11.04)	88.63 (12.89)	0.00
19.	Interest on fixed capital of irrigation equipments	16.60 (2.35)	0.00	29.70 (4.79)	38.60 (4.32)	28.51 (4.15)	0.00
20.	Rental value of land	64.20 (9.11)	52.30 (13.17)	52.10 (8.41)	66.70 (7.47)	57.44 (8.36)	35.40 (12.23)
21.	Others	-	-	-	-	-	-
22.	Total expenses	705.00 (100.00)	397.10 (100.00)	619.50 (100.00)	893.10 (100.00)	687.42 (100.00)	289.50 (100.00)
23.	Irrigation related expenses as percentage to total	28.20	4.57	38.96	32.80	32.60	0.00

* Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Table 4.7.11 Operationwise cost of cultivation of COTTON IIND CROP

(Amount in Rs./acre)

Sl. No.	Item	CWF N=2	CFF N=1	WFF N=4	Overall* N=7	RFF N=6
1.	Preparatory cultivation	342.78 (9.41)	247.00 (12.55)	418.60 (14.45)	382.32 (12.68)	370.02 (22.54)
2.	Seeds & sowing					
3.	Nursery raising & maintainance	-	-	-	-	-
4.	Transplantation	-	-	-	-	-
5.	Manures & manuring	770.08 (21.15)	593.00 (30.13)	561.86 (19.40)	621.48 (20.61)	397.97 (24.24)
6.	Plant protection	527.25 (14.43)	235.00 (11.93)	283.37 (9.78)	345.49 (11.46)	88.88 (5.40)
7.	Weeding & intercultivation	196.62 (5.40)	150.00 (7.62)	192.35 (6.64)	189.66 (6.29)	114.85 (7.00)
8.	Harvesting	491.56 (13.50)	150.00 (7.62)	366.99 (12.67)	381.24 (12.65)	314.58 (19.16)
9.	Post harvest expenses					
10.	Land revenue & taxes	4.00 (0.11)	4.00 (0.20)	4.00 (0.14)	4.00 (0.13)	4.00 (0.24)
11.	Owned & hired machinery charges	98.70 (2.21)	40.00 (2.03)	46.40 (1.60)	60.08 (1.99)	18.00 (1.10)
12.	Depreciation and maintainance on farm buildings, machinery & equipments	148.30 (4.07)	145.30 (7.38)	136.40 (4.71)	140.45 (4.66)	67.50 (4.11)
13.	Interest on fixed capital of other capital equipments	22.40 (0.67)	3.20 (1.53)	14.50 (0.50)	18.08 (0.60)	10.10 (0.62)
14.	Interest on working capital	137.40 (3.77)	77.10 (3.92)	99.20 (3.42)	107.61 (3.60)	74.30 (4.53)
15.	Irrigation labour charges	98.31 (2.70)	60.00 (3.05)	59.23 (2.04)	69.96 (2.32)	0.00
16.	Irrigation fuel charges	233.70 (6.42)	0.00	174.30 (6.02)	174.65 (5.79)	0.00
17.	Canal water charges	13.10 (0.36)	12.00 (0.61)	0.00	4.66 (0.15)	0.00
18.	Depreciation and maintainance on irrigation structures, machines and equipments	175.70 (4.83)	0.00	191.70 (6.62)	169.90 (5.63)	0.00
19.	Interest on fixed capital of irrigation equipment	44.60 (1.22)	0.00	53.90 (1.85)	46.46 (1.54)	0.00
20.	Rental value of land	336.60 (9.24)	225.00 (11.43)	293.60 (10.14)	299.09 (9.92)	181.50 (11.06)
21.	Others	-	-	-	-	-
22.	Total expenses	3641.10 (100.00)	1968.60 (100.00)	2896.40 (100.00)	3014.83 (100.00)	1641.70 (100.00)
23.	Irrigation related expenses as percentage to total	15.53	3.66	16.54	15.43	-

* Overall indicates average of irrigated strata

Figures in paranthesis are percentage to total

Table 4.7.12 Operation wise cost of cultivation of RAGI IST CROP

(Amount in Rs./acre)

Sl. No.	Item	CWF N=1	WFF N=2	SWF N=2	Overall* N=5
1.	Preparatory cultivation	225.76 (23.66)	212.44 (29.86)	189.26 (21.66)	206.80 (24.63)
2.	Seeds & sowing				
3.	Nursery raising & maintainance	-	-	-	-
4.	Transplantation	-	-	-	-
5.	Manures & manuring	241.40 (25.31)	144.48 (20.28)	228.06 (23.12)	202.98 (24.17)
6.	Plant protection	0.00	0.00	0.00	0.00
7.	Weeding & intercultivation	78.18 (8.19)	0.00	56.48 (6.46)	42.87 (5.11)
8.	Harvesting	195.46 (20.48)	164.18 (23.06)	183.60 (21.00)	180.08 (21.45)
9.	Post harvest expenses				
10.	Land revenue & taxes	4.00 (0.42)	4.00 (0.56)	4.00 (0.46)	4.00 (0.48)
11.	Owned & hired machinery charges	0.00	0.00	0.00	0.00
12.	Depreciation and maintainance on farm building, machinery & equipments	98.90 (10.36)	91.00 (12.78)	97.90 (11.20)	95.80 (11.41)
13.	Interest on fixed capital of other capital investments	14.90 (0.56)	9.70 (1.36)	16.50 (1.89)	13.75 (1.64)
14.	Interest on working capital	27.30 (2.86)	19.20 (2.70)	23.90 (2.73)	23.19 (2.76)
15.	Irrigation labour charges	0.00	0.00	0.00	0.00
16.	Irrigation fuel charges	0.00	0.00	0.00	0.00
17.	Canal water charges	0.00	0.00	0.00	0.00
18.	Depreciation and maintainance on irrigation structure machinery and equipments	0.00	0.00	0.00	0.00
19.	Interest on fixed capital of irrigation equipments	0.00	0.00	0.00	0.00
20.	Rental value of land	68.30 (7.60)	66.90 (7.40)	74.30 (8.50)	70.19 (8.36)
21.	Others	-	-	-	-
22.	Total expenses	954.20 (100.00)	711.90 (100.00)	874.00 (100.00)	839.66 (100.00)
23.	Irrigation related expenses as percentages to total	0.00	0.00	0.00	0.00

* Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Table 4.7.13 Operation wise cost of cultivation of RAGI IIND CROP and TOMATO IIND CROP

(Amount in Rs./acre)

Sl. No.	Item	Ragi IInd crop		Tomato IInd crop		
		CFF N=1	RFF N=3	WFF N=1	SWF N=2	Overall* N=3
1.	Preparatory cultivation					
2.	Seeds & sowing	287.56 (22.76)	136.64 (30.32)	412.99 (16.29)	358.95 (11.49)	388.97 (13.90)
3.	Nursery raising & maintainance	-	-	77.44 (3.05)	157.91 (5.05)	113.20 (4.05)
4.	Transplantation	-	-	-	-	-
5.	Manures & manuring	209.84 (16.60)	72.31 (16.04)	544.12 (21.46)	699.16 (22.38)	613.03 (21.91)
6.	Plant protection	0.00	0.00	123.90 (4.89)	254.70 (8.15)	182.03 (6.51)
7.	Weeding & intercultivation	116.58 (9.22)	36.00 (7.99)	103.25 (4.07)	127.35 (4.08)	113.96 (4.07)
8.	Harvesting					
9.	Post harvest expenses	244.30 (19.33)	99.75 (22.13)	464.62 (18.32)	662.22 (21.20)	552.44 (19.75)
10.	Land revenue & taxes	4.00 (0.32)	4.00 (0.89)	4.00 (0.16)	4.00 (0.13)	4.00 (0.14)
11.	Owned and hired machinery charges	0.00	0.00	20.00 (0.79)	18.80 (0.60)	19.47 (0.69)
12.	Depreciation and maintainance on farm buildings, machinery & equipments	98.80 (7.82)	45.00 (9.98)	91.00 (3.59)	97.90 (3.13)	94.07 (3.36)
13.	Interest on fixed capital of other capital investments	14.90 (1.18)	6.70 (1.49)	9.70 (0.38)	16.50 (0.58)	12.72 (0.45)
14.	Interest on working capital	24.90 (1.97)	11.50 (2.55)	69.70 (2.75)	87.40 (2.80)	77.57 (2.77)
15.	Irrigation labour charges	27.72 (2.20)	0.00	180.68 (7.12)	114.61 (3.67)	151.32 (5.41)
16.	Irrigation fuel charges	70.50 (5.58)	0.00	87.00 (3.43)	101.70 (3.26)	93.53 (3.34)
17.	Canal water charges	11.90 (0.94)	0.00	0.00	12.00 (0.38)	5.33 (0.19)
18.	Depreciation and maintainance on irrigation structures, machinery and equipments	5.31 (4.20)	0.00	95.70 (3.77)	88.80 (2.84)	92.63 (3.31)
19.	Interest on fixed capital of irrigation equipments	13.50 (1.07)	0.00	26.90 (1.06)	34.80 (1.11)	30.41 (1.09)
20.	Rental value of land	86.00 (6.81)	38.80 (8.61)	225.00 (8.87)	287.50 (9.20)	252.78 (9.04)
21.	Others	-	-	-	-	-
22.	Total expenses	1263.60 (100.00)	450.70 (100.00)	2536.00 (100.00)	3124.30 (100.00)	2797.47 (100.00)
23.	Irrigation related expenses as percentage to total	13.99	-	15.39	11.26	13.34

* Overall indicates average of irrigated strata

Figures in paranthesis are percentage to total

Table 4.7.14 Operation wise cost of cultivation of CHAMA (LITTLE MILLET) IST CROP

(Amount in Rs./acre)

Sl. No.	Item	WFF N=3	RFF N=5
1.	Preparatory cultivation	209.80 (30.47)	158.19 (33.54)
2.	Seeds & sowing		
3.	Nursery raising & maintainance	0.00	0.00
4.	Transplantation	0.00	0.00
5.	Manures & manuring	169.00 (24.55)	123.09 (26.09)
6.	Plant protection	0.00	0.00
7.	Weeding & intercultivation	0.00	0.00
8.	Harvesting	114.40 (16.02)	84.62 (17.95)
9.	Post harvest expenses		
10.	Land revenue & taxes	4.00 (0.58)	4.00 (0.85)
11.	Owned & hired machinery charges	0.00	0.00
12.	Depreciation and maintainance on farm building, machinery & equipments	91.10 (13.23)	45.10 (9.56)
13.	Interest on fixed capital of other capital investments	9.70 (1.41)	6.70 (1.42)
14.	Interest on working capital	18.20 (2.64)	12.20 (2.59)
15.	Irrigation labour charges	0.00	0.00
16.	Irrigation fuel charges	0.00	0.00
17.	Canal water charges	0.00	0.00
18.	Depreciation and maintainance on irrigation structures, machinery & equipments	0.00	0.00
19.	Interest on fixed capital of irrigation equipments	0.00	0.00
20.	Rental value of land	72.30 (10.50)	37.80 (8.01)
21.	Others	-	-
22.	Total expenses	688.50 (100.00)	471.70 (100.00)
23.	Irrigation related expenses as percentage to total	0.00	0.00

Figures in paranthesis are percentages to total

Table 4.7.15 Operation wise cost of cultivation of CHAMA (LITTLE MILLET) IIND CROP

(Amount in Rs./acre)

Sl. No.	Item	CWF N=1	WFF N=2	SWF N=1	RFF N=8	Overall* N=4
1.	Preparatory cultivation	159.29 (17.43)	167.97 (25.76)	148.71 (19.08)	120.40 (31.45)	158.58 (20.73)
2.	Seeds & sowing					
3.	Nursery raising & maintainance	0.00	0.00	0.00	0.00	-
4.	Transplantation	0.00	0.00	0.00	0.00	-
5.	Manures & manuring	199.53 (21.84)	65.56 (10.05)	91.83 (11.79)	69.00 (18.03)	108.90 (14.23)
6.	Plant protection	0.00	0.00	0.00	0.00	-
7.	Weeding and intercultivation	47.73 (5.23)	0.00	0.00	0.00	11.93 (1.56)
8.	Harvesting	154.66 (16.94)	107.96 (16.56)	149.72 (19.20)	91.70 (23.96)	135.30 (17.68)
9.	Post harvest expenses					
10.	Land revenue & taxes	4.00 (0.44)	4.00 (0.61)	4.00 (0.51)	4.00 (1.04)	4.00 (0.52)
11.	Owned & hired machinery charges	0.00	0.00	0.00	0.00	0.00
12.	Depreciation and maintainance charges, farm building, machinery & equipments	98.90 (10.82)	91.10 (13.97)	98.00 (17.58)	45.10 (11.78)	95.64 (12.50)
13.	Interest on fixed capital of other capital investments	14.90 (1.63)	9.70 (1.49)	16.60 (2.13)	6.70 (1.75)	13.59 (1.78)
14.	Interest on working capital	16.00 (1.75)	13.10 (2.01)	14.40 (1.85)	8.10 (2.12)	14.31 (1.87)
15.	Irrigation labour charges	19.09 (2.09)	16.31 (2.50)	16.64 (2.14)	0.00 -	17.13 (2.24)
16.	Irrigation fuel charges	61.30 (6.71)	50.80 (7.79)	72.40 (9.29)	0.00	61.53 (8.04)
17.	Canal water charges	12.00 (1.31)	0.00	12.00 (1.54)	0.00	7.50 (0.98)
18.	Depreciation and maintainance on irrigation structures, machinery and equipments	46.10 (5.05)	55.80 (8.56)	63.20 (8.11)	0.00	56.15 (7.34)
19.	Interest on fixed capital of irrigation equipments	11.70 (1.28)	15.70 (2.41)	24.70 (3.17)	0.00	18.08 (2.36)
20.	Rental value of land	68.50 (7.50)	54.00 (8.28)	67.00 (8.60)	37.80 (9.87)	62.50 (8.17)
21.	Others	-	-	-	-	-
22.	Total	913.70 (100.00)	652.00 (100.00)	779.20 (100.00)	382.80 (100.00)	765.14 (100.00)
23.	Irrigation related expenses as percentage to total	16.44	21.26	24.25	-	20.96

* Overall indicates average of irrigated strata

Figures in paranthesis are percentage to total

Table 4.7.16 Operation wise cost of cultivation of BLACKGRAM IST CROP

(Amount in Rs./acre)

Sl. No.	Item	CWF N=1	CFF N=1	WFF N=2	SWF N=2	Overall* N=6	RFF N=3
1.	Preparatory cultivation	197.33 (24.53)	196.00 (29.33)	163.60 (33.22)	188.00 (23.53)	183.67 (26.21)	161.79 (45.28)
2.	Seeds & sowing						
3.	Nursery raising & maintainance	0.00	0.00	0.00	0.00	0.00	0.00
4.	Transplantation	0.00	0.00	0.00	0.00	0.00	0.00
5.	Manures & manuring	218.70 (27.17)	185.80 (27.80)	125.80 (25.54)	192.40 (24.07)	177.55 (25.34)	56.22 (15.74)
6.	Plant protection	0.00	0.00	0.00	0.00	0.00	0.00
7.	Weeding & intercultivation	40.00 (4.97)	0.00	12.00 (2.44)	60.00 (7.50)	36.67 (5.23)	0.00
8.	Harvesting	146.67 (8.22)	90.00 (13.46)	38.00 (7.72)	160.00 (20.02)	116.11 (16.57)	47.99 (13.44)
9.	Post harvest expenses						
10.	Land revenue and taxes	4.00 (0.50)	4.00 (0.60)	4.00 (0.81)	4.00 (0.50)	4.00 (0.57)	4.00 (1.12)
11.	Owned and hired machinery charges	0.00	0.00	0.00	0.00	0.00	0.00
12.	Depreciation and maintainance on farm buildings, machinery & equipments	98.90 (12.29)	96.70 (14.47)	91.10 (8.50)	97.90 (12.25)	96.04 (13.71)	45.10 (12.63)
13.	Interest on fixed capital of other capital investments	14.90 (1.85)	19.90 (2.98)	9.70 (1.97)	16.60 (2.08)	14.77 (2.11)	6.70 (1.88)
14.	Interest on working capital	16.30 (2.03)	11.00 (1.65)	7.70 (1.56)	19.40 (2.43)	14.70 (2.10)	7.60 (2.13)
15.	Irrigation labour charges	0.00	0.00	0.00	0.00	0.00	0.00
16.	Irrigation fuel charges	0.00	0.00	0.00	0.00	0.00	0.00
17.	Canal water charges	0.00	0.00	0.00	0.00	0.00	0.00
18.	Depreciation and maintainance on irrigation structures, machines and equipments	0.00	0.00	0.00	0.00	0.00	0.00
19.	Interest on fixed capital of irrigation equipments	0.00	0.00	0.00	0.00	0.00	0.00
20.	Rental value of land	68.00 (8.45)	65.00 (9.72)	40.60 (8.24)	60.90 (7.62)	56.90 (2.12)	27.80 (7.78)
21.	Others	-	-	-	-	-	-
22.	Total expenses	804.80	668.40	492.50	799.20	700.75	357.20
23.	Irrigation related expenses on percentage to total	0.00	0.00	0.00	0.00	0.00	0.00

* Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Table 4.7.17 Operation wise cost of cultivation of BLACKGRAM IIND CROP

(Amount in Rs./acre)

