ECONOMIC ANALYSIS OF DRIP IRRIGATION IN OIL PALM CULTIVATION IN EAST GODAVARI DISTRICT OF ANDHRA PRADESH

BY

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B.Sc. (Ag.)

THESIS SUBMITTED TO THE
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CERTIFICATE

This is to certify that the thesis entitled **"ECONOMIC ANALYSIS OF DRIP IRRIGATION IN OIL PALM CULTIVATION IN EAST GODAVARI DISTRICT OF ANDHRA PRADESH"** submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** in the major field of **Agricultural Economics** of the Acharya N.G. Ranga Agricultural University, Hyderabad, is a record of the bonafide research work carried out by **Miss. B.MRUDULA** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part has been fully acknowledged. All the assistance and help received during the course of investigations have been duly acknowledged by the author of the thesis.

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Miss. B.MRUDULA has satisfactorily prosecuted the course of research and that the thesis "**ECONOMIC ANALYSIS OF DRIP IRRIGATION IN OIL PALM CULTIVATION IN EAST GODAVARI DISTRICT OF ANDHRA PRADESH"** submitted is the result of original research work and of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.

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DECLARATION

I, Miss. B.MRUDULA, hereby declare that the thesis entitled "**ECONOMIC ANALYSIS OF DRIP IRRIGATION IN OIL PALM CULTIVATION IN EAST GODAVARI DISTRICT OF ANDHRA PRADESH"** submitted to the Acharya N.G. Ranga Agricultural University for the degree of **MASTER OF SCIENCE IN AGRICULTURE** in the major field of ***Agricultural Economics*** is the result of the original research work done by me. It is further declared that the thesis or any part thereof has not been published earlier in any manner.

Place : **(B.MRUDULA)**

Date : **BAM-10-38**

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Date : **(B.MRUDULA)**

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LIST OF SYMBOLS AND ABBREVIATIONS

et al.	:	and other workers
&	:	and
APMIP	:	Andhra Pradesh Micro Irrigation Project
BCR	:	Benefit- Cost Ratio
C.P.O	:	Chief Planning Office
CMI	:	Conventional Method of Irrigation
^0C	:	Degree celsius
$	:	Dollar
$/ha	:	Dollar per hectare
DMI	:	Drip Method of Irrigation
etc.	:	etcetra
E_o	:	Evaporation
FUE	:	Fertilizer Use Efficiency
FPE	:	Fraction of Pan Evaporation
FFB	:	Fresh Fruit Bunches
GFCL	:	Godavari Fertilisers and Chemicals Limited
>	:	Greater than
ha	:	Hectare
hrs/day	:	Hours per day
INCID	:	Indian National Committee on Irrigation and Drainage
IEM	:	Industrial Entrepreneurs' Memorandum
ISOPOM	:	Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize
IRR	:	Internal rate of return
IWMI	:	International Water Management Institute

kg	:	Kilogram
kg/ha	:	Kilogram per Hectare
kg/plant	:	Kilogram per plant
km	:	kilometre
kwh/ha	:	Kilowatt-hour per hectare
KB	:	Krishik Bandhu
lakh/acre	:	Lakh/ acre
<	:	Less than
Ltd	:	Limited company
l/hour/day	:	Litre per hour per day
LCDI	:	low-cost drip irrigation
M/s	:	Messrs
MIP	:	Micro Irrigation Project
mm	:	millimeter
M ha	:	Million hectare
NFCL	:	Nagarjuna Fertilizers and Chemicals Limited
viz.,	:	Namely
NABARD	:	National Bank for Agricultural and Rural Development
N/K Ratio	:	Net Benefit-Investment Ratio
NPW	:	Net Present Worth
No.	:	Number
OPAE	:	Oil Palm Area Expansion
OPDP	:	Oil Palm Development Programme
oil/ha	:	Oil per Hectare
oil/ ha/ year	:	Oil per hectare per year
PBP	:	Payback period
%	:	Per cent
Pvt.Ltd	:	Private limited company
qtl	:	Quintal
RKVY	:	Rashtriya Krishi Vikas Yojana

Rs	:	Rupees
Rs/ha	:	Rupees per hectare
TMOP	:	Technology Mission on Oilseeds and Pulses
i.e.,	:	That is
'000' ha	:	Thousand Hectares
'000' tones	:	Thousand tonnes
t/ha	:	Tonnes per hectare
USA	:	United States of America
WUE	:	Water use efficiency
WTO	:	World Trade Organization

ABSTRACT

Name of the Author	:	**B. MRUDULA**
Title of Thesis	:	**"ECONOMIC ANALYSIS OF DRIP IRRIGATION IN OIL PALM CULTIVATION IN EAST GODAVARI DISTRICT OF ANDHRA PRADESH "**
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The present study was conducted in East Godavari district of Andhra Pradesh with the major objectives to (1)analyze the cost structure of drip irrigation system in Oil palm cultivation (2) to appraise the economic viability and financial feasibility of installing drip irrigation system in Oil palm cultivation with and without subsidy components (3) to assess the comparative economics and benefits of drip irrigation system over conventional method of irrigation and (4) to study the possible constraints in installation, execution and maintenance of drip irrigation system in Oil palm cultivation and offer relevant suggestions. A total sample of 120 farmers were selected randomly i.e., 60 drip irrigated and 60 conventionally irrigated farmers. The important analytical tools employed in the study were the project evaluation techniques such as PBP, NPW, B-C Ratio, IRR, N/K Ratio and Switching values were used to study the financial feasibility of Oil palm plantations with drip method of irrigation and conventional method of irrigation.

The per hectare total cost for the life period of 25 years with DMI in Oil palm was Rs.23, 16,804 and Rs. 12, 15,234 for CMI. The per hectare total establishment cost for DMI in Oil palm was Rs. 1,19,733 and Rs. 86,830 for CMI. The per hectare total maintenance cost for DMI in Oil palm was Rs. 21,97,071 and Rs. 11,28,404 for CMI. The cost of drip irrigation system was Rs. 2, 60,000 and with 90 per cent subsidy was Rs. 26,000 in Andhra Pradesh under APMIP.

The higher WUE of 15.35 kg/ha/mm was obtained in DMI to that of CMI system of 5.03 kg/ha/mm. The WUE in terms of water consumed to produce one unit of output was 65.11 mm/ha/kg and 198.77 mm/ha/kg for DMI and CMI respectively. Water saving is 32 per cent in DMI compared to CMI.

The total yield per hectare for the entire economic life period was 503 tonnes under DMI and 224 tonnes under CMI. The total income obtained from one ha during the entire life period of Oil palm under drip irrigation was Rs. 31, 50,792 and Rs.15, 28,416.

The payback period, net present worth, benefit-cost ratio, IRR and N/K ratio in the study area for drip method of irrigation was found to be 0.67 years, Rs. 2, 91,259, 1.87, 50.52 and 10.92 respectively. Similarly for conventional irrigation the Payback period, Net Present Worth, B-C ratio, IRR was 1.02 years, Rs. 98406, 1.43 and 41.46 respectively. The drip irrigation is financially viable compared to conventional irrigation.

The payback period, net present worth, benefit-cost ratio and IRR based on incremental costs and benefits between two irrigation systems in Oil palm were 0.33 years, Rs. 1, 89,020, 2.74 and 53.90 per cent respectively. The studies also showed that the drip irrigation in Oil palm is viable even without subsidy both for drip system and plant material.

It is understood from the study that capital cost required to install drip irrigation is relatively high. Therefore, measures can primarily be taken to reduce the cost of drip irrigation equipment by promoting production and supply of low cost drip systems. Considering the high yield per hectare through drip method of irrigation in Oil palm cultivation compared to conventional method of irrigation, drip irrigation technology should be expanded to all the Oil palm cultivation areas as a mandatory as majority of the farmers are large farmers and is financially viable even without subsidy. Subsides related to plant material, cost of cultivation, INM, IPM, fertilization, tree guards, vermicompost pits, intercrops etc can be reduced. Subsidy related to drip systems, diesel or electric pumps, bore wells land water harvesting methods can be continued to bring entire Oil palm area under drip irrigation methods as it is more productive and viable. Since Oil palm plantations with DMI are viable financially and economically even without subsidy in drip, subsidies can be rationally reduced. As an alternative for reduction of subsidies, loans from banks shall be provided for adoption of DIS in Oil palm cultivation.

Chapter I

INTRODUCTION

Irrigation plays a vital role to achieve the food security and sustainable livelihoods. It also plays a paramount role in increasing the use and efficacy of yield increasing inputs enhancing cropping intensity as well as productivity of crops. Apart from benefiting the farmers, irrigation development also helps to increase the employment opportunities and wage rate of the agricultural landless labours (Narayanamoorthy, 2001). But today, this essential resource is under severe threat. Growing national, regional and seasonal irrigation water scarcities in the country posed several challenges to the Government to combat this situation. The challenge of growing irrigation water scarcity was heightened by the increasing costs of developing new irrigation water sources. Past experiences also indicated that inappropriate management of irrigation has led to severe problems like excessive water depletion, reduction in water quality, water logging, salinization, lowering of ground water tables due to pumping at unsustainable rates, intrusion of salt water in some coastal areas etc. Moreover increasing demand from other sectors viz., industrial and household sectors also put tremendous pressure on the available limited water resources to the agricultural sector.

In this context, efficient use of irrigation water gains priority with reference to short run and long run perspectives of Indian agriculture. Micro irrigation in general and Drip irrigation in particular has received considerable attention from the irrigation specialists, economists, policy makers, researchers etc., for its perceived ability to contribute significantly to ground water resources utilization and management, agricultural productivity, economic growth and environmental sustainability.

A study by the International Water Management Institute (IWMI) has shown that around 50 per cent of the increase in demand for water by the year 2025 can be met by increasing the effectiveness of irrigation (Seckler *et al.,* 1998). One of the main reasons for the low coverage of irrigation is poor water

use efficiency under the conventional method of irrigation, which is predominantly a practice in Indian agriculture. The on-farm irrigation efficiency in properly designed and managed drip system is estimated to be about 90 per cent, which is only about 35 to 40 per cent for conventional method of irrigation. (INCID, 1994).

The drip technology was spread from Israel to Australia and to the United States of America (USA) by late sixties and eventually throughout the world. This technology was introduced in India in early 1970's but larger adoption of it was in 1980's particularly in fruit, vegetable and cash crops. Drip method of Irrigation (DMI), also known as trickle irrigation or micro-irrigation supplies water constantly at regular intervals to the root zone of the crop through a network of pipes with the help of emitters. Unlike the conventional method of irrigation, the efficiency of water use is extremely high in DMI as it substantially reduces the evaporation, conveyance and distribution losses of water (Narayanmoorthy and Deshpande, 2005).

DMI system is considered as the most suitable water saving technique, eliminating water channels; bringing more area under irrigation and reducing the use of purchased inputs. DMI reduces the cost of cultivation, minimizes the tillage of plough and reduces soil erosion. Studies carried out in countries like Israel, Jordan, USA and India have shown that drip method of irrigation increases crop productivity by 20-90 per cent and reduces water use by 30-70 per cent for different crops (Postal et al., 2001).The chemical inputs such as fertilizers and other nutrients can be applied in a balanced manner at the required time and quantity for crops. DMI also reduces the cost of cultivation required for performing the operations like ploughing, weeding, irrigation, labour and energy use compared to the conventional method of irrigation. (Narayanamoorthy, 2001a). Besides, increased adoption of DMI also generates many environmental benefits and increases the productivity of crops mainly by reducing moisture stress for crops. Today, drip equipment is also specifically designed to enable Oil palm growers to make use of existing farm infrastructure such as variable topography, water sources and qualities.

Oil palm (*Elaeis guinensis)* is the highest edible oil yielding perennial crop and can be the primary source for achieving self sufficiency in edible oil production by reducing imports. Oil palm produces 4 to 6 tonnes of crude palm oil/ha (oil from the fibrous mesocarp) and 0.4 to 0.6 tonnes of palm kernel oil/ha (oil from the kernels) starting from the fourth to the 25th year of its productive life span compared to production of less than one tonne/ha from other oil seeds. Oil palm cultivation is expanding worldwide owing to price competitiveness, techno-economic superior attributes for various edible and non-edible applications and assured feedstock supplies round the year to mills. However, within the context of declining water reserves, rising fertilizer, energy and labour costs in Oil palm; production systems necessitate the use of innovative water management technologies to ensure higher productivity, use efficiency, profitability of water sources, pumps, plant densities and crop age.

Oil palm being a fast growing crop with high productivity and biomass production requires adequate irrigation. Annual water requirement is in the range of 2000 mm. Hence to meet the huge water requirements of the crop, drip irrigation system is best suited. Additional practical benefits are water application at a rate closer to plant water uptake and fertigation scheduling according to crop developmental phases that affect soil water regime and plant response. It is thus expected to improve Fresh Fruit Bunches (FFB) yield, reduce water and nutrient leaching from drainage below the root zone.

Problem Statement

India currently produces less than 50 per cent of its requirements of edible oils. The imports of vegetable oil witnessed a surge during 2008-09 and 2009-10. Imports increased from 5.60 million tonnes in 2007-08 to 8.18 million tonnes in2008-09 and 8.82 million tonnes in 2009-10. Almost stagnant domestic production of oil seeds and increased consumption of edible oils has increased dependency on imports in recent years. India is the third largest importer of palm oil. Oil Palm Development Programme (OPDP) was launched during 1991-92 under the Technology Mission on Oilseeds and Pulses (TMOP)

with a focus on area expansion in the states of Andhra Pradesh, Karnataka, Tamil Nadu, Orissa, Gujarat and Goa. A special Programme on Oil palm area expansion (OPAE) under RKVY was undertaken in 2011-12 in order to augment the production of palm oil by Rs. 2.5 to 3 lakh tonnes in next five years. Under this programme Rs. 49,000 ha i.e., 66.67 per cent of the total targeted area of 60,000 ha is proposed with an outlay of Rs. 19,200 lakhs in Andhra Pradesh itself out of Rs. 30,000 lakhs of total outlay. Drip irrigation and supply of diesel or electric pump sets are given major analysis under this OPAE under RKVY, with varying levels of subsidy components, because of expensive nature of technology.

The subsidy per cent in Andhra Pradesh varies according to the land holdings of the farmers i.e., 90 per cent (< 5ha), 75 per cent (5-10 ha) and 50 per cent (>10 ha). (APMIP, 2012). Oil palm is cultivated in about 1, 03,563 ha of Andhra Pradesh. Drip irrigation is practiced in Oil palm to conserve water, increase water and fertilizer use efficiency, to optimize FFB and oil yields. The per cent of crops under drip irrigation in East Godavari district is 53 per cent (7496.81 ha) under Oil palm, 21 per cent under cocoa, 16 per cent under coconut and the remaining 10 per cent distributed to small acreage crops. In East Godavari district, the area under canals, tube wells and filter points, tanks and other irrigated sources are 68 per cent, 22 per cent, 7 per cent and 3 per cent respectively (C.P.O, 2009).The investigations also revealed that in East Godavari delta, the farmers resort for using drip irrigation in Oil palm cultivation in a significant proportion of 64.49 per cent (7496.81 ha) of total Oil palm cultivated area (APMIP, 2012). As Oil palm accounted for 53 per cent of drip irrigation among all the crops, with a view to analyze the economic prospects of drip irrigation technology and to have comparative picture with the conventional method of irrigation in cultivating Oil palm in the district was taken up for the research study.

Research Questions of the Study

1) Is investment on drip irrigation economically viable in Oil palm cultivation under varied conditions of escalating costs and reduced profits?
2) What are the benefits of drip method of irrigation compared with the conventional method of irrigation in Oil palm cultivation?
3) How far the subsidy given by the Government helps the farmers and is the Oil palm cultivation viable and economical even without subsidy?
4) Whether Micro Irrigation Project (MIP) can continue without subsidy component?
5) What are the possible constraints in installation, execution and maintenance of drip irrigation system in Oil palm cultivation?

To find solutions to the above research questions, the following objectives were framed.

Objectives

The present study was taken up with the following objectives.

1) To analyze the cost structure of drip irrigation system in Oil palm cultivation.
2) To appraise the economic viability and financial feasibility of installing drip irrigation system in Oil palm cultivation with and without subsidy components.
3) To assess the comparative economics and benefits of drip method of irrigation system over conventional method of irrigation
4) To study the possible constraints in installation, execution and maintenance of drip irrigation system in Oil palm cultivation and offer relevant suggestions.

Scope of the Study

The results of the study would be very useful to encourage drip method of irrigation in Oil palm and it would indicate whether there is any scope for expanding drip irrigation in Oil palm without subsidy component. The cost structure gives useful information regarding fixation of the price per unit to the administrators and policy makers regarding the profitability of drip method of irrigation as compared to the conventional method of irrigation.

The study appraises the economic viability and financial feasibility of installing of drip irrigation system in Oil palm cultivation with and without subsidy components. The study gives the scope that investment of drip irrigation is economically viable even without Government subsidy.

The results of the NPW, B-C ratio tell about the profitability of practicing drip irrigation and worthiness of the investment. The study also throws light on the constraints in installation, execution and maintenance of drip irrigation system in Oil palm cultivation and offer relevant suggestions.

Limitations of the Study

Research studies conducted by individuals are always confronted with various bottlenecks and hence the present study is not an exception to such limitations. The data was collected with limited sample of respondents of Oil palm cultivation in East Godavari district. Hence, the generalizations have to be restricted to the area where similar agro-climatic and socio-economic conditions prevail in the districts of Andhra Pradesh. The data was collected through survey method by interviewing farmers on the cost and returns of Oil palm for drip and conventional methods of irrigation were for different years. Therefore, the objective of the study was limited to the extent that the farmers were able to recapitulate from their memory as they did not maintain any farm records, answer the questions from their memory recalls which are bound to have many inherent limitations. However, cross- checking of the data collected helped in minimising the re-call bias.

Structure of the Study

The study is organised into six chapters.

Chapter -I	:	Introduction, problem statement, objectives, scope and limitations of the study
Chapter - II	:	Review of literature pertaining to present study and review of past studies
Chapter -III	:	Describes the material and methods used in the study, sampling procedure and hypotheses formulated
Chapter - IV	:	Describes the agro economic features of the present study
Chapter - V	:	The results of the study were discussed in this chapter
Chapter -VI	:	The chapter concludes with the summary and conclusions along with policy implications.

Chapter II

REVIEW OF LITERATURE

This chapter presents a brief review of literature pertaining to the Oil palm cultivation and drip method of irrigation. Concepts and conceptualization is essential parts in any research study. Review of concepts used in earlier studies help us to adopt, modify and improve the conceptual framework and provide a link with past approaches. Hence, an attempt is made to review the various methods used in the earlier studies to specify the concepts used and adopted in the present study. The literature available on present study has been organized under the following heads.

1. Establishment and maintenance costs and financial feasibility of Oil palm cultivation.
2. Economic viability and financial feasibility of installing drip irrigation system in Oil palm cultivation.
3. Comparative economics and benefits of drip irrigation system over conventional method of irrigation.
4. Studies on drip irrigation system with and without subsidy components.
5. Constraints in installation, execution and maintenance of drip irrigation system in Oil palm cultivation.

2.1 ESTABLISHMENT AND MAINTENANCE COSTS AND FINANCIAL FEASIBILITY OF OIL PALM CULTIVATION.

Kumar (1992) in his study reported that the cost of production of Oil palm to raise one hectare of plantation upto fourth year was Rs. 30,000 and further revealed that the cost of maintenance per year was about Rs. 6,500 per hectare.

Radhika (1995) in her study on economics of Oil palm cultivation in Andhra Pradesh concluded that the establishment cost of the crop during the first year was Rs. 14,826 per hectare of which the cost of planting material accounted for highest expenditure of Rs. 6,636. The maintenance cost of Oil palm orchards ranged from Rs. 5,391 to Rs. 7,727 per hectare in fourth year.

Rangachary (1995) in his study on economic analysis of Oil palm cultivation in West Godavari district of Andhra Pradesh revealed that the cost of cultivation during the pre-bearing period form first year to third year was Rs. 34,081.07 per hectare and average cost of cultivation form fourth and fifth year bearing orchard was Rs. 7,009.31 per hectare per year. The NPW, BCR and IRR were Rs. 5474.57, 0.85 and -2.42 per cent which indicated that the investment made on Oil palm orchard upto fifth year was not profitable.

Motilal (1996) worked out the net returns from Oil palm cultivation during its life span of 25 to 30 years which ranged from Rs. 40,000 to Rs. 90,000 per hectare depending upon the management of crop.

Srilatha (2000) from her study in Oil palm in Nellore district reported that the total cost per hectare was Rs. 6,33,627.20 and Rs. 6,17,377.20 without and with subsidy respectively with respective net incomes of Rs. 3,29,507.89 and Rs. 3,45,757.89. Even at higher discount rate of 24 per cent, the Oil palm cultivation was found economically viable.

2.2 ECONOMIC VIABILITY AND FINANCIAL FEASIBILITY OF INSTALLING DRIP IRRIGATION SYSTEM IN OIL PALM CULTIVATION

Jadhav *et al.* (1990) reported that the yields of tomato cultivar pusa rubi were 48t/ha for a drip irrigation system with pressure-compensating emitters and 32 t/ha when furrow irrigation was used. The benefit-cost ratios were 5.15 and 2.96 respectively for the drip and furrow methods.

Muralidhara *et al.* (1994) concluded that the discounted returns (at 12 percent) from one hectare of grapes, ber and citrus worked out was higher in case of DMI as compared to CMI. The earning power of drip irrigated grapes, ber and citrus was also higher i.e.17, 28.5 and 29 percent, respectively.

Sivanappan (1995) suggested that the investment in drip irrigation is economically viable for different crops since the B-C ratio estimated was more than one. While the B-C ratio for pomegranate was estimated to be 5.16, the same is estimated to be 1.83 for cotton, which is a less-water intensive as well as a narrow spaced crop.

Narayanamoorthy (1997) indicated that the cost incurred on drip system was Rs. 27495, Rs. 16418 and Rs. 22044 for grapes, ber and kinnow, respectively. Thus, the payback period of drip system worked out to be five years for grapes while it was four years in case of ber and kinnow respectively.

Polak and Adhikari (1997) concluded from their studies in U.S.A that the development of low cost drip irrigation systems have been recognized as a critical need. A simplified low cost drip system was developed and tested which reduces the capital costs to $250/ha.

Anand *et al.* (1998) while comparing the economics of drip and surface irrigation systems in grapes observed that the cost of cultivation per acre of Grapes in drip irrigation worked out to be Rs. 19,975 while it was Rs. 21,658 in case of surface irrigation. The cost of production per acre of grapes under drip irrigation was lower by 7.77 per cent when compared to surface irrigation.