Sl. No.	Item	CWF N=1	CFF N=1	WFF N=3	SWF N=2	Overall N=7	RFF N=3
1.	Preparatory cultivation	276.17 (32.57)	293.30 (32.56)	176.85 (31.32)	217.18 (26.59)	211.93 (2.67)	153.10 (44.34)
2.	Seeds & sowing						
3.	Nursery raising & maintainance	0.00	0.00	0.00	0.00	0.00	0.00
4.	Transplantation	0.00	0.00	0.00	0.00	0.00	0.00
5.	Manures & manuring	79.51 (9.37)	183.36 (20.16)	25.58 (4.53)	93.82 (11.49)	41.73 (10.04)	43.46 (12.59)
6.	Plant protection	0.00	0.00	0.00	0.00	0.00	0.00
7.	Weeding & intercultivation	0.00	66.67 (7.33)	0.00	35.55 (4.35)	20.12 (2.82)	0.00
8.	Harvesting	181.39 (21.40)	133.33 (14.36)	54.00 (9.56)	142.21 (17.41)	103.78 (14.53)	55.14 (15.97)
9.	Post harvest expenses						
10.	Land revenue & taxes	4.00 (0.47)	4.00 (0.44)	4.00 (0.71)	4.00 (0.49)	4.00 (0.56)	4.00 (1.16)
11.	Owned and hired machinery charges	0.00	0.00	0.00	0.00	0.00	0.00
12.	Depreciation and maintainance on farm buildings, machinery & equipments	98.80 (11.65)	96.80 (10.65)	91.10 (16.13)	98.00 (12.00)	94.76 (13.27)	45.10 (13.06)
13.	Interest on fixed capital of other capital investments	14.90 (1.76)	20.10 (2.21)	9.70 (1.72)	16.60 (2.03)	13.71 (1.92)	6.70 (1.94)
14.	Interest on working capital	14.30 (1.69)	11.10 (1.22)	7.60 (1.35)	13.40 (1.64)	10.55 (1.48)	7.30 (2.11)
15.	Irrigation labour charges	13.43 (1.58)	20.67 (2.27)	25.27 (4.47)	12.34 (1.51)	19.30 (2.70)	0.00
16.	Irrigation fuel charges	52.80 (6.23)	0.00	52.10 (9.22)	54.10 (6.62)	46.89 (6.56)	0.00
17.	Canal water charges	12.00 (1.42)	12.00 (1.32)	0.00	12.00 (1.47)	6.50 (0.28)	0.00
18.	Depreciation and maintainance on irrigation structures, machines and equipments	39.70 (4.68)	0.00	57.30 (10.15)	47.30 (5.80)	45.88 (6.42)	0.00
19.	Interest on fixed capital of irrigation equipments	10.10 (1.19)	0.00	16.10 (2.85)	18.50 (2.27)	14.64 (2.05)	0.00
20.	Rental value of land	50.70 (5.98)	68.00 (7.43)	45.20 (8.00)	51.70 (6.33)	50.51 (7.07)	30.50 (8.83)
21.	Others	-	-	-	-	-	-
22.	Total expenses	847.80 (100.00)	909.30 (100.00)	564.80 (100.00)	816.70 (100.00)	714.30 (100.00)	345.30 (100.00)
23.	Irrigation related expenses on percentage to total	15.10	3.59	26.69	17.66	18.65	-

* Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Table 4.7.18 Operation wise cost of cultivation of HORSEGRAM IIND CROP

(Amount in Rs./acre)

Sl. No.	Item	CWF N=1	WFF N=2	SWF N=1	Overall* N=4	RFF N=8
1.	Preparatory cultivation	182.50 (24.41)	150.00 (28.35)	190.29 (27.02)	163.41 (26.94)	178.50 (48.13)
2.	Seeds & sowing					
3.	Nursery raising & maintainance	0.00	0.00	0.00	-	0.00
4.	Transplantation	0.00	0.00	0.00	-	0.00
5.	Manures & manuring	50.50 (6.74)	28.60 (5.40)	0.00	30.50 (5.03)	39.40 (10.62)
6.	Plant protection	0.00	0.00	0.00	-	0.00
7.	Weeding and intercultivation	0.00	0.00	44.89	5.61	0.00
8.	Harvesting	150.00 (20.26)	32.00 (6.06)	139.64 (19.62)	74.96 (12.36)	58.90 (15.88)
9.	Post harvest expenses					
10.	Land revenue & taxes	4.00 (0.53)	4.00 (0.76)	4 .00 (0.56)	4.00 (0.66)	4.00 (1.08)
11.	Owned & hired machinery charges	0.00	0.00	0.00	-	0.00
12.	Depreciation and maintainance on farm building, machinery & equipments	98.90 (13.23)	91.10 (17.21)	98.00 (13.77)	93.91 (15.48)	45.10 (12.16)
13.	Interest on fixed capital of other capital investments	14.90 (2.00)	9.70 (1.83)	16.50 (2.32)	11.85 (1.95)	6.80 (1.83)
14.	Interest on working capital	9.80 (1.31)	5.90 (1.11)	10.00 (1.40)	7.39 (1.22)	7.00 (1.89)
15.	Irrigation labour charges	15.00 (2.00)	8.00 (1.51)	9.98 (1.40)	10.00 (1.65)	0.00
16.	Irrigation fuel charges	76.20 (10.19)	60.60 (11.45)	56.10 (7.88)	63.94 (10.54)	0.00
17.	Canal water charges	11.60 (1.55)	0.00	12.00 (1.69)	4.40 (0.73)	0.00
18.	Depreciation and maintainance on irrigation structures, machinery and equipments	57.30 (7.67)	66.60 (12.59)	49.00 (6.89)	62.08 (10.23)	0.00
19.	Interest on fixed capital of irrigation equipments	14.50	18.70	19.20	17.71	0.00
20.	Rental value of land	62.50 (8.36)	54.00 (10.20)	60.00 (8.43)	56.88 (9.38)	31.20 (8.41)
21.	Others	-	-	-	-	-
22.	Total expenses	747.70 (100.00)	529.20 (100.00)	711.60 (100.00)	606.64 (100.00)	370.90 (100.00)
23.	Irrigation related expenses as percentage to total	23.35	29.08	20.56	26.07	-

* Overall indicates average of irrigated strata

Figures in paranthesis are percentage to total

Table 4.7.19 Operation wise cost of cultivation of COWPEA IST CROP

(Amount in Rs./acre)

Sl. No.	Item	CFF N=2	WPF N=2	Overall* N=4	RFF N=1
1.	Preparatory cultivation	274.82 (32.96)	151.00 (40.84)	212.91 (35.38)	134.00 (37.70)
2.	Seeds & sowing				
3.	Nursery raising & maintainance	-	-	-	-
4.	Transplantation	-	-	-	-
5.	Manures & manuring	250.37 (30.03)	0.00	125.19 (20.81)	86.00 (24.20)
6.	Plant protection	0.00	0.00	-	0.00
7.	Weeding & intercultivation	0.00	0.00	-	0.00
8.	Harvesting	104.81 (12.57)	67.50 (18.26)	86.16 (14.32)	42.00 (11.82)
9.	Post harvest expenses				
10.	Land revenue & taxes	4.00 (0.48)	4.00 (1.08)	4.00 (0.66)	4.00 (1.13)
11.	Owned & hired machinery charges	0.00	0.00	-	0.00
12.	Depreciation & maintainance on farm building, machinery & equipments	96.60 (11.59)	91.20 (24.67)	93.90 (15.61)	45.10 (12.69)
13.	Interest on fixed capital of other capital investments	20.10 (2.41)	9.70 (2.62)	14.90 (2.48)	6.70 (1.89)
14.	Interest on working capital	17.00 (2.04)	5.80 (1.57)	11.40 (1.89)	7.60 (2.14)
15.	Irrigation labour charges	0.00	0.00	-	0.00
16.	Irrigation fuel charges	0.00	0.00	-	0.00
17.	Canal water charges	0.00	0.00	-	0.00
18.	Depreciation and maintainance on irrigation structures, machinery & equipments	0.00	0.00	-	0.00
19.	Interest on fixed capital of irrigation equipments	0.00	0.00	-	0.00
20.	Rental value of land	66.00 (9.92)	40.50 (10.95)	53.25 (8.85)	30.00 (8.44)
21.	Others	-	-	-	-
22.	Total expenses	833.70 (100.00)	369.70 (100.00)	601.71 (100.00)	355.40 (100.00)
23.	Irrigation related expenses as percentage to total	0.00	0.00	0.00	0.00

* Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Figures in paranthesis are percentages to total

4.8 Optimisation of irrigation water

An attempt was made to optimise the available irrigation water through the use of linear programming technique. The analysis was done collectively for all the sample farms in each of the irrigated category, taking the aggregate of area under each crop. Existing perinneal crops like coconut have been excluded from the calculations whereas some other annuals/perinneals like banana and mulberry have also been considered as alternative crops in the L.P. The model that was used was

Maximise $Z = C'X$

Subject to $AX \leq B$ and $X \geq 0$

$X = (x_1\ x_2\ ---\ x_p)'$ where x_i is the area under crop i

$C' = (c_1\ c_2\ ---\ c_p)'$ where c_i is the net income from unit area of the crop i

$B = (b_1\ b_2\ ---\ b_p)'$ where b_i is the maximum input available for the i^{th} activity

$A = (aij)_{n \times p}$ where aij is the level of i^{th} input required per unit area under crop j

As stated above, farms have been considered in aggregate, with the total area under each category being considered for

Table 4.7.19 Operation wise cost of cultivation of COWPEA IST CROP

(Amount in Rs./acre)

Sl. No.	Item	CFF N=2	WFF N=2	Overall* N=4	RFF N=1
1.	Preparatory cultivation	274.82 (32.96)	151.00 (40.84)	212.91 (35.38)	134.00 (37.70)
2.	Seeds & sowing				
3.	Nursery raising & maintainance	-	-	-	-
4.	Transplantation	-	-	-	-
5.	Manures & manuring	250.37 (30.03)	0.00	125.19 (20.81)	86.00 (24.20)
6.	Plant protection	0.00	0.00	-	0.00
7.	Weeding & intercultivation	0.00	0.00	-	0.00
8.	Harvesting	104.81 (12.57)	67.50 (18.26)	86.16 (14.32)	42.00 (11.82)
9.	Post harvest expenses				
10.	Land revenue & taxes	4.00 (0.48)	4.00 (1.08)	4.00 (0.66)	4.00 (1.13)
11.	Owned & hired machinery charges	0.00	0.00	-	0.00
12.	Depreciation & maintainance on farm building, machinery & equipments	96.60 (11.59)	91.20 (24.67)	93.90 (15.61)	45.10 (12.69)
13.	Interest on fixed capital of other capital investments	20.10 (2.41)	9.70 (2.62)	14.90 (2.48)	6.70 (1.89)
14.	Interest on working capital	17.00 (2.04)	5.80 (1.57)	11.40 (1.89)	7.60 (2.14)
15.	Irrigation labour charges	0.00	0.00	-	0.00
16.	Irrigation fuel charges	0.00	0.00	-	0.00
17.	Canal water charges	0.00	0.00	-	0.00
18.	Depreciation and maintainance on irrigation structures, machinery & equipments	0.00	0.00	-	0.00
19.	Interest on fixed capital of irrigation equipments	0.00	0.00	-	0.00
20.	Rental value of land	66.00 (9.92)	40.50 (10.95)	53.25 (8.85)	30.00 (8.44)
21.	Others	-	-	-	-
22.	Total expenses	833.70 (100.00)	369.70 (100.00)	601.71 (100.00)	355.40 (100.00)
23.	Irrigation related expenses as percentage to total	0.00	0.00	0.00	0.00

* Overall indicates average of irrigated strata

Figures in paranthesis are percentages to total

Table 4.7.20 Operationwise cost of cultivation of COWPEA IIND CROP

(Amount in Rs./acre)

Sl. No.	Item	WFF N=1	RFF N=2
1.	Preparatory cultivation	180.00 (26.74)	150.00 (48.00)
2.	Seeds & sowing		
3.	Nursery raising & maintainance	0.00	0.00
4.	Transplantation	0.00	0.00
5.	Manures & manuring	69.60 (10.34)	36.30 (11.62)
6.	Plant protection	0.00	0.00
7.	Weeding & intercultivation	0.00	0.00
8.	Harvesting	30.00 (4.46)	29.00 (9.28)
9.	Post harvest expenses		
10.	Land revenue & taxes	4.00 (0.59)	4.00 (1.28)
11.	Owned & hired machinery charges	0.00	0.00
12.	Depreciation and maintainance on farm building, machinery & equipments	91.20 (13.55)	45.10 (14.43)
13.	Interest on fixed capital of other capital investments	9.70 (1.44)	6.70 (2.14)
14.	Interest on working capital	7.70 (1.14)	6.40 (2.05)
15.	Irrigation labour charges	12.00 (1.78)	0.00
16.	Irrigation fuel charges	84.40 (12.54)	0.00
17.	Canal water charges	0.00	0.00
18.	Depreciation and maintainance on irrigation structure, machinery & equipments	92.80	0.00
19.	Interest on fixed capital of irrigation equipments	26.10	0.00
20.	Rental value of land	65.60 (9.75)	35.00 (11.20)
21.	Others	-	-
22.	Total expenses	673.10 (100.00)	312.50 (100.00)
23.	Irrigation related expenses as percentage to total	31.99	-

Figures in paranthesis are percentages to total

4.8 Optimisation of irrigation water

An attempt was made to optimise the available irrigation water through the use of linear programming technique. The analysis was done collectively for all the sample farms in each of the irrigated category, taking the aggregate of area under each crop. Existing perinneal crops like coconut have been excluded from the calculations whereas some other annuals/perinneals like banana and mulberry have also been considered as alternative crops in the L.P. The model that was used was

Maximise $Z = C'X$

Subject to $AX \leq B$ and $X \geq 0$

$X = (x_1\ x_2\ ---\ x_p)'$ where x_i is the area under crop i

$C' = (c_1\ c_2\ ---\ c_p)'$ where c_i is the net income from unit area of the crop i

$B = (b_1\ b_2\ ---\ b_p)'$ where b_i is the maximum input available for the i^{th} activity

$A = (aij)_{n \times p}$ where aij is the level of i^{th} input required per unit area under crop j

As stated above, farms have been considered in aggregate, with the total area under each category being considered for

optimal utilisation of irrigation water and not the individual farms water use and the consequent profit, which is usually taken in such calculation. Net income has been calculated over (Cost B - rental value of land).

Optimisation of irrigation water was tried under the present level of water use as well as under normative levels of -10% and +10% of the present water use. This sort of normative situations can arise consequent to shortage or excess of rain or shortage/excess of irrigation water that is available.

The optimum plans evolved under existing levels of water use and normative levels of -10% and +10% levels of water use for the various irrigated categories have been given in Table 4.8.1 to Table 4.8.4.

4.8.1 Canal with well fed farms

Table 4.8.1 gives a comparative picture of the present cropping pattern as well as optimum cropping patterns evolved out of the linear programming. It can be seen that in all the optimum plans (under various situations), there has been marginal increase in the gross cropped area.

Gross cropped area increased from 137.05 acres to 139.42 acres when the present level of water use was optimised. Crops other than paddy 1st crop and groundnut 1st and 2nd crops have disappeared and tomato as well as mulberry have been suggested. Area under groundnut 1st crop

has increased from 17.5 acres to 21.57 acres (23.26% rise) and that of groundnut 2nd crop from 26.3 acres to 41.05 acres (56.08% rise). Paddy 1st crop has maintained its status quo areawise, at 41.05 acres. The new plan suggests that introduction of tomato in 21.57 acres and mulberry in 14.18 acres will be beneficial. All these changes have resulted in the substantial increase of net income from Rs. 1.13 lakhs to Rs. 2.33 lakhs (105.5% rise) in the optimum plan.

Normative plan under -10% level of water use indicate an increase in gross cropped area, elimination of all crops other than paddy 1st crop and groundnut 1st and 2nd crops and introduction of tomato and mulberry. Area under paddy 1st crop got reduced to 36.94 acres from 41.05 acres (-10% change). That of groundnut 1st crop increased from 17.50 acres to 27.10 acres (+54.86%) and groundnut 2nd crop from 26.30 acres to 36.94 acres (+40.46%). Tomato 2nd crop and mulberry, which got introduced, had an area of 27.1 acres and 12.76 acres respectively. Even in normative plan of -10% level water use, the net farm income was much higher at 2.2 lakhs when compared to the present income of 1.13 lakhs (93.8% increase).

Results of the optimisation conducted for normative water availability situation of +10% than the existing level of water use indicate almost the same result as the above two optimisations. Crops other than paddy 1st crop and groundnut 1st and 2nd crops have disappeared. New crops of tomato and mulberry have been suggested. Paddy 1st crop

occupies an area of 45.15 acres compared to the present area of 41.05 acres (9.99% increase. Groundnut 1st crop was suggested in 16.05 acres compared to 17.50 acres in the present plan (-8.29% change) and groundnut 2nd crop was suggested in 45.15 acres from the present 26.30 acres (71.67% increase). Tomato was suggested to be cultivated in 16.05 acres and mulberry in 15.60 acres. The gross cropped area increased marginally from 137.85 acres to 138.00 acres and the net farm income from Rs. 1.13 lakhs to Rs. 2.46 lakhs (117.22% change).

To sum it up, one can see that the present level of water use in canal with well irrigated farms is sub optimal in nature as indicated by a shift in cropping pattern and resultant increase in gross cropped area and net income in the alternate optimisations that were tried. Even in a theoritically water deficient situation, the net farm income would be 93.8% higher than the present level of income.

4.8.2 Canal fed farms

Results of the optimisation tried with available water, on canal fed farms have been presented in Table 4.8.2.

When the present level of use of water was optimised, it was seen that minor crops like sorghum, pulses etc. have given way to one of the major cultivated crops namely groundnut. The optimum plan suggests cultivation of groundnut 1st crop in 11.75 acres compared to 8.25 acres now under the

crop (+42.42% rise) and groundnut 2nd crop in 30.71 acres compared to 23.50 acres (+30.68% rise) that the crop presently occupied. Area under paddy 1st crop has remained at the same level of 56.85 acres whereas that of paddy 2nd crop has marginally got reduced to 37.89 acres from 38.85 acres (-2.47%). The gross cropped area has marginally increased from 136.45 acres to 137.20 acres (+0.55% increase) and the net farm income from Rs. 1.56 lakhs to Rs. 1.60 lakhs (+2.5%).

Normative plan evolved under reduced levels of water availability at -10% suggests reduction in area under paddy 1st crop from 56.85 acres to 51.17 acres (-9.99% fall and paddy 2nd crop from 38.85 acres to 31.35 acres (-19.31% fall). Area under groundnut 1st crop has been suggested to be increased from 8.25 acres to 17.43 acres (+111.27% increase) and groundnut 2nd crop from 23.50 acres to 37.25 acres (+58.51% rise). Rest of the crops other than paddy and groundnut have been eliminated. The gross cropped area was marginally higher at 137.20 acres and net farm income was low at Rs. 1.508 lakhs compared to 1.560 lakhs previously (-3.41% fall).

Optimisation was tried at normative levels of +10% higher level of water availability than the present level of water use. Results indicate that it would be beneficial to cultivate more of paddy and groundnut 2nd crop and less of groundnut 1st crop. As per the plan, all other crops have to be eliminated. Area under paddy 1st crop has been

suggested to be increased to 62.53 acres from 56.85 acres (+9.99% rise), that of paddy 2nd crop from 38.85 acres to 43.03 acres (+10.76% increase) and groundnut 2nd crop from 23.50 acres to 25.57 acres (+8.81% increase). The area under groundnut 1st crop has been suggested to be reduced to 6.07 acres from the present level of 8.25 acres (-26.24% fall) and other crops have been eliminated. The net farm income has increased from Rs. 1.56 lakhs to Rs. 1.69 lakhs (+8.36% rise).

The conclusions that can be drawn from the above results are:

1) Crops other than paddy and groundnut are not that paying as to justify their cultivation when crop water use is also taken into account.

2) As water availability increases, it will be beneficial for the farms to allocate more of area to paddy and less of area to groundnut. This holds true vice-versa also.

3) Reduction and increase in water availability results in less than proportionate reduction as well as increase respectively, in the net farm income.

4.8.3 Well fed farms

Table 4.8.3 gives a comparative idea of the present as well as optimum cropping patterns that were evolved out of the optimisation trails, in the well fed category.

When the existing level of available water was optimised, it was seen that crops other than paddy, groundnut, cotton and tomato were eliminated. In the optimum plan, the area under paddy 1st crop remained same whereas that of groundnut 1st crop increased from 49.05 acres to 61.19 acres (+24.75% rise) and groundnut 2nd crop increased from 61.30 acres to 70.10 acres (+14.36% increase). Cotton crop was suggested in 12.86 acres compared to present level of cultivation of 7.00 acres (+83.71% increase). Area under tomato 2nd crop was suggested to be increased from 1.00 acre to 14.39 acres. Mulberry crop which was introduced into the L.P. model was suggested in 14.66 acres. The gross cropped area in the optimum plan was lower at 218.95 acres compared to 225.40 acres previously (-2.86% fall). This reduction is mainly due to the introduction of mulberry crop, which is an year round crop (had the same space been occupied by some of the seasonals round the year, the gross cropped area figures would have gone up). The net farm income increased remarkeably in the optimum plan from 1.026 lakhs to Rs. 2.246 lakhs (+118.80% rise).

Optimum plan evolved for normative water dificient situation of -10% suggests reduction of area under paddy 1st crop from 45.75 acres to 41.18 acres (-9.99% fall). Groundnut 1st crop was suggested in 67.68 acres compared to the present extent of 49.05 acres (+37.98% rise) and groundnut 2nd crop in 62.52 acres compared to the present

level of 61.20 acres (+1.99% rise). Mulberry was suggested to be cultivated in 12.74 acres of the cropped area, cotton was suggested in 12.54 acres and tomato in 13.37 acres. All other crops have been suggested to be eliminated in the optimum plan. Even though the gross cropped area has come down from 225.4 acres to 210.03 acres (-6.82% fall), the net farm income was higher at Rs. 2.036 lakhs compared to Rs. 1.026 lakhs (+98.36% rise).

Normative plan evolved for a 10% excess water situation suggests cultivation of paddy 1st crop in 50.33 acres compared to 45.75 acres (+10.01% rise). Groundnut 1st crop was suggested in 55.15 acres compared to 49.05 acres being presently cultivated (+12.44% rise), groundnut 2nd crop in 80.28 acres (+30.96% rise), cotton 2nd crop in 14.15 acres compared to 7.00 acres (+102.14% increase) and tomato in 11.05 acres compared to the present area of 1.00 acre. Mulberry which was an introduced crop was suggested to be cultivated in 16.12 acres. The gross cropped area was higher at 227.08 acres compared to 225.40 acres (+0.75% rise) and the net farm income was higher at Rs. 2.419 lakhs compared to Rs. 1.026 lakhs (+135.60% rise).

The optimisations tried in well fed farms reveal the following:

1) Present cropping pattern is suboptimal in use of resources. A shift in the cropping would be in line with optimum use of available water and land.

2) Rational use of water resource will increase net farm income. It is possible to achieve a net farm income of almost double the present level even at reduced levels of water availability if the available water is used rationally.

3) Increase in water availability results in a more than proportionate increase in net farm income.

4.8.4 Spout fed well irrigated farms

Table 4.8.4 gives an idea of the present as well as optimum cropping patterns in the spout fed well irrigated category of farms.

When the existing level of water use was tried to be optimised, it was seen that crops other than paddy, groundnut and tomato were uneconomical to be cultivated. Paddy 1st crop maintained it's statusquo area-wise by occupying an area of 63.00 acres in the optimum plan. Area under groundnut 1st crop increased from 13.00 acres to 24.83 acres (+91.00% rise), that of groundnut 2nd crop increased from 47.50 acres to 63.00 acres (+32.63% rise) and tomato 2nd crop's area increased from 0.80 acres to 24.83 acres. Mulberry was suggested to be grown in 12.47 acres. The gross cropped area increased from 180.40 acres to 188.13 acres (+4.28%) and net farm income from Rs. 1.686 to Rs. 2.697 lakhs (+59.91% increase).

Optimum plan evolved for a normative situation of -10% level of water availability suggests reduction in area under paddy 1st crop from 63 acres to 56.81 acres (-9.83% fall). Groundnut 1st crop is suggested to be raised in 32.27 acres compared to 13.00 acres (+148.23% rise) and groundnut 2nd crop in 56.81 acres compared to 47.50 acres (+19.60% rise). Area under tomato 2nd crop has been suggested to be increased to 32.27 acres and mulberry has been suggested to be introduced in 11.22 acres. The gross cropped area has increased from 180.40 acres to 189.38 acres (+4.98% rise) and net farm income was also higher at Rs. 2.55 lakhs compared to Rs. 1.686 lakhs (+51.29% increase).

Optimisation tried for a normative 10% additional water availability situation reveals that increasing area under paddy 1st crop from 63.00 acres to 69.30 acres (+10% rise) would be in line with increasing profits. Groundnut 1st crop was suggested to be raised in 17.29 acres compared to 13.00 acres (+33.00% increase) and groundnut 2nd crop in 69.30 acres compared to the present level of 47.50 acres (+45.89% rise). Tomato 2nd crop, was suggested to be raised in 17.29 acres compared to the present level of 0.80 acres. All other crops other than those mentioned above have been suggested to be eliminated from the cropping pattern. Additionally, mulberry has been suggested for cropping in 13.71 acres. The gross cropped area increased from 180.40 acres to 186.89 acres (+3.60% rise). Net farm income increased from Rs. 1.686 lakhs to Rs. 2.843 lakhs (+68.55% rise).

The result of optimisations reveals that the present cropping pattern is sub-optimal in nature with respect to use of resources. Net income for the farms in aggregate can be increased even at reduced levels of water availability if resources are used optimally.

Table 4.8.1 Canal + well fed (CWF) farms: Present cropping pattern and optimum cropping patterns compared

(Area in acres)

Crop	Present cropping pattern under existing level of water use	Optimum cropping pattern under (a) Existing level of water use	%age change of(3) over(2)	(b) -10% level of water use	%age change of(4) over(2)	(c) +10% level of water use	%age change of(5) over(2)
(1)	(2)	(3)		(4)		(5)	
Paddy I*	41.05	41.05	0.00	36.94	-10.01	45.15	9.99
Paddy II*	22.25	0.00	-100.00	0.00	-100.00	0.00	-100.00
Groundnut I	17.50	21.57	23.26	27.10	54.86	16.05	-8.29
Groundnut II	26.30	41.05	56.08	36.94	40.46	45.15	71.67
Groundnut III	3.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Sugarcane (N.P.)	6.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Sugarcane (Rat.)	4.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Tapioca	3.75	0.00	-100.00	0.00	-100.00	0.00	-100.00
Sorghum I	1.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Sorghum II	1.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Cotton II	3.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Ragi I	1.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Ragi II	0.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Chama II	2.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Black gram I	1.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Black gram II	0.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Horse gram II	2.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Sesamum III@	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Banana@	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tomato II@	0.00	21.57	-	27.10	-	16.05	-
Mulberry@	0.00	14.18	-	12.76	-	15.60	-
Gross cropped area (acres)	137.85	139.42	1.14	140.84	2.17	138.00	0.11
Net farm income (Rs.)	113436.40	233121.50	105.51	219836.40	93.80	246402.70	117.22

* I refers to first crop, II means second crop and III means third crop

@ These are crops introduced into the L.P.

Table 4.8.2 Canal fed (CFF) farms: Present cropping pattern and optimum cropping patterns compared

(Area in acres)

Crop	Present cropping pattern under existing level of water use	Optimum cropping pattern under					
		(a) Existing level of water use	%age change of(3) over(2)	(b) -10% level of water use	%age change of(4) over (2)	(c) +10% level of water use	%age change of(5) over(2)
(1)	(2)	(3)		(4)		(5)	
Paddy I	56.85	56.85	0.00	51.17	-9.99	62.53	9.99
Paddy II	38.85	37.89	-2.47	31.35	-19.31	43.03	10.76
Groundnut I	8.25	11.75	42.42	17.43	111.27	6.07	-26.42
Groundnut II	23.50	30.71	30.68	37.25	58.51	25.57	8.81
Sorghum I	0.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Sorghum II	3.75	0.00	-100.00	0.00	-100.00	0.00	-100.00
Cotton II	1.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Blackgram I	1.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Blackgram II	0.75	0.00	-100.00	0.00	-100.00	0.00	-100.00
Cowpea I	2.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Gross cropped area (acres)	136.45	137.20	0.55	137.20	0.55	137.20	0.55
Net farm income (Rs.)	156142.90	160051.30	2.50	150813.60	-3.41	169194.40	8.36

Table 4.8.3 Well fed farms(WFF): Present cropping pattern and optimum cropping patterns compared

(Area in acres)

Crop	Present cropping pattern under existing level of water use	Optimum cropping pattern under					
		(a) Existing level of water use	%age change of(3) over (2)	(b) -10% level of water use	%age change of(4) over(2)	(c) +10% level of water use	%age change of(5) over(2)
(1)	(2)	(3)		(4)		(5)	
Paddy I	45.75	45.75	0.00	41.18	-9.99	50.33	10.01
Paddy II	8.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Groundnut I	49.05	61.19	24.75	67.68	37.98	55.15	12.44
Groundnut II	61.30	70.10	14.36	62.52	1.99	80.28	30.96
Sugarcane (NP)	14.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Sorghum I	3.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Sorghum II	15.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Cotton II	7.00	12.86	83.71	12.54	79.14	14.15	102.14
Ragi I	1.30	0.00	-100.00	0.00	-100.00	0.00	-100.00
Tomato II	1.00	14.39	1339.00	13.37	1237.00	11.05	1005.00
Chama I	3.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Chama II	3.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Blackgram I	2.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Blackgram II	3.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Cowpea: I	2.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Cowpea II	0.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Horsegram II	5.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Groundnut III@	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sesamum III@	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sugarcane (Rat)@	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tapioca@	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Banana@	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mulberry@	0.00	14.66	-	12.74	-	16.12	-
Gross cropped area (acres)	225.40	218.95	-2.86	210.03	-6.82	227.08	0.75
Net farm income(Rs)	102685.70	224686.40	116.80	203683.60	98.36	241931.30	135.60

@ These are crops introduced into the L.P.

Table 4.8.4 Spout-fed well irrigated farms (SWF): Present cropping pattern and optimum cropping patterns compared

(Area in acres)

Crop	Present cropping pattern under existing level of water use	Optimum cropping pattern under					
		(a) Existing level of water use	%age change of(3) over(2)	(b) -10% level of water use	%age change of(4) over(2)	(c) +10% level of water use	%age change of(5) over(2)
(1)	(2)	(3)		(4)		(5)	
Paddy I	63.00	63.00	0.00	56.81	-9.83	69.30	10.00
Paddy II	15.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Groundnut I	13.00	24.83	91.00	32.27	148.23	17.29	33.00
Groundnut II	47.50	63.00	32.63	56.81	19.60	69.30	45.89
Sugarcane (NP)	4.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Sugarcane (Rat.)	8.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Tapioca	2.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Sorghum I	4.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Sorghum II	10.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Ragi I	1.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
Tomato II	0.80	24.83	303.75	32.27	3933.75	17.29	2061.25
Chama II	3.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Blackgram I	4.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Blackgram II	2.30	0.00	-100.00	0.00	-100.00	0.00	-100.00
Cowpea I	0.30	0.00	-100.00	0.00	-100.00	0.00	-100.00
Horsegram II	1.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
Banana@	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sesamum III@	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Groundnut III@	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mulberry@	0.00	12.47	-	11.22	-	13.71	-
Gross cropped area (acres)	180.40	188.13	4.28	189.38	4.98	186.89	3.60
Net farm income(Rs)	168681.80	269743.35	59.91	255205.40	51.29	284308.40	68.55

@ These are crops introduced into the L.P.

4.8.5 Inter category comparisons

Response to the excercises of optimising irrigation water has been different with respect to the various categories of irrigation. This is evident from the range of change in cropping pattern and the resultant net income when the existing level of water use was optimised using the tool of L.P. While there is a significant change in cropping pattern and net income in the case of well fed farms, the proportion of change (with respect to net farm income) is comparatively less in case of spout-fed well irrigated farms and almost negligible for canal fed farms.

It can be seen that there is a suggestion in the optimum plans for concentrating on few prominent crops rather than going in for a large number of crop mixes. Optimum plan for existing level of water use indicate that except in the case of well fed farms, the gross cropped area has been more in all the categories. The net income change was for a better by 118.8% in the well fed farms, +105.51% in canal with well fed farms, +59.91% in spout-fed well irrigated farms and only +2.50% in canal fed farms. This throws light to the fact that water utilisation has been almost near to optimum

levels in case of canal fed farms and far from optimum levels in the case of other categories.

Normative plan developed for a possible reduction in water availability by 10% indicate that except in the case of canal fed farms, in all other categories, the net income was even far higher than the income from present cropping pattern. This clearly indicates that it isnot the water availability that matters much but it is the rational use of the scarce input that is more important. Optimum plans clearly demonstrate the possibility of increasing net income by adopting a judicious crop mix, even for lower levels of water availability.

Similarly, normative plans developed for increased levels of water availability also indicate a clear possibility of increasing net farm income. However, the projected increase is not uniform for all the categories of farms. While there is an increase of net income by just 8.36% for canal fed farms, the increase in income for well fed farms was 135.6%, that of canal with well fed farms was 117.22% and spout fed well irrigated farms was 68.55%. This clearly calls for measures of augmenting water supply in all the categories and especially in the latter three categories mentioned above. Further development of minor irrigation by renovation/deepening of existing wells and tanks will be highly beneficial, if hydrogeological conditions permit doing so.

It is felt that a discussion on crop wise changes in the optimum plans will be useful. Table 4.8.5.1 to 4.8.5.7 gives an idea of the shift in cropped area under the various crops that have been suggested in the optimum plans.

a) Paddy Ist crop

Shift in cropped area under paddy Ist crop is given in Table 4.8.5.1. When irrigation water use was tried to be optimised at existing level of availability, it was seen that there was no change in the cropped area, which remained constant at 206.65 acres, for all the irrigated farms taken together. This indicates that the first crop paddy uses the water input in the most economic manner, and no further economisation of this input is possible. Normative plans with reduced and increased water availabilities of -10% and +10% indicate an almost proportionate reduction and increase (-9.94% and +10.0% respectively) in the cropped area.

Thus it can be safely concluded that there is no question of substitution of area under first crop of paddy by any other crop and optimum area under first crop of paddy can be increased or decreased in the same proportion of increase or decrease of water availability under irrigated conditions.

b) Paddy IInd crop

It is interesting to note from Table 4.8.5.2 that except for canal fed farms, the second crop of paddy got eliminated from the optimum plans of all other irrigated categories.

In the case of canal irrigated farms, optimum plans with existing level of water use shows a reduction in the crop area from 38.85 to 37.89 acres. A 10% reduction in water availability from the existing level brought about a 19.31% reduction in the area under the normative plan. An increase in water availability by 10% would result in an increase of area by 10.76% in the optimal plan for canal fed farms. This leads to the inference that as water availability decreases, there would be need for more than proportionate decrease in crop area allotment for paddy IInd crop, in order to optimise water use. Similarly, as water availability increases, an almost proportionate increase in the crop area would result in optimum use of water.