Dash (1998) found that the Benefit-Cost Ratio (BCR) of sugarcane cultivated under DMI was estimated to be 1.53 in Orissa.

Frank *et al.* (1998) reported that incremental conversion to sub-drip irrigation requires a net increase in annual costs of $178/acre in potato from the experiments in Florida. The increase in net costs is primarily a result of the fixed costs of the drip tubing and the variable costs associated with its maintenance.

O'Brien *et al*. (1998)from their studies on corn in America indicated that economic factors and forces that tend to either increase irrigated crop income or that tend to increase costs equally between the irrigation system alternatives tend to either favor subsurface drip irrigation or are neutral to the investment decision between the two options "high price and high cost" scenarios of economic factors favors subsurface drip irrigation investments.

Rosario *et al.* (2000) studied on drip fertigation Philippines on cotton grown under drip fertigation was shorter but produced more balls than those grown under the conventional method. Return above variable cost and benefit-cost ratio was higher and better in drip irrigation than conventional method. Partial budget analysis showed that drip fertigation is economically feasible and profitable over the conventional method.

Shukla *et al.* (2000) indicated that the average initial cost of mango with the drip system was 730-850 $/ha, and the net cash inflow for 10 years was 25000 - 27 000 $/ha.

Rolbiecki and Rzekanowski (2001) demonstrated that the water use efficiency was higher in carrot in case of drip system as compared to sprinkler irrigation from his studies in Poland. The use of drip irrigation was cost effective.

Malik and Luhach (2002) reported that the fixed capital cost of drip set remained almost same for all the crops and the variation in variable cost of drip sets of crops is mainly due to the variation in number of plants and spacing for each crop. He observed that the labour and electricity charges were much lower in drip method of irrigation in comparison to other methods of irrigation from his experiments with grape, ber and citrus in Haryana. The IRR values for grapes, ber and citrus are 17 per cent 28.5 per cent and 259 respectively. The investment in drip irrigation was found sound and economically viable and the cultivators are advised to make use of drip sets.

Narayanamoorthy (2003) concluded form his experiments in sugarcane in Maharashtra that drip method of irrigation reduced the cost of cultivation especially in labour intensive operations like weeding, irrigation and ploughing. When labour cost reduces, the total cost of cultivation also reduces because labour cost constitutes a considerable portion in cost of cultivation. Cost saving is found in fertigation.

Westarp and Schreier (2004) indicated that the recent introduction of low-cost drip irrigation (LCDI) to Nepal represents an affordable means of expanding irrigation into rainfed areas, thereby increasing land productivity.

Cetin *et al*. (2004) indicated that in present value terms, a grower could spend up to $3999 for the apple varieties 'Granny Smith' and $2324 for 'Golden Delicious' in Turkey per ha for drip irrigation systems and still break even. The NPV values were $ 2584 to Granny Smith and $ 909 for golden Delicious respectively.

Senzanje and Rwakatiwana (2004) studies showed that low cost drip systems can perform reasonably well and a practical combination of operational parameters exists that maximize technical performance.

Reddy *et al.* (2004) in their paper discussed the economic feasibility and prospects of adopting drip irrigation for fruits, vegetables, sugarcane and cotton, Out of 6.5 M ha cultivated area under the above crops, 5.5 M ha is suitable for drip irrigation. An economic analysis of selected crops under drip shows that the net profits range from Rs. 4700 to Rs. 19780/ha. Fruit crops are more favored with a maximum B: C ratio of 3.43 followed by sugarcane 2.41.

Chinnappa and Hippargi (2005) from Karnataka reported that there is substantial saving in cost of cultivation (Rs. 8837) of drip-irrigated gardens which is due to decreased use of labour and inputs. The results of economic feasibility indicated that investment on drip irrigation technology for arecanut cultivation is economically feasible.

Niggi *et al.* (2005) concluded that the cost-benefit analysis in Kenya showed that farm ponds with drip irrigation are feasible solutions to persistent crop failures in semi-arid areas which dominant most countries in Sub-Saharan Africa.

Mohanty *et al.* (2006) concluded that the additional income from turmeric was about Rs. 23,700 per ha/year which means that a good part of the investment in drip.

Ravibhat and Sujatha (2006) reported that the cost of cultivation during bearing stage in conventional method of arecanut cultivation was Rs. 60,242 while with drip fertigation it reduced to Rs. 26,377.

Jalajakshi and Jagadish (2009) demonstrated that the Krishik Bandhu (KB) drip irrigation technology has much higher benefit-cost ratios, ranging from 1.5 in sugarcane production in the Erode region to 5.68 in chilli production in the Indore region. There has been a considerable saving in labour cost in the application of irrigation water in the case of KB drip irrigation technology besides facilitating Fertigation.

Almas *et al.* (2010) concluded that drip requires the highest capital investment. However it is considered the least labour-intensive method of irrigation due to automation. Adoption of drip would result in 18-20 percent reduction in water used for irrigation while maintaining crop.

Boesen *et al.* (2010) reported that irrigation costs are significantly increased (more than doubled), and the total production costs are increased by 10 per cent (deficit drip irrigation) and 23 per cent by partial root drying in potato in Serbia.

Çetin *et al.* (2010) from Turkey indicated that all growers reported positive results with the drip irrigation system. Despite the relatively high initial investment, drip irrigation for peach production in the study area is profitable. Because of the high market price of the fruits, analysis showed that the drip irrigation system would be a profitable investment.

Ramah *et al.* (2010) reported that though the initial capital investment was high (Rs. 82,041) towards drip fertigation system in maize in Coimbatore. The benefits obtained would be greater considering the longer life of the system. Drip irrigated crops have higher net return and B-C ratio when compared to the conventional methods of irrigation.

Wu *et al*. (2010) reported that drip irrigation system cost can be reduced effectively by using optimal design methods and decreasing the system pressure.

Sankaranarayanan *et al*. (2011) reported that the cost of cultivation is higher with existing drip system (Rs 32,865/ha) as compared to polytube drip system (Rs27, 190/ha) and micro tube drip system (Rs 27,244/ha) and ridges and furrow method of irrigation (Rs. 25, 550/ha) in Bt cotton from his experiments in China.

An overview of the above studies shows that the initial investment in drip irrigation system in most of the cases was high. But the analysis using discounting cash flow techniques such as NPW, BCR and IRR showed that the investment in drip irrigation is economically viable and financial feasible.

2.3 COMPARATIVE ECONOMICS AND BENEFITS OF DRIP IRRIGATION SYSTEM OVER CONVENTIONAL METHOD OF IRRIGATION

Magar *et al.* (1988) concluded that drip irrigation technologies promise 30–70 per cent improvement in water use efficiency, besides offering significantly higher yields and several other benefits.

Nagaraj *et al.* (1989) reported that the area under drip irrigation yielded better quality coconuts in terms of size, copra content and quality which in turn were reflected in the price received.

Kandaswamy (1990) concluded that the results of increased yield, water saving labour saving, quality produced and reduced weed growth have been obtained through drip irrigation.

Morita *et al.* (1990) reported that amount of drip irrigation was 2.5 mm per day and that of the spray irrigation was 5.0 mm. Therefore the drip irrigation was water saving compared with the spray irrigation. The highest yield was obtained under the condition of the drip irrigation and the quality of sugarcane was ameliorated slightly by the irrigation treatment.

Daniel (1992) found that besides water saving of about 17.7 percent, the weed population was also found to be very less under DMI when compared to FMI.

Indian National Committee on Irrigation and Drainage (1994) reported that drip irrigation technologies promise 30–70 per cent improvement in water use efficiency, besides offering significantly higher yields and several other benefits.

Narayanamoorthy (1995) concluded that the reduction in water consumption in drip method of irrigation also reduces the energy use (electricity) that is required to lift the water from irrigation wells.

Narayanamoorthy (1996) estimated that electricity saving due to DMI was about 2430 kwh/ha for banana and 1470 kwh/ha for grapes.

Rosegrant (1997) concluded that water use efficiency under flood method of irrigation is estimated to be only around 40 percent mainly due to huge losses through evaporation, conveyance and distribution. Unlike FMI; water use efficiency can be achieved over 90 percent in DMI.

Anand *et al.* (1998) concluded that the cost of production of grapes was lower by 7.77 per cent in the conventional method of irrigation. The yield and return per acre of grapes was higher under drip irrigation compared to surface irrigation.

Camp (1998) showed that yield response for over 30 crops indicated that crop yield for subsurface drip was greater than or equal to that for other irrigation methods, including surface drip, and required less water in most cases.

Deshmukh *et al*. (1998) indicated that the automatic drip irrigation is found to be effective in increasing yield and water saving in sugarcane as compared to manually controlled drip irrigation and conventional method of irrigation.

Dhonde and Banger (1998) reported that because of less moisture stress under DMI, the recovery rate of sugarcane cultivated under DMI was found to be higher when compared to the crop cultivated using CMI in Maharashtra.

Sankpal *et al,* (1998) reported that water use efficiency was estimated to be 999.91 for DMI; the same was estimated to be only around 391 for CMI. Besides yield increase and water saving, recovery rate of sugarcane cultivated under DMI was also found to be higher when compared to the crops cultivated under CMI.

Venugopal and Rajkumar (1998) indicated that single cane weight, cane girth, cane length, number of inter-nodes, leaf length and leaf breadth were also found to be higher with sugarcane cultivated under drip method of irrigation when compared to the same cultivated under flood method of irrigation in Baramba of Orissa.

Shikhamany and Srinivas (1999) studied the response of Thompson Seedless grapes to different evaporation replenishment rates under drip and basin irrigation systems at Bangalore. Drip irrigation recorded marginally higher yields compared to furrow irrigation, although the differences were not significant. The water use with drip irrigation was 25 per cent less compared with furrow irrigation.

Shrivastava *et al,* (2000) concluded that three years pooled results showed that drip irrigation, in general, increased banana yield as compared to surface method along with water saving of 30 per cent, 43 per cent and 56 per cent in 0.45, 0.60 and 0.75 FPE (Fraction of Pan Evaporation) respectively.

Goldhamer *et al.* (2002) from California reported that when compared with a conventional flood irrigation system, the buried-drip system reduced orchard humidity and dew duration and increased temperature in pistachios. This significantly reduced leaf symptoms of the disease and fruit infection at harvest. Additionally, more shells split open with the buried drip method, resulting in a higher yield of marketable pistachios.

Narayanamoorthy (2001b) in Maharashtra indicated that the water saving due to DMI is about 29 per cent in banana, 37 per cent in grapes and about 44 per cent in sugarcane.

Dhawan (2002) indicated that the DMI reduces the cost of cultivation, especially in labour intensive operations like weeding, irrigation, ploughing, etc.

Surve *et al.,* (2002) from their experiments at Rahuri in cucumber reported that the per cent increase in yield due to drip irrigation over surface method of irrigation ranged from 5.54 to 40.74 per cent.

Prasad *et al.* (2003) concluded that in Jodhpur, the pomegranate plants irrigated through drip were more vigorous than basin irrigation system. Irrigation through drip at the rate of 8 l/hour/day for three hours increased the yield from 17.7 kg/plant under control to 28.2 kg/plant with a considerable reduction in cracking. The quality of fruits in terms of weight, size and juice content was better under drip irrigated plants as compared to basin irrigation system.

Dhanapal *et al.* (2004) conducted an experiment with 'Chowghat Orange Dwarf' x 'West Coast Tall' and 'West Coast Tall' Coconut (*Cocos nucifera* L.) and studied the influence of drip irrigation on nut yield and nut characters at Kasaragod, Kerala. The treatments consisted of three levels of drip irrigation [33, 66 and 100 per cent of open pan evaporation (E_o) daily] along with basin irrigation (100 per cent of E_o) and rainfed control. Drip irrigation resulted in water saving and the nut yield was on a per with 100 per cent through drip and 100 per cent of E_o through basin irrigation. Rainfed control and 33 per cent of E_o through drip treatments recorded significantly lower nut yield in both the cultivars. The nut characters like nut weight, copra thickness, and copra content were superior under irrigated treatments compared to rainfed control.

Phene (2004) results indicate that accurate management of water and fertilizers with sub surface drip irrigation systems is the next step in producing extremely high yield of high quality processing tomatoes and therefore high gross and net returns compared to conventional methods of irrigation. Similar high yields have also been obtained with sweetcorn, cantaloupes, broccoli, cotton, alfa alfa, grape and nut trees. Drip Irrigation has been shown to greatly improve water use efficiency.

Maisiri *et al*. (2005) concluded that in the vegetable english giant nape, drip irrigation used about 35 per cent of the water used by the surface irrigation systems thus giving much higher water use efficiencies. It was concluded that low cost drip systems achieved water saving of more than 50 per cent compared to surface irrigation system from their experiments in Zimbabwe.

Narayanamoorthy and Deshpande (2005) indicated that unlike the FMI, the efficiency of properly designed and managed drip irrigation system is about 90 percent, whereas it is about 70 percent for sprinklers but just 40 percent for the surface irrigation system.

Narayanamoorthy (2006a) reported that consumption of electricity per hectare is quite low for drip irrigated crops as compared to the same crops cultivated with flood method of irrigation. Electricity saving due to DMI is estimated to be about 1059 kwh/ha for sugarcane, about 1476 kwh/ha for grapes and about 2434 kwh/ha for banana. Efficiency in electricity use is also found to be very high in all the three crops cultivated under drip method of irrigation.

Saini *et al.* (2006) demonstrated that drip irrigation method gave substantially higher net returns for vegetable crop sequence, because water saved with drip irrigation method can be used to irrigate the additional area in Ludhiana. The net return with drip was 3.6 times higher as compared to conventional irrigation method.

Satyendrakumar *et al*. (2007) study revealed that using this system, Onion production was more profitable as compared to existing irrigation practice.

Najafi and Tabatabaei (2007) concluded that drip irrigation provides better soil moisture in the root zone, less water runoff, and less surface evaporation from their experiments in Iran on potato and tomato. The results show that the maximum crop yield. Additionally, the results show considerable reduction of surface evaporation in drip irrigation treatments.

Ward *et al.* (2007) showed that a subsidy for drip irrigation of US$115 per acre is enough to maintain original income through the producer's investment in the drip technology even with 100 fewer acre-feet of water to apply.

Narayanamoorthy (2008) concluded that cultivating cotton under drip method of irrigation in Maharashtra provides a number of different benefits to farmer over flood method of irrigation. Drip irrigation reduces the cost of irrigation about 50 per cent helps in reducing the cost on weeding; inter culture as well as on preparatory works. Water saving due to adoption of drip method of irrigation is about 45 percent over flood irrigation.

Moezzi *et al.* (2009) indicated that in the drip tape system the water use efficiency (WUE) is significantly higher in comparison to the surface irrigation method so that the WUE of 2.7 kg per cubic meter for the lettuce in surface method was raised to 7.3 kg per cubic meter by drip tape method in South West Iran. Also, the uniformity of the water distribution along the lateral pipes with 150 m long was almost 98 per cent.

Shedeed *et al*. (2009) recorded in Egypt significantly higher total dry matter production (3.60 t/ha) and leaf area index (LAI) (3.15) in tomato under drip irrigation over furrow irrigation (2.86 t/ha and 2.27) respectively.

Al-Amoud (2010) indicated that there is an increase in the yield and a considerable saving in water compared to the conventional drip irrigation method in date palm trees in Alwatania. In addition there was a high increase in water use efficiency using the subsurface system. The subsurface systems prove to be durable and highly efficient for irrigating Date palm trees.

Gupta *et al*. (2010) reported that the proper management of drip irrigation and fertigation with appropriate amount of water and fertilizer significantly enhance the yield and quality of capsicum with maximum water and Fertilizer Use Efficiency (FUE). The FUE was recorded with the treated combination of 80 per cent ET through drip and 60 per cent through fertigation.

Narayanamoorthy (2010) concluded that the drip method of irrigation can be used as a defective tool to achieve the macro objectives of conservation agriculture. Drip method of irrigation helps to conserve different resources including water. A significant amount of saving in irrigation water, electricity, cost of cultivation and a substantial increase in the productivity of sugarcane, banana, grape and cotton can be achieved by adopting the drip method of irrigation. The results of benefit cost analysis suggest that the investment in drip method is also economically viable.

Panigrahi *et al*. (2012) reported that the drip irrigation in Mandarins provides heavier fruits, with lower acidity and higher total soluble solids were harvested in Drip irrigation as compared with Basin Irrigation.

Ren *et al*. (2010) from China reported that the comparison of new spring wheat planting pattern based on drip irrigation system with conventional methods, and some new practices based on the modern drip irrigation on wheat will gain higher yield, save more water. This will give some advice on how to plant spring wheat in these areas.

Thompson *et al*. (2010) indicated that for broccoli production with subsurface-drip irrigation on sandy loam or finer soils, fertigation can be applied as infrequently as monthly, without compromising crop yield or quality, or causing excessive nitrogen losses.

Sureshkumar and Palanisami (2010) revealed from their studies on different drip irrigated crops in Coimbatore that the adoption of drip irrigation technology has increase the net sown area, net irrigated area and thereby helped in achieving higher cropping intensity and irrigation intensity. It has been found

that there is a significant shift towards commercial crops from annual crops. Drip method of irrigation has a significant impact on resources saving, cost of cultivation, yield of crops and farm profitability. It is also observed that the drip irrigation has a significant bearing on private costs and benefits and hence profitable to farmers.

Dursun and Ozden (2011) concluded that drip irrigation system not only prevents the moisture stress of trees and salification, but also provides an efficient use of fresh water resource in dwarf cherry in Anatolia. In addition, the developed irrigation method removes the need for workmanship for flooding irrigation.

An overview of the above studies shows that drip method of irrigation compared to conventional method of irrigation results in high water use efficiency, increased water saving, fertilizer use efficiency, increased yield and returns and increased the quality of the produce. It also reduced the weed problems, reduced labour intensive operation, reduced water consumptions and electricity consumption. Besides these, drip method of irrigation further generated many environmental benefits.

2.4 STUDIES ON DRIP IRRIGATION SYSTEM WITH AND WITHOUT SUBSIDY COMPONENTS

Duncan (1986) reported that the most spectacular evidence of impact on agricultural production by a subsidy measure is that of import restrictions on competing agricultural outputs. He concluded that the path of technology in agriculture is enhanced by the application of agricultural subsidies. Their effectiveness depends on proper planning and streamlining of subsidy measures so as to ensure the realization of increased production efficiency.

Pemberton (1989) indicated that the introduction of a subsidy on milk in 1973 did not prevent a 25.6 per cent drop in the fresh milk supply. However a 29 per cent increase on the price of milk resulted in an increase supply to 1972 levels. Dairy farmers are price sensitive but need a large price to increase their production. In contrast to the situation in fresh milk, broiler production expanded rapidly after the subsidy programme was started

Oil Palm Development Programme in Andhra Pradesh (1995) introduced by NABARD estimated the unit cost of Oil palm cultivation for a period of four years at Rs. 38,000 per hectare including the cost of planting material. For this it was proposed to extend the subsidy to the farmer's upto Rs. 16,250 per hectare.

Dhawan (2000) concluded that the case for public subsidy in drip irrigation partly, if not entirely, rests on social returns being far in excess of private returns accruing to drip investors.

Narayanamoorthy (2004) suggested that that the investment in drip method of irrigation is economically viable even without subsidy from his experiments in sugarcane in Maharashtra. Obviously, the B-C ratio and NPW improves further when subsidy amount is taken for calculation.

Luquet *et al*. (2005) concluded that it would require subsidies for irrigation equipment in tomato and cotton of at least 40 per cent for low water tariffs to 60 per cent for high water tariffs, to make the transfer from furrow to drip irrigation acceptable in Turkey.

Narayanamoorthy (2005a) indicated that as a proportion of the total capital cost of drip set, subsidy amount accounts for about 35 to 37 percent, which is within a limit of provision made by the Government of Maharashtra.

Narayanamoorthy (2006b) reported that the adoption of micro-irrigation cannot be increased without providing subsidy because of its capital-intensive nature. There is no doubt that micro-irrigation is a capital-intensive technology, but it does not mean that its adoption of cannot be increased without subsidy. Subsidy can be a necessary condition for encouraging the adoption of micro-irrigation, but cannot be a sufficient condition for sustaining the growth of it, as many other factors determine the adoption of the same.

Scheierling *et al.* (2006) indicated that public subsidies for promoting the adoption of water-conserving on-farm irrigation technologies are frequently cited as means for making additional water available for higher-valued uses in the water-scarce western United States. The cost-effectiveness of different subsidy arrangements for generating delivery reductions is also assessed, and implications for their implementation are derived

Khalache and Khaire (2007) recognized their need for information on prices of Fig during harvesting, subsidy for drip irrigation, and use of low cost technology for processing figs and cold storage in Pune.

Narayanamoorthy (2007) indicated that the rate of subsidy provided through government schemes is fixed uniformly for both water-intensive as well as less water-intensive crops. Special subsidy program may be introduced for water-intensive crops like sugarcane, banana, vegetables, etc. Differential subsidy rates can be fixed based on the types of crops and the rate of consumption of water.

Sreedhar and Babu (2007) concluded that the proportion of relatively better-off sections in the society in terms of caste and landholding size who availed of the subsidy and adopted the drip and sprinkler irrigation system was greater when compared to the weaker sections from their studies on different crops in Anantapur. The provision of adequate funds, a rational policy for subsidy, arrangements for bank finance, and an adequate support system are required for the faster propagation of micro irrigation systems in the drought prone areas.

Narayanamoorthy (2008) concluded that the net present worth and benefit-cost ratio estimated using discounted cash flow technique shows that the drip investment in cotton cultivation in Maharashtra is economically viable under both 'with' and 'without' subsidy conditions.

Berrada (2009) from Morocco reported that where the state is providing pressurized and filtered water to the farm gate and farms also get 60 per cent subsidy from the government for on farm drip irrigation investment.

Brinegar and Ward (2009) revealed that the per hectare total cost incurred on furrow, drip and drip with subsidy at 50 per cent was Rs 96,337, Rs 77,852 and Rs 71,552 respectively in U.S.A. Thus, shifting from furrow irrigation to drip irrigation system and drip with subsidy, estimated benefit cost ratio (B:C) of 1.24:1, 1.54:1 and 1.68:1 was found indicating 30 and 44 per cent additional net profit in drip.

Chinnappa and Nagaraj (2009) concluded that the discounted cash flow analysis revealed that the investment on arecanut with drip irrigation is economically feasible even without government subsidies in Karnataka. The government subsidies are required to promote large scale adoption of drip irrigation technology and should be continued to better water management.

Dineshkumar *et al.,* (2009) studies showed that sprinkler with diggie is economically viable for the farmers even without subsidies in orchards and cash crops. Since the social costs are less than the social benefits, the subsidies are justifiable as it makes the private benefits exceed the private costs in Rajasthan.