However, in the aggregate, optimum plans for irrigated categories other than the canal fed one call for a drastic reduction in cropped area under second crop of paddy both in the existing levels of water use as well as in normative levels of -10% and +10% of use of water. For the canal fed farms, the suggested reduction is only marginal.

c) Groundnut Ist crop

Shift in cropped area under optimal plans for groundnut Ist crop is given in Table 4.8.5.3. The overall figures for the irrigated farms indicate that there would be an increase in area under optimum plan by 35.92% when present level of water use was optimised. The area increased from 87.80 acres to 119.34 acres. This positive change varied from 23.26% in

case of canal with well irrigated farms, to 91% in the case of spout fed well irrigated farms.

In the optimum plans for normative level of -10% water use, the area under first crop of groundnut increased substantially to 144.48 acres from 87.80 acres (64.56% rise). When water availability increased by 10%, the area under the crop increased by only 7.7% (from 87.8 acre to 94.56 acres), indicating a less than proportionate increase in acreage vis-a-vis water availability, in optimum plans. In fact, for canal with well irrigated farms and canal irrigated farms, an increase in water availability resulted in a decrease of cropped area. As a whole, it can be inferred that for groundnut Ist crop, an increase in water availability would necessitate a less than proportionate increase in cropped area and a decrease in water availability would need an increase in cropped area, for the cropping pattern to be optimum with respect to use of water.

d) Groundnut IInd crop

Table 4.8.5.4 gives an idea of the shift in cropped area for second crop of groundnut under optimal plans. The overall acreage for the irrigated farms increased from 158.6 to 204.86 (29.17% rise) when the existing level of water use was optimised.

Under normative level of -10% (of the existing level of water use) also, the optimum crop area increased from

158.6 acres to 193.52 acres (22.02% rise). When water availability was increased by 10%, the optimum area increased by 38.9%. An exception to the general rule was found in canal fed farm were a 10% increase in water use brought about a less than proportionate (8.81%) increase in optimum acreage.

Inference of the analysis is that in both the optimisations under existing levels of water use and water use at normative levels of -10% and +10%, the optimum area under groundnut second crop was more than the present acreage under it. However, the increase in area under -10% level of water use was less than the percentage increase in area at +10% level of water use.

e) Tomato IInd crop

There was a substantial increase in area under Tomato in the optimum plans, as can be seen from Table 4.8.5.5. Tomato crop got itself introduced in the optimum plans in the case of canal with well irrigated farms. The overall figures for irrigated categories, when the existing level of water use was optimised, indicate that an increase in area by 3277.2% (from 1.8 acres to 60.79 acres) would be in line with the objectives of the linear programming application i.e., increase in net income and optimisation of use of available water. When optimum plans were derived at -10% levels of water use, the area under tomato still increased, to 72.74 acres. When water level was increased by +10%, the optimum plans indicated an acreage of 44.39

which showed a reduction when compared to the optimum acreage under existing level of water use (60.79 acres).

The general inference that can be drawn from the optimum plans for tomato second crop is that, as water availability increases, the optimum area under it gradually decreases and vice versa.

f) Cotton IInd crop

Optimum plans for the irrigated farms taken overall, at different levels of water use indicate an increase in cropped area under cotton IInd crop, as can be seen from Table 4.8.5.6. Whereas the area under cotton got totally wiped off in the optimal plans for canal with well and canal irrigated categories, the crops area got increased in the optimal plans for the well fed category of farms. The overall area increased from 11 to 12.86 acre in the optimum plans for existing level of water use, mainly influenced by an increase in the area under well fed farms. When the water availability was reduced by 10%, the area, eventhough 14% more than the present cropped area, decreased to 12.54 from 12.86 (the optimum aree at existing level of water use). When water availability was increased, the area under the crop increased to 14.15 from 11 acres. The general inference that was drawn was that as water availability increases, the area under cotton also increases and as water availability decreases, the optimum area also decreases vis-a-vis the optimum area under existing level of water use.

g) Mulberry

Table 4.8.5.7 gives a picture of the position of Mulberry crop in the optimal plan. Mulberry being a perinneal crop needs water round the year. This cannot be provided under the canal irrigated category, where, water will be available only for 9 to 10 months. Mulberry is a relatively new crop started to be cultivated in the Chittur Block around 1985. The cost and returns were estimated and was introduced in the L.P. in all categories except the canal fed one. Remarkably enough, the crop got introduced itself in the crop mixes of all the categories under all levels of irrigation water availability.

For all the irrigated farms, the optimum area for Mulberry under existing levels of water use was found to be 41.31 acres. When water availability was restricted by 10% in the normative plans, the area came down to 36.72 acres and when the water availability was increased by 10%, the optimum area changed to 45.43 acres. It can thus be inferred that as water availability increases, optimum area under Mulberry also increases.

Table 4.8.5.1 Shift in cropped area under optimal plans - Paddy Ist crop

(Area in acres)

Sl. No.	Category of Irrigation	Cropped area under existing level of water use	Cropped area under optimum plans with (a) Existing level of water use	%age change of (4) over (3)	(b) -10% level of water use	%age change of (5) over (3)	(c) +10% level of water use	%age change of (6) over (3)
(1)	(2)	(3)	(4)		(5)		(6)	
1.	CWF	41.05	41.05	0.0	36.94	-10.01	45.15	9.99
2.	CFF	56.85	56.85	0.00	51.17	-9.99	62.53	9.99
3.	WFF	45.75	45.75	0.00	41.18	-9.99	50.33	10.01
4.	SWF	63.00	63.00	0.00	56.81	-9.83	69.30	10.00
5.	OVERALL	206.65	206.65	0.00	186.10	-9.94	227.31	10.00

Table 4.8.5.2 Shift in cropped area under optimal plans - Paddy IInd crop

(Area in acres)

Sl. No.	Category of irrigation	Cropped area under existing level of water use	Cropped area under optimum plans with					
			(a) Existing level of water use	%age change of (4) over (3)	(b) -10% level of water use	%age change of (5) over (3)	(c) +10% level of water use	%age change of (6) over (3)
(1)	(2)	(3)	(4)		(5)		(6)	
1.	CWF	22.25	0.00	-100.00	0.00	-100.00	0.00	-100.00
2.	CFF	38.85	37.85	-2.47	31.35	-19.31	43.03	10.76
3.	WFF	8.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
4.	SWF	15.50	0.00	-100.00	0.00	-100.00	0.00	-100.00
5.	OVERALL	84.60	37.85	-55.21	31.35	-62.94	43.03	-49.14

Table 4.8.5.3 Shift in cropped area under optional plans - Groundnut Ist crop

(Area in acres)

Sl. No.	Category of irrigation	Cropped area under existing level of water use	Cropped area under optimum plans with					
			(a) Existing level of water use	%age change of (4) over (3)	(b) -10% level of water use	%age change of (5) over (3)	(c) +10% level of water use	%age change of (6) over (3)
(1)	(2)	(3)	(4)		(5)		(6)	
1.	CWF	17.50	21.57	23.26	27.10	54.86	16.05	-8.29
2.	CFF	8.25	11.75	42.42	17.43	111.27	6.07	-26.42
3.	WFF	49.05	61.19	24.75	67.68	37.98	55.15	12.44
4.	SWF	13.00	24.83	91.00	32.27	148.23	17.29	33.00
5.	OVERALL	87.80	119.34	34.92	144.48	64.56	94.56	7.70

Table 4.8.5.4 Shift in cropped area under optimal plans - Groundnut IInd crop

(Area in acres)

Sl. No.	Category of irrigation	Cropped area under existing level of water use	Cropped area under optimum plans with					
			(a) Existing level of water use	%age change of (4) over (3)	(b) -10% level of water use	%age change of (5) over (3)	(c) +10% level of water use	%age change of (6) over (3)
(1)	(2)	(3)	(4)		(5)		(6)	
1.	CWF	26.30	41.05	56.08	36.94	40.46	45.15	71.67
2.	CFF	23.50	30.71	30.68	37.25	58.51	25.57	8.81
3.	WFF	61.30	70.10	14.36	62.52	1.99	80.28	30.96
4.	SWF	47.50	63.00	32.63	56.81	19.60	69.30	45.89
5.	OVERALL	158.60	204.86	29.17	193.52	22.02	220.30	38.90

Table 4.8.5.5 Shift in cropped area under optimal plans - Tomato IInd crop

(Area in acres)

Sl. No.	Category of irrigation	Cropped area under existing level of water use	Cropped area under optimum plans with					
			(a) Existing level of water use	%age change of (4) over (3)	(b) -10% level of water use	%age change of (5) over (3)	(c)+10% level of water use	%age change of (6) over (3)
(1)	(2)	(3)	(4)		(5)		(6)	
1.	CWF	0.00	21.57	-	27.10	-	16.05	-
2.	CFF	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.	WFF	1.00	14.39	1339.00	13.37	1237.00	11.05	1005.00
4.	SWF	0.80	24.83	3003.75	32.27	3993.75	17.29	2061.25
5.	OVERALL	1.80	60.79	3277.22	72.74	3941.11	44.39	2366.11

Table 4.8.5.6 Shift in cropped area under optimal plans - Cotton IInd crop

(Area in acres)

Sl. No.	Category of irrigation	Cropped area under existing level of water use	Cropped area under optimum plans with					
			(a) Existing level of water use	%age change of (4) over (3)	(b) -10% level of water use	%age change of (5) over (3)	(c) +10% level of water use	%age change of (6) over (3)
(1)	(2)	(3)	(4)		(5)		(6)	
1.	CWF	3.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
2.	CFF	1.00	0.00	-100.00	0.00	-100.00	0.00	-100.00
3.	WFF	7.00	12.86	83.71	12.54	79.14	14.15	102.14
4.	SWF	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.	OVERALL	11.00	12.86	16.91	12.54	14.00	14.15	28.64

Table 4.8.5.7 Shift in cropped area under optimal plans - Mulberry

(Area in acres)

Sl. No.	Category of irrigation	Cropped area under existing level of water use	Cropped area under optimum plans with					
			(a) Existing level of water use	%age change of (4) over (3)	(b) -10% level of water use	%age change of (5) over (3)	(c) +10% level of water use	%age change of (6) over (3)
(1)	(2)	(3)	(4)		(5)		(6)	
1.	CWF	0.00	14.18	-	12.76	-	15.60	-
2.	CFF	0.00	0.00	0.00	0.00	-	0.00	-
3.	WFF	0.00	14.66	-	12.74	-	16.12	-
4.	SWF	0.00	12.47	-	11.22	-	13.71	-
5.	OVERALL	0.00	41.31	-	36.72	-	45.43	-

4.8.5 Effect of optimisation in use of related inputs

Optimisation in use of irrigation water result in evolution of new cropping patterns which make rational use of irrigation water. However, the change in cropping pattern directly influences the use of related inputs. In the present study, the linear programming application exercise was done based on the assumption that both labour and capital are freely available and they do not constitute to be a constraint. Eventhough this is true with the case of a place like Chittur Block, it would be worthwile to ponder on the effect of the optimal plans on the pattern of use of both these inputs.

4.8.5(a) Use of labour input in optimum plans

Table 4.8.4.1 gives an idea of the shift in labour input use, in the optimal plans. It can be seen that there is an increase in use of labour input in both the optimal plans evolved under existing level of water use as well as normative levels of -10% and +10% variation in water use. An increase of 13.84% in use of labour is observed in the optimal plans evolved under existing level of water use. The change was maximum in the case of spout fed well irrigated farms (+13.84%) and minimum for canal fed farms (+2.29%).

Even in the normative plans evolved with -10% level of water use, the labour input use was more than that of the

present level by 7.91%. This positive increase was seen in all the categories except canal fed farms, in which case, it was -4.19%. In the case of normative plans evolved with +10% level of water use, the labour input use was high by 19.14%, on the aggregate. The increase ranged from 8.1% for canal fed farms to 26.48% for spout fed well irrigated farms.

If the labour input use at optimum plan developed with existing level of water use is taken as the base, then it can be said that as water availability increase (+10% level), the labour input use also increase and as water availability decreases (-10%), the labour input use also decreases.

4.8.5(b) Use of working capital

Table 4.8.5.2 gives an indication of the shift in use of working capital in optimal plans. In all the optimal plans that were evolved, the use of working capital was less than the present use. The working capital requirement for the optimal plan developed with existing level of water use indicated a reduction of 5.11% from that of the present level. However, in the case of canal fed farms, the working capital requirement increased by 2.29%.

In the case of normative plans with -10% level of water use, the working capital requirement was less by 9.06%. Optimum plans developed at +10% level of water use also indicated a reduced level of use of working capital, to the

tune of -0.74% from the present level of its use for the aggregate of irrigated farms. While optimal plans for canal fed farms and spout fed well irrigated farms required a working capital of +6.73% and +4.09% from the present level of working capital use, that of canal with well irrigated farms and well fed farms showed a reduction of -6.28% and -4.36% respectively.

In general, it can be said that the newly evolved plans are less working capital intensive in nature.

Table 4.8.6.1 Shift in labour input use (in value terms) in optimum plans

(Amount in Rs.)

Sl. No.	Category of irrigation	Labour input use under existing level of water use	Labour input use under optimum plans with					
			(a) Existing level of water use	%age change of (4) over (3)	(b) -10% level of water use	%age change of (6) over (3)	(c) +10% level of water use	%age change of (8) over (3)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	CWF	107579.50	118318.70	+9.98	113992.10	+5.96	122641.10	+14.00
2.	CFF	112479.50	115059.90	+2.29	107761.20	-4.19	121595.90	+8.10
3.	WFF	125162.30	148813.20	+18.88	137701.90	+10.00	157653.20	+25.94
4.	SWF	128785.80	157461.20	+22.27	152077.00	+18.09	162864.10	+26.48
5.	OVERALL	474027.10	539653.0	+13.84	511532.20	+7.91	564774.30	+19.14

Table 4.8.6.2 Shift in the use of working capital in optimum plans

(Amount in Rs.)

Sl. No.	Category of irrigation	Capital input use under existing level of water use	CAPITAL INPUT USE UNDER OPTIMUM PLANS WITH					
			(a) Existing level of water use	%age change of (4) over (3)	(b) -10% level of water use	%age change of (6) over (3)	(c) + 10% level of water use	%age change of (8) over (3)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	CWF	147270.70	134528.90	-8.65	131034.20	-11.02	138023.70	-6.28
2.	CFF	94336.40	96495.30	+2.29	91583.10	-2.92	100682.10	+6.73
3.	WFF	191239.60	172653.80	-9.72	160290.90	-16.18	182903.20	-4.36
4.	SWF	166185.80	164757.30	-0.86	161858.20	-2.60	172984.60	+4.09
5.	OVERALL	599032.50	568435.30	-5.11	544766.60	-9.06	594593.60	-0.74

Summary

SUMMARY

The role and importance of irrigation in Indian agriculture has been understood by policy makers of past and present. But somehow, the utilisational aspects of it have not been satisfactorily conceived. This has been pointed out by research workers in recent times. The broad objectives of the present study were to examine the existing pattern of use of irrigation and to suggest optimal plans for the use of this scarce input in an area where it is relatively scarce but at the same time having flexibility in cropping pattern. Specifically, the objectives were to

i) Compare the principal sources of irrigation with respect to their adequacy and influence over cropping pattern

ii) To estimate the cost and technical co-efficients on farms

iii) To develop optimal plans for farms differing with respect to source of irrigation, and

iv) To suggest means for optimal use of irrigation water

The study is based on sample survey. Kunnankathupathy village in Chittur Development Block was purposively chosen as the study area. For this village, there were four systems of irrigation, viz. canals, wells, canal with wells and spout fed wells. These were treated as separate strata. Twenty

samples each from canal fed farms and well fed farms were taken. Fifteen samples were drawn from canal with well source of irrigation and "spout fed well" irrigated farms. Twenty samples were taken from rainfed farms also, to act as control. Thus the total sample size was ninety. Farmers having an area of two or more acres were alone selected. The stratum samples so drawn were analysed.

Besides the use of averages, Friedman's two way analysis of variance was also used as a tool for the study. Estimation of water requirement of crops was done climatologically by following the methods suggested by FAO and some other research workers. Optimisation of irrigation water was attempted using linear programming technique. The results of the study are summarised as follows. The total area under all the 90 farms put together came to 543.4 acres, with an average of 6.04 acres per farm. Average area under canal fed farms was the lowest at 3.59 acres and the highest was for spout fed well irrigated farms, at 8.18 acres. The overall average family size was 5.87. Canal fed farm category had the smallest average family size with 5.2 members, while canal with well category had the largest family size with 6.6 members. Average farm family size of rainfed farms was less than the overall average, at 5.7 members.

No household in the sample had completely illiterate members. The educational status of the sample farms was on the whole moderate, with 45.66% of the families having members of highest educational status in the group "upto SSLC".

Farms of the sample area were fairly and almost evenly distributed between Black loam (53.3%) and Red loam (46.7%) soils. Fragmentation of holdings was absent resulting in one of the two soil types being almost exclusive for any particular farm.

Paddy, groundnut, sugarcane, sorghum and coconut were the important crops in irrigated farms with paddy playing the dominant role by occupying an area of 40.56% of the gross cropped area. Except well fed category of farms, this was the general trend in the irrigated group. The well fed category of farms seem to be a marginal case between the irrigated and rainfed group with its cropping pattern seen predominated with groundnut in 46.16% and other low water requiring crops of sorghum, pulses, minor millets and cotton in 19.16% of the area. Only 22.48% of the gross cropped area was under paddy cultivation in this category.

Groundnut, sorghum, minor millets, pulses and paddy were the important crops in rainfed category. Groundnut was the dominant crop occupying 35.71% of the gross cropped area. Paddy occupied only 11.01% of the cropped area.

When season wise cropped area was examined, it was clear that the general pattern of paddy Ist crop and groundnut IInd crop was followed in the irrigated farms. The trend in rainfed farms was to prefer crops like groundnut, millets and pulses, which require low soil moisture.

Cropping intensity of irrigated farms was 177.20%, while that of rainfed farms was only 158.31%. Taken category wise, canal fed farms had highest cropping intensity of 198.2% while spout fed well farms had the lowest at 166.90%. The difference in intensity of cropping between irrigated and rainfed farms can be attributed to the benefit of irrigation. Responding to the question on adequacy or not of irrigation water, majority of the farmers deriving the benefits of irrigation from canal (directly or indirectly) feel that their water requirement is met adequately. However, majority of the farmers depending on ground water alone (the well fed farm group) felt that their water requirement is being met only partially.

Use of inputs like seeds, plant protection chemicals, manures and fertilizers, tractor/tiller/bullock labour, hired human labour and short term credit has been markedly more in irrigated farms when compared to the rainfed ones. However, the use of family labour and the proportion of family labour charges to total cost of cultivation, was found to be higher for rainfed farms than the irrigated farms.

Among the irrigated categories, but for the use of hired human labour and family labour, there doesn't seem to exist any significant difference among the groups with respect to use of inputs. Spout fed well irrigated farms used the highest quantum of hired human labour while well

fed farms used the lowest of it. Similarly, use of family labour was the highest for canal with well irrigated farms and the lowest for well fed farms.

All the irrigated categories other than canal fed farms used electrically operated pumps for lifting water. Higher horse power pumpsets were seen to be used more by the spout fed well irrigated farms.

Average amount of short term credit availed of was the highest in spout fed well irrigated farms and the lowest in canal fed farms. Average credit availed per acre of gross cropped area was however the highest in canal with well irrigated farms and the lowest in well fed category of farms.

Crop output obtained was definitly higher for irrigated farms when compared to rainfed farms. Among the irrigated farms, output obtained, both in terms of quantity and value was high for canal with well and spout fed well categories of farms and low for the well fed farms.

Taken crop wise, there did not seem to exist any statistically significant difference with respect to use of inputs except in the case of paddy IInd crop and cotton. Spout fed well irrigated farms were seen to use more of inputs for the former crop and canal with well irrigated farms were using more of inputs in the latter. In general, use of seeds and fertilizers has been irrational. Seeds, nitrogen and potash were seen to be used in excess in most of the cases whereas phosphate was used less than the

recommended dosages. Rainfed farms used low amount of inputs for almost all crops, indicating risk aversion. This difference in input use between rainfed farms on the one hand and irrigated farms on the other, has to be attributed to the effect of irrigation.

Capital value net of depreciation of irrigation structures, machinery and equipments was taken as a measure of investment on irrigation. Canal fed farms did not make any private investment for the sake of irrigation, in the recent times. For rest of the irrigated farms taken together, investment on irrigation per acre cm of water, per acre of net sown area, and per acre of gross irrigated area were Rs. 16.19, Rs. 774.29 and Rs. 437.50 respectively. Among the different categories, investment on irrigation was the highest for spout fed well irrigated farms and the lowest for canal with well fed farms.

Investments other than those for irrigation was higher in irrigated farms by about three times (Rs. 329.90 per acre) when compared to rainfed farms. Within the irrigated farms, this was the highest for canal fed farms and the lowest for well fed farms.

The cost per acre cm of water excluding labour charges, came to Rs. 12.73 for the irrigated farms. Fuel/electricity charges constituted the largest share in this (Rs. 5.63 per acre cm) and the canal water charges constituted the lowest share, at Rs. 0.34 per acre cm. Among the irrigated farm

groups, canal fed farms had the lowest (Rs. 0.30) cost per acre cm., while well fed farms had the highest cost,at Rs. 14.41 per acre cm.

Irrigation related expenses (inclusive of labour charges) taken crop wise, was highest for sugarcane, followed by paddy IInd crop. Blackgram IInd crop had the lowest expense per acre. Even though statistically there was no significant difference among the various categories (other than canal fed group), there is a slight indication that the spout fed well irrigated farms had the highest irrigation related expenses and canal with well irrigated farms had the lowest expenses per acre.

Irrigation related expenses as percentage to total cost of cultivation was the highest for the well fed farms and the lowest for the canal with well irrigated farms. It was negligible for the canal fed farms when compared to rest of the irrigated groups. In general, irrigation related expenses formed almost 1/6th to 1/5th of the total cost of cultivation.

Cost of cultivation and net margins were definitely higher for irrigated farms when compared to the rainfed farms. Within the irrigated farms, there exists significant difference among the various categories with respect to cost of cultivation. The cost was lower for canal fed and well fed farm categories and was higher for rest of the two categories. While the cost in canal fed farms was less due to the low irrigation cost, that in well fed farms was less due to the low level of use of almost all inputs.

Cost of cultivation was higher for paddy Ist crop compared to paddy IInd crop, in irrigated farms. The net margin was however, higher for the former crop. Similarly, even though the cost was higher for groundnut IInd crop when compared to groundnut Ist crop, the net margin was higher for the second crop. Cost of cultivation was lower and net returns higher for the ratoon crop of sugarcane when compared to new planted crop. Tapioca was found to be a reasonably paying crop in the irrigated categories.

Optimisation of available irrigation water was done collectively for the farms in each category, using the linear programming technique. The existing seasonal and annual crops were taken up in calculations whereas some other annuals and perinneals were also consdered as alternative crops. Irrigation was tried to be optimised under the present level of water use as well as under normative levels of -10% and +10% of the present water use.

Results of optimisation of irrigation water in canal with well irrigated farms indicate that crops other than paddy Ist crop, groundnut Ist and IInd crops are not beneficial to be cultivated. Additionally, cultivation of tomato IInd crop and mulberry has been suggested in the optimal plans. In the case of canal fed farms, crops other than paddy and groundnut disappeared in the optimum plans. For the well fed farms, apart from elimination of crops other than paddy Ist crop and groundnut Ist and IInd crops, cotton, tomato and mulberry have been additionally suggested

for cultivation in the optimum plans. Crops other than paddy Ist crop, groundnut Ist and IInd crops and tomato have been adviced to be eliminated in the optimum plans for spout fed well farms. However, mulberry is suggested to be introduced. In general, there is a suggestion in the optimum plans for concentrating on a few prominent crops rather than going in for a large number of crop mixes.

Gross cropped area has increased in the optimum plans under all categories for all levels of irrigation, except in the case of well fed farms. Similarly, net farm income has improved in the optimum plans in all the categories irrespective of increase or decrease of water use, except in the case of optimum plans with reduced levels of water availability in canal fed farms.

Taken crop wise, area under paddy Ist crop remained unchanged when the present level of water use was optimised. However, except for canal fed farms, paddy IInd crop got totally eliminated in the optimum plans of irrigated farms. The decline in the area under paddy IInd crop in the canal fed farms when present level of water use was optimised, was marginal. It can be safely concluded from the above facts that the present status of area under paddy for the first crop season is optimum. This almost holds true for the second crop also in canal fed farms. Given the situation in the study area, there isn't any irrationality in use of water in the case of paddy Ist crop in all the irrigated farms and paddy IInd crop in the canal fed category of farms.

In general, optimum area under paddy Ist crop can be increased or decreased in a beneficial manner in the same proportion of increase or decrease of available water. In the case of paddy IInd crop, the present level of allocation of area is suboptimal for farms other than the canal fed ones. Redistribution of both cropped area as well as the scarce water input is called for.

The optimum plans for different situations of water availability indicated an increase in cropped area under groundnut. For the first crop of groundnut, a decrease in water availability responded by an increase in cropped area and an increase in water availability necessitates a less than proportionate increase in area, for the cropping pattern to be optimum with respect to use of water. In fact, there was a reduction in area under optimum plans with normative levels of +10% increase in water, for canal fed and canal with well fed farms. For groundnut IInd crop, in all the optimisations, the cropped area was more than the present acerage under it. However, the increase in area under normative levels of -10% water availability was less than the percentage increase in area at +10% levels of water use.

In the case of tomato crop, optimum plans indicate an increase in cropped area as water availability decreases and cropped area decreased with increase in availability of water. For cotton crop, as water availability increases,

the cropped area under optimum plan increases and, as water availability decreases, cropped area also decreases. Area under mulberry crop in the optimum plans increased with increased levels of water availability.

The change in net income in the optimum plans was not uniform when the present level of water use was optimised. There is a significant positive change in net income in the case of canal with well fed farms and well fed farms (+105.51% and +118.8% respectively). The proportion of change is comparatively less for spout fed well irrigated farms (+59.91%) and almost negligible for canal fed farms (+2.50% only). This throws light to the fact that water utilisation has almost been near to optimum levels in the case of canal fed farms and far from optimum in rest of the categories. Except for the canal fed farms, the optimum plans developed for normative levels of -10% water availability indicate higher net income than the income from present cropping pattern. This points to the fact that the optimum use of available water is more important than simply increasing the level of water availability.

Effect of optimisation in the use of related inputs was examined for labour and working capital. It was seen that there is an increase in use of labour input in all the optimal plans that were evolved. However, if the labour input use at optimum plan developed with existing

level of water use is taken as the base, it can be said that as water availability increases, the labour input use also increases and as water availability decreases, the labour input use also decreases. Taken overall, the present level of use of working capital was revealed to be higher, with the optimum plans (which yield higher net income) requiring lower amounts of this input.

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Appendices

Appendix I QUESTIONAIRE FOR DATA COLLECTION

I. Identification

1. Name and address :
2. Village :
3. Soil type :

II. Family details:

Sl. No.	Sex	Age	Educational status	Occupation/ activity	Remarks

III. Land use:

No. of plot/ fragment	Land area operated			Type of tenure		
	Wet	Garden	Dry	Total	Own	Leased in	Leased out

Appendix I (Contd.)

IV. Cropping pattern (Reference year:)

a. Perennial crops — Area/No.

1.

2.

Total

b. Annual/Seasonal crop details: (Season wise area)

Crop	Virippu	Mundakan	Punja	Total	Remarks
Paddy					
Groundnut					
Maize					
Cotton					
Vegetables					
Sugarcane					
Others:					
1.					
2.					

V. Buildings and other structures:

Sl. No.	Particulars	Mention Kutch or Pucca	Year of construction	Value of construction	Expected life (years)	Annual maintenance cost	Present value	Remarks
1.	Residential building							
2.	Farm shed							
3.	Cattle shed							
4.	Store shed							
5.	Water tank							
6.	Compound wall							
7.	Others:							
	a.							
	b.							
	c.							

VI. Farm implements and machinery:

Sl. No.	Specification	No.	Year of purchase	Purchase value	Expected life	Annual maintenance	Remarks
1.	Implements:						
	County plough						
	Improved plough						
	Levelling plank						
2.	Hand tools:						
	Spade						
	Pick axe						
	Sickle						
3.	Machinery:						
	Tractor						
	Power tiller						
4.	Transport:						
	a. Bullock carts						
	b. Hand carts						
5.	Plant protection:						
	Hand sprayer						
	Power sprayer						
	Duster						
6.	Others:						
	1.						
	2.						

VII . Irrigation structure and equipment:

Sl. No.	Item	No.	Specification	Year of construction/ installation	Value of construction/ purchase	Annual maintenance cost (Rs)	Remarks
1.	Well						
2.	Tube well						
3.	Pumpset						
4.	Pumpshed						
5.	Pond/Tank						
6.	Channels						
7.	Pipeline system						
8.	Others						
	. . . .						
	. . . .						

VIII. Operational costs (own use + hiring out):

Sl. No.	Item	No.of hours per day	No.of days per week	No. of month in a year	Fuel cost/ electricity	Repair and maintenance cost per year	Remarks
1.	Tractor						
2.	P.Tiller						
3.	Pumpset						
4.	Others						
	. . . .						
	. . . .						

IX. Irrigation details:

(a) Source of irrigation:

(b) Name of canal system: from which water is obtained

(c) 1. No. of wells/spout fed wells/tanks

2. Wether water source is: adequate/partially adequate/inadequate

(d) Type of lift used: Human/Bullock/Electric/Diesel/Others (pumpset pumpset(specify)

(e) Crop wise irrigation details:

Crop	Area	Season	No. of irrigations given	Labour cost per irrigation	Remarks

(f) Canal irrigation charges made:

X. Details of loan obtained:

Sl. No.	Agency	Type of loan	Date of borrowing	Purpose	Amount	Interest rate	Amount outstanding

XI. Income particulars:

(a) Income from sale of water if any:

(b) Crop output & returns:

1. Perennials/annuals:

Sl. No.	Crop	Total production		Price/unit		Total	Remarks
		Main product	Bye product	Main product	Bye product		

2. Seasonal crops:

Sl. No.	Season	Crop	Total production		Price/unit		Total	Remarks
			Main product	Bye product	Main product	Bye product		

XII. Expenditure:

(a) Land revenue/tax paid

XII B. Cost of cultivation of perinnieal crops:

Crop: Variety:

Wage rate: Men: Women: Tractor rent/hour: Area:

Sl. No.	Operations	Animal labour Bullock(Pairs) Tractor/Tiller				Human Labour												Input used		Total cost
						Men								Women						
						Family				Hired				Family				Hired							
		No.	Days	Hrs.	Rs.	No.	Days	Hrs.	Rs.	No.	Days	Hrs.	Rs.	No.	Days	Hrs.	Rs.	No.	Days	Hrs.	Rs.	Qty.	Cost Rs.	Ps.	Rs.
1.	Weeding and intercultivation																								
2.	Manures and fertilizers application																								
	Types: 1.																								
	2.																								
	3.																								
	4.																								
	5.																								
3.	Irrigation																								
4.	Plant protection																								
5.	Harvesting																								
6.	Others:																								
	a.																								
	b.																								
	c.																								
7.	Total cost																								

XII C. Cost of cultivation of seasonal/annual crops

Crop: Season: Variety: Fragment No: Area:

Sl. No.	Operations	Animal labour Bullock(Pairs) Tractor/Tiller				Human Labour										Input used		Total cost	Remarks
						Men						Women							
						Family				Hired				Hired					
		No.	Days	Hrs.	Rs.	No.	Days	Hrs.	Rs.	No.	Days	Hrs.	Rs.	No.	Days	Hrs.	Rs.	Qty. Kg.	Cost Rs. Ps.	Rs.	
1.	Preparatory cultivation																				
2.	Seeds & sowing																				
3.	Nursery raising and maintainance																				
4.	Transplantation																				
5.	Manures & fertilizers																				
	Types: 1.																				
	2.																				
	3.																				
	4.																				
	5.																				
6.	Irrigation																				
7.	Plant protection																				
8.	Weeding & intercultivation																				
9.	Harvesting																				
10.	Other operations																				
	a.																				
	b.																				
	c.																				
11.	Total																				

Appendix II PAN COEFFICIENT (K_p) FOR CLASS A PAN FOR DIFFERENT GROUNDCOVER AND LEVELS OF MEAN RELATIVE HUMIDITY AND 24 HOUR WIND

Class A pan	Case A: Pan placed in short green cropped area				Case B1/ Pan placed in dry fallow area			
RH mean %		low <40	medium 40 - 70	high >70		low <40	medium 40 - 70	high >70
Wind km/day	Windward side distance of green crop m				Windward side distance of dry fallow m			
Light <175	1	0.55	0.65	0.75	1	0.70	0.80	0.85
	10	0.65	0.75	0.85	10	0.60	0.70	0.80
	100	0.70	0.80	0.85	100	0.55	0.65	0.75
	1000	0.75	0.85	0.85	1000	0.50	0.60	0.70
Moderate 175-425	1	0.50	0.60	0.65	1	0.65	0.75	0.80
	10	0.60	0.70	0.75	10	0.55	0.65	0.70
	100	0.65	0.75	0.80	100	0.50	0.60	0.65
	1000	0.70	0.80	0.80	1000	0.45	0.55	0.60
Strong 425-700	1	0.45	0.50	0.60	1	0.60	0.65	0.70
	10	0.55	0.60	0.65	10	0.50	0.55	0.65
	100	0.60	0.65	0.70	100	0.45	0.50	0.60
	1000	0.65	0.70	0.75	1000	0.40	0.45	0.55
Very strong >700	1	0.40	0.45	0.50	1	0.50	0.60	0.65
	10	0.45	0.55	0.60	10	0.45	0.50	0.55
	100	0.50	0.60	0.65	100	0.40	0.45	0.50
	1000	0.55	0.60	0.65	1000	0.35	0.40	0.45

Source: "Guidelines for predicting crop water requirements" by Doorenbos, J., and Pruitt, W.O.1984. FAO Irrigation and Drainage paper 24, FAO, Rome, Page 34.