Roy and Ray (2009) reported that fertilizer subsidy incurs huge quantity of govt. exchequers and become a great concern for policy makers in the event of WTO agreement wherein India faces a continuous pressure from the international body to reduce this subsidy. This will help increase in total agricultural production and productivity and keep the Indian farmers competitive in the international level.

The Times of India (2009) reported that the state government would extend 90 per cent subsidy to big farmers adopting drip irrigation system from February 1.

Reddy *et al*., (2010) indicated that the B-C ratio of mulberry is coming down drastically mainly due to labour and high initial cost, though Rs.1.0 lakh/acre is being provided towards construction of rearing and shed, mulberry saplings cost, drip equipments etc., by Govt. of Andhra Pradesh as subsidy.

Ward (2010) indicated that higher subsidies make it more economically attractive for irrigators to invest in drip irrigation infrastructure in Rio-grand basin.

Prasilova *et al.,* (2011) indicated that if subsidy is directed to large-scale producers as well as to geographically unfavorably situate small-scale producers, it can not only miss its own target, but even depend on the existing problem. It is now becoming apparent that prospering large companies have an overall bigger

profit from each crown of the subsidized price than small farms, which were originally the reason to implement the subsidies. The size structure of agricultural companies in the Czech Republic has so far been relatively favorable with respect to subsidies.

Sumbwanyambe *et al., (*2012) we have shown that a government subsidy in a developing country can result in the increase or decrease of information "have nots" leading to the tragedy of (anti)commons. They have also shown that a correct subsidy, given customer sensitivities, can promote desired revenue and that the revenue is a concave function of price.

An overview of the above studies shows that drip irrigation is a capital intensive technology and its adoption can be further increased by providing subsidy. Studies showed that drip investment is economically viable even without subsidy. Subsidy for drip irrigation further acts as a measure to enhance the drip irrigation.

2.5 CONSTRAINTS IN INSTALLATION, EXECUTION AND MAINTENANCE OF DRIP IRRIGATION SYSTEM.

Srinivas (1989) revealed the problems in production and marketing of coconut as farmers were not following recommended package of practices and there were no facilities for providing information regarding the high yielding varieties.

Rao and Rajasekhar (1992) identified major constraints in Oil palm cultivation like non- availability of plant material, narrow genetic base of higenous tenerae problems in acquiring plant material , pests and diseases, organizational problems.

DiGeorge (1994) from Nevada concluded that even watering of vegetables and other row crops by trickling equipment can be more expensive than with other methods, because of the seasonal necessity of removing the lateral piping. This necessity increases operation and maintenance expenses significantly.

Government of India (1994) reported that the capital cost required for installing drip system for different crops has been increasing over the years due to increase in the cost of materials used for manufacturing the drip system.

Rangachary (1995) identified some problems regarding production and processing of Oil palm viz., technological problems organizational problems, price problems and processing problems.

O'Brien *et al*. (1998) concluded that center pivot cropping systems have higher estimated net returns than drip irrigation. Net returns of Drip Irrigation are very sensitive to system longevity or life. Ongoing efforts are needed in the design and development of efficient, low cost, SDI and center pivot irrigation and cropping systems.

Srilatha (2000) reported that the major production problems of Oil palm identified were shortage of power supply and price fluctuations and the major processing problems were non-availability of raw material and paucity of labour during peak seasons.

Postel *et al.* (2001) concluded from his experiments in U.S.A that drip irrigated farmers have problems with baffles, poor fittings and too much shifting and disputes over water.

Sorensen *et al*., (2001) reported that rodent and insect damage occurred with the thin–wall drip tubing from his experiments in peanut, corn and cotton in Georgia. Injecting chlorine and pesticides seemed to correct these problems.

Assouline *et al.* (2002) from his experiments in sweet corn in Israel indicated that micro drip supplies water at a low rate during early all the time plant needs it. When compared with conventional drip irrigation methods using high dripper discharge, the low applications rate mostly affects the water content distribution. Visual observations indicate that under micro drip irrigation, the root system was shallower and denser compared to conventional irrigation system.

Gurav *et al.* (2003) reported that drip irrigation requires high initial cost, regular maintenance, unavailability of technical guidance, and quality spare parts locally, were the most important constraints reported by the drip adopters in Sugarcane in Maharashtra. The major suggestions given by the drip adopters include: timely provision and availability of subsidies and loans; reduction in total initial cost of the drip unit; provision of regular after sales services by the drip set suppliers; and technical training to drip adopters.

Wilson and Bauer (2004) reported that if emitters are poorly placed, too far apart or too few in number, root development may be restricted by the limited soil area wetted. Water seeping at ground level is hard to see and makes it difficult to know if the system is working properly. An indicator device that raises and lowers a flag to show when water is flowing is available to overcome this issue.

Belder *et al.* (2005) concluded that the promotion of drip irrigation is generally not suitable as a component of humanitarian assistance programs. The survey results also highlight the need for continuing monitoring and advisory assistance.

Kulecho and Weatherhead (2005) revealed that the majority of farmers in Kenya who discontinued using micro-irrigation stopped due to lack of maintenance, irrelevant cultural background, and unreliable water supply.

Namara *et al.* (2005) from their studies in Maharashtra and Gujarat indicated that the adoption of micro irrigation requires technical and economic efficiency. It also indicates that the higher share of cereal and pulses in the cropping pattern lower the probability of adopting micro irrigation technology.

Shashidhara *et al.* (2007) from his studies on arecanut and banana in Dharwad indicated that a high per cent of farmers had expressed the problem of non-availability of quality material (95.55 per cent) and no follow up services by drip agencies (81.11 per cent). The other constraints like high initial investment cost, lack of capital to cover maximum holding under drip irrigation and delay in sanction of loan were experienced by 62.22, 56.66 and 53.33 per cent of farmers, respectively.

Francois *et al.* (2008) indicated that additional maintenance and operation burden of filtering and cleaning drippers is substantial.

Simonne *et al.* (2008) from Florida reported that drip irrigation in vegetables requires an economic investment, maintenance and high-quality water. Water application pattern must match planting pattern, safety, leak repair, drip-tape disposal causes extra cleanup costs after harvest.

Devasirvatham (2009) reported that the two important objections to drip irrigation, the high ongoing cost and the disruption to normal cultural practices. However, Drip irrigation may have significant problems with poor or uneven surface wetting, leading to problems with crop germination and establishment.

Prasad and Kumar (2009) concluded that the major constraints perceived by Oil palm growers in Karnataka were lack of sufficient irrigation water and problems in harvesting of FFB. The major suggestions given by the respondents were to provide assured power supply, financial assistance from banks and increasing the subsidy for cultivation and in installation of drip system.

Barse *et al*. (2010) indicated that drip farmers of orange in Amaravati taluka faced constraints like load shading of electricity for too long interval (10-14 hrs/day) expressed by 100 per cent of orange growers, damage due to rodents (85.00 per cent), choking of micro tubes and drippers (81.66 per cent), non-availability of repair services (85.00 per cent) and lack of technical knowledge is 70.00 per cent and lack of knowledge about application of fertilizer (fertigation) (71.66 per cent). To overcome these constraints it was observed that provide regular supply of electricity, Increase the subsidy and facility on drip irrigation by government and training should be given to the farmers regarding operation, maintenance, repairing and application of water soluble fertilizers.

Bobojonov *et al.* (2010) indicated that more expensive technologies, such as drip irrigation, typically purchased and used by a single farmer, are currently beyond the financial means of the average farmer due to income constraints posed by the state order system.

Landge *et al.* (2010) revealed that banana growers in Ardhapur faced many problems like regular load shading of electricity for too long interval in day time that was expressed by 93.78 per cent and 89.58 per cent of drip and flood irrigated banana growers, respectively. To overcome these constraints it was observed that supply of electricity that was suggested by 87.50 per cent and 83.33 per cent of drip and flood irrigated banana growers, respectively.

Arun and Singh (2011) reported that 80 per cent of the farmer's high initial investment was the major factor for the non adoption of drip irrigation system. Lack of knowledge and delays in getting subsidies were the other important factors for the non adoption of the drip irrigation.

Liu *et al*. (2012) from China reported that emitter clogging is the major problem for extending the drip irrigation technology.

An overview of the above studies shows that the constraints faces with drip irrigation were high initial cost, problem with emitters, unavailability of quality spare parts, requirement of regular maintenance, non availability of repair services and lack of technical knowledge.

Chapter III

MATERIAL AND METHODS

The design of the study is an important component of research. To realize the various objectives of the study, an appropriate methodology describing sampling design, data collection and tools of analysis for the conduct of the study are inevitable. In this chapter the methodology adopted for the present study including the selection and description of the study area, sampling design, collection of data and analytical tools employed are presented under the following heads.

1. Sampling design
2. Collection of data
3. Tools of analysis
4. Methods of computation

3.1 SAMPLING DESIGN

Multi-stage random sampling technique was followed for the purpose of selection of primary sampling units. The sampling framework was provided in Figure.3.1

3.1.1 Sampling Procedure

3.1.1.1 Selection of the district

East Godavari district was selected purposively as it has an area of 11,265.05 ha of Oil palm plantations in the district. Out of these 64.49 per cent area i.e., 7496.81 ha constituted of Drip irrigation. More over in East Godavari district Oil palm consists of 53 per cent of total drip irrigated area under different crops.

3.1.1.2 Selection of mandals

In East Godavari district all the mandals having Oil palm plantations were arranged in the descending order of the area under Oil palm and the top three mandals having the largest area under Oil palm were selected purposively for the study.

3.1.1.3 Selection of villages

From each mandal two Oil palm cultivating villages were randomly selected to make a total of six villages for the study of drip irrigation.

The pattern of selection of the mandal, villages and plantations are depicted in the figure.

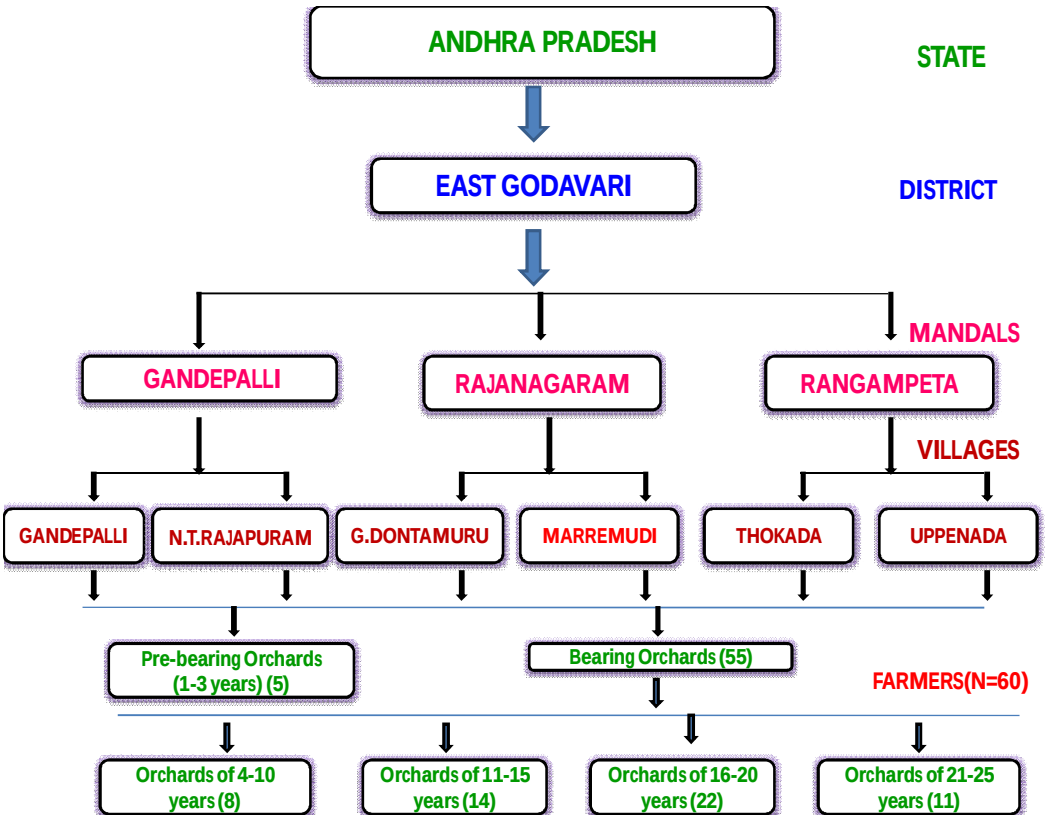


Figure 3.1 Diagram showing selection of respondents

3.1.1.4 Selection of Respondents

The drip irrigated Oil palm growers in each village were listed and were stratified into two groups viz., those having pre-bearing orchards (1-3 years) and those having bearing orchard (4-25 years). The farmers were selected according to their probability distribution in each age category. Farmers having pre-bearing orchards of 1-3 years age constitute five farmers. Farmers having bearing orchard were again stratified into those having orchards of 4-10 years age (8), 11-15 years age (14), 16-20 years age (22) and 21-25 years age (11). Total sample size of 60 drip irrigated farmers were selected. Another group of 60 conventionally irrigated farmers were selected from the same villages and stratified among the pre-bearing orchards of 1-3 years age with 13 farmers and bearing orchards were orchards of 4-10 years age (8), 11-15 years age (11), 16-20 years age (12) and 21-25 years age (16). According to probability proportion of plantation age, the distribution of the selected growers is furnished in the table 3.1.

Table 3.1. Plantation age-wise classification of Oil Palm respondents

Age of oil palm plantation	Drip method of irrigation		Conventional method of irrigation	
	No. of farmers	per cent of farmers to the total respondents	No. of farmers	per cent of farmers to the total respondents
1-3	5	8.33	13	21.67
4-10	8	13.33	8	13.33
11-15	14	23.33	11	18.33
16-20	22	36.67	12	20
21-25	11	18.33	16	26.67
Total sample	60	100.00	60	100.00

3.2 COLLECTION OF DATA

3.2.1 Primary Data

The primary data pertaining to the drip method of irrigation and conventional method of irrigation in Oil palm was obtained through survey method. A pre-tested questionnaire was used prior to the actual data collection. This helped to modify the questionnaire by dropping the irrelevant information and questions. This also helped in getting rid of the important missing variables. Farmers in the research area were surveyed according to this well designed questionnaire. The questionnaire is mainly focused on the information related to the details of drip method of irrigation in comparison with the conventional method of irrigation in Oil palm. The data collection was carried out during December 2011, January 2012 and February 2012.

3.2.2 Secondary Data

Secondary data pertaining to the agro-economic aspects of the study area were collected from the District Chief Planning Officer, Kakinada, East Godavari. Details regarding the drip irrigation area, subsidy rates were collected from Andhra Pradesh Micro Irrigation Project, Kakinada, East Godavari.

3.3 METHODS OF COMPUTATION OF COSTS

3.3.1 Human Labour

There are three types of human labour viz., family labour, permanent labour and casual labour. The family labour was imputed at the general wage rate prevailing for the casual labours in the locality. In case of permanent labour payment made in kind like grain, meals and other pre-requisites are evaluated at market rates, besides payments made in cash on monthly basis or yearly are added. The daily wage rate has been taken into consideration.

3.3.2 Machine Labour

Hired machine labour has been charged at the actual hire charges paid. In the case of owned machine labour maintenance costs and receipts if any were considered to estimate the net maintenance charges.

3.3.3 Planting Material

The cost of planting material purchased was valued at the subsidized purchase price.

3.3.4 Manures and Fertilizers

Farm produced manures were charged at the prevailing market rate of the locality. Fertilizers purchased were charged at the rate actually paid.

3.3.5 Plant Protection Chemicals

Actual prices paid for the plant protection chemicals by the growers were considered.

3.3.6 Land Revenue

Actual amount paid by the growers towards land revenue was taken into account.

3.3.7 Interest on Working Capital

Interest was charged at the rate of 13.5 per cent per annum for the life period of the crop which is the prevailing bank rate for Oil palm plantations.

3.3.8 Interest on Fixed Capital

Interest on present value of fixed assets (excluding land) has been calculated at 13.5 per cent per annum.

3.3.9 Depreciation

The depreciation was worked out for the items like farm machinery and implements, farm buildings. Depreciation was calculated by straight line method.

3.3.10 Rental Value of Owned Land

Actual rents prevailed in the study area were considered for the calculation of rental value of owned land.

3.3.11 Farm Assets

The physical property owned by the farm such as land, farm buildings, livestock, machinery and implements were included under farm assets.

3.3.12 Cost of Cultivation

Cost of various inputs and input services used for raising a crop in a unit area.

3.3.13 Cost of Production

The expenditure incurred in producing a unit quantity of output.

3.3.14 Variable Costs

Costs included the maintenance costs of the bearing garden i.e., cost of farmyard manures and chemical fertilizers, cost of operations such as ploughing, manuring, plant protection, watch and ward including harvesting, interest on working capital and land revenue etc.

3.3.15 Fixed Costs

Cost associated with the owing of fixed resources. Depreciation, interest on fixed capital, rental value of owned land and land revenue were considered as fixed costs.

3.3.16 Computation of Costs and Returns

Oil palm is a perennial crop with an approximate bearing life span of 25 years. Hence, the cost incurred can be classified into two categories viz.,

1. Establishment cost
2. Maintenance cost

3.3.16.1 Establishment cost

The establishment cost included all the expenditure incurred during pre-bearing period of 1- 3 years for the establishment of Oil palm orchard. It includes the initial cost invested in drip irrigation system, costs incurred on items like land preparation, digging pits, planting material, manures, fertilizers, plant protection chemicals , watch and ward and costs on miscellaneous items were considered as establishment costs. It was calculated for both drip irrigation and conventional irrigation in Oil palm.

3.3.16.2 Maintenance cost

All recurring costs required for maintaining the orchard during peak periods such as expenditure on cultural practices, maintenance costs of drip irrigation system, manures and fertilizers, plant protection chemicals and their application charges were considered as maintenance costs. Besides these, land revenue and cess were also considered for working out the maintenance cost of orchard.

3.3.17 Annual Share of Establishment Costs /Annuity of Drip Irrigation System

The annuity of Oil Palm was distributed over the life of 25 years of Oil palm. Present worth of annuity for drip irrigation system was calculated for the first 10 years as the life span of drip irrigation is 10 years and it will be replaced after 10 years. Then for the remaining 15 years, future worth of annuity is calculated as the drip irrigated system is replaced and careful maintenance of the system then lasts for about 15 years.

3.4 TOOLS OF ANALYSIS

The data collected was subjected to tabular, percentage and average analysis. Discounted and undiscounted cash flow techniques were used.

3.4.1 Tabular Analysis

Tabular analysis with WUE (water use efficiency) of drip method of irrigation compared to conventional method of irrigation in Oil palm. Undiscounted and Discounted techniques were used to obtain payback period, net present worth, benefit-cost ratio, internal rate of returns and sensitivity analysis.

3.4.1.2 WUE

Water use efficiency in kg/ha-mm was calculated by dividing the yield (Y) with the responsive total consumptive use of water for the crop period. The total water utilized was calculated by knowing the number of irrigations given by each sample and the height of the water applied in centimeters for each irrigation over the area of land. The following equation was used for calculating the water consumption and WUE.

WUE = Y/ N* H*A

Where

Y = yield of Oil palm

N = no of irrigations during the crop growing period.

H = height of water level per each irrigation (cm)

A = Area in sq.m (10000 Sq.m is one hectare).

3.4.3 Project Evaluation Techniques

Undiscounted and discounted cash flow techniques were used to evaluate the investment and to find out the technical feasibility and economic viability of drip method of irrigation compared to conventional method of irrigation in Oil palm plantations.

3.4.3.1 Undiscounted cash flow technique

3.4.3.1.1 Payback period (PBP)

A person willing to invest in a long term project would like to know when he will get back the money invested. It was estimated by summing up all the undiscounted net profits over the years to make up the initial investment incurred for establishing during pre-bearing period. It is the length of time from the beginning of the investment before the net benefits return the capital investment.

As a measure of investment worth, the payback period has two important weaknesses. Firstly it fails to consider earnings after the payback period. Secondly, it does not adequately take into consideration the timing of proceeds.

$$\text{Payback period} = {}^{I}/_{E}$$

Where I= Investment of the project

E= annual net cash inflows

3.4.3.2 Discounted Cash Flow Techniques

The discounted cash flow method for evaluation of long term projects is a process of finding the present worth of an amount received (or) paid in the future. This technique has an advantage that future cash flows are reduced to a single sum at specific point of time and this facilitates comparison between alternative investment choices if any. Interest on working capital, fixed capital, depreciation and annuity were excluded while estimating the stream of costs over the economic life period of Oil palm plantations. The following discounted cash flow measures were used in the analysis viz., net present worth, benefit-cost ratio, internal rate of returns, net benefit- investment ratio and sensitivity analysis.

3.4.3.2.1 Net present worth (NPW)

The more straight forward discounted cash flow measure of project worth is net present worth. This criterion assesses the present worth of accrued benefits over costs and ranks the investments for selection among the alternatives as well as indicates the order of preference to be given.

The net present worth should be positive to indicate that the project investment is economically feasible and financially sound.

In calculating the net present worth the difference between the present value of the cost streams and present value of benefit streams were considered at discount rate of 13.5 per cent.

$$\text{Net present worth} = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}$$

Where B_t = benefits in rupees for t^{th} year

C_t = cost in rupees for t^{th} year

i = discount rate = 13.5 per cent

n = number of years =25 years

3.4.3.2.2 Benefit-Cost Ratio (BCR)

It is the ratio between discounted cash inflows and discounted cash outflows and the ratio should be unity (or) more for an investment to be considered worthwhile.

Mathematically, it can be represented as

$$\text{Benefit-Cost ratio} = \sum_{t=1}^{n} \frac{B_t/(1+i)^t}{C_t/(1+i)^t}$$

Where n= number of years = 25 years

i = discount rate = 13.5 per cent

B_t = benefits in rupees in t^{th} year

C_t = cost in rupees in t^{th} year

3.4.3.2.3 Internal Rate of Return (IRR)

It represents the average earning capacity of an investment over the economic life period of the project. It is that discount rate which just makes the net present worth of cash flow equal to zero. In other words, the benefit-cost ratio calculated at IRR is unity.

Mathematically, it can be represented as

$$IRR = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} = 0$$

Where n= number of years

i = discount rate

B_t = benefits in rupees in t^{th} year

C_t = cost in rupees in t^{th} year

IRR is the maximum interest that a project could pay for the resources used for the project is to recover its investment. The IRR is arrived through interpolation technique by using different discount rates so as to see that the net present worth is equated to zero. Therefore, the project costs and benefits are discounted at a certain rate to find out the present worth of the project. Again by selecting a higher discount rate, the costs and returns are discounted throughout the project period to get a negative present worth. The IRR should be more than the discount rate being considered for economic feasibility and financial soundness.

$$IRR = \begin{pmatrix} Lower \\ discount \\ rates \end{pmatrix} + \begin{pmatrix} Difference \\ between \\ the\ two \\ discount\ rates \end{pmatrix} * \left[\frac{\begin{matrix} Present\ worth\ of\ cash \\ flow\ at\ lower\ discount\ rate \end{matrix}}{\begin{matrix} Absolute\ difference\ between \\ present\ worth\ of \\ cash\ flow\ at\ the\ two\ discount\ rates \end{matrix}} \right]$$

When the IRR that is calculated is greater than the market rate of interest, then the investment is considered viable.

3.4.3.2.4 Net Benefit-Investment Ratio (N/K Ratio)

This is one of the discounted techniques used for selecting the beneficial project among alternative projects. This is obtained by simply dividing the present worth of positive net incremental benefits by the present worth of negative net incremental benefits. The selection criterion is that the project is accepted, if its N/K ratio is greater than one and higher when two projects are compared.

But we should remember that the discount rates should be realistic and generally it is the interest rate at which the funds of the projects are borrowed. This N/K ratio maximizes the return per unit of investment made in independent projects.

$$\text{N/K ratio} = \frac{\text{The present worth of the sum of positive net incremental benefits}}{\text{The present worth of the sum of negative net incremental benefits}}$$

3.4.3.2.5 Sensitivity analysis

An analytical technique to test systematically what happens to the earning capacity of a project even if it differs from the estimates made about them in planning. A means of dealing with uncertainty about future events and values. A sensitivity analysis is done by varying one element or a combination of the elements and determining the effect of that change on the outcome, most often on the measure of project worth. Sensitivity tests need not be directed at the effect of a change on a measure of project worth.

Mathematically it can be represented as

Sensitivity analysis =

$$\begin{pmatrix} Lower\ per\ cent \\ short\ fall \\ of\ benefits \end{pmatrix} + \begin{pmatrix} Difference\ between \\ the\ higher\ and\ lower\ per\ cent \\ short\ fall\ of\ benefits \end{pmatrix} * \begin{pmatrix} \frac{Present\ worth\ at\ lower\ per\ cent\ short\ fall\ of\ benefits}{Absolute\ differenece\ of\ present\ worth\ of\ higher\ short\ fall\ and\ lower\ per\ cent\ short\ fall\ of\ benefits} \end{pmatrix}$$

3.4.3.2.5 Switching value

A variation of sensitivity analysis is the “switching value”. In calculation of switching value we see how much an element (costs and benefits) would have to change in an unfavorable direction before the project would no longer meet the minimum level of acceptability.

3.4.3.3 Viability of drip irrigation with or without subsidy

The NPW, BCR, IRR, N/K ratios were worked out under the situations.

A: Oil palm under drip irrigation system

a. with subsidy conditions

b. without subsidy conditions

B: Oil palm under conventional methods of irrigation

A comparison of the viability of the Oil palm cultivation under the above three situations were made using the above techniques.

3.5 HYPOTHESES

The following null hypotheses were formulated for testing the present study

1. The costs and returns vary between drip method of irrigation and conventional method of irrigation in Oil palm cultivation.

2. It was hypothesized that the Oil palm cultivation is financially feasible without subsidy in drip irrigation.

3. It was hypothesized that the Oil palm cultivation is financially feasible without subsidy on plant material.

4. Drip irrigation was superior in terms of water use efficiency and productivity in Oil palm over conventional method of irrigation.

Chapter IV

AGRO-ECONOMIC FEATURES

The success of agriculture depends not only on agro-climatic conditions of the region, *viz.*, soil, temperature, rainfall but also on the physical environment in which it is taken up. Further the agricultural economy is not only influenced by the socio-economic features and infrastructural facilities available in the region but also by the demographic features, land holding distribution, cropping pattern and occupational distribution of the people. In order to have a comprehensive idea about the various techno-economic aspects of the study area, an attempt was made to discuss briefly the profile of study area.

4.1 AGRO-ECONOMIC FEATURES OF EAST GODAVARI DISTRICT

4.1.1 Historical Background

East Godavari District is situated on the northeast of the state of Andhra Pradesh in India. Its district headquarters is Kakinada. It is the second richest district in the whole country. This district was formed in 1925 when old Godavari district was divided into west and East Godavari districts.

4.1.2 Boundaries

East Godavari District is situated in the geographical co-ordination of 16^0 $30^{'}$ and 18^0 $20^{'}$ of the Northern Latitude and 81^0 $30^{'}$ and 82^0 36' of the Eastern Longitude which extends over an area of 10,807 sq. km. with coastal length of 144 kms. The district is bounded by Visakhapatnam district on the North & West Godavari district on the South, Bay of Bengal on the East & Khammam district on the West. The district can be broadly classified into three natural zones the Delta, Upland and Agency tracks.

4.1.3 Administrative Set-up

There are five revenue divisions with head quarters at Kakinada, Peddapuram, Rajahmundry, Rampachodavaram and Amalapuram. The district consists of 60 revenue mandals and 58 mandal parishads. 1011 Gram Panchayats exist in the District. There are two Municipal Corporations viz., Kakinada and Rajahmundry as well as seven municipalities viz., Samalkot, Pithapuram, Peddapuram, Tuni, Ramachandrapuram, Mandapeta and Amalapuram.

4.1.4 Demographic Particulars

The population of the district as per 2011 census is 51,51,549 of which male and female are 25,69,419 and 25,82,130 respectively. The district has a population density of 477 inhabitants per sq. km. The district has a sex ratio of 1005 females for every 1000 males and a literacy rate of 71.35 per cent.

4.1.5 Soils

The main soils in the district are Alluvial (Clay loamy), Red soils, Sandy loams and Sandy clay. The soils are mostly the Alluvial in Godavari Delta area accounting for 15 per cent of the total area and Sandy clay at tail end portions of Godavari. There are Red loamy soils in uplands and agency area of the district.

4.1.6 Land Utilization Pattern

Land utilization pattern of the district is shown in the table 4.1 so as to have a comprehensive idea regarding the land utilization pattern.

The total geographical area of the district is 10, 80,700 hectares. During the year 2008-09, the area covered by forests is 3, 23,244 hectares which forms 29.91 per cent to the total geographical area. The net cropped area of the district is 42, 6,765 hectares. Area sown more than once is 3, 12,506 hectares and cultivable waste is 17,770 hectares.

Table 4.1. Land utilization pattern

S.No	Classification of the area	Area (ha)	Per cent to the total area
1	Forests	323244	29.91
2	Barren and uncultivated wastes	78490	7.26
3	Land put to non-agricultural use	139345	12.89
4	Cultivable waste	17770	1.64
5	Permanent pastures and other grazing lands	21211	1.96
6	Land put under miscellaneous trees	8453	0.78
7	Current fallows	32637.14	3.02
8	Other fallows	32830	3.04
9	Net cropped area	426765	39.49
10	Total Geographical area	1080700	100.00
11	Total cropped area	739271	--
12	Area sown more than once	312506	--

Source: Chief Planning Office, Kakinada (2008-09)

4.1.7 Climate and Rainfall

The climate is comparatively equitable and although it is very warm in May with a maximum temperature of 39.6^0c and with a minimum temperature of 28.2^0c.

Table 4.2. Rainfall received during 2008-09 in East Godavari district (Rainfall in mm)

S.No	Particulars	Rainfall in mm	Percentage
1	South-west monsoon (June- September)	807.2	77.98
2	North-east monsoon (October- December)	171.6	16.58
3	Winter (January- February)	-	-
4	Hot weather period (March- May)	56.3	5.44
	Total	**1035.1**	**100**

Source: Agricultural Census, Chief Planning Office, Kakinada (2008-09)

Month wise rainfall for the selected district is presented in table 4.2 for 2008-09 agricultural year. The monsoon breaks usually in the middle of June and brings good rain up to the middle of October. The south-west monsoon provides nearly 2/3rd of the total annual rainfall which evenly spreads over the district.

The annual normal rainfall of the East Godavari district is 1035 mm. Normal rainfall of south-west monsoon is 807 *i.e.,* 77.98 per cent of the annual normal rainfall which is vital for the crops during kharif season. Normal rainfall of north-east monsoon is 171.60 mm *i.e.,* 16.58 per cent of annual normal rainfall.

4.1.8 Irrigation

Irrigation plays a vital role in production of agricultural produce. Any yield increasing practice can be exploited fully when they are practiced along with this resource. In view of this, area irrigated by different sources in this district is included in the table 4.3.

Table 4.3. Net area irrigated by different sources in East Godavari district 2008-09

(Area in Hectares)

S.No.	Source	Area	Per cent to gross irrigated area
1	Canals	3,40,832	67.74
2	Tanks	35,362	7.03
3	Tube wells & Filter points	1,14,045	22.67
4	Other wells	193	0.04
5	Lift irrigation	9752	1.94
6	Other sources	2944	0.59
7	Gross area irrigated	5,03,128	100.00
8	Area irrigated more than once	2,15,028	42.74
9	Net area irrigated	2,88,100	57.26

Source: Agricultural Census, Chief Planning Office, Kakinada (2008-09)

East Godavari district consists of net irrigated area of 2, 88,100 hectares. East Godavari channel commands 67.74 per cent under canals, 22.67 per cent under tube wells and filter points respectively. It is seen from the table that the canal irrigation is the predominant source for the district.

4.1.9 Rivers

The Principal rivers flowing in the district are Godavari and Yeleru. The Thandava and Pampa river canals supply water to a limited area in the district.

4.1.10 Cropping Pattern

Table 4.4. Area under principle crops in East Godavari district, 2008-09 (in Ha)

Crop	*Kharif*	*Rabi*	Total	Per cent to total area
Paddy	2,40,231	1,69,861	4,10,092	58.4
Jowar	658	--	658	0.09
Bajra	823	--	823	0.12
Maize	1,602	6,581	8,183	1.17
Ragi	552	115	667	0.09
Horsegram	41	552	593	0.08
Greengram	315	43,577	43,892	6.25
Blackgram	995	31,934	32,929	4.69
Redgram	721	--	721	0.1
Other pulses	60	1,094	1,154	0.16
Chillies	553	702	1,255	0.18
Sugarcane	13,592	14,766	28,358	4.04
Mango	18722	--	18,722	2.67
Banana	15,363	6,770	22,133	3.15
Cashew nut	33,248	--	33,248	4.73
Oil palm	11,625	--	11,625	1.66
Tapioca	16,210	--	16,210	2.31
Cotton	7,432	--	7,432	1.06
Ground nut	35	451	486	0.07
Sesamum	715	969	1,684	0.24
Coconut	50,214	--	50,214	7.15
Tobacco(n)	1,594	1,009	2,603	0.37
Tobacco(v)	3,083	2,541	5,624	0.8
Flowers	1,062	1,031	2,093	0.3
Other non food crops	802	--	802	0.11
Gross area sown	4,20,248	28,1,953	7,02,201	58.4

Source: Chief Planning Office, Kakinada (2008-09)

The predominant crops grown in the district are paddy (58.40 per cent), and maize (1.17 per cent) among cereals, greengram (6.25 per cent) and blackgram (4.69 per cent) among pulses, coconut (7.15 per cent), cashew nut (4.73 per cent), sugar cane (4.04 per cent), banana (3.15 per cent), mango (2.67 per cent) and tapioca (2.31 per cent) among non-food and commercial crops.

Vegetables crops grown in the district are bottle gourd, ridge gourd, bitter gourd, snake gourd, coccinia, cluster bean, brinjal, bhendi, cucumber, green chilli and cauliflower etc. These vegetable crops are grown in all three seasons of the year. The table 4.4 revealed that 58.40 per cent of the total cropped area is occupied by Paddy, 7.15 per cent by coconut, 6.25 per cent by greengram and 4.73 per cent by cashewnut in East Godavari district.

4.1.11 Land holdings distribution

There are about 7, 01, 470 land holdings with a total area of 6, 81, 262 ha in the district as per 2005-06 survey (Table 4.5).

Table 4.5. Distribution of land holdings and Area operated by Different size classes.

S.No.	Type of farmer	No	Per cent to total	Area (ha.)	Per cent to total
1	Marginal farmer (< 1 ha)	5,41,689	78.99	2,23,559	16.19
2	Small farmer (1-2 ha)	90,324	13.17	188422	13.64
3	Semi-medium farmers (2-4 ha)	40,330	5.88	269,281	19.5
4	Medium (4-10 ha)	12,410	1.81	6,81,262	49.33
5	Large (>10 ha)	1,031	0.15	18,451.59	1.34
6	**Total**	**6,85,784**	**100**	**5,19,254.89**	**100.00**

Source: Agricultural Production Plan (2007-08)

4.1.12 Agro-Industrial Scenario

107 Large & Medium Scale industries with an investment of Rs.8,800 crores are providing employment to 19,181 persons. Prominent industries are Rice milling, Oil refining, Solvent extraction, Sea food processing, Chemicals and Fertilizers, Paper industries, Automobile components, Sugar mills, Beverages, Bio-mass power plants and Gas based power plants etc. 56 Large & Medium Scale industries obtained IEM's and 26 industries are under implementation.

East Godavari District is having a good potential for Food and Agro Processing Industries such as Cashew, Palm Oil Refinery, Bio-Diesel, Meat Processing units, Sago Distilleries, Essential oils, Shrimp processing, Solvent extractions, Iodized salt, Coir units, Rice mills, Mineral industries like Glazed tiles, Flooring tiles, Roof tiles, Refractory bricks, Runners, Graphite crucibles and Distilleries using waste fruits or Sago etc.

M/s.NFCL (Nagarjuna Fertilizers and Chemicals Limited), M/s.GFCL(Godavari Fertilizers and Chemicals Limited); M/s.Ruchi Infrastructure Ltd., M/s.Kedia Over Seas Ltd, M/s.Arani Agro Oils Ltd., M/s.Aclmar Oils and Fats, M/s.Nikhil Refineries Ltd., M/s.Sarada Agro Oils Pvt.Ltd., M/s.NCS Estates Ltd., M/s.Shalimara Agro Oils, M/s.Agarwal Oil industries uses palm crude as raw material. About Rs.3,500 crores investment pumped in these industries for infrastructure and daily 5,000 tonnes of crude palm oil is refined in these industries and a turnover of about Rs. 6,000 cores takes place.

4.2 DETAILS OF OIL PALM

4.2.1 Oil Palm Cultivation in India

In India, Andhra Pradesh stands first in the area of Oil palm occupying 60.32 per cent i.e., 1, 03,563ha followed by Karnataka and Tamilnadu occupying 12.49 per cent and 10.76 per cent consisting of 21,442 ha and 18,474 ha respectively.

Table 4.6. Oil Palm Cultivation in India

S.No	State	Area in hectares	Per cent to total area
1	Andhra Pradesh	1,03,563	60.32
2	Karnataka	21,442	12.49
3	Tamil Nadu	18,474	10.76
4	Mizoram	9,759	5.68
5	Kerala	5,583	3.25
6	Orissa	6,432	3.75
7	Gujarat	2,403	1.40
8	Goa	876	0.51
9	**Total**	**1,71,680**	**100.00**

Source: Technology Mission of Oilseeds, Department of Agriculture & Cooperation Ministry of Agriculture (2006-07)

4.2.2 Area under Oil palm Cultivation and Adoption of Drip Irrigation in East Godavari District

Oil palm occupies a total of 11,625.01 ha in East Godavari district. Out of this area, drip irrigation constitutes a significant portion of 64.49 per cent i.e., 7496.81 ha. Gandepalli mandal stands first in area in East Godavari with 23 per cent, of which 21 per cent constitutes drip irrigation. It is followed by the Rajanagarm and Peddapuram mandals with 18 per cent and 12 per cent, within which drip irrigated area accounts for 16 per cent and 18 per cent respectively.

4.2.3 Area Coverage under Drip Irrigation in East Godavari District

Adoption of drip irrigation is prominent in East Godavari District covering an area of 14156.13 ha. Oil palm occupied a significant position in the district by occupying 52.96 per cent to the total drip irrigated crops covering an area of 7496.81 ha. (Table 4.7) It is followed by Horticultural crops and Agricultural crops covering 23.15 per cent and 19.20 per cent with an area of 3276.88 ha and 2718.36 ha respectively. Area under different mandals in Oil palm and the area under drip irrigation in Oil palm are given in the table 4.8.

Table 4.7. Area Coverage under Drip Irrigation in East Godavari District

S.No	Crop	Area(ha)	Per cent to total
1	Oil palm	7496.81	52.96
2	Horticulture crops	3276.88	23.15
3	Agricultural crops	2718.36	19.20
4	Sugarcane	387.5	2.74
5	Tobacco	259.12	1.83
6	Mulberry	17.46	0.12
7	**Total**	**14156.13**	**100.00**

Source: Andhra Pradesh Micro Irrigation Project (APMIP). Kakinada, 2012.

Table 4.8 Area under Oil palm cultivation and drip irrigation in East Godavari district

S.No	Mandal	Total area under Oil palm(ha)	Oil palm area under drip irrigation (ha)	Per cent of Oil palm area under drip irrigation in the mandal
1	Gandepalli	2693.43 (23.17)	1560.62 (20.82)	57.94
2	Rajanagaram	2106.00 (18.12)	1214.52 (16.20)	57.67
3	Rangampeta	1419.00 (12.21)	1109.86 (14.80)	78.21
4	Peddapuram	902 (7.76)	521.46 (6.96)	57.81
5	Jaggampeta	1131.00 (9.73)	447.21 (5.97)	39.54
6	Tuni	493 (4.24)	211.68 (2.82)	42.94
7	Sankhavaram	458 (3.94)	214.83 (2.87)	46.91
8	Other mandals with less coverage of Oil palm area	2422.58 (20.84)	2216.63 (29.57)	91.50
	TOTAL	**11,625.01 (100.00)**	**7,496.81 (100.00)**	**64.49**

Note: Figures in parenthesis indicate the percentage to total

Source: Andhra Pradesh Micro Irrigation Project (APMIP). Kakinada, 2012

4.3 AGRO-ECONOMIC FEATURES OF THE SELECTED MANDALS

The three mandals selected for the study are Gandepalli, Rajanagaram and Rangampeta. Six villages from these three mandals were selected, Gandepalli, N.T Rajapuram from Gandepalli mandal, G.Dontamuru, Marremudi from Rajanagaram mandal and Thokada, Uppenada from Rangampeta mandal for the present study.

4.3.1 Demographic Features

Details of population, literacy rate, labour force and cultivators are important in influencing the economy. The details of population of selected mandal were presented in the table 4.9.

The population of Gandepalli mandal as per 2001 census is 52,462 of which 50.07 per cent *i.e.,* 26269 is males and the remaining 49.93 per cent *i.e.,* 26,193 is females. The population density is 322 per sq. km. and the percentage of literacy is 45.06 per cent. The population of Rajanagaram mandal as per 2001 census is 92,916 of which 50.67 per cent *i.e.,* , 47,078 is males and the remaining 49.33 per cent *i.e.,* 45,838 is females and the percentage of literacy is 51.40 per cent The population density is 396 per sq. km.The population of Rangampeta mandal as per 2001 census is 54,623 of which 50.90 per cent *i.e,* 27,805 is males and the remaining 49.10 per cent *i.e.,* 26,818 is females. The population density is 376 per sq. km. and the percentage of literacy is 45.

Table 4.9. Demographic features of selected mandals (2001 census)

S.No	Particulars	Unit	Gandepalli		Rajanagaram		Rangampeta	
			2001	Per cent to total population	2001	Per cent to total population	2001	Per cent to total population
1	Total population	No	52,462	100.00	92,916	100.00	54,623	100.00
	a) Male	No	26,269	50.07	47,078	50.67	27,805	50.90
	b) Female	No	26,193	49.93	45,838	49.33	26,818	49.10
2	Density of population	Per sq.km	322	-	396	-	376	-
3	Females per 1000 males	No	997	-	974	-	965	-
4	Literates	No	23,642	45.06	47,761	51.40	24,581	45.00
	a) Male	No	12,400	23.64	24,904	26.80	12,687	23.23
	b) Female	No	11,242	21.43	22,857	24.60	11,894	21.77
5	Cultivators	No	3,546	6.76	5,276	5.68	3,438	6.29
6	Agricultural labour	No	15,200	28.97	19,329	20.80	14,137	25.88

Source : Hand book of statistics 2007-08, Chief Planning Office, East Godavari District

4.3.2 Land Utilization Pattern

Land utilization pattern of the selected mandals is shown in the table 4.10 so as to have a comprehensive idea regarding the land utilization pattern.

Table 4.10 reveals that in Gandepalli mandal net sown area occupies 71.85 per cent of the total geographical area followed by other fallows, land put to non-agricultural use and forests with 9.35 per cent, 8.75 per cent and 2.73 per cent respectively. This table also reveals that net area sown in Rajanagaram mandal occupies prime place with 71.92 per cent followed by land put to non-agricultural use, other fallows by 18.93 per cent and 4.28 per cent respectively

Table 4.10. Land utilization pattern in selected mandals in 2007-08

(Area in hectares)

S.No.	Classification of the area	Gandepalli	Rajanagaram	Rangampeta
1	Forests	4.51 (2.73)	662 (2.82)	-- (0.00)
2	Barren and uncultivated land	-- (0.00)	221 (0.94)	-- (0)
3	Land put to non-agricultural use	1447 (8.75)	4444 (18.93)	1463 (10.08)
4	Cultivable waste	-- (0.00)	45 (0.19)	20 (0.14)
5	Permanent pastures and other grazing lands	393 (2.38)	20 (0.09)	393 (2.71)
6	Miscellaneous tree crops & grooves not included in net area sown	-- (0.00)	70 (0.36)	131 (0.90)
7	Current fallows	819 (1.64)	-- (0.73)	350 (7.07)
8	Other fallows	1547 (9.35)	1005 (4.28)	895 (6.17)
9	Net area sown	11887 (71.85)	16888 (71.92)	11258 (77.59)
10	Total cropped area	13802 (83.43)	20364 (86.72)	14309 (98.61)
11	Area sown more than once	1915 (11.58)	3476 (114.80)	3051 (21.03)
	Total geographical area	**13364 (100.0)**	**17217 (100.0)**	**7990 (100.0)**

Note : Figures in parenthesis indicate the percentage to total
Source : Hand book of statistics (2007-08)

In Rangampeta mandal the net area sown occupies prime place with 77.59 per cent followed by land put to non-agricultural use, permanent pastures and current fallows by 10.08 per cent, 2.77 and 7.07 per cent respectively.