Appendix III DATA ON CLIMATIC PARAMETRES

Year and month	Total rainfall (mm)	Temperature Mean Max.	Temperature Mean Min.	Average PEP* measurement	Wind velocity (average)	Relative humidity % I	Relative humidity % II
1986							
January	5.0	34.54	19.96	7.47	N.A.	78	57
February	13.3	34.86	20.41	7.78	7.60	75	52
March	-	37.05	23.29	9.10	9.07	75	53
April	41.3	39.25	24.71	10.41	9.63	74	59
May	48.4	35.43	23.65	6.73	15.35	78	61
June	385.3	29.36	21.84	6.48	13.44	92	87
July	279.8	29.19	22.81	4.57	14.59	92	86
August	383.0	27.65	22.04	5.71	14.07	91	83
September	39.2	32.21	22.38	7.44	12.90	87	76
October	102.7	31.81	22.39	5.70	7.07	81	74
November	68.6	30.61	21.29	5.23	6.39	77	71
December	16.2	32.06	21.06	5.48	9.08	74	55
1987							
January	-	32.93	20.65	7.44	9.02	71	50
February	-	33.71	20.32	8.53	7.48	69	45
March	54.0	35.64	21.19	0.25	8.35	69	43
April	16.5	38.13	23.87	9.21	10.02	76	62
May	133.2	36.48	23.42	8.44	9.97	78	62
June	196.3	31.20	23.40	3.94	11.66	86	77
July	293.4	29.63	23.17	4.02	12.05	90	78
August	177.2	30.06	22.30	5.03	11.84	89	78
September	62.2	32.47	22.03	5.21	10.12	85	74
October	82.7	32.97	21.68	4.11	7.07	85	74
November	84.7	31.02	21.53	2.77	6.39	78	72
December	89.2	30.04	21.52	3.17	9.08	72	53

* PEP is Pan Evapourimetre

Source: Integrated Seed Development farm, Eruthempathy and Community Development Block Office, Chittur, Long 76°52'E, Lat. 10°44'N, Ht. Approx. 85m above MSL

Appendix IV AVERAGE MONTHLY EFFECTIVE RAINFALL AS RELATED TO MEAN MONTHLY RAINFALL AND MEAN MONTHLY CONSUMPTIVE USE

(U.S D.A. SCS, 1969)

Monthly mean rainfall mm	Mean monthly consumptive use, mm													
	25	50	75	100	125	150	175	200	225	250	275	300	325	350
	Mean monthly effective rainfall, mm													
12.5	7.5	8.0	8.7	9.0	9.2	10.0	10.5	11.2	11.7	12.5	12.5	12.5	12.5	12.5
25.0	15.0	16.2	17.5	18.0	18.5	19.7	20.5	22.0	24.5	25.0	25.0	25.0	25.0	25.0
37.5	22.5	24.0	26.2	27.5	28.2	29.2	30.5	33.0	36.2	37.5	37.5	37.5	37.5	37.5
50.0	25.0	32.2	34.5	35.7	36.7	39.0	40.5	43.7	47.0	50.0	50.0	50.0	50.0	50.0
62.5	at 41.7	39.7	42.5	44.5	46.0	48.5	50.5	53.7	57.7	62.5	62.5	62.5	62.5	62.5
75.0		46.2	49.7	52.7	55.0	57.5	60.2	63.7	67.5	73.7	75.0	75.0	75.0	75.0
87.5		50.0	56.7	60.2	63.7	66.0	69.7	73.7	77.7	84.5	87.5	87.5	87.5	87.5
100.00		at 80.7	63.7	67.7	72.0	74.2	78.7	83.0	87.7	95.0	100.0	100.0	100.0	100.0
112.5			70.5	75.0	80.2	82.5	87.2	92.7	98.0	105.0	111.0	112.0	112.0	112.0
125.0			75.0	81.5	87.7	90.5	95.7	102.0	108.0	115.0	121.0	125.0	125.0	125.0
137.5			at 122.0	88.7	95.2	98.7	104.0	111.0	118.0	126.0	132.0	137.0	137.0	137.0
150.0				95.2	102.0	106.0	112.0	120.0	127.0	136.0	143.0	150.0	150.0	150.0
162.5				100.0	109.0	113.0	120.0	128.0	135.0	145.0	153.0	160.0	162.0	162.0
175.0				at 160.0	115.0	120.0	127.0	135.0	143.0	154.0	164.0	170.0	175.0	175.0
187.5					121.0	126.0	134.0	142.0	151.0	161.9	170.0	179.0	185.0	187.0
200.0					125.0	133.0	140.0	148.0	158.0	168.0	178.0	188.0	196.0	200.0
225.0					at 197.0	144.0	151.0	160.0	171.0	182.0				
250.0						150.0	161.0	170.0	183.0	194.0				
275.0						at 240.0	171.0	181.0	194.0	205.0				
300.0							175.0	190.0	203.0	215.0				
325.0							at 287.0	198.0	213.0	224.0				
350.0								200.0	220.0	232.0				
375.0								at 331.0	225.0	240.0				
400.0									at 372.0	247.0				
425.0										250.0				
										at 412.0				
450.0	25	50	75	100	125	150	175	200	225	250				

Source: "Water requirement and irrigation management of crops in India", IARI Monograph No.4, Water Technology Centre, IARI, New Delhi

Appendix V CALCULATION OF AVAILABLE WATER IN THE ROOT ZONE OF CROPS

a) Field capacity and wilting co-efficient of Valiyavallampathy soils (clay loam)

Depth in cm	Wilting co-efficient	Field capacity
0 - 15	26.00	41.00
15 - 30	27.00	37.00
30 - 45	27.70	40.00
45 - 60	29.00	43.00
Average	27.42	40.25

Ref: Ushakumari, 1983. Unpublished M.Sc.(Ag.) thesis submitted to the KAU, Department of Soil Science and Agrl. Chemistry, College of Horticulture, Trichur.

b) Field capacity in mm $= \frac{FC\% \times B.D. \times \text{Depth in mm}}{100}$

Where B.D. is bulk density = 1.45 for clay loams

FC in mm $= \frac{40.25 \times 1.45 \times 600}{100} = 350$ mm

c) Wilting co-efficient in mm $= \frac{W.C.\% \times B.D. \times \text{Depth in mm}}{100}$

$= \frac{27.42 \times 1.45 \times 600}{100} = 238.55$

d) Available water in mm = FC - WC = 111 mm

This is rounded and taken as 100 mm in the present study

Appendix VI WORKING SHEET FOR CALCULATION OF IRRIGATION REQUIREMENT OF CROPS

Sl. No.	Crop & month	No.of days	ET_o	K_c	ET crop mm/day	ET crop total for month	Soil water need	Total water need (mm)	Rainfall (mm)	75% Effective Rainfall	Antecedent soil moisture (mm)	Total available moisture (mm)	Irrigation requirement (mm)
1.	Tapioca												
	Planting date: 6th May '86												
	January '87	31	4.46	0.60	2.67	82.8	25.0	107.8	0.0	0.0	25.0	25.0	82.8
	February '87	28	5.12	0.54	2.76	77.3	25.0	102.3	0.0	0.0	25.0	25.0	77.3
	March '87	31	4.95	0.42	2.08	64.5	25.0	89.5	54.0	35.4	25.0	60.4	6.1
	April '87	1	5.53	0.35	1.94	1.9	48.0	49.9	0.0	0.0	2.0	2.0	-
	May '86	25	4.04	0.35	1.41	35.3	25.0	60.3	37.1	24.2	25.0	49.2	-
	June '86	30	5.51	0.39	2.15	64.5	36.1	100.6	385.3	100.6	13.9	114.5	-
	July '86	31	2.97	0.52	1.54	47.7	0.0	47.7	279.8	47.7	50.0	97.7	-
	August '86	31	3.71	0.60	2.30	71.3	0.0	71.3	383.0	71.3	50.0	121.3	-
	September '86	30	4.83	0.60	2.90	87.0	0.0	87.0	39.2	28.4	50.0	78.4	33.6
	October '86	31	4.28	0.60	2.70	83.7	25.0	108.7	102.7	63.9	25.0	88.9	19.8
	November '86	30	3.92	0.60	2.35	70.5	25.0	95.5	68.6	44.0	25.0	69.0	26.5
	December '86	31	3.29	0.60	1.97	61.1	25.0	86.1	16.2	11.1	25.0	36.1	50.0
	Total												296.1
2.	Coconut												
	January '87	31	4.46	0.85	3.79	117.5	25.0	142.5	0.0	0.0	25.0	25.0	117.5
	February '87	28	5.12	0.85	4.35	121.8	25.0	146.8	0.0	0.0	25.0	25.0	121.8
	March '87	31	4.95	0.85	4.21	130.5	25.0	155.5	54.0	40.4	25.0	65.4	90.1
	April '87	30	5.53	0.85	4.70	141.0	25.0	166.0	16.5	13.4	25.0	38.4	127.6
	May '86	31	4.04	0.85	3.43	106.3	25.0	131.3	48.4	34.6	25.0	59.6	71.7
	June '86	30	5.51	0.85	4.68	140.4	25.0	165.4	385.3	165.4	25.0	190.4	-
	July '86	31	2.97	0.85	2.52	78.1	0.0	78.1	279.8	78.1	50.0	128.1	-
	August '86	31	3.71	0.85	3.15	97.6	0.0	97.6	383.0	97.6	50.0	147.6	-
	September '86	30	4.83	0.85	4.11	123.3	0.0	123.3	39.2	30.8	50.0	80.8	67.5
	October '86	31	4.28	0.85	3.64	112.8	25.0	137.8	102.7	69.4	25.0	94.4	43.4
	November '86	30	3.92	0.85	3.33	99.9	25.0	124.9	68.6	47.4	25.0	72.4	52.5
	December '86	31	3.29	0.85	2.80	86.8	25.0	111.8	16.2	11.8	25.0	36.8	75.0
	Total												767.1

Appendix VI (Contd.)

Sl. No.	Crop & month	No.of days	ET_o	K_c	ET crop mm/day	ET crop total for month	Soil water need	Total water need (mm)	Rainfall (mm)	75% Effective Rainfall	Antecedent soil moisture (mm)	Total available moisture (mm)	Irrigation requirement (mm)
3.	Groundnut Ist crop												
	Sowing date: 1st May												
	May '86	31	4.04	0.51	2.06	63.8	25.0	88.8	48.4	32.2	25.0	57.2	6.6
	June '86	30	5.51	0.84	4.63	138.9	50.0	188.9	385.3	188.9	0.0	188.9	-
	July '86	31	2.97	0.97	2.88	89.3	0.0	89.3	279.8	89.3	50.0	139.3	-
	August '86	18	3.71	0.69	2.56	46.1	0.0	46.1	383.0	46.1	50.0	96.1	-
	Total												6.6
4.	Groundnut IInd crop												
	Sowing on 11th September												
	September '86	20	4.83	0.50	2.42	48.4	25.0	73.4	39.2	24.0	25.0	49.0	24.4
	October '86	31	4.28	0.70	2.996	92.9	25.0	117.9	109.1	71.0	25.0	96.0	21.9
	November '86	30	3.92	0.95	3.724	111.7	25.0	136.7	68.6	49.0	25.0	74.0	62.7
	December '86	29	3.29	0.80	3.29	76.33	25.0	101.3	16.2	11.0	25.0	36.0	65.3
	Total												174.3
5.	Groundnut IIIrd crop												
	Sowing on 1st January												
	January '87	31	4.46	0.51	2.27	70.4	25.0	95.4	0.0	0.0	25.0	25.0	95.4
	February '87	28	5.12	0.80	4.10	114.8	25.0	139.8	0.0	0.0	25.0	25.0	139.8
	March '87	31	4.95	0.94	4.65	144.1	25.0	169.1	54.0	41.5	25.0	66.5	102.6
	April '87	20	5.53	0.71	3.93	78.6	25.0	103.6	0.0	0.0	25.0	25.0	78.6
	Total												416.4

Appendix VI (Contd.)

Sl. No.	Crop & month	No.of days	ET_o	K_c	ET crop mm/day	ET crop total for month	Soil water need	Total water need (mm)	Rainfall (mm)	75% Effective Rainfall	Antecedent soil moisture (mm)	Total available moisture (mm)	Irrigation requirement (mm)
6.	Sugarcane												
	Planting on 1st October												
	October '86	31	3.68	0.55	2.02	62.6	25.0	87.6	102.7	62.6	25.0	87.6	-
	November '86	30	3.00	0.80	2.40	72.0	25.0	97.0	68.6	44.1	25.0	69.1	27.9
	December '86	31	2.60	0.95	2.47	76.6	25.0	101.6	16.2	11.7	25.0	36.7	64.9
	January '87	31	4.47	1.00	4.47	138.6	25.0	163.6	0.0	0.0	25.0	25.0	138.6
	February '87	28	4.90	1.05	5.15	144.2	25.0	169.2	0.0	0.0	25.0	25.0	144.2
	March '87	31	5.21	1.05	5.47	169.6	25.0	194.6	54.0	44.5	25.0	69.5	125.1
	April '87	30	5.89	1.05	6.18	185.4	25.0	210.4	16.5	15.0	25.0	40.0	170.4
	May '87	31	4.55	1.05	4.78	148.2	25.0	193.2	90.8	67.9	25.0	92.9	100.3
	June '87	30	4.04	1.05	4.24	127.2	25.0	152.2	290.8	152.2	25.0	177.2	-
	July '87	31	2.79	1.05	2.93	90.8	0.0	90.8	286.6	90.8	50.0	140.8	-
	August '87	26	3.49	0.80	2.79	72.54	0.0	72.5	264.6	72.5	50.0	122.5	-
	Total												771.4
7.	Pulses & vegetables Ist crop												
	Sowing on 1st June												
	June '86	30	5.51	0.54	2.97	89.1	25.0	114.1	385.3	114.1	25.0	139.1	-
	July '86	31	2.97	0.97	2.88	89.3	0.0	89.3	279.8	89.3	50.0	139.3	-
	August '86	31	3.71	0.87	3.23	100.1	0.0	100.1	383.0	100.1	50.0	150.1	-
	September '86	3	4.83	0.36	1.74	5.2	0.0	5.2	0.0	0.0	50.0	50.0	-
	Total												
8.	Pulses & vegetables IInd crop												
	Sowing on 10th September												
	September	20	4.83	0.50	2.42	48.4	15.0	63.4	39.2	25.9	35.0	60.9	12.5
	October	31	4.28	0.83	3.55	106.5	25.0	131.5	102.7	68.5	25.0	93.5	38.0

Appendix VI (Contd.)

Sl. No.	Crop & month	No.of days	ET_o	K_c	ET crop mm/day	ET crop total for month	Soil water need	Total water need (mm)	Rainfall (mm)	75% Effective Rainfall	Antecedent soil moisture (mm)	Total available moisture (mm)	Irrigation requirement (mm)
8.	Contd.												
	November '86	30	3.92	1.03	4.04	125.2	25.0	150.2	68.6	49.9	25.0	74.9	75.3
	December	14	3.29	0.56	1.84	25.7	25.0	50.7	16.2	10.4	25.0	35.4	15.3
	Total												141.1
9.	Pulses & vegetables IIIrd crop												
	Sowing on 5th January												
	January '87	26	4.46	0.52	2.32	60.3	25.0	85.3	0.0	0.0	25.0	25.0	60.3
	February '87	28	5.12	0.91	4.66	130.5	25.0	155.5	0.0	0.0	25.0	25.0	130.5
	March '87	31	4.95	0.74	3.66	113.5	25.0	138.5	54.0	38.8	25.0	63.8	74.7
	April '87	10	5.53	0.49	2.71	27.1	25.0	52.1	0.0	0.0	25.0	25.0	27.1
	Total												292.6
10.	Sesamum Ist crop												
	Sowing on 1st May												
	May '86	31	4.04	0.54	2.18	67.6	25.0	92.6	48.4	32.5	25.0	57.5	10.1
	June '86	30	5.51	0.92	5.07	152.1	50.0	227.1	385.3	227.1	0.0	227.1	-
	July '86	29	2.97	0.73	2.17	62.9	0.0	62.9	279.8	62.9	50.0	112.9	-
	Total												10.1
11.	Sesamum IInd crop												
	Sowing on 1st September												
	September '86	30	4.83	0.54	2.61	78.3	0.0	78.3	39.2	28.2	50.0	78.2	25.1
	October '86	31	4.28	0.91	3.90	120.9	25.0	145.9	102.7	70.7	25.0	95.7	50.2
	November '86	29	3.92	0.73	2.86	82.9	25.0	107.9	68.6	45.4	25.0	70.4	37.5
	Total												112.8

Appendix VI (Contd.)

Sl. No.	Crop & month	No.of days	ET_o	K_c	ET crop mm/day	ET crop total for month	Soil water need	Total water need (mm)	Rainfall (mm)	75% Effective Rainfall	Antecedent soil moisture (mm)	Total available moisture (mm)	Irrigation requirement (mm)
12.	Sesamum IIIrd crop												
	Sowing on 1st January												
	January '87	31	4.46	0.54	2.41	74.71	25.0	99.71	0.0	0.0	25.0	25.0	74.71
	February '87	28	5.12	0.92	4.71	131.89	25.0	156.9	0.0	0.0	25.0	25.0	131.89
	March '87	31	4.95	0.74	3.66	113.55	25.0	138.6	54.0	39.0	25.0	64.0	74.60
	Total												281.20
13.	Sorghum Ist crop												
	Sowing on 25th May												
	May '86	5	4.04	0.50	2.02	10.1	25.0	35.1	18.0	7.7	25.0	32.7	-
	June '86	30	5.51	0.53	2.92	87.6	27.4	115.0	385.3	115.0	22.6	137.6	-
	July '86	31	2.97	0.93	2.76	85.6	0.0	85.6	279.8	85.6	50.0	135.6	-
	August '86	31	3.71	1.00	3.71	115.0	0.0	115.0	383.0	115.0	50.0	165.0	-
	September '86	13	4.83	0.64	3.09	40.2	0.0	40.2	0.0	0.0	50.0	50.0	15.2
	Total												15.2
14.	Sorghum IInd crop												
	Sowing on 15th September												
	September '86	15	4.83	0.50	2.42	36.3	25.0	61.3	39.2	25.6	25.0	50.6	10.7
	October '86	31	4.28	0.57	2.44	75.6	25.0	100.6	102.7	63.6	25.0	88.6	12.0
	November '86	30	3.92	1.03	4.04	121.2	25.0	146.2	68.6	49.5	25.0	74.5	71.7
	December '86	31	3.29	0.88	2.89	89.6	25.0	114.6	16.2	12.3	25.0	37.3	77.3
	January '87	3	4.46	0.53	2.36	7.1	25.0	32.1	0.0	0.0	25.0	25.0	32.1
	Total												203.8

Appendix VI (Contd.)