4.3.3 Distribution of Land Holdings

Distribution of land holdings of selected mandals under marginal, small, semi-medium, medium and large farmers are given in the table 4.11. Table 4.11. reveals that Gandepalli mandal consists of 8,841 marginal farmers followed by 2,613 small farmers and 1,134 semi -medium farmers. Rajanagaram mandal consists of 11,972 marginal farmers followed by 3,143 small farmers and 1,529 semi –medium farmers. Rangampeta mandal consists of 8,130 marginal farmers followed by 2,303 small farmers and 1,129 semi –medium farmers.

Table 4.11. Distribution of Land Holdings of Selected Mandals in 2008-09

(Area in ha)

S.No.	Type of Farmer	Gandepalli		Rajanagaram		Rangampeta	
		No	**Area**	**No**	**Area**	**No**	**Area**
1	Marginal farmer (< 1 ha)	8841	4046.99	11972	5340.52	8130	3502.91
2	Small farmer (1-2 ha)	2613	3655.45	3143	4387.65	2303	3239.79
3	Semi-medium farmers (2-4 ha)	1134	3060.91	1529	4113.40	1129	3029.01
4	Medium (4-10 ha)	274	1551.43	519	2883.32	412	2191.77
6	Large (>10 ha)	41	704.72	47	658.35	24	300.63
	Total	**12903**	**13019.50**	**3337**	**17383.24**	**13590**	**12264.11**

Source: Hand Book of Statistics (2008-09)

4.3.4 Rainfall Pattern

Month wise rainfall for the selected mandals is presented in Table 4.12. Table 4.12. revealed that most of the rainfall in Gandepalli mandal was distributed in June, July, August and September months and very less rainfall in January, February, March and April .

In Rajanagaram mandal, the rainfall was very less in January, February, March and April and it was also known that most of the rainfall received in June, July, August and September months.

Table 4.12 reveals that most of the rainfall in Rangampeta mandal received in during June to September months and very less rainfall during January and April.

Table 4.12. Rainfall received during 2008-09 in selected mandals

(Rainfall in mm)

S.No.	Months	Gandepalli	Rajanagaram	Rangampeta
1	January	--	--	--
2	February	--	--	--
3	March	--	--	--
4	April	--	8.60	--
5	May	53.80	92.40	31.00
6	June	135.80	211.80	163.80
7	July	150.20	223.20	100.20
8	August	196.60	341.40	222.40
9	September	71.60	79.80	59.80
10	October	15.00	31.00	61.80
11	November	41.44	43.20	47.40
12	December	3.0	1.80	1.80
	Total	**667.44**	**1033.20**	**688.20**

Source: Hand book of statistics 2008-2009

4.3.5 Cropping Pattern

The predominant crops grown in the selected mandals are paddy and maize among cereals, greengram and blackgram among sugarcane, mango, cashewnut, oil palm and tapioca among non-food and commercial crops. Among vegetable crops grown in the district are bottle gourd, ridge gourd, bitter gourd, snake gourd, coccinia, clusterbean, brinjal, bhendi, cucumber, greenchilli and cauliflower etc. These vegetable crops are grown in all the three seasons of the year.

Cropping pattern gives the particular idea of crops grown in Gandepalli mandal. The cropping pattern of Gandepalli mandal was given in the table 4.13.This table reveals that paddy occupied prime place in Gandepalli mandal by 34.05 per cent followed by sugarcane, cashew nut and tapioca by 10.87 per cent, 9.24 per cent, and 7.67 per cent respectively.

Table 4.13. revealed that in Rajanagaram, paddy occupied prime place to total gross sown area by 40.19 per cent followed by cashewnut and mango with 20.28 per cent and 8.34 per cent respectively.

Table 4.13. revealed that Paddy occupied a prime place in total gross sown area of Rangampeta mandal with 32.88 per cent and it was followed by Cashew nut, Tapioca and Sugar cane with 17.11 per cent, 13.15 per cent and 7.10 per cent respectively.

4.3.6 Irrigation sources

Irrigation plays a vital role in agricultural production. Any yield increasing practice can be exploited fully when they are practiced along with this resource. In view of this, area irrigated by different sources in this mandals is included in the table 4.14.

Table 4.13. Cropping pattern in selected mandals during 2008-09

(Area in hectares)

S.No	Crop name	Gandepalli		Rajanagaram		Rangampeta	
		Area	per cent to total area	Area	per cent to total area	Area	per cent to total area
1	Paddy	4,700	33.45	8,185	44.32	4,705	31.61
2	Maize	117	0.83	31	0.17	44	0.3
3	Greengram	298	2.12	135	0.73	254	1.71
4	Blackgram	423	3.01	367	1.99	832	5.59
5	Redgram	58	0.41	12	0.06	17	0.11
6	Other pulses	90	0.64	--	--	560	3.76
7	Chillies	61	0.43	--	--	--	--
8	Sugarcane	1,500	10.68	980	5.31	1,016	6.83
9	Mango	866	6.16	1,698	9.19	718	4.82
10	Banana	68	0.48	31	0.17	17	0.11
11	Cashew nut	1,275	9.07	4,129	22.36	2,448	16.44
12	Tapioca	1,058	7.53	40	0.22	1,882	12.64
13	Cotton	410	2.92	--	--	205	1.38
14	Oil Palm	2,693	19.17	2,106	11.4	1419	9.53
15	Ground nut	10	0.07	19	0.1	106	0.71
16	Sesamum	116	0.83	60	0.32	405	2.72
17	Coconut	62	0.44	624	3.38	57	0.38
18	Tobacco	246	1.75	53	0.29	201	1.35
19	**Total**	**14,051**	**100**	**18,470**	**44.32**	**14,309**	**31.61**

Source: Hand Book of Statistics (2008-09), East Godavari district, A.P

Table 4.14. Net area irrigated by different sources and intensity of irrigation in selected mandals 2008-09 (Area in Hectares)

S.No	Source	Gandepalli	Rajanagaram	Rangampeta
1	Tanks	2,047 (31.10)	1,561 (16.33)	1,767 (39.14)
2	Tube wells	4,536 (68.90)	6,033 (63.09)	1,913 (42.37)
3	Lift irrigation	--	1,968 (20.58)	835 (18.49)
4	Total	6,583 (100.00)	9,562 (100.00)	4,515 (100.00)
5	Area irrigated more than once	1,068	256	769
6	Gross irrigated area	7,651	5,284	12173

Note : Figures in parenthesis indicate the percentage to total
Source : Hand book of statistics (2008-09)

Table 4.14. reveals that highest proportion of 68.90 per cent is irrigated under tube wells in Gandepalli mandal, followed by 31.10 percent under tanks. This table also reveals that highest proportion of 42.34 per cent is irrigated under tube wells in Rajanagaram mandal followed by 39.14 and 18.49 percent area under tanks and lift irrigation sources respectively.

In Rangampeta mandal the highest proportion of 63.09 per cent is irrigated under tube wells followed by 20.58 and 16.33 percent area under lift irrigation and tanks sources respectively.

4.4 SPECIAL PROGRAMME ON OIL PALM AREA EXPANSION (OPAE) UNDER RKVY (RASHTRIYA KRISHI VIKAS YOJANA) IN ANDHRA PRADESH

4.4.1 Objective

A special initiative is being undertaken under RKVY during 2011-12 for implementation of a Special Programme on Oil Palm Area Expansion (OPAE) in order to augment the production of palm oil by 2.5 to 3.00 lakh tonnes in the next five years by expanding Oil palm area to a target of 60,000 ha.

4.4.2 Proposal

It is proposed to undertake area expansion in 60000 hectares during 2011-12 through Special Programme on OPAE under RKVY. Priority will be given to expand area under the purview of existing mills so as to increase the technical and economic viability of their operations. Out of Rs. 30,000 lakhs outlay proposed about 64 per cent of the outlay i.e., Rs. 19,200 is proposed for spending in Andhra Pradesh state itself by expanding the area by Rs. 40,000 ha (66.74 per cent) in the state out of 60,000 ha in the outlay.

Table 4.15. State wise summary of proposed outlay

S.No	States	Outlay proposed (Rs. in Lakhs)	per cent to total amount
1	Andhra Pradesh	19,200	64.00
2	Karnataka	3,360	11.20
3	Tamil Nadu	3,360	11.20
4	Gujarat	480	1.60
5	Orissa	1,776	5.92
6	Mizoram	1,480	4.93
7	Chhattisgarh	48	0.16
8	Maharashtra	96	0.32
9	ICAR	200	0.67
	Total	30,000	100.00

Source: Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, 2011

4.4.3 Oil Palm Area Expansion (OPAE) Programme

OPAE will be implemented through State Government through Department of Agriculture or Horticulture.There are eight states under OPAE with an allocation under RKVY of Rs. 300 crores. Government of India has been promoting Oil Palm Development Programme under the Centrally Sponsored Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM).

Table 4.16. Proposed Assistance under OPAE

S.No	Interventions	OPAE (Rs.)	ISOPOM(Rs.)
1	Planting Material per ha	10,000	7500
2	Cultivation Cost per ha – for 1st year.	6,000	4600
3	Drip Irrigation	As per NMMI	Adopted NMMI
4	Diesel/Electric Pump Sets per unit	10,000	10,000
5	Support for intercropping per ha	10,000	NA
6	INM/IPM/Fertigation & PP Chemicals/Tree Guards per ha	5,000	NA
7	Construction of Vermi- Compost pits per Unit	15,000	NA
8	Bore wells /water harvesting/ Fertigation tanks per unit	50,000	NA
9	Oil Palm processing units (Subsidy/Unit)	2.50 Crore	NA
10	Research & Monitoring by ICAR.	2.00 Crore	Ongoing Program

Source: Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, 2011

In order to bring 60000 hectares area under Oil palm cultivation during 2011-12, it is proposed to provide incentives to growers for identified critical interventions viz; planting material, compensation for loss of income of the farmers during the gestation period, pump set, drip irrigation system, support for intercropping, vermi-compost pit, bore wells, water harvesting tanks, fertigation tanks, fertigation and tree guards etc.

Table 4.17. Proposed targets of area expansion under Oil palm for OPAE under RKVY

S.No	Interventions	Andhra Pradesh	Total
1	Proposed Area expansion targets for OPAE under RKVY	40000	60000
2	Per cent of total targeted area	66.67	100
3	Supply of Diesel /Electric pump set		
	(a) Physical (No. of Benefits)	33127	49690
	(b) Finance (Rs. in Lakhs)	3312.67	4969
4	Intercropping		
	(a) Physical (No. of Benefits)	20000	30000
	(b) Finance (Rs. in Lakhs)	2000	3000
5	INM/IPM/Fertigation & PP Chemicals/tree		
	(a) Physical (No of Benefits)	40000	60000
	(b) Finance (Rs. in Lakhs)	2000	3000
6	Construction of Vermi-compost pits		
	(a) Physical (No of Benefits)	3333	5000
	(b) Finance (Rs. in Lakhs)	500	750
7	Subsidy for bore wells/Water harvresting/fertigation		
	(a)Physical (No of Benefits)	2077	3115
	(b) Finance (Rs. in Lakhs)	1038.33	1557.5

Source: Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, 2011

Chapter V

RESULTS AND DISCUSSION

The present study embodies the results of field investigation concerned in the economic analysis of drip method of irrigation in Oil palm cultivation in East Godavari district. The important findings of the study are presented along with relevant discussion. For easy understanding and convenience this chapter is divided into the following sub heads.

1. Characteristics of selected holdings.
2. Establishment costs of Oil palm plantations in Drip and Conventional methods of irrigation.
3. Cost structure of Drip Irrigation System.
4. Maintenance costs of Oil palm cultivation in Drip and Conventional methods of irrigation.
5. Yields and returns of Oil palm cultivation with Drip and Conventional methods of irrigation.
6. Financial viability of Drip method of irrigation in Oil palm plantations vis-a-vis Conventional methods of irrigation.
7. Water Use Efficiency in Drip irrigation and Conventional methods of irrigation in Oil palm cultivation.
8. Constraints in Drip irrigation system in Oil palm cultivation.
9. Discussion

5.1 CHARACTERISTICS OF SELECTED HOLDINGS

5.1.1 Farm Family Composition

A comprehensive idea of the composition of the family, working potential of the farm families, educational status of agricultural workers is needed for the research to be executed in a proper prospective way.

It could be observed from table 5.1. that the average size of the family of drip irrigated farmers was 5.15 with 47.57 per cent males, 29.51 per cent females and 22.92 per cent children. Among them 21.74 per cent male and 1.56 per cent female members were working on farm. Total number of farm workers in the family was 23.30 per cent. The average literacy level of the family was 63.68 per cent.

Table- 5.1. Farm family particulars among the selected Oil palm growers of drip irrigation and conventional methods of irrigation

S.No	Particulars	Drip method of irrigation		Conventional method of irrigation	
		Average members per family	Per cent to total family members	Average members per family	Per cent to total family members
1	Size of the family				
	(a)Males	2.45	47.57	2.22	45.03
	(b)Females	1.52	29.51	1.46	29.61
	(c)Children	1.18	22.92	1.25	25.36
	Total:-	5.15	100	4.93	100
2	Farm working members				
	(a)Males	1.12	21.74	1.51	30.63
	(b)Females	0.08	1.56	0.21	4.26
	Total:-	1.2	23.3	1.72	34.89
3	Literacy level	3.28	63.68	2.71	54.96

Similarly it could be observed from table 5.1. that the average size of the family of conventionally irrigated farmers was 4.93 with 45.03 per cent males, 29.61 per cent females and 25.36 per cent children. Among them 30.63 per cent male and 4.26 per cent female members were working on farm. Total number of farm workers in the family constituted 34.89 per cent. The average literacy level of the family was 54.96 per cent.

5.1.2 Pattern of Land Holdings

Oil palm is a wide spaced perennial crop with a juvenile period of three years. As Oil palm requires abundant quantities of water, drip method irrigation (DMI) is best suited for Oil palm. Hence there is a good scope for utilizing horizontal and vertical space for growing intercrops. Crops selected for intercropping should be compatible with the main crop and should not compete with Oil palm for light, nutrients, etc. Intercrops are the source of income during early life of any orchard. It helps to cushion the costs incurred during the pre-bearing period of the orchard, prevents weeds and also helps in soil conservation. To compensate the high establishment costs of Oil palm orchards to certain extent in the pre-bearing period, farmers took up intercrops like vegetables, pulses, cocoa and banana etc. These crops brought in reasonably good income to the farmers without affecting the main crop.

The average size of the holding was 11.42 ha for drip irrigated farmers and 8.63 ha for conventionally irrigated farmers. Area under Oil palm was about 70 per cent to the total operational holding of the selected sample. The selected sample consisted of different age group plantations. The sample was classified according to the age of plantations and the details are present in table 5.2. In the sample, majority of plantations were in the age group of 16-20 years which constituted 37 per cent of the total number of farmers. 23 per cent of the sample was in the plantation age group of 11-15 years. Among the conventional farmers sample, older age plantations i.e., above 16 years constituted 47 per cent of the sample. Because of older age plantations these groups of farmers have not gone for the adoption of drip method of irrigation.

Table 5.2. Age-wise classification of Oil Palm farmers in the selected sample and their experience

Age of Oil palm plantation	Drip method of irrigation				Conventional method of irrigation			
	Sample farmers		Average area under each group		Sample farmers		Average area under each group	
	No. of farmers	Per cent to total farmers	Average area(ha)	Per cent to total area	No. of farmers	Per cent	Average area(ha)	Per cent to total area
1-3	3	5.00	3.47	5.06	8	13.33	4.32	8.56
4-5	2	3.33	5.29	7.72	5	8.33	7.32	14.50
6-10	8	13.33	9.63	14.05	8	13.33	14.85	29.42
11-15	14	23.33	13.8	20.14	11	18.33	6.28	12.44
16-20	22	36.66	22.01	32.12	12	20.00	12.87	25.50
20-25	11	18.33	14.32	20.90	16	26.67	4.83	9.57
Total	60	100.0	68.52	100.00	60	100.00	50.47	100.00

5.1.3 Source of Irrigation

The main source of irrigation for both the conventional and drip irrigated plantations were tanks followed by tube wells and minor areas under lift irrigation. The area under different irrigation sources was presented in the table 5.3.

Table 5.3. Source of irrigation in Oil palm (Hectares)

Age of Oil palm plantation	Drip method of irrigation			Conventional method of irrigation		
	Tanks	Tube wells	Lift irrigation	Tanks	Tube wells	Lift irrigation
1-3	3.47 (5.70)	--	--	4.32 (11.24)	--	--
4-5	4.97 (8.17)	0.32 (4.29)	--	5.18 (13.48)	2.14 (19.89)	--
6-10	6.39 (10.50)	3.24 (43.43)	--	9.65 (25.11)	5.2 (48.33)	--
11-15	13.80 (22.69)	--	--	6.28 (16.34)	--	--
16-20	19.58 (32.19)	2.2 (29.49)	0.23 (100.00)	8.17 (21.26)	3.42 (48.33)	1.28 (100.00)
20-25	12.62 (20.75)	1.7 (22.79)	--	4.83 (12.57)	--	--
Total	60.83 (100.00)	7.46 (100.00)	0.23 (100.00)	38.43 (100.00)	10.76 (100.00)	1.28 (100.00)

Note: Figures in parentheses indicate percentages to total costs

5.2 ESTABLISHMENT COSTS OF OIL PALM PLANTATIONS

Oil palm is a perennial oil seed crop and once established the crop can be economically cultivated for about 25 years. The gestation period of Oil palm orchard is about three years. The economic yield starts from fourth year onwards. Therefore the cost incurred in establishing the orchard during the pre-bearing period was considered as establishment cost. The establishment costs included were the expenditure on land preparation, digging of pits, plant material and planting, manures, fertilizers and plant protection etc. The maintenance costs included were the expenditure on manuring, fertilization, plant protection, irrigation, weeding, watch and ward, harvesting and transportation.

The study of costs and returns of Oil palm cultivation and comparing with and without drip irrigation help the farmers to improve future Oil palm production with a view to maximize net profits by adopting drip irrigation and efficient resource management practices. In the present study, total costs were discussed under two groups viz., variable costs and fixed costs. Variable costs include expenditure on labour utilized for performing different cultural practices and expenditure on material inputs like planting material, manures, fertilizers and plant protection chemicals etc. The fixed costs were depreciation on working assets, interest on fixed capital, rental value of owned land, land revenue, annuity of Oil palm and annuity of drip irrigation system in case of drip method of irrigation.

5.2.1 Establishment Costs in Oil palm plantations during pre-bearing period (1-3 years)

Oil palm requires evenly distributed annual rainfall of 2000 mm without a defined dry season. Water deficiency adversely affects flower initiation, sex differentiation and therefore results in low sex ratio due to production of more male inflorescences. Hence to meet the requirements of Oil palm DMI is adopted.

The establishment costs included the cost incurred in establishment of the orchard as well as the cost incurred to maintain the same till it comes to bearing. These costs i.e., costs incurred upto third year can also be termed as pre-bearing costs.

5.2.1.1. Establishment costs under Drip method of Irrigation (DMI)

The details of establishment costs in the first three years of Oil palm plantation are presented in the table 5.4.

Establishment costs have been divided into variable costs and fixed costs. The total establishment costs expended per hectare of Oil palm with drip method of irrigation(DMI) during its pre- bearing period (1-3 years) stood at Rs. 1,19,733 of which Rs 40,542 (33.86 per cent) were variable costs and Rs. 79,190 (66.14 per cent) were fixed costs.

During the pre-bearing period, the drip irrigation system installed in the first year accounted for major item i.e., Rs. 26,000 constituting 21.71 per cent. Most of the farmers in the initial stages received 90 per cent subsidy for drip irrigation irrespective of the land holdings and hence drip irrigation with 90 per cent subsidy was taken into account. It was followed by rental value of owned land (19.01 per cent), fertilizers (11.90 per cent), interest on fixed capital (11.71 per cent), depreciation charges (7.61 per cent), human labour (6.68 per cent), manures (5.01 per cent), annuity of drip irrigation system (4.86 per cent), interest on working capital (4.03 per cent) , plant protection chemicals (2.17 per cent) , machine labour (2.09 per cent) , plant material (1.98 per cent) and land revenue (1.24 per cent).

Table 5.4. Establishment Costs in Oil Palm Plantations –Drip Method of Irrigation (Rs/ha)

S.No	Cost particulars	Year 1	Year 2	Year 3	Total establishment cost/ha
I	**Variable costs**				
1	Human labour	4416.00 (7.78)	1880.00 (6.11)	1700.00 (5.28)	7996.00 (6.68)
2	Machine labour	1500.00 (2.64)	500.00 (1.63)	500.00 (1.55)	2500.00 (2.09)
3	Plant material	2145.00 (3.78)	225.00 (0.73)		2370.00 (1.98)
4	Manures	2000.00 (3.52)	2000.00 (6.50)	2000.00 (6.21)	6000.00 (5.01)
5	Fertilizers	2228.00 (3.92)	4668.00 (15.18)	7358.00 (22.85)	14254.00 (11.90)
6	Plant protection chemicals	800.00 (1.41)	800.00 (2.60)	1000.00 (3.11)	2600.00 (2.17)
7	Interest on working capital	1767.01 (3.11)	1359.85 (4.42)	1695.33 (5.26)	4822.20 (4.08)
I	Subtotal of variable costs (1 to7)	14856.02 (26.16)	11432.86 (37.18)	14253.33 (44.26)	40542.20 (33.86)
II	**Fixed costs**				
1	Land revenue	494.00 (0.87)	494.00 (1.61)	494.00 (1.53)	1482.00 (1.24)
2	Rental value of owned land	7721.89 (13.60)	8019.73 (26.0)	7025.05 (21.81)	22766.66 (19.01)
3	Drip irrigation system	26000.00 (45.79)	--	--	26000.00 (21.71)
4	Depreciation	3036.00 (5.35)	3036.00 (9.87)	3036.00 (9.43)	9108.00 (7.61)
5	Interest on fixed capital	4672.32 (8.23)	4672.32 (15.20)	4672.32 (14.51)	14016.96 (11.71)
6	Annuity of drip system	--	3092.51 (10.06)	2724.68 (8.46)	5817.19 (4.86)
II	Subtotal of fixed costs(1 to 6)	41924.21 (73.84)	19314.56 (62.82)	17952.05 (55.74)	79190.81 (66.14)
	Total costs (I+ II)	**56780.22 (100)**	**30747.41 (100)**	**32205.38 (100)**	**119733.01 (100)**

Note: 1. Figures in parentheses indicate percentages to total costs

2. Plant material cost at subsidized rates of Rs 15 per plant against the actual cost of Rs. 55 per plant.

3. Drip irrigation system cost at subsidized rates of Rs 26,000 per unit/ha against the actual cost of Rs. 2, 60,000 unit/ha.