Sl. No.	Crop & month	No.of days	ET_o	K_c	ET crop mm/day	ET crop total for month	Soil water need	Total water need (mm)	Rainfall (mm)	75% Effective Rainfall	Antecedent soil moisture (mm)	Total available moisture (mm)	Irrigation requirement (mm)
15.	Sorghum IIIrd crop												
	Sowing on 6th January												
	January '87	25	4.46	0.50	2.23	55.8	25.0	80.8	0.0	0.0	25.0	25.0	55.8
	February '87	28	5.12	0.76	3.89	108.9	25.0	133.9	0.0	0.0	25.0	25.0	108.9
	March '87	31	4.95	1.05	5.20	161.2	25.0	186.2	54.0	43.5	25.0	68.5	117.7
	April '87	26	5.53	0.68	3.76	97.8	25.0	122.8	0.0	0.0	25.0	25.0	97.8
	Total												380.2
16.	Millets Ist crop												
	Sowing on 1st June												
	June '86	30	5.51	0.54	2.97	89.1	25.0	114.1	385.3	114.1	25.0	139.1	-
	July '86	31	2.97	0.97	2.88	39.3	0.0	89.3	279.8	89.3	50.0	139.3	-
	August '86	31	3.71	0.87	3.23	100.1	0.0	100.1	383.0	100.1	50.0	150.1	-
	September '86	3	4.83	0.35	1.69	5.1	0.0	5.1	0.0	0.0	50.0	50.0	-
	Total												Nil
17.	Millets IInd crop												
	Sowing on 10th September												
	September '86	20	4.83	0.50	2.42	48.4	6.0	54.4	39.2	25.9	44.0	69.9	3.5
	October '86	31	4.28	0.82	3.51	108.8	25.0	133.8	102.7	68.8	25.0	93.8	40.0
	November '86	30	3.92	1.03	4.04	121.2	25.0	146.2	68.6	49.5	25.0	74.5	71.7
	December '86	14	3.29	0.56	1.84	25.8	25.0	50.8	16.2	10.4	25.0	35.4	15.4
	Total												130.6
18.	Millets IIIrd crop												
	Sowing on 1st January												
	January '87	31	4.46	0.54	2.41	74.7	25.0	99.7	0.0	0.0	25.0	25.0	74.7
	February '87	28	5.12	0.98	5.02	140.6	25.0	165.6	0.0	0.0	25.0	25.0	140.6

Appendix VI (Contd.)

Sl. No.	Crop & month	No.of days	ET_o	K_c	ET crop mm/day	ET crop total for month	Soil water need	Total water need (mm)	Rainfall (mm)	75% Effective Rainfall	Antecedent soil moisture (mm)	Total available moisture (mm)	Irrigation requirement (mm)
18.	Contd.												
	March '87	31	4.95	0.91	4.50	139.5	25.0	164.5	54.0	41.2	25.0	66.2	98.3
	April '87	5	5.53	0.40	2.21	11.1	25.0	36.1	0.0	9.9	25.0	25.0	11.1
	Total												324.7
19.	Tomato IInd crop												
	Sowing on 1st September												
	September '86	30	4.83	0.54	2.61	78.3	25.0	103.3	39.2	28.2	25.0	53.2	50.1
	October '86	31	4.28	1.01	4.32	133.9	25.0	158.9	102.7	72.8	25.0	97.8	61.1
	November '86	30	3.92	0.99	3.88	116.4	25.0	141.4	68.6	49.1	25.0	74.1	67.3
	December '86	4	3.29	0.65	2.14	8.6	25.0	33.6	16.2	3.6	25.0	28.6	5.0
	Total												183.5
20.	Tomato IIIrd crop												
	Sowing on 11th January												
	January '87	20	4.46	0.50	2.23	44.6	25.0	69.6	0.0	0.0	25.0	25.0	44.6
	February '87	28	5.12	0.83	4.25	118.9	25.0	143.9	0.0	0.0	25.0	25.0	118.9
	March '87	31	4.95	1.09	5.39	167.1	25.0	192.1	54.0	44.2	25.0	69.2	122.9
	April '87	16	5.53	0.80	4.42	70.7	25.0	95.7	0.0	0.0	25.0	25.0	70.7
	Total												357.1
21.	Cotton IInd crop												
	Sowing on 22nd August												
	August '86	10	3.71	0.50	1.86	18.6	0.0	18.6	383.0	18.6	50.0	68.6	-
	September '86	30	4.83	0.50	2.42	72.6	0.0	72.6	39.2	27.8	50.0	77.8	19.8
	October '86	31	4.28	0.75	3.21	99.5	25.0	124.5	102.7	67.4	25.0	92.4	32.1
	November '86	30	3.92	1.13	4.43	132.9	25.0	157.9	68.6	50.8	25.0	75.8	82.1
	December '86	31	3.29	1.14	3.75	116.3	25.0	141.3	16.2	12.6	25.0	37.6	103.7
	January '87	31	4.46	0.95	4.24	131.4	25.0	156.4	0.0	0.0	25.0	25.0	131.4
	February '87	17	5.12	0.73	3.74	63.6	25.0	88.6	0.0	0.0	25.0	25.0	63.6
	Total												432.7

Appendix VI (Contd.)

Sl. No.	Crop & month	No.of days	ET_o	K_c	ET crop mm/day	ET crop total for month	Soil water need	Total water need (mm)	Rainfall (mm)	75% Effective Rainfall	Antecedent soil moisture (mm)	Total available moisture (mm)	Irrigation requirement (mm)
22.	Banana Nendran												
	Planting on 1st September												
	September '86	30	4.11	0.70	2.88	86.31	25.0	111.31	50.7	35.5	25.5	60.5	50.8
	October '86	31	3.68	0.70	2.58	79.86	25.0	104.86	102.7	66.0	25.0	91.0	13.8
	November '86	30	3.00	0.75	2.25	67.50	25.0	92.5	68.6	44.95	25.0	69.95	22.6
	December '86	31	2.60	0.90	2.34	72.54	25.0	97.5	16.2	9.0	25.0	34.0	63.5
	January '87	31	4.47	0.95	4.25	131.60	25.0	156.6	0.0	0.0	25.0	25.0	131.6
	February '87	28	4.90	1.00	4.90	137.20	25.0	162.2	0.0	0.0	25.0	25.0	137.2
	March '87	31	5.21	1.00	5.21	161.50	25.0	186.5	54.0	42.7	25.0	67.7	118.8
	April '87	30	5.89	1.00	5.89	176.70	25.0	201.7	16.5	13.1	25.0	38.1	163.6
	May '87	31	4.55	1.00	4.55	141.10	25.0	166.1	90.8	66.0	25.0	91.0	75.1
	June '87	30	4.04	1.00	4.04	121.20	25.0	146.2	290.8	146.2	25.0	171.2	0.0
	July '87	31	2.79	1.00	2.79	86.50	0.0	86.5	286.6	86.5	50.0	136.5	0.0
	Total												777.0

Sl. No.	Crop & month	No.of days	ET_o (mm/day)	K_c	ET crop (mm/day)	Mean percolation/ day	Total daily water use	Puddling requirement (mm)	Monthly water requirement	Monthly Rainfall	75% effective rainfall	Total irrigation requirement
1.	Paddy Ist crop											
	Planting on 5th June											
	June '86	25	5.51	1.10	6.06	5.0	11.06	150.0	498.00	372.3	279.2	218.80
	July '86	31	2.97	1.10	3.25	5.0	8.25	-	255.75	297.8	223.3	32.45
	August '86	31	3.71	1.03	3.82	5.0	8.82	-	273.42	383.0	287.3	-
	September '86	8	4.83	0.92	4.42	5.0	9.42	-	75.36	-	-	72.36
	Total											323.61

Appendix VI (Contd.)

Sl. No.	Crop & month	No.of days	ET_o (mm/day)	K_c	ET crop (mm/day)	Mean percolation/ day	Total daily water use	Puddling requirement (mm)	Monthly water requirement	Monthly Rainfall	75% Effective Rainfall	Total irrigation requirement
2.	Paddy IInd crop											
	Planting on 25th September											
	September '86	5	4.83	1.10	5.31	5.0	10.31	150.0	201.55	39.2	29.40	172.15
	October '86	31	4.28	1.10	4.71	5.0	9.71	-	301.01	102.7	77.03	223.98
	November '86	30	3.92	1.05	4.12	5.0	9.12	-	273.60	68.6	51.45	222.15
	December '86	29	3.29	0.95	3.13	5.0	8.13	-	235.77	16.2	12.15	223.62
	Total											841.90

Sl. No.	Season & month	No. of days	ET_o (mm/day)	K_c	ET crop (mm/day)	Mean percolation/ day	Total daily water use	Monthly water use (mm)	Rainfall	75% Effective rainfall	Irrigation requirement in nursery (mm)
1.	Kharif										
	Sowing on 10th May										
	May '86	20	4.04	1.1	4.44	-	4.44	88.8	37.1	27.82	60.98
	June '86	5	5.51	1.1	6.06	-	6.06	30.3	13.0	9.75	20.55
	Total										81.53
2.	Rabi										
	Sowing on 5th September										
	September '86	25	4.83	1.1	5.31	5.0	10.31	257.7	-	-	257.7

Appendix VII ESTIMATION OF WATER AVAILABILITY AT FARM LEVEL

To estimate the water supply at farm level, crop water requirement was used as proxy. The crops considered were paddy, groundnut, cholam, chumbu, cotton and ragi. Water supply is normally stated in number of days of supply in the distributory or number of minutes (based on water allowance) at the farm level. If there is no water shortage in the canal, the distributory should receive the designed supply for its command area. In such areas, it is assumed that farmers will use the water to meet the full requirements of the crops. Hence, it is assumed that deviation in the cropping pattern is due to the water availability to the farmer. The water requirements for these crops by soil type and season were obtained from the Agricultural Research Station, located in the LBP command area.

These research station estimates were then adjusted downward according to the reduced yields which farmers achieved, relative to the maximum yields recorded in the Research Station. It is thus assumed that fertilizer applications are also due only to water availability. Hence, the farmer who obtained maximum yield had a water supply equal to the research station water requirements data; the water supply estimates for farmers with lower yields were scaled down proportionately (For example, Farmer A has grown three crops, viz. paddy, groundnut and cholam. His yield was; Paddy = 1000 kg per acre, groundnut = 300 kg per acre, and cholam = 400 kg per acre. The Research station's per acre yield for these crops were: Paddy = 2000 kg, groundnut = 600 kg, and cholam = 900 kg. The research station water use for these crops were: Paddy = 44 acre inches, groundnut = 26 acre inches and cholam = 18 acre inches. From this Farmer A water supply will be calculated as follows:

Appendix VII (Contd.)

$$\left\{\frac{44}{2000} \times 1000\right\} + \left\{\frac{26}{600} \times 300\right\} + \left\{\frac{18}{900} \times 400\right\} = 43.00 \text{ acre inches)}$$

To check this procedure, water flows at different locations were measured and compared with estimated supplies. The actually measured supplies and adjusted research station water requirements were very close (see Appendix 3) and justified the method of estimation. A few cases of low yield due to excess water use, and pest and diseases attack were also observed. Since, they accounted for a small fraction of the sample, (i.e., 16 out of 150 farms), they were considered as exceptional cases and dropped from the analysis.

Source: "Irrigation water management: The determinants of canal water distribution in India - a micro analysis" by Palanisami, K. (1984) Agricole Publishing Academy, New Delhi-24, Page 117-118.

Appendix VIII YIELD RESPONSE FACTORY (KY) VALUES

Crop	Vegetative period			Flowering period	Yield formation	Ripening	Total growing period
	Early (1a)	Late (1b)	Total				
Alfalfa			0.7-1.1				0.7-1.1
Banana							1.2-1.35
Bean			0.2	1.1	0.75	0.2	1.15
Cabbage	0.2				0.45	0.6	0.95
Citrus							0.8-1.1
Cotton			0.2	0.5		0.25	0.85
Grape							0.85
Groundnut			0.2	0.8	0.6	0.2	0.7
Maize			0.4	1.5*	0.5	0.2	1.25*
Onion			0.45		0.8	0.3	1.1
Pea	0.2			0.9	0.7	0.2	1.15
Pepper							1.1
Potato	0.45	0.8			0.7	0.2	1.1
Safflower		0.3		0.55	0.6		0.8
Sorghum			C.2	0.55	0.45	0.2	0.9
Soybean			0.2	0.8	1.0		0.85
Sugarbeet							
beat							0.6-1.0
sugar							0.7-1.1
Sugarcane			0.75		0.5	0.1	1.2
Sunflower	0.25	0.5		1.0	0.8		0.95
Tobacco	0.2	1.0			0.5		0.9
Tomato			0.4	1.1	0.8	0.4	1.05
Water melon	0.45	0.7		0.8	0.8	0.3	1.1
Wheat							
winter			0.2	0.6	0.5		1.0
spring			0.2	0.65	0.55		1.15

Source: "Yield response to water" by Doorenbos, J., and Kassam, A.H., 1979. FAO irrigation and drainage paper No.33. FAO, Rome, Page: 39.

Appendix IX.1 (A) OPERATION WISE PER ACRE COST OF CULTIVATION OF MULBERRY CROP, INTRODUCED IN LINEAR PROGRAMMING

1st Year (Amount in Rs)

	Items	SWF	WFF	SWF
1.	Preparatory cultivation	1240.00	1240.00	1240.00
2.	Planting materials & planting	720.00	720.00	720.00
3.	Nursery raising & maintainance	-	-	-
4.	Transplantation	-	-	-
5.	Manures and manuring	926.00	926.00	926.00
6.	Plant protection	75.00	75.00	75.00
7.	Weeding and intercultivation	320.00	320.00	320.00
8.	Harvesting charges@	400.00	400.00	400.00
9.	Post harvest expenses	-	-	-
10.	Land revenue and taxes	8.00	8.00	8.00
11.	Owned and hired machinery charges	25.00	25.00	25.00
12.	Depreciation and maintainance on farm building, machinery and equipments	296.70	273.40	294.00
13.	Interest on fixed capital of other investments	44.80	29.00	49.70
14.	Interest on working capital	390.00	390.00	390.00
15.	Irrigation labour charges	240.00	240.00	240.00
16.	Irrigation (fuel) charges	405.00	448.50	415.50
17.	Canal water charges	24.00	0.00	24.00
18.	Depreciation and maintainance on irrigation structures, machinery and equipments	304.60	497.00	363.10
19.	Interest on fixed capital of irrigation equipments	81.00	138.80	149.30
20.	Rental value of land*	824.10	841.80	970.90
21.	Others	-	-	-
22.	Total expenses (Cost C)	6324.20	6572.50	6610.50
23.	Cost B@	5924.20	6172.50	6210.50
24.	Cost B - Rental value of land	5100.10	5330.70	5239.60

@ Harvesting charges are considered as family labour expenses and therefore, Cost C - Harvesting charges will give Cost B

* Rental value of sugarcane crop under the respective categories have been considered here.

Note: None of the sample farms were seen to grow Mulberry. It is a newly introduced crop in the area, being cultivated by some progressive farmers. Five such farmers were interviewed and the average of cost of cultivation was taken. The same method was adopted in the case of other crops also, that have been introduced in the L.P. application.

Appendix IX.1 (B) OPERATION WISE PER ACRE COST OF CULTIVATION OF MULBERRY CROP

2nd to 16th year* (Amount in Rs)

	Item	CWF	WFF	SWF
1.	Preparatory cultivation/ pruning	180.00	180.00	180.00
2.	Planting materials & planting	-	-	-
3.	Nursery raising & maintainance	-	-	-
4.	Transplantation	-	-	-
5.	Manures and manuring	1656.10	1656.10	1565.10
6.	Plant protection	150.00	150.00	150.00
7.	Weeding and intercultivation	840.00	840.00	840.00
8.	Harvesting charges@	900.00	900.00	900.00
9.	Post harvest expenses	-	-	-
10.	Land revenue and taxes	8.00	8.00	8.00
11.	Owned and hired machinery charges	50.00	50.00	50.00
12.	Depreciation and maintainance on farm building, machinery and equipments	296.70	273.40	294.00
13.	Interest on fixed capital of other investments	44.80	29.00	49.70
14.	Interest on working capital	375.80	375.80	375.80
15.	Irrigation labour charges	240.00	240.00	240.00
16.	Irrigation (fuel) charges	405.00	448.50	415.50
17.	Canal water charges	24.00	-	24.00
18.	Depreciation and maintainance on irrigation structures, machinery and equipments	304.60	497.00	363.10
19.	Interest on fixed capital of irrigation equipments	81.00	138.80	149.30
20.	Rental value of land	824.10	841.80	970.90
21.	Others	-	-	-
22.	Total expenses (Cost C)	6380.10	6628.40	6666.40
23.	Cost B@	5780.10	6028.40	6066.40
24.	Cost B - Rental value of land	4956.00	5187.00	5096.00

@ Rs.600/- out of the harvesting charges considered as family labour contribution. Hence cost B = (Cost C - Rs.600/-)

* Life of Mulberry plantation taken as 16 years

Appendix IX.1 (Contd.)

C. Expenses incurred in rearing of silk worm

(a) 1st year:

1.	Initial investment on shed, implements etc. for rearing 200 dfls at a time	Rs. 8,000.00
2.	Cost of disease free layings (dfls) $\frac{200}{\text{batch}}$ x 2 batches @ Rs.50/100 dfls	Rs. 200.00
3.	Labour and other miscellaneous items	Rs. 450.00
4.	Interest on fixed investment (@10%)	Rs. 800.00
5.	Interest on working capital (@ 11%)	Rs. 35.75
	Total	Rs. 9,485.75

(b) Recuring expenses for other three years in a four year cycle

1.	Cost of 1000 dfls (@ 200/batch x 5 batches per year)	Rs. 500.00
2.	Cost of labour and other miscellaneous items	Rs. 1,125.00
3.	Interest on fixed investment (@ 10%)	Rs. 800.00
4.	Interest on working capital (@ 11%)	Rs. 35.75
	Total	Rs. 2,460.00

(c) Cost on 5th, 9th and 13th year (the years which need replacement of the fixed investments)

1.	Investment on shed, implements etc.	Rs. 8,000.00
2.	Cost of 1000 dfls	Rs. 500.00
3.	Cost of labour and other miscellaneous items	Rs. 1,125.00
4.	Interest on fixed investment (@ 10%)	Rs. 800.00
5.	Interest on working capital (@ 11%)	Rs. 35.75
	Total	Rs. 10,460.75

Appendix IX.1 (Contd.)

D. Income from Silkworm Rearing

(a) First year:

40 kgs coccoons/100 dfls x 400 dfls = 160 kgs

Price per kg of coccoon (Approx.) after considering marketing cost = Rs.50/kg.

Therefore, income for 1st year = Rs.8,000/-

(b) Second year onwards:

Coccoon yield - 40 kgs/100 dfls x 1000 dfls = 400 kgs

Income from 400 kgs @ Rs.50/kg = Rs.20,000/-

(c) Present worth of returns (discounting method)

	Year	Income Rs.	Df at 15%	Present worth
i)	First year	8,000.00	0.87	6,960.00
ii)	Second year onwards, upto end of 16th year	20,000.00	5.085	101,700.00
	Total			108,660.00

i.e. Net present worth of benefits = Rs. 1,08,660.00

Appendix IX.1 (Contd.)

E. Calculation of present worth of cost for Mulberry plantation and Silkworm rearing

Category: CWF farms

Year	Mulberry plantation cost (Cost C)	Silkworm rearing cost	Total	Discount factor at 15%	Present worth of (Cost C)
1	6324	9486	15810	0.870	13754.7
2, 3 & 4	6380	2461	8841	1.986	17558.2
5	6380	10461	16841	0.497	8370.0
6, 7 & 8	6380	2461	8841	1.135	10036.5
9	6380	10461	16841	0.284	4782.8
10,11 & 12	6380	2461	8841	0.649	5737.8
13	6380	10461	16841	0.163	2745.1
14,15 & 16	6380	2461	8841	0.371	3280.0
	Net present worth of (Cost C)				= 66263.1

Calculation of NPW of cost at considerations of (Cost B - Rental value of land)

Year	Plantation cost (Cost B - RVL)	Rearing cost	Total	Discount factor at 15%	Present worth of (Cost B - RVL)
1	5100	9486	14586	0.870	12689.8
2, 3 & 4	4596	2461	7417	1.986	14730.1
5	4956	10461	15417	0.497	7662.2
6, 7 & 8	4056	2461	7417	1.135	8418.3
9	4956	10461	15417	0.284	4378.4
10,11 & 12	4956	2461	7417	0.649	4813.6
13	4956	10461	15417	0.163	2513.0
14,15 & 16	4956	2461	7417	0.371	2751.7
	Net present worth of (Cost B-RVL)				= 57957.1

Note: In a similar fashion, the present worth of costs were calculated for WFF and SWF categories

	CWF	WFF	SWF
Net present worth of (Cost C)	66263	67741	67968
Net present worth of (Cost B - RVL)	57957	59333	58791

Appendix IX.1 (Contd.)

(F) Mulberry plantation & silkworm rearing - Amortization of costs and benefits

The costs and benefits were amortized using the following formula, to yield amortized annual costs and annual benefits:

$$\text{Amortized cost/benefit} = \frac{P \times R(1+R)^N}{(1+R)^N - 1}$$

Where N = life period i.e. 16 years

R = rate of interest = 15%

P = present worth of cost/benefit

The resultant annual amortized cost/benefit is as follows

	Cost (Rs)	CWF	WFF	SWF
1.	Annual cost taking (Cost B - RVL)	9733.7	9964.8	9873.8
2.	Annual cost taking (Cost C)	11128.7	11376.9	11415.1
3.	Gross value of product (NPW.B)	18249.2	18249.2	18249.2
4.	Net margin over (Cost B-RVL)	+8515.5	+8284.4	+8375.4
5.	Net margin over (Cost C)	+7120.5	+6872.3	+6384.1

Appendix IX.2 PER ACRE COST OF CULTIVATION OF BANANA (NENDRAN)

(Amount in Rs)

	Item	Category CWF	WFF	SWF
1.	Hired human labour	4110.00	4110.00	4110.00
2.	Bullock labour	-	-	-
3.	Tractor/tiller charges	-	-	-
4.	Seeds	1150.00	1150.00	1150.00
5.	Manures	1200.00	1200.00	1200.00
6.	Fertilizers	2447.20	2447.20	2447.20
7.	Plant protection chemicals	120.00	120.00	120.00
8.	Irrigation (Fuel) charges	419.60	464.60	430.40
9.	Canal water charges	24.00	-	24.00
10.	Land revenue & taxes	8.00	8.00	8.00
11.	Owned & hired machinery charges	3220.00	3220.00	3220.00
12.	Depreciation and maintainance on farm building, machinery and equipments	296.70	273.40	294.00
13.	Depreciation and maintainance on irrigation structures, machinery & equipments	315.50	511.30	376.00
14.	Interest on working capital	1510.10	1509.00	1513.80
	COST A	14821.10	15013.50	14893.40
15.	Rental value of land*	824.10	841.80	970.90
16.	Interest on fixed capital of irrigation investments	80.00	143.70	147.20
17.	Interest on fixed capital of other investments	44.80	29.00	49.70
	COST B	15770.00	16028.00	16061.20
18.	Family labour charges	300.00	300.00	300.00
	COST C	16070.00	16328.00	16361.00
19.	Product			
	a) Main product (kgs)	9000	9000	9000
	b) Bye product	L.S.	L.S.	L.S.
20.	Value of			
	a) Main product (Rs)	18000.00	18000.00	18000.00
	b) Bye product (Rs)	1500.00	1500.00	1500.00
21.	Total a + b	19500.00	19500.00	19500.00
22.	a) Profit over Cost A	+4678.90	+4486.50	+4606.60
	b) Profit over Cost B	+3730.00	+3472.00	+3438.80
	c) Profit over Cost C	+3430.00	+3172.00	+3138.80
23.	Cost B - Rental value of land	14945.90	15186.20	15090.30
24.	Profit over (Cost B-RV)	+4554.10	+4313.80	+4409.70

* Rental value taken as that of sugarcane crop under the respective categories

Appendix IX.3 PER ACRE COST OF CULTIVATION OF SESAMUM 3RD CROP AND SUGARCANE (RATOON) CROP

	Item	SESAMUM		SUFARCANE (RAT.)	
		CWF	WFF	SWF	WFF
1.	Hired human labour	285.00	285.00	285.00	1434.50
2.	Bullock labour	150.00	150.00	150.00	-
3.	Tractor/tiller charges	-	-	-	-
4.	Seeds	24.00	24.00	24.00	-
5.	Manures	-	-	-	-
6.	Fertilizers	133.00	133.00	133.00	1058.60
7.	Plant protection chemicals	-	-	-	100.00
8.	Irrigation (fuel) charges	151.80	168.10	155.80	461.30
9.	Canal water charges	8.00	-	8.00	-
10.	Land revenue & taxes	3.00	3.00	3.00	8.00
11.	Owned & hired machinery charges	-	-	-	19.50
12.	Depreciation & maintainance on farm building, machinery & equipments	98.10	91.00	98.00	273.40
13.	Depreciation & maintainance on irrigation structures, machinery & equipments	114.10	185.10	136.10	507.58
14.	Interest on working capital	19.70	18.30	20.80	343.20
	COST A	986.70	1057.50	1013.70	4206.08
15.	Rental value of land	130.00	130.00	130.00	772.50
16.	Interest on fixed capital of irrigation investments	29.00	52.00	53.30	142.71
17.	Interest on fixed capital of other investments	14.90	9.70	16.70	29.00
	COST B	1160.60	1249.20	1213.70	5150.29
18.	Family labour charges	50.00	50.00	50.00	150.30
	COST C	1210.60	1299.20	1263.70	5300.59
19.	Product				
	a) Main product (kgs)	130	130	130	27.5tons
	b) Bye product	-	-	-	-
20.	Value of				
	a) Main product (Rs)	1300.00	1300.00	1300.00	7725.00
	b) Bye product	-	-	-	-
21.	Total a + b	1300.00	1300.00	1300.00	7725.00
22.	a) Profit over Cost A	+313.30	+242.50	+286.30	+3518.92
	b) Profit over Cost B	+139.40	+50.80	+86.30	+2574.71
	c) Profit over Cost C	+89.40	+0.80	+36.30	+2424.41
23.	Cost B - Rental value of land	1030.60	1119.20	1083.70	4377.79
24.	Profit over (Cost B - RV)	+269.40	+180.80	+216.40	+3347.21

Appendix IX.4 PER ACRE COST OF CULTIVATION OF TAPIOCA, GROUNDNUT 3RD CROP AND TOMATO 2ND CROP

Item	Tapioca	Groundnut 3rd crop		Tomato 2nd crop
	WFF	WFF	SWF	CWF
1. Hired human labour	1632.30	513.40	513.40	572.60
2. Bullock labour	200.00	71.40	71.40	187.50
3. Tractor/tiller charges	0.00	77.10	77.10	0.00
4. Seeds	458.70	467.40	467.40	87.50
5. Manures	346.70	0.00	0.00	125.00
6. Fertilizers	588.30	333.70	333.70	375.00
7. Plant protection chemicals	53.30	38.60	38.60	162.50
8. Irrigation (fuel) charges	177.10	249.00	230.70	99.10
9. Canal water charges	0.00	0.00	8.00	8.00
10. Land revenue & taxes	8.00	3.00	3.00	3.00
11. Owned & hired machinery charges	5.30	14.30	14.30	18.80
12. Depreciation & maintainance on farm building, machinery and equipments	273.40	91.00	98.00	98.90
13. Depreciation & maintainance on irrigation structures, machinery & equipments	194.80	274.00	201.50	74.50
14. Interest on working capital	413.10	47.50	55.10	87.50
15. COST A	4351.00	2180.40	2112.20	1899.90
15. Rental value of land	554.00	245.70	245.70	287.50
16. Interest on fixed capital of irrigation investments	54.80	77.00	78.90	18.90
17. Interest on fixed capital of other investments	29.00	9.80	33.00	14.90
COST B	4988.80	2512.90	2469.80	2221.20
18. Family labour charges	129.30	88.60	88.60	868.80
COST C	5118.10	2601.50	2558.40	3090.00
19. Product				
a) Main product (kgs)	7200.00	1056.20	1056.20	2875.00
b) Bye product	L.S.	400.00	400.00	-
20. Value of				
a) Main product (Rs)	5040.00	2357.10	2357.10	2875.00
b) Bye product	500.00	100.00	100.00	-
21. Total a + b	5540.00	2457.10	2457.10	2875.00
22. a) Profit over Cost A	+1189.00	+276.70	+344.90	+975.10
b) Profit over Cost B	+551.20	-55.80	-12.70	+653.80
c) Profit over Cost C	+421.90	-144.40	-101.30	-215.00
23. Cost B - Rental value of land	4434.80	2267.20	2224.10	1933.70
24. Profit over (Cost B - RV)	+1105.20	+189.90	+233.00	+941.30

Appendix X VARIOUS CROP COMBINATIONS TRIED IN THE LINEAR PROGRAMMING APPLICATION

Season	Crop combinations																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Canal fed farms																								
1st Season	P	GN	P	P	GN	P	S	GN	BG	BG	GN	BG												
2nd Season		GN	P	GN	P	S	S	C	GN	P	S	S												
3rd Season																								
Spout fed well irrigated farms																								
1st Season	P	P	P	GN	GN	GN	P	P	GN	P	P	P	P	GN						GN				
2nd Season		P	GN	GN	GN	GN	P	GN	T	HG	HG	P	GN	T	Bana-na	S.C. (NP)	S.C. (Rat)	Tap-ioca	Mulb-erry	GN				
3rd Season					GN	SE	GN	GN	GN	SE	GN	SE	SE	SE						T				
Canal + well fed farms																								
1st Season	P	P	P	GN	GN	GN	P	GN	GN	P	P	GN	GN	P	P	GN	GN	BG	P					
2nd Season		P	GN	GN	T	HG	HG	C	GN	P	GN	GN	P	P	GN	T	T	HG	HG	Bana-na	S.C. (NP)	S.C. (Rat)	Tap-ioca	Mulb-erry
3rd Season									SE	GN	GN	GN	GN	SE	SE	GN	SE	SE	SE					
Well fed farms																								
1st Season	P	P	GN	GN	GN	GN	P	P	GN	P	GN	GN	R	P	P	P	P	P	GN					
2nd Season		GN	GN	T	VG	HG	VG	HG	GN	GN	GN	C	GN	GN	HG	VG	HG	VG	T	S.C. (Rat)	Bana-na	S.C. (NP)	Mulb-erry	Tap-ioca
3rd Season									SE	GN	GN		GN	SE	SE	GN	GN	SE	GN					

Expansions: P - Paddy, GN - Groundnut, S - Sorghum, C - Cotton, BG - Blackgram, SE - Sesamum, T - Tomato, HG - Horsegram, VG - Vignagram(Cowpea) R - Ragi, S.C. (NP) - Sugarcane New Planting, S.C. (Rat) - Sugarcane Ratoon.

A COMPARATIVE STUDY ON THE ECONOMIC EFFICIENCY OF DIFFERENT SOURCES OF IRRIGATION IN CHITTUR DEVELOPMENT BLOCK

By

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ABSTRACT OF A THESIS

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ABSTRACT

A study was conducted in Chittur Development Block to compare the economic efficiencies of different sources of irrigation in the area. Kunnamkattupathy Village in the Block was purposively selected for this. The objectives were to (a) compare the principal sources of irrigation with respect to their adequacy and influence over cropping pattern, (b) to estimate the cost and technical co-efficients on farms (c) to develop optimal plans for farms differing with respect to source of irrigation and (d) to suggest means for optimal use of irrigation water.

Stratified random sampling was the technique used to select farms and pretested schedule was used to gather information from the farmers of the village. The study area had four different systems of irrigation, viz.,canal, canal + well, well and spout fed well. Relevent data were collected from twenty samples each of canal fed, well fed and rainfed farms and fiftcen samples each of canal with well and spout fed well irrigated farms, by personal interview.

Average area per farm was 6.04 acres with canal fed farms having the lowest area, of 3.59 acres and spout fed well irrgated farms having the highest average area of 8.18 acres. Farms of the sample area were evenly distributed between the black loam and red loam soils.

Paddy was the dominant crop being cultivated in irrigated farms and groundnut was the dominant one in rainfed farms. Season wise cropped area indicated a general pattern of paddy Ist crop and groundnut IInd crop in the irrigated farms. Rainfed farms concentrated on low water requiring crops, rather than paddy.

Cropping intensity in irrigated farms was 177.20% while that of rainfed farms was only 158.31%. Most of the farmers deriving benefit of canal water either directly or indirectly felt that their water requirement was being met adequately while majority of farmers depending ground water alone felt that their requirement of water is being met only partially.

Except for family labour, all other inputs were used at higher levels in irrigated farms compared to the rainfed farms. Among the irrigated categories, the well fed farms were found to use comparatively lower quantities of various inputs.

Crop output obtained both in terms of quantity and value, was higher for irrigated farms compared to rainfed farms. Among the irrigated farms, output was high for canal with well and spout fed well irrigated farms and low for well fed farms. In general, the level of use of seeds and fertilizers were not quite rational. Except in the case of phosphate, all other inputs were used in excess over recommended dosages.

Apart from canal fed farms, investment on irrigation was the highest for spout fed well irrigated farms and the lowest for canal with well fed farms. Cost per acre cm of irrigation water was the highest for well fed farms and the lowest for canal fed farms. Irrigation related expenses were the highest for sugarcane and the lowest for blackgram IInd crop.

Cost of cultivation was high for irrigated farms, so also the net margins, as compared to rainfed farms. Canal fed and well fed farms had lower cost of cultivation and the other two categories had high cost of cultivation. Among the major crops, net margins were relatively high for paddy Ist crop, groundnut IInd crop, sugarcane (ratoon) and tapioca.

Optimisation of irrigation water was done collectively for all the farms in each of the irrigation systems using the technique of linear programming. The results in general indicated that it would be economical to concentrate on a few important crops rather than going in for a large number of crop mixes as at present. Crops other than paddy, groundnut, cotton and tomato have been eliminated and mulberry has been suggested. The present status of area under paddy Ist crop has been found to be optimum. Normative plans indicate that as water availability increases, it will be desirable to increase the area under paddy Ist crop, in the same proportion.

However, except in the case of canal fed farms, paddy IInd crop has been suggested to be replaced by other better paying and water efficient crops.

Irrigation water use in canal fed farms was found to be almost near to optimum levels. In the rest of the categories, even for reduced levels of water availability, income could be increased substantially through alternative plans, over the present level, thereby pointing out the fact that it is the optimum use of available water that is more important than simply increasing the level of water availability.

Optimum plans evolved were more labour intensive and less capital intensive indicating that the present level of capital use was higher and labour use was lower.