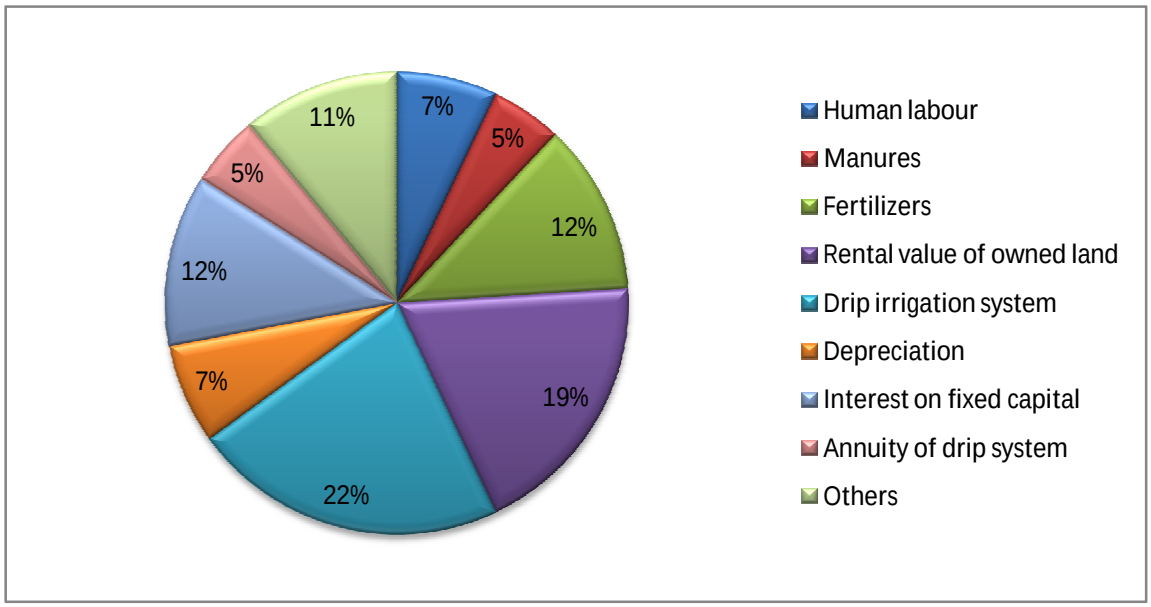


Fig. 5.1. Establishment Costs in Oil Palm Plantations -Drip Method of Irrigation

The total costs incurred to establish one hectare of Oil palm during the first year amounted to Rs. 56,708 out of which Rs. 14,856 (26.16 per cent) was spent on variable resources and the remaining Rs. 41,924 (73.84 per cent) pertained to fixed costs. Among the fixed costs, drip irrigation system took a lion's share with Rs. 26,000 which accounted for 45.79 per cent of total costs incurred during the first year of establishing Oil palm with drip irrigation. Drip irrigation system (DIS) is expensive and with the help of subsidy by Government at 90 per cent; the cost of drip system accounted for Rs. 26,000. As in the study area most of the farmers are benefitted by the subsidy at the rate of 90 per cent which was considered for the computation of costs.

Rental value of owned land was the second major item which constituted 13.60 per cent of the total costs with an amount of Rs. 7,722 followed by interest on fixed capital (8.23 per cent), depreciation (5.35 per cent) and land revenue (0.87 per cent) during the first year.

Among the variable costs, human labour occupied the first place constituting 7.78 per cent of total costs with an amount of Rs. 4,416 followed by fertilizers (3.92 per cent), plant material (3.78 per cent), manures (3.52 per cent), interest on working capital (3.1 per cent), machine labour (2.64 per cent) and plant protection chemicals (1.41 per cent). The plant material was taken at the subsidized rate of Rs. 15 per plant provided to the farmers against an actual cost of Rs.55 per plant. The operations such as land preparation, digging of pits, planting etc require more human labour and hence the expenditure incurred on human labour was higher in the first year of establishment of Oil palm orchard.

The cost incurred to maintain one hectare of Oil palm plantations during the remaining years of pre-bearing periods (second and third years) stood at Rs. 30,747 and Rs. 32,205 respectively. The respective total variable cost on an average per hectare during the above said years were Rs. 11,433 and Rs. 14,253 which accounted for 37.18 per cent and 44.26 per cent respectively. In second and third years fertilizer cost turned out to be the major item of variable cost which worked out to be Rs. 4,668 (15.18 per cent) and Rs. 7,358 (22.58 per cent) respectively. The cost of fertilizers increased from second year to third year. The reason for higher fertilizer application in Oil palm plantations is that Oil palm is a gross feeder which demands a balanced and adequate supply of fertilizers during the initial stages of its life i.e., pre-bearing period.

Next to the cost of fertilizers, manures were found to be the major item of the cost in second and third years of pre-bearing period. The cost of manures was same during second and third years which stood around Rs. 2,000.

Human labour was the third important item of variable expenditure in second and third years of pre-bearing period. The cost of human labour decreased form Rs. 1,880 (6.11 per cent) during second year to Rs. 1,700 (5.28 per cent) in the third year. The other important items of variable costs were interest on working capital

amounting to Rs. 1,359 (4.42 per cent) and Rs. 16,95 (5.26 per cent) followed by plant protection chemicals Rs. 800 (2.60 per cent) and Rs. 1,000 (3.11 per cent) rspectivley. Plant materials accounted for Rs.225 for gap filling. The other items of variable costs were machine labour which accounted for about 1.63 per cent and 1.83 per cent for second and third years respectively.

Rental value of owned labour formed the major part of fixed costs during the second and third year. It accounted for 26.08 per cent and 21.81 per cent of the total costs. The interest on fixed capital, annuity of dip system, depreciation charges and land revenue formed other important items of fixed costs in the order.

5.2.1.2 Establishment Costs of Oil Palm Plantations in Conventional Method of Irrigation (CMI)

The details of establishment costs in the first three years of Oil palm plantation in conventional method of irrigation (CMI) are presented in the table 5.5.

The total costs expended per hectare of Oil palm with CMI during its pre-bearing period (1-3 years) stood at Rs. 86,831 of which Rs. 45,719 (52.65 per cent) was variable costs and Rs. 41,112 (47.35 per cent) were fixed costs.

During the pre-bearing period i.e., in the first three years rental value of owned land (26.22 per cent) accounted for major share followed by interest on fixed capital (17.03), fertilizers (16.42 per cent), human labour (11.42 per cent), manures (6.91 per cent), interest on working capital (6.54 per cent), machine labour (5.64 per cent) and plant protection chemicals (2.99 per cent), plant material (2.73 per cent), depreciation charges (2.39 per cent) and land revenue (1.71 per cent).

The total costs incurred to establish one hectare of Oil palm during the first year amounted to Rs. 30,918 out of which Rs. 17,082 (58.18 per cent) was spent on variable resources and the remaining Rs. 13,836 (41.82 per cent) pertained to fixed costs. Among the fixed costs, rental value of owned land took a lion’s share with Rs. 7,722 which accounted for 24.97 per cent of total costs incurred during first

year of establishing Oil palm with CMI. Next to the rental value of owned land, interest on fixed capital was the second major item of fixed costs constituting 15.94 per cent of the total costs with an amount of Rs. 4,929 followed by depreciation (2.24 per cent) and land revenue (1.60 per cent).

Among the variable costs, human labour occupied the first place constituting 16.61 per cent of total costs with an amount of Rs. 5,136 followed by machine labour (8.09 per cent), interest on working capital (7.35 per cent), fertilizers (7.21 per cent), plant material (6.94 per cent), manures (6.47 per cent) and plant protection chemicals (2.59 per cent). The operations such as land preparation, digging of pits, planting etc required more human labour and hence the expenditure incurred on human labour was higher in the first year of establishment of Oil palm plantations.

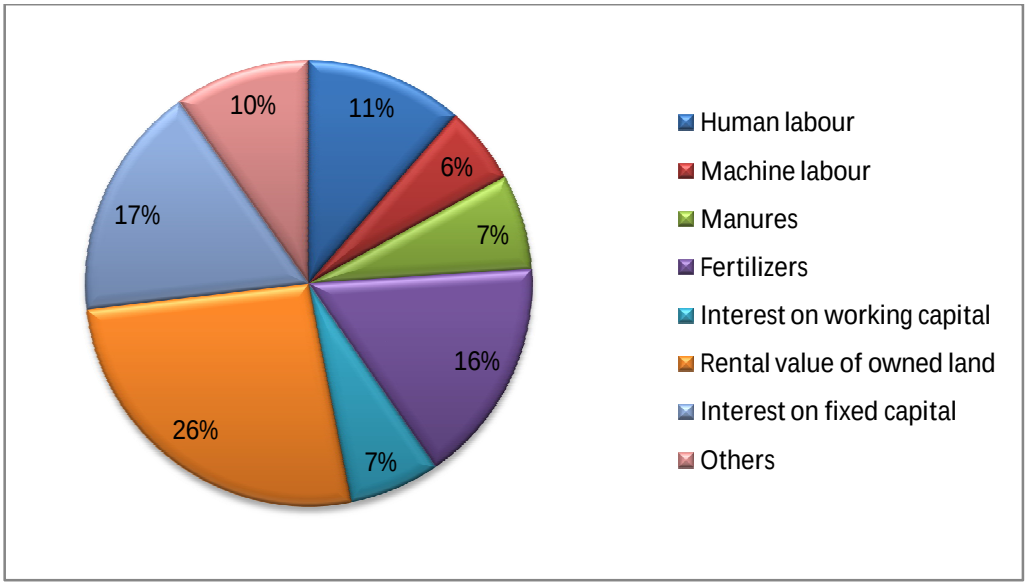


Figure 5.2. Establishment Costs in Oil Palm Plantations -Conventional Method of Irrigation

Table 5.5. Establishment Costs in Oil Palm Plantations - Conventional Method of Irrigation (Rs/ha)

S.No.	Cost particulars	Year 1	Year 2	Year 3	Total establishment cost/ha
I	**Variable costs**				
1	Human labour	5136 (16.61)	2480 (9.17)	2300 (7.97)	9916 (11.42)
2	Machine labour	2500 (8.09)	1200 (4.44)	1200 (4.16)	4900 (5.64)
3	Plant Material	2145 (6.94)	225 (0.83)		2370 (2.73)
4	Manures	2000 (6.47)	2000 (7.40)	2000 (6.93)	6000 (6.91)
5	Fertilizers	2228 (7.21)	4668 (17.26)	7358 (25.49)	14254 (16.42)
6	Plant protection chemicals	800 (2.59)	800 (2.96)	1000 (3.46)	2600 (2.99)
7	Interest on working capital	2273.13 (7.35)	1535.36 (5.68)	1871 (6.48)	5679.31 (6.54)
I	Subtotal of variable costs (1 to 7)	17082.13 (55.25)	12908.35 (47.73)	15729.83 (54.48)	45719 (52.65)
II	**Fixed costs**				
1	Land revenue	494 (1.60)	494 (1.83)	494 (1.71)	1482 (1.71)
2	Rental value of owned land	7721.89 (24.97)	8019.73 (29.66)	7025.05 (24.33)	22766.66 (26.22)
4	Depreciation	692 (2.24)	692 (2.56)	692 (2.40)	2076 (2.39)
5	Interest on fixed capital	4928.93 (15.94)	4928.93 (18.23)	4928.93 (17.07)	14786.79 (17.03)
II	Subtotal of fixed costs (1 to 5)	13836.80 (44.75)	14134.70 (52.27)	13140.00 (45.52)	41111.45 (47.35)
	Total costs (I+ II)	30918.95 (100.00)	27043.01 (100.00)	28868.81 (100.00)	86830.77 (100.00)

Note: 1. Note: Figures in parentheses indicate percentages to total costs

2. Plant material cost at subsidized rates of Rs. 15 per plant against the actual cost of Rs. 55 per plant.

The cost incurred to maintain one hectare of Oil palm plantations during the remaining years of pre-bearing periods (second and third years) stood at Rs. 29,043 and Rs. 28,869 respectively. The respective total variable costs on an average per hectare during the next two years were Rs. 12,908 and Rs. 15,730 which accounted for 47.73 per cent and 54.48 per cent respectively. In second and third years fertilizer cost turned out to be the major item of variable cost which worked out to Rs. 4,668 (17.26 per cent) and Rs. 7,358 (25.49 per cent). The cost of fertilizers increased from second year to third year. Next to the cost of fertilizers manures was found to be major item of the cost in second and third years of pre-bearing period. The cost of manures was same during the second and third years which stood around Rs. 2,000.

Human labour was the third important item of variable expenditure in second and third years of pre-bearing period. The cost of human labour decreased form Rs. 2,480 (9.17 per cent) during second year to Rs. 2,300 (7.97 per cent) in third year. The other important items of variable costs were interest on working capital amounting to Rs. 1,535 (5.68 per cent) and Rs. 1,871 (6.48 per cent) followed by plant protection chemicals Rs. 800 (2.96 per cent) and Rs. 1,000 (3.46 per cent). Plant materials accounted for Rs.225 for the gap filling. The other items of the variable costs were machine labour which accounted for about 4.44 per cent and 4.16 per cent for second and third years respectively.

Rental value of owned land formed the major part of fixed costs during second and third year. It accounted for 29.66 per cent and 24.33 per cent of total costs. The interest on fixed capital, depreciation charges and land revenue formed other important items of fixed costs in the order.

From the above discussion it could be observed that the establishment cost of Oil palm plantations with DMI in Oil palm exceeded the establishment cost of Oil palm with CMI by 38 per cent. Considerable change was observed in the variable costs for drip method of irrigation and conventional method of irrigation which stood at Rs. 40,542 and Rs. 45,119 respectively i.e., 11 per cent less in DMI to that

of CMI. The human labour and machine labour in the CMI was greater by 24 per cent and 96 per cent respectively compared to DMI as the labour requirement for conventional irrigation, fertilizer application and other operations were more in case of CMI. The cost of plant material, manures, fertilizers, plant protection chemicals remained same in both the methods of irrigation as the requirement for Oil palm remained same. The interest on fixed capital for the conventional irrigation system exceeded the drip irrigations system by five per cent due to involvement of more equipment.

Fixed costs were more in DMI over CMI due to the involvement of the initial investment of Rs. 26,000 in drip irrigation system in the first year by DMI. The land revenue remained same in both the irrigation methods. The depreciation charges were more in case of DMI i.e., Rs. 9,108 compared to Rs. 2,076 of CMI i.e., 37 per cent more in case of DMI. This is due to the inclusion of the depreciation charges of drip irrigation system. The annuity of drip irrigation system also played a major share in the fixed cost of DMI i.e., Rs. 5,818. Contrary to the case with the fixed costs, the variable costs were less in case of DMI (Rs. 40,542) than CMI (Rs. 45,719) by 13 per cent.

To sum up the establishment cost for drip method of irrigated plantations were higher by 38 per cent over conventionally irrigated plantations due to the capital intensive technology of drip irrigation.

5.2.4 Returns during Pre-Bearing Period from Inter Crops

Oil palm is a wide spaced perennial crop with a juvenile period of three years. During the gestation period intercrops are grown. The intercrops grown mainly are vegetables, pulses such as greengram, blackgram and Horticultural crops such as banana and cocoa. These crops brought in reasonably good income to the farmers without affecting main crop. The per hectare gross income, total costs and net income from intercrops from first to third year of Oil palm with and without drip method of irrigation and conventional method of irrigation are presented in table 5.6.

Table 5.6. Costs and returns from inter crops in oil palm plantations with DMI and CMI during pre-bearing period

S.No	Particulars	Drip method of irrigation				Conventional method of irrigation			
		First year	Second year	Third year	Total of three years	First year	Second year	Third year	Total of three years
1	Cost of cultivation of inter crops	6839.25	7340.30	8245.38	22424.93	8432.90	9261.93	8821.35	26516.18
2	Gross income from Inter crops	23165.70	24059.20	21075.52	68300.42	22550.40	24059.20	21075.00	67684.60
3	Net income from Inter crops	16326.45	16718.90	12830.14	45875.49	14117.50	14797.27	12253.65	41168.42
4	Establishment cost of Oil palm	56780.22	30747.41	32205.38	119733.00	46070.40	29950.36	31440.68	107461.40
5	Net establishment cost of Oil palm	40453.77	14028.51	19375.24	73857.51	31952.9	15153.09	19187.03	66292.98

The gross income obtained from inter crops with DMI during its pre-bearing period amounted to Rs. 68,300 per hectare which was obtained from the sale of intercrops during the first three years. The returns from inter crops in CMI was Rs. 67,684. It was also evident that Oil palm orchardists incurred Rs. 1, 19,733 towards cost of cultivation of Oil palm with DMI during its pre bearing period and Rs 22,425 were incurred to raise intercrops. To establish one hectare of conventionally irrigated Oil palm Rs. 94,480 and to raise intercrops Rs. 26,516 were incurred. The net income from inter crops was deducted to arrive the net establishment cost of Oil palm plantations during the pre-bearing period. The net establishment of Oil palm plantations was Rs.73, 857 in DMI and Rs.66, 293 in CMI during pre-bearing period.

5.3 COST STRUCTURE OF DRIP IRRIGATION SYSTEM

Drip irrigation system is considered as the most suitable water saving technique, eliminating water channels; bringing more area under irrigation and reducing the use of purchased inputs. Drip irrigation involves application of water only at the roots of the plant where it is required and thereby saving more water and brings more area under irrigation. The crop yields by this method of irrigation are higher with reduction in cost of fertilizers, pesticides and power for irrigation.

5.3.1 Cost components of Drip Irrigation System

Drip irrigation system was very expensive which accounted for Rs. 2, 60,000 in Oil palm. As it accounts for huge outlet of investment initially, the Government is providing subsidy to the farmers to encourage them to adopt the drip irrigation.

In DIS, a minimum of four drippers has to be placed for each palm. If each dripper discharges eight liters of water per hour, seven hours of irrigation per day will be sufficient to discharge 224 liters per day. Drippers should be checked periodically for proper discharge of water. DIS was the most expensive item. The total system cost constitutes of Rs. 2, 60,000 for Oil palm. The DIS mainly constitutes three parts i.e., Head control constituting 38.13 per cent, Water carrier system constituting 16.41 per cent and Water distribution system constituting of 36.02 Per cent. The other charges included 9.44 per cent. The detailed cost components are presented in the table 5.7

Table 5.7. Cost Structure of Drip Irrigation System per Hectare of Oil palm Plantations

S.No.	Cost component	Cost in Rupees (Rs.)	Percentage share to total
I	**Head control unit**		
1	Filtration unit-screen filter	26,700	10.27
2	Fertilizer and Head tank	14,500	5.58
3	Non return valve	14,400	5.54
4	Throttle valve	8,730	3.36
5	Air release and vacuum breaker valve	3,840	1.48
6	Pressure gauge	1,550	0.60
7	Optional items	29,430	11.32
	Sub total	**99,150**	**38.13**
II	**Water carrier system**		
1	PVC pipes for main pipe line	7,800	3.00
2	PVC pipes for sub main pipe line	24,200	9.31
3	Control valve	9,740	3.75
4	Flush valve	920	0.35
	Sub total	**42660**	**16.41**
III	**Water distribution system**		
1	Plain laterals	48,636	18.71
2	Jets assembled	28,048	10.79
3	Hole plugs	450	0.17
4	Grommet	465.5	0.18
5	Start connector	448	0.17
6	Nipple	335.6	0.13
7	End cap	409.5	0.16
8	Spaghetti	706.5	0.27
9	Accessories	14,150.9	5.44
	Sub total	**93,650**	**36.02**
IV	**Other Charges**		
1	Fittings and accessories	6,000	2.31
2	Transportation	3,580	1.38
3	Installation charges	3,000	1.15
4	Taxes	369.6	0.14
5	Other charges	11,590.4	4.46
6	**Sub total**	**24,540**	**9.44**
I+ II+ III +IV	**Total**	**2,60,000**	**100.00**

Source: Andhra Pradesh Micro Irrigation Project (APMIP). Kakinada, 2012.

The subsidy rates varied according to the land holdings of the farmers i.e., 90 per cent subsidy for the farmers with land holdings < 5 ha, 75per cent subsidy for the farmers with land holdings 5-10 ha and 50 per cent subsidy for the farmers with land holding >10 ha. However majority of the farmers' claimed 90 per cent subsidy by showing land holding less than 5 ha. The revised subsidy rates for DIS and pump sets under RKVY are given in Chapter IV table 4.17.

5.4 MAINTENANCE COSTS OF OIL PALM PLANTATIONS DURING BEARING PERIOD

5.4.1 Maintenance Costs of Oil Palm Plantations during Bearing Period in Drip Method of Irrigation (DMI)

The cost of maintenance of Oil palm per hectare from fifth to 25th year for DMI is presented in the table 5.8. It was revealed from the results that the total costs per hectare increased gradually from Rs. 55,905 in fourth year to Rs. 1, 49,802 in 25th year. The variable costs increased from Rs. 19,111 from fourth year to sixth year (Rs. 20,019) and then remained constant during the remaining period of life (Rs. 20,473). The fixed cost rose from Rs. 36,794 in fourth year to Rs. 1, 29,329 in 25th year. It is interesting to note that the share of fixed costs in total costs increased from 65.82 per cent in fourth year to 86.33 per cent in 25th year of plantations due to increased annuity value of drip system as it needs replacement after 10 years and also due to the rental value of owned land.

The fertilizer accounted for maximum expenditure during the bearing period in variable costs i.e., 13 to 5 per cent of total costs. It remained constant throughout the bearing period i.e., Rs. 7,358. It accounted for major expenditure because Oil palm is a gross feeder and demands a balanced and adequate supply of fertilizers for good growth and yield during bearing period. Human labour was the next major item of operational costs i.e., 4 to 10 per cent costs incurred on human labour

increased continuously from Rs. 5,482 to Rs. 6,080 in seventh year and then remained constant. The increase in labour cost was mainly due to increased human labour requirement for harvesting operation and for weeding operations. Manures remained constant throughout the bearing period.

Interest on working capital was the next major item of variable cost i.e., 4 to 2 per cent of total costs. It increased from Rs. 2,273 in fourth year to Rs. 2,435 during seventh year and then remained constant.

Among fixed costs, rental value of owned land took a lion's share in the range of 27 to 31 per cent and increased from Rs. 15,033 in fourth year to Rs. 46,980 in 25th year. This increase was due to increased Oil palm yield during bearing period. Hence the rental value of owned land also started rising steeply with each passing year. The annuity of drip irrigation system accounts for Rs. 2,400 in fourth year and gradually decreased to Rs. 1,122 10^{th} year i.e., from 4 to 1 per cent. But after 10 years, the drip irrigation system (DIS) was replaced due to end of its life span. It was replaced with new DIS in 11^{th} year and proper maintenance of the DIS, the system run upto 25^{th} year. The present value of annuity was calculated upto 10^{th} year and from 11^{th} year to 25^{th} year future value of annuity was calculated and hence it gradually increased from Rs. 12,453 in 11^{th} year to Rs. 73,317 in 25^{th} year.

The present value of annuity of drip system upto first 10 years accounted for 4.3 to 1.4 per cent and from 11^{th} year onwards accounted for 13 to 49 per cent in total maintenance costs due to new replacement costs of drip form 11^{th} year and calculation of future value of drip system. The present value of annuity calculated for Oil palm plantations accounted for Rs. 11,157 in fourth year and gradually decreased to Rs. 829 in 25^{th} year i.e., from 20 to 0.55 per cent. Land revenue, depreciation charges and interest on fixed capital formed other important items of fixed costs in the order.

Table 5.8. Maintenance Costs in Oil palm plantations during bearing period – Drip Method of Irrigation (Rs/ha)

S.No.	Cost particulars	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
I	**Variable costs**							
1	Human labour	5480.00 (9.80)	5680.00 (10.5)	5880.00 (8.71)	6080.00 (8.00)	6080.00 (7.22)	6080.00 (7.31)	6080.00 (7.39)
2	Machine labour	800.00 (1.43)	1000.00 (1.85)	1200.00 (1.78)	1400 .00 (1.84)	1400.00 (1.66)	1400.00 (1.68)	1400.00 (1.70)
3	Manures	2000.00 (1.43)	2000.00 (3.70)	2000.00 (2.96)	2000.00 (2.63)	2000.00 (2.37)	2000.00 (2.40)	2000.00 (2.43)
4	Fertilizers	7358.00 (13.16)	7358.00 (13.63)	735.008 (10.91)	7358.00 (9.68)	7358.00 (8.73)	7358.00 (8.84)	7358.00 (8.94)
5	Plant protection chemicals	1200.00 (2.15)	1200.00 (2.22)	1200.00 (1.78)	1200.00 (1.58)	1200.00 (1.42)	1200.00 (1.44)	1200.00 (1.46)
6	Interest on working capital	2273.13 (4.07)	2327.13 (4.31)	2381.13 (3.53)	2435.13 (3.20)	2435.13 (2.89)	2435.13 (2.93)	2435.13 (2.96)
I	Subtotal of variable costs (1 to 6)	19111.13 (34.15)	19565.13 (36.24)	20019.13 (29.67)	20473.13 (26.94)	20473.13 (24.30)	20473.13 (24.60)	20473.13 (24.87)
II	**Fixed costs**							
1	Land revenue	494.00 (0.88)	494.00 (0.91)	494.00 (0.73)	494.00 (0.65)	494.00 (0.59)	494.00 (0.59)	494.00 (0.60)
2	Rental value of owned land	15033.60 (26.89)	18792.00 (34.81)	28188.00 (41.78)	37584.00 (49.45)	46980.00 (55.77)	46980.00 (56.45)	46980.00 (57.05)
3	Depreciation	3036.00 (5.43)	3036.00 (5.62)	3036.00 (4.50)	3036.00 (3.99)	3036.00 (3.60)	3036.00 (3.65)	3036.00 (3.69)
4	Interest on fixed capital	4672.32 (8.36)	4672.32 (8.65)	4672.32 (6.92)	4672.32 (6.15)	4672.32 (5.55)	4672.32 (5.61)	4672.32 (5.68)
5	Annuity of drip system	2400.59 (4.29)	2115.06 (3.92)	1863.49 (2.76)	1641.84 (2.16)	1446.55 (1.72)	1274.50 (1.53)	1122.90 (1.36)
6	Annuity of oil palm	11157.97 (19.9)	5315.15 (9.84)	9198.61 (13.63)	8104.50 (10.66)	7140.53 (8.48)	6291.22 (7.56)	5542.92 (6.73)
II	Subtotal of fixed costs (1 to 6)	36794.49 (65.8)	34424.53 (63.76)	47452.43 (70.33)	55532.67 (73.06)	63769.41 (75.70)	62748.04 (75.10)	61848.15 (75.13)
	Total costs (I+ II)	**55905.62 (100)**	**53989.66 (100.00)**	**67471.56 (100.00)**	**76005.80 (100.00)**	**84242.54 (100.00)**	**83221.10 (100.00)**	**82321.20 (100.00)**

Note: Figures in parentheses indicate percentages to total costs

5.8 (cont.)

Table 5.8. Maintenance Costs in Oil palm plantations during bearing period – Drip Method of Irrigation (Rs/ha)

S.No.	Cost particulars	Year 11	Year 12	Year 13	Year 14	Year 15
I	**Variable costs**					
1	Human labour	6080.00 (6.54)	6080.00 (6.46)	6080.00 (6.37)	6080.00 (6.25)	6080.00 (6.13)
2	Machine labour	1400.00 (1.51)	1400.00 (1.49)	1400.00 (1.47)	1400.00 (1.44)	1400.00 (1.41)
3	Manures	2000.00 (2.15)	2000.00 (2.13)	2000.00 (2.09)	2000.00 (2.06)	2000.00 (2.01)
4	Fertilizers	7358.00 (7.91)	7358.00 (7.82)	7358.00 (7.71)	7358.00 (7.57)	7358.00 (7.41)
5	Plant protection chemicals	1200.00 (1.29)	1200.00 (1.28)	1200.00 (1.26)	1200.00 (1.23)	1200.00 (1.21)
6	Interest on working capital	2435.13 (2.62)	2435.13 (2.59)	2435.13 (2.55)	2435.13 (2.51)	2435.13 (2.45)
I	Subtotal of variable costs (1 to 6)	20473.13 (22.02)	20473.13 (21.76)	20473.13 (21.44)	20473.13 (21.06)	20473.13 (20.62)
II	**Fixed costs**					
1	Land revenue	494.00 (0.53)	494.00 (0.53)	494.00 (0.52)	494.00 (0.51)	494.00 (0.50)
2	Rental value of owned land	46980.00 (50.52)	46980.00 (49.93)	46980.00 (49.20)	46980.00 (48.33)	46980.00 (47.33)
3	Depreciation	3036.00 (3.26)	3036.00 (3.23)	3036.00 (3.18)	3036.00 (3.12)	3036.00 (3.06)
4	Interest on fixed capital	4672.32 (5.02)	4672.32 (4.97)	4672.32 (4.89)	4672.32 (4.81)	4672.32 (4.71)
5	Annuity of drip system	12452.76 (13.39)	14133.89 (15.02)	16041.96 (16.80)	18207.63 (18.73)	20665.66 (20.82)
6	Annuity of oil palm	4883.63 (5.25)	4302.76 (4.57)	3790.98 (3.97)	3340.07 (3.44)	2942.79 (2.96)
II	Subtotal of fixed costs (1 to 6)	72518.72 (77.98)	73618.97 (78.24)	75015.26 (78.56)	76730.02 (78.94)	78790.77 (78.38)
	Total costs (I+ II)	92991.85 (100)	94092.1 (100)	95488.39 (100)	97203.15 (100)	99263.90 (100)

Note: Figures in parentheses indicate percentages to total costs

5.8 (cont.)

Table 5.8. Maintenance Costs in Oil palm plantations during bearing period – Drip Method of Irrigation (Rs/ha)

S.No.	Cost particulars	Year 16	Year 17	Year 18	Year 19	Year 20
I	**Variable costs**					
1	Human labour	6080.00 (5.98)	6080.00 (5.81)	6080.00 (5.64)	6080.00 (5.44)	6080.00 (5.23)
2	Machine labour	1400.00 (1.38)	1400.00 (1.34)	1400.00 (1.30)	1400.00 (1.25)	1400.00 (1.21)
3	Manures	2000.00 (1.97)	2000.00 (1.91)	2000.00 (1.85)	2000.00 (1.79)	2000.00 (1.72)
4	Fertilizers	7358.00 (7.23)	7358.00 (7.04)	7358.00 (6.82)	7358.00 (6.59)	7358.00 (6.34)
5	Plant protection chemicals	1200.00 (1.18)	1200.00 (1.15)	1200.00 (1.11)	1200.00 (1.07)	1200.00 (1.03)
6	Interest on working capital	2435.13 (2.39)	2435.13 (2.33)	2435.13 (2.26)	2435.13 (2.18)	2435.13 (2.10)
I	Subtotal of variable costs (1 to 6)	20473.13 (20.13)	20473.13 (19.58)	20473.13 (18.98)	20473.13 (18.32)	20473.13 (17.63)
II	**Fixed costs**					
1	Land revenue	494.00 (0.49)	494.00 (0.47)	494.00 (0.46)	494.00 (0.44)	494.00 (0.43)
2	Rental value of owned land	46980.00 (46.19)	46980.00 (44.93)	46980.00 (43.55)	46980.00 (42.05)	46980.00 (40.45)
3	Depreciation	3036.00 (2.99)	3036.00 (2.90)	3036.00 (2.81)	3036.00 (2.72)	3036.00 (2.61)
4	Interest on fixed capital	4672.32 (4.59)	4672.32 (4.47)	4672.32 (4.33)	4672.32 (4.18)	4672.32 (4.02)
5	Annuity of drip system	23455.52 (23.06)	26622.01 (25.46)	30215.98 (24.68)	34295.14 (30.70)	38924.99 (33.51)
6	Annuity of oil palm	2592.77 (2.55)	2284.38 (2.18)	2012.68 (2.12)	1773.28 (1.59)	1562.36 (1.35)
II	Subtotal of fixed costs (1 to 6)	81230.61 (79.87)	84088.71 (80.42)	87410.97 (77.94)	91250.74 (81.68)	95669.67 (82.37)
	Total costs (I+ II)	**101703.70 (100)**	**104561.80 (100)**	**107884.10 (100)**	**111723.90 (100)**	**116142.80 (100)**

Note: Figures in parentheses indicate percentages to total costs

5.8 (cont.)

Table 5.8. Maintenance Costs in Oil palm plantations during bearing period – Drip Method of Irrigation (Rs/ha)

S.No.	Cost particulars	Year 21	Year 22	Year 23	Year 24	Year 25
I	**Variable costs**					
1	Human labour	6080.00 (5.02)	6080.00 (4.79)	6080.00 (4.55)	6080.00 (4.61)	6080.00 (4.06)
2	Machine labour	1400.00 (1.16)	1400.00 (1.10)	1400.00 (1.05)	1400.00 (0.99)	1400.00 (0.93)
3	Manures	2000.00 (1.65)	2000.00 (1.57)	2000.00 (1.50)	2000.00 (1.42)	2000.00 (1.34)
4	Fertilizers	7358.00 (6.07)	7358.00 (5.79)	7358.00 (5.51)	7358.00 (5.21)	7358.00 (4.91)
5	Plant protection chemicals	1200.00 (0.99)	1200.00 (0.94)	1200.00 (0.90)	1200.00 (0.85)	1200.00 (0.80)
6	Interest on working capital	2435.13 (2.01)	2435.13 (1.92)	2435.13 (1.82)	2435.13 (1.72)	2435.13 (1.63)
I	Subtotal of variable costs (1 to 6)	20473.13 (16.89)	20473.13 (16.12)	20473.13 (15.32)	20473.13 (14.50)	20473.13 (13.67)
II	**Fixed costs**					
1	Land revenue	494.00 (0.41)	494.00 (0.39)	494.00 (0.37)	494.00 (0.35)	494.00 (0.33)
2	Rental value of owned land	46980.00 (38.76)	46980.00 (36.99)	46980.00 (35.15)	46980.00 (33.27)	46980.00 (31.36)
3	Depreciation	3036.00 (2.50)	3036.00 (2.39)	3036.00 (2.27)	3036.00 (2.15)	3036.00 (2.03)
4	Interest on fixed capital	4672.32 (3.85)	4672.32 (3.68)	4672.32 (3.50)	4672.32 (3.31)	4672.32 (3.12)
5	Annuity of drip system	44179.86 (36.45)	50144.14 (39.48)	56913.60 (42.59)	64596.94 (45.75)	73317.52 (48.94)
6	Annuity of oil palm	1376.53 (1.14)	1212.79 (0.95)	1068.54 (0.80)	941.45 (0.67)	829.47 (0.55)
II	Subtotal of fixed costs (1 to 6)	100738.70 (83.11)	106539.30 (83.88)	113164.50 (84.68)	120720.70 (85.50)	129329.30 (86.33)
	Total costs (I+ II)	**121211.80 (100)**	**127012.40 (100)**	**133637.60 (100)**	**141193.84 (100)**	**149802.40 (100)**

Note: Figures in parentheses indicate percentages to total costs

5.4.2 Maintenance Costs in Oil Palm Plantations during Bearing Period-Conventional Method of Irrigation (CMI)

The cost of maintenance of Oil palm plantations under CMI per hectare from fifth to 25th year was presented in the table5.9. The results revealed that the total costs per hectare increased gradually from Rs. 43,901 in fourth year to Rs. 49,968 in 25th year. The variable costs increased from Rs. 19,111 from fourth year to Rs. 20,019 (43 to 40 per cent) in sixth year and then remained constant during the remaining period of life Rs. 20,473. The fixed cost rose from Rs. 24,790 in fourth year to Rs. 22,705 in 25th year i.e., from 56 to 59 per cent. It was noted that the share of fixed costs in total costs varied between 56.47 per cent in fourth year to 59 per cent in 25th year of plantations.

Among the variable costs the fertilizer accounted for maximum expenditure (17 to 15 per cent) during the bearing period in total costs. It remained constant throughout the bearing period i.e., Rs. 7,358. Human labour was the next major item of operational costs and their share constituted 13 to 12 per cent in total costs. The costs incurred on human labour increased continuously from Rs. 5,482 to Rs. 6,080 in seventh year and then remained constant, the increase in labour cost was mainly due to increasing human labour requirement for harvesting operation and for weeding operations. Manures remained constant throughout the life time i.e., Rs. 2000 which stood around one per cent.

Interest on working capital, an item of variable cost increased from Rs. 2,273 in fourth year to Rs. 2,435 during eighth year and then remained constant at 4 to 5 per cent. Among fixed costs, rental value of owned land took a lion's share and increased from Rs. 7,517in fourth year to Rs. 22,550 in 25th year i.e., 17 to 45 per cent. This increase was due to increased Oil palm yield during bearing period. Hence the rental value of owned land also started rising steeply with each passing year.

Table 5.9. Maintenance Costs in Oil palm plantations during bearing period – Conventional Method of Irrigation (Rs/ha)

S.No.	Cost particulars	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
I	**Variable costs**							
1	Human labour	5480 .00 (12.48)	5680.00 (13.44)	5880.00 (11.67)	6080.00 (11.37)	6080 .00 (10.80)	6080 .00 (10.97)	6080.00 (11.12)
2	Machine labour	800 .00 (1.82)	1000.00 (2.37)	1200.00 (2.38)	1400.00 (2.62)	1400 .00 (2.49)	1400 .00 (2.53)	1400.00 (2.56)
3	Manures	2000.00 (4.56)	2000 .00 (4.73)	2000.00 (3.97)	2000.00 (3.74)	2000 .00 (3.55)	2000 .00 (3. 61)	2000.00 (3.66)
4	Fertilizers	7358 .00 (16.76)	7358.00 (17.41)	7358 .00 (14.61)	7358.00 (13.76)	7358.00 (13.07)	7358 .00 (13.27)	7358.00 (13.46)
5	Plant protection chemicals	1200.00 (2.73)	1200.00 (2.84)	1200.00 (2.38)	1200.00 (2.24)	1200 .00 (2.13)	1200.00 (2.16)	1200.00 (2.19)
6	Interest on working capital	2273.13 (5.18)	2327.13 (5.51)	2381.13 (4.73)	2435.13 (4.55)	2435.13 (4.33)	2435.13 (4.39)	2435.13 (4.45)
I	Subtotal of variable costs (1 to 6)	19111.13 (43.53)	19565.10 (46.29)	20019.10 (39.75)	20473.13 (38.28)	20473.13 (36.38)	20473.13 (36.94)	20473.13 (37.44)
II	**Fixed costs**							
1	Land revenue	494.00 (1.13)	494.00 (1.17)	494 .00 0.98)	494.00 (0. 92)	494.00 (0.88)	494.00 (0.89)	494.00 (0.90)
2	Rental value of owned land	7516.80 (17.12)	11275.20 (26.67)	15033.6 (29.85)	18792.00 (35.14)	22550.40 (44.07)	22550.40 (40.68)	22550.40 (41.24)
3	Depreciation	692.00 (1.58)	692.00 (1.64)	692 .00 (1.37)	692.00 (1.29)	692 .00 (1.23)	692.00 (1.25)	692.00 (1.27)
4	Interest on fixed capital	4928.93 (11.23)	4928.93 (11.66)	4928.93 (9.79)	4928.93 (9.22)	4928.93 (8.76)	4928.93 (8.89)	4928.93 (9.01)
5	Annuity of oil palm	11158.00 (25.42)	5315.15 (12.57)	9198.61 (18.26)	8104.51 (15.15)	7140.53 (12.69)	6291.22 (11.35)	5542.92 (10.14)
II	Subtotal of fixed costs (1 to 7)	24789.70 (56.47)	22705.28 (53.71)	30347.14 (60.25)	33011.44 (61.72)	35805.86 (63.62)	34956.55 (63.06)	34208.25 (62.56)
	Total costs (I+ II)	43901.00 (100.00)	42270.40 (100.00)	50366.30 (100.00)	53485.00 (100.00)	56279.00 (100.00)	55429.70 (100.00)	54681.40 (100.00)

Note: Figures in parentheses indicate percentages to total costs.

5.9 (cont.)

Table 5.9. Maintenance Costs in Oil palm plantations during bearing period – Conventional Method of Irrigation (Rs/ha)

S.No.	Cost particulars	Year 11	Year 12	Year 13	Year 14	Year 15
I	**Variable costs**					
1	Human labour	6080.00 (11.25)	6080 .00 (11.38)	6080.00 (11.49)	6080.00 (11.59)	6080.00 (11.67)
2	Machine labour	1400 .00 (2.59)	1400 .00 (2.62)	1400.00 (2.65)	1400.00 (2.67)	1400.00 (2.69)
3	Manures	2000.00 (3.70)	2000.00 (3.74)	2000 .00 (3.78)	2000.00 (3.81)	2000 .00 (3.84)
4	Fertilizers	7358 .00 (13.62)	7358 .00 (13.77)	7358 .00 (13.90)	7358 .00 (14.02)	7358.00 (14.13)
5	Plant protection chemicals	1200.00 (2.22)	1200 .00 (2.25)	1200.00 (2.27)	1200 .00 (2.29)	1200.00 (2.30)
6	Interest on working capital	2435.13 (4.51)	2435.13 (4.56)	2435.13 (4. 60)	2435.13 (4.64)	2435.13 (4.68)
I	Subtotal of variable costs (1 to 6)	20473.13 (37.90)	20473.1 (38.31)	20473.1 (38.68)	20473.1 (39.01)	20473.1 (39.31)
II	**Fixed costs**					
1	Land revenue	494.00 (0.91)	494 .00 (0.92)	494.00 (0.93)	494 .00 (0.94)	494.00 (0.95)
2	Rental value of owned land	22550.40 (41.74)	22550.40 (42.20)	22550.40 (42.60)	22550.40 (42.97)	22550.4 (43.30)
3	Depreciation	692.00 (1.28)	692.00 (1.29)	692 .00 (1.31)	692.00 (1.32)	692 .00 (1.33)
4	Interest on fixed capital	4928.93 (9.12)	4928.93 (9.22)	4928.93 (9.31)	4928.93 (9.39)	4928.93 (9.39)
5	Annuity of oil palm	4883.63 (9.04)	4302.76 (8.05)	3790.98 (7.16)	3340.07 (6.36)	2942.79 (5.65)
II	Subtotal of fixed costs (1 to 5)	33549 (62.10)	32968.10 (61.69)	32456.30 (61.32)	32005.4 0(60.99)	31608.10 (60.69)
	Total costs (I+ II)	54022.09 (100.00)	53441.20 (100.00)	52929.40 (100.00)	52478.50 (100.00)	52081.30 (100.00)

Note: Figures in parentheses indicate percentages to total costs

5.9 (cont.)

Table 5.9. Maintenance Costs in Oil palm plantations during bearing period – Conventional Method of Irrigation (Rs/ha)

S.No.	Cost particulars	Year 16	Year 17	Year 18	Year 19	Year 20
I	**Variable costs**					
1	Human labour	6080.00 (11.75)	6080.00 (11.82)	6080 .00 (11.89)	6080 .00 (11.94)	6080 .00 (11.99)
2	Machine labour	1400 .00 (2.71)	1400.00 (2.72)	1400 .00 (2.74)	1400.00 (2.75)	1400 .00 (2.76)
3	Manures	2000.00 (3.87)	2000 .00 (3.89)	2000 .00 (3.91)	2000 .00 (3.93)	2000 .00 (3.94)
4	Fertilizers	7358 .00 (14.22)	7358.00 (14.31)	7358.00 (14.38)	7358 .00 (14.45)	7358.00 (14.51)
5	Plant protection chemicals	1200 .00 (2.32)	1200.00 (2.33)	1200 .00 (2.35)	1200 .00 (2.36)	1200 .00 (2.37)
6	Interest on working capital	2435.13 (4.71)	2435.13 (4.74)	2435.13 (4.76)	2435.13 (4.78)	2435.13 (4.80)
I	Subtotal of variable costs (1 to 6)	20473.10 (39.58)	20473.10 (39.81)	20473.10 (40.02)	20473.10 (40.21)	20473.10 (40.38)
II	**Fixed costs**					
1	Land revenue	494 .00 (0.95)	494 .00 (0.96)	494 .00 (0.97)	494 .00 (0.97)	494 .00 (0.97)
2	Rental value of owned land	22550.40 (43.59)	22550.40 (43.85)	22550.40 (44.09)	22550.40 (44.29)	22550.40 (44.48)
3	Depreciation	692 .00 (1.34)	692 .00 (1.35)	692.00 (1.35)	692.00 (1.36)	692 .00 (1.36)
4	Interest on fixed capital	4928.93 (9.53)	4928.93 (9.59)	4928.93 (9.64)	4928.93 (9.68)	4928.93 (9.72)
5	Annuity of oil palm	2592.77 (5.01)	2284.38 (4.44)	2012.67 (3.93)	1773.27 (3.48)	1562.36 (3.08)
II	Subtotal of fixed costs (1 to 5)	31258.10 (60.42)	30949.7 0 (60.19)	30678 .00 (59.98)	30438.60 (59.79)	30227.70 (59.62)
	Total costs (I+ II)	51731.20 (100.00)	51422.80 (100.00)	51151.10 (100.00)	50911.70 (100.00)	50700.80 (100.00)

Note: Figures in parentheses indicate percentages to total costs

5.9 (cont.)

Table 5.9. Maintenance Costs in Oil palm plantations during bearing period – Conventional Method of Irrigation (Rs/ha)

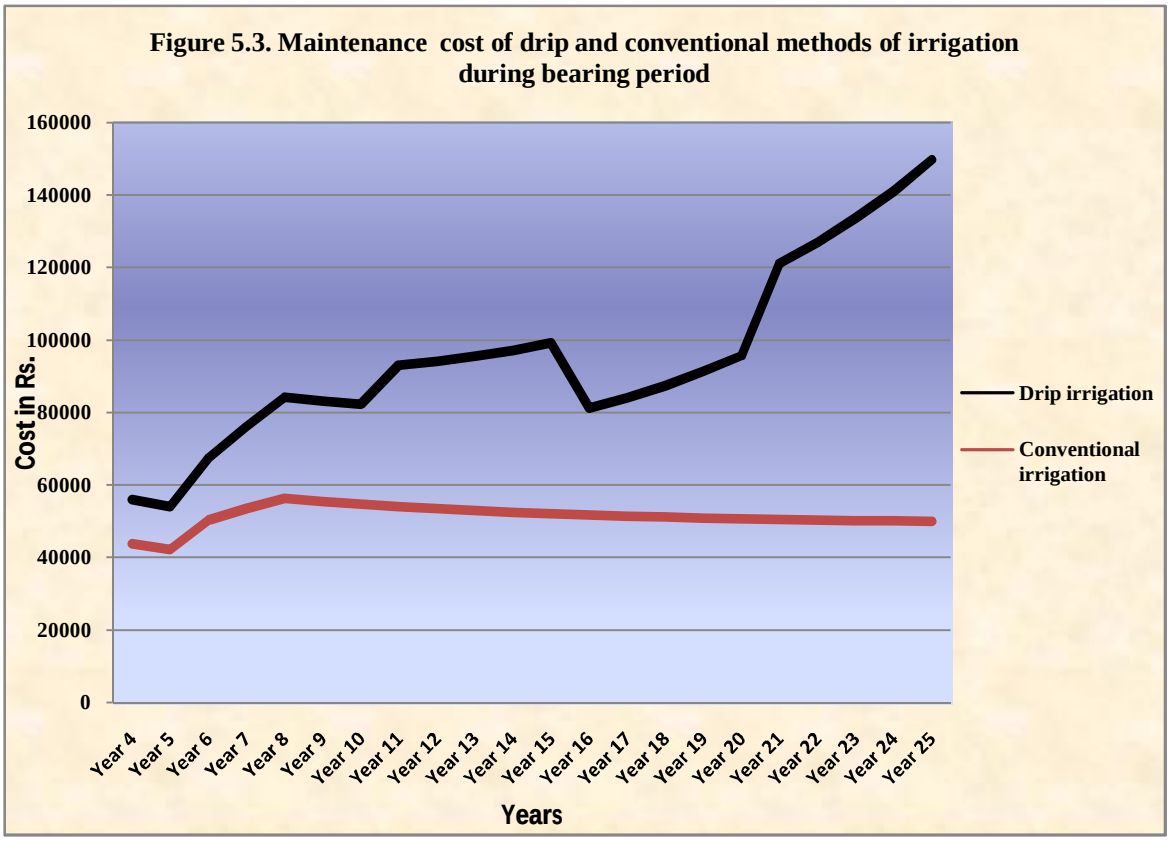
S.No.	Cost particulars	Year 21	Year 22	Year 23	Year 24	Year 25
I	**Variable costs**					
1	Human labour	6080.00 (12.04)	6080 .00 (12.08)	6080 .00 (12.11)	6080 .00 (12.14)	6080 .00 (12.17)
2	Machine labour	1400.00 (2.77)	1400.00 (2.78)	1400 .00 (2.79)	1400.00 (2.80)	1400 .00 (2.80)
3	Manures	2000 .00 (3.96)	2000 .00 (3.97)	2000 .00 (3.98)	2000 .00 (3.99)	2000.00 (4.00)
4	Fertilizers	7358 .00 (14.57)	7358.00 (14.61)	7358 .00 (14.66)	7358.00 (14.69)	7358.00 (14.73)
5	Plant protection chemicals	1200 .00 (2.38)	1200.00 (2.39)	1200.00 (2.39)	1200.00 (2.40)	1200.00 (2.40)
6	Interest on working capital	2435.13 (4.82)	2435.13 (4.84)	2435.13 (4.85)	2435.13 (4.86)	2435.13 (4.87)
I	Subtotal of variable costs (1 to 6)	23449.40 (40.53)	23449.40 (40.66)	23449.40 (40.78)	23449.40 (40.88)	23449.40 (40.97)
II	**Fixed costs**					
1	Land revenue	494.00 (0.98)	494 .00 (0.98)	494.00 (0.98)	494.00 (0.99)	494 .00 (0.99)
2	Rental value of owned land	22550.40 (44.64)	22550.40 (44.79)	22550.40 (44.91)	22550.40 (45.03)	22550.40 (45.13)
3	Depreciation	692.00 (1.37)	692.00 (1.37)	692.00 (1.38)	692 .00 (1.38)	692 .00 (1.38)
4	Interest on fixed capital	4928.93 (9.76)	4928.93 (9.79)	4928.93 (9.82)	4928.93 (9.84)	4928.93 (9.86)
5	Annuity of oil palm	1376.53 (2.72)	1212.8 (2.41)	1068.54 (2.13)	941.44927 (1.88)	829.471 (1.66)
II	Subtotal of fixed costs (1 to 5)	30041.90 (59.47)	29878.10 (59.34)	29733.90 (59.22)	29606.77 (59.12)	29494.80 (59.03)
	Total costs (I+ II)	50515.00 (100.00)	50351.30 (100.00)	50207.00 (100.00)	50079.90 (100.00)	49967.90 (100.00)

Note:. Figures in parentheses indicate percentages to total costs

The present value of annuity was calculated for Oil palm orchard which accounted for Rs. 11,158 (25 per cent) in fourth year and gradually decreased to Rs. 829 (1.67 per cent) in 25th year. Interest on fixed capital, land revenue, depreciation charges shared 11.23 to 9.86 per cent, 1.13 to 0.99 per cent and 1.58 to 1.38 per cent and of fixed costs respectively.

From the above discussion it was observed that the maintenance cost for DMI was higher and increased gradually compared to CMI from 27 per cent in fourth to 200 per cent in 25th year. The major role was played by the annuity of drip irrigation and rental value of owned land in case of DMI. There is no much variation in total variable costs between the two systems of irrigations.

Figure 5.3. Maintenance cost of drip and conventional methods of irrigation during bearing period



5.4.3 Borrowings from Banks

In Oil palm, as most of the farmers are large farmers they do not borrow money from banks. A very little percentage of farmers borrow money from banks and as it is a long duration crop, the loan was obtained at the interest rate of 13.5 per cent.

5.5 YIELDS AND RETURNS OF OIL PALM CULTIVATION WITH DRIP AND CONVENTIONAL METHODS OF IRRIGATION

5.5.1 Harvesting

Proper and timely harvesting of fruit bunches is an important operation which determines the quality of oil to a great extent. The yield is expressed as fresh fruit bunches (FFB) in kg per hectare per year. As the fruit ripens oil content increase to 80 - 85% in mesocarp. Ripeness of the fruit is determined by the degree of detachment of the fruit from bunches, change in colour and change in texture of the fruit.

5.5.1.1 Frequency of Harvesting

Harvesting rounds should be made as frequent as possible to avoid over ripening of bunches. In lean period of production, harvesting can be made less frequent and it should be more frequent in peak periods. Harvesting rounds of 7-14 days are generally practiced. In India, harvesting is usually carried out with a chisel of 6 - 9 cm wide attached to a wooden pole or light hollow aluminium pipe. Bunches are cut without damaging the petiole of the leaf that supports it.

5.5.2 Yields and Returns during Bearing Period -Drip Method of Irrigation

Oil palm yields start from fourth year and continues upto its lifetime of 25 years. The particulars of table 5.10. indicated that the yield per hectare increased gradually from 8 tonnes in fourth year to 25 tonnes in 25^{th} year when practiced under DMI. Accordingly the gross incomes also increased from Rs 50,112 fourth

year to Rs. 1, 56,600 in 25th year. The yield and income increased continuously during the yield increasing period i.e., from fifth year to 25th year ranging from 52 to 40 per cent in DMI over CMI.

Table 5.10. Yield and income difference in DMI and CMI in Oil palm per ha

Year	Yield in tons of FFB				Income in Rs			
	Drip irrigation	Conventional Irrigation	Yield difference	per cent difference	Drip irrigation	Conventional Irrigation	Income difference	per cent difference
4	8	4	4	50	50112	25056	25056	50
5	10	6	4	40	62640	37584	25056	40
6	15	8	7	46.67	93960	50112	43848	46.67
7	20	10	10	50	125280	62640	62640	50
8-25	25	12	13	52	156600	75168	81432	52

Note: Income valued at the average price of Rs.6264/ton of FFB

5.5.3 Yields and Returns during Bearing Period -Conventional Method of Irrigation

Oil palm yields start from fourth year and continues up to its lifetime of 25 years. The particulars of table 5.10. indicated that the yield per hectare increased gradually from 4 tonnes in fourth year to 12 tonnes in 25th year when practiced under CMI. Accordingly the gross income also increased from Rs 25,056 in fourth year to Rs. 75,168 in 25th year. The yield and income increased continuously during the yield increasing period i.e., from fifth year to 25th year.

From the results obtained it can be concluded that the yield in DMI was around 50 per cent higher to CMI in Oil palm and drip irrigation helps in achieving greater yield compared to CMI and thereby results in higher income.

5.5.4 Price determination in Oil palm

The price of Oil palm Fresh Fruit Bunches (FFBs) is fixed by the Price Fixation Committee constituted by the State Governments. The price is revised by the committee on a quarterly basis. The prices of FFB will depend upon the international prices of crude palm oil and it has been established that international prices of crude petroleum has a bearing on the prices of crude palm oil. Another factor which influences the prices of palm oil and consequently FFB's price is the import duty structure fixed for palm oil. The average price considered was Rs 6264 per ton of FFB in the present study based on the enquiries from the sampled farmers.

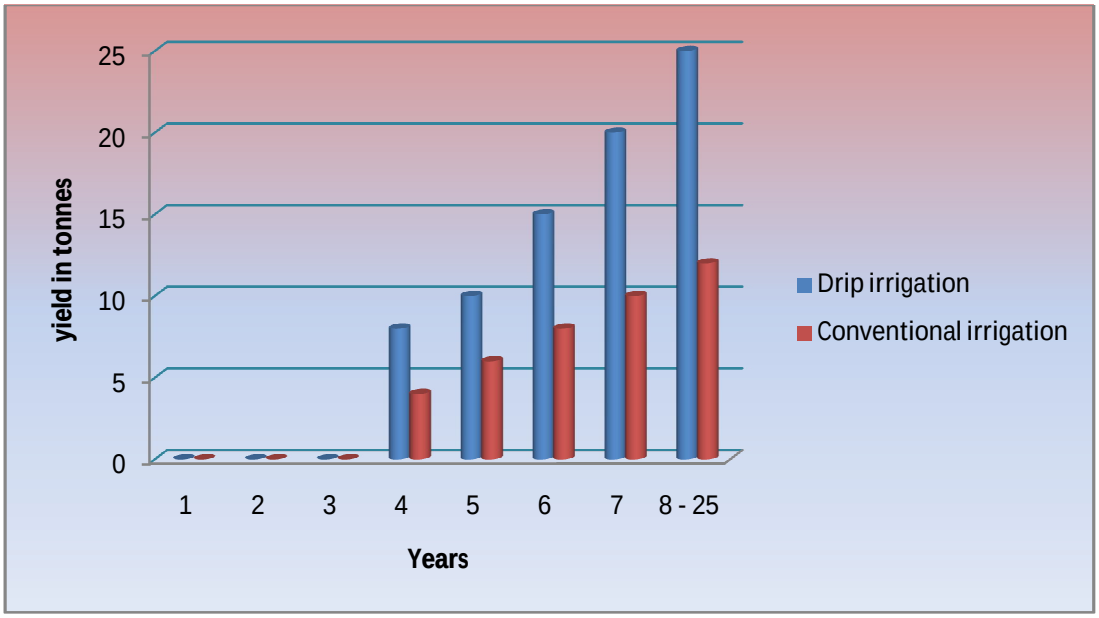


Figure 5.4. Yield difference in drip and conventional methods of irrigation

5.6 FINANCIAL VIABILITY OF DMI VIS-A VIS CMI IN OIL PALM PLANTATIONS

5.6.1 Financial Viability of DMI

The costs and returns are not the perfect measures to assess the profitability from investment made on Oil palm cultivation with DMI and to compare with CMI. The costs and returns are not comparable with the returns from field crops that are grown in the area before making choice on any enterprise. It becomes necessary to examine the economic feasibility of that enterprise. The length of the period of particular enterprise plays a key role in the selection of indicators that would examine the financial feasibility of the enterprise. Several techniques are available for evaluating the financial viability of DMI and CMI in Oil palm plantations. In this study, project evaluation techniques were employed to study the financial feasibility of Oil palm plantations with DMI and CMI. Undiscounted cash flow techniques such as payback period and discounted cash flow techniques such as Net Present Worth (NPW), Benefit-Cost Ratio (BCR), Internal Rate of Return (IRR), Net –Benefit to Investment Ratio (N/K Ratio) and Switching values were employed to examine the financial feasibility of investment on DMI vis-a vis CMI in Oil palm cultivation.

5.6.1.1 Undiscounted Cash Flow Techniques

5.6.1.1.1 Payback period of DMI

Payback period is the period required to repay the initial investment incurred in establishing the garden. The payback period in the study area for DMI was found to be 0.62 years and 1.02 years for CMI. Considering only the drip irrigation system cost the payback period is 2.03 years. Therefore, it can be concluded that the period required to repay the initial investment is less for DMI.

5.6.1.2 Discounted Cash Flow Techniques

The costs and benefits from Oil palm plantations were discounted at the rate of 13.5 per cent discount rate as it is the rate at which the commercial banks normally lend to Oil palm plantations development in the study area.

5.6.1.2.1 Net Present Worth (NPW)

It was observed from that the net present worth for DMI in Oil palm was Rs. 2, 91,259 and CMI was Rs. 98406.14 at 13.5 Per cent discount rate. The higher NPW of drip irrigation indicated the soundness of the investment made in drip irrigation in Oil palm plantations. The investment in Oil palm with DMI is worthwhile from the fourth year of plantations i.e., from the starting of bearing period as the present worth is positive and higher than present costs.

5.6.1.2.2 Benefit-Cost Ratio (BCR)

The benefit-cost ratio of DMI in Oil palm was worked out to be 1.87 and for CMI was 1.43. The discounted benefit-cost ratio which indicates the rate of returns for a rupee capital of investment reiterated that the investment made in DMI is quite profitable which indicated that the DMI in Oil palm cultivation is financially feasible.

5.6.1.2.3 Internal Rate of Return (IRR)

The IRR was found out to be 50.52 per cent for DMI which was nearly four times higher than the bank rate of interest on long term loan. The IRR for CMI was 41.46 and was less than IRR of DMI. Considering the IRR, DMI compared to CMI is economically feasible**.**

5.6.1.2.4 Net Benefit Investment Ratio (N/K Ratio)

The N/K ratio of DMI is 10.92 which were more than one. Hence it is worthwhile investment.

Table 5.11. NPW of drip method of irrigation in Oil Palm with df @ 13.5%

Year	Costs	Returns	Net returns	df @13.5%	NPW
1	47304.9	16326.45	-30978.4	0.8811	-27293.8
2	18586.7	16718.9	-1867.83	0.7763	-1449.92
3	20077.1	12830.14	-7246.91	0.6839	-4956.39
4	32365.6	50112	17746.4	0.6026	10693.7
5	36524	62640	26116	0.5309	13865.2
6	46320	93960	47640	0.4678	22284.2
7	56116	125280	69164	0.4121	28504.2
8-25	1179216	2818800	1639584	2.7403	249612
				NPW=	2,91,258.9

Note: Net returns from inter crops considered during the pre-bearing period

Table 5.12. NPW of conventional method of irrigation in Oil Palm with df @ 13.5%

Year	Costs	Returns	Net returns	df @13.5%	NPW
1	23024.89	14117.5	-8907.39	0.8811	-7847.92
2	19886.73	14797.27	-5089.46	0.7763	-3950.75
3	21377.05	12253.65	-9123.4	0.6839	-6239.78
4	24848.8	25056	207.2	0.6026	124.8551
5	29007.2	37584	8576.8	0.5309	4553.507
6	33165.6	50112	16946.4	0.4678	7926.88
7	37324	62640	25316	0.4121	10433.36
8-25	739483.2	1353024	613540.8	2.7403	93405.99
				NPW=	98,406.14

Note: Net returns from inter crops considered during the pre-bearing period

Table-5.13. B-C ratio of drip method of irrigation in Oil Palm with df @ 13.5%

Year	Costs	Returns	df @13.5%	PW Cost	PW Benefit
1	47304.9	16326.45	0.8811	41678.3	14384.54
2	18586.7	16718.9	0.7763	14428.2	12978.25
3	20077.1	12830.14	0.6839	13731.3	8774.933
4	32365.6	50112	0.6026	19503	30196.6
5	36524	62640	0.5309	19391	33256.2
6	46320	93960	0.4678	21666.7	43950.9
7	56116	125280	0.4121	23126.8	51631
8-25	1179216	2818800	2.7403	179524.9	429136.6
	Total			3,33,050.1	6,24,309
				B-C Ratio	**1.87**

Note: Net returns from inter crops considered during the pre-bearing period

Table-5.14. B-C ratio of conventional method of irrigation in Oil Palm with df @ 13.5%

Year	Costs	Returns	df @13.5%	PW Cost	PW Benefit
1	23024.89	14117.5	0.8811	20286.24	12438.33
2	19886.73	14797.27	0.7763	15437.31	11486.56
3	21377.05	12253.65	0.6839	14620.43	8380.654
4	24848.8	25056	0.6026	14973.45	15098.31
5	29007.2	37584	0.5309	15400.2	19953.71
6	33165.6	50112	0.4678	15513.6	23440.48
7	37324	62640	0.4121	15382.15	25815.51
8-25	739483.2	1353024	2.7403	112579.58	205985.5
	Total			224193	322599.1
				B-C Ratio	**1.44**

Note: Net returns from inter crops considered during the pre-bearing period

Table-5.15. Internal rate of return of drip method of irrigation in Oil Palm

Year	Costs	Returns	Net returns	df @50%	NPW at 50%	df @55%	NPW at 55%
1	47304.89	16326.45	-30978.4	0.6667	-20652.3	0.6452	-19986.1
2	18586.73	16718.9	-1867.83	0.4444	-830.145	0.4162	-777.451
3	20077.05	12830.14	-7246.91	0.2963	-2147.23	0.2685	-1946.07
4	32365.6	50112	17746.4	0.1975	3505.46	0.1733	3074.564
5	36524	62640	26116	0.1317	3439.14	0.1118	2919.095
6	46320	93960	47640	0.0878	4182.39	0.0721	3435.434
7	56116	125280	69164	0.0585	4048.01	0.0465	3217.794
8-25	1179216	2818800	1639584	0.1170	10655.12	0.0846	7702.181
	Total				2200.45		-2360.54
					IRR		50.52

Note: Net returns from inter crops considered during the pre-bearing period

Table-5.16. Internal rate of return of conventional method of irrigation in Oil Palm

Year	Costs	Returns	Net returns	df @40%	NPW at 40%	df @45%	NPW at 45%
1	23024.89	14117.5	-8907.39	0.7143	-6362.42	0.6897	-6143.02
2	19886.73	14797.27	-5089.46	0.5102	-2596.66	0.4756	-2420.67
3	21377.05	12253.65	-9123.4	0.3644	-3324.85	0.328	-2992.63
4	24848.8	25056	207.2	0.2603	53.93586	0.2262	46.87246
5	29007.2	37584	8576.8	0.1859	1594.722	0.156	1338.09
6	33165.6	50112	16946.4	0.1328	2250.657	0.1076	1823.347
7	37324	62640	25316	0.0949	2401.59	0.0742	1878.534
8-25	739483.2	1353024	613540.8	0.2366	8064.848	0.1647	5613.595
			Total		2081.817		-855.883
					IRR		41.46%

Note: Net returns from inter crops considered during the pre-bearing period

Table 5.17. N/K ratio of drip method of irrigation in Oil Palm with df @ 13.5%

Year	Incremental Costs	Incremental Benefits	Net Benefits	df @13.5%	PW of incremental net benefit
1	24280	2208.95	-22071.1	0.8811	0.8811
2	-1300	1921.63	3221.63	0.7763	0.7763
3	-1300	576.49	1876.49	0.6839	0.6839
4	7516.8	25056	17539.2	0.6026	0.6026
5	7516.8	25056	17539.2	0.5309	0.5309
6	13154.4	43848	30693.6	0.4678	0.4678
7	18792	62640	43848	0.4121	0.4121
8-25	439732.8	1465776	1026043	2.7403	2.7403
PW of negative net incremental benefits					-19445.86
PW of positive net incremental benefits					212298.6
				N/K ratio	**10.92**

Note: Net returns from inter crops considered during the pre-bearing period

5.6.1.2.5 Sensitivity Analysis

Switching Values: A switching value determines how much an element (costs or benefits) would have to change in an unfavorable direction before the investment activity would no longer meet the minimum level of acceptability as indicated by one of the measures of present worth. The costs of Oil palm plantation with drip irrigation could rise by 87 per cent before the B: C ratio would be driven to one. Similarly the benefits could fall by 46 per cent before the ratio would be driven to one. (Table 5.18)

Table 5.18. Switching values of drip method of irrigation in Oil Palm

S.No	Switching values	Per cent
Based on B:C Ratio		
1	Increased total costs	87
2	Decrease in total incremental benefits	46
Based on N/K Ratio		
3	Increased investment costs	58
4	Decrease in net incremental benefits	31

The N/K ratio may also be used to make a quick estimate of switching value. The investment costs could rise as much as 58 per cent before the N/K ratio would be driven to one and the benefits could fall by 31 per cent before the ratio become one which indicated the profitability.

It is evident from the above switching values that the investment on drip irrigation in Oil palm is a profitable proposition and is economically viable even if the costs could raise by 87 per cent and benefits could fall by 46 per cent in future period.

5.6.2 Incremental Costs and Benefits

The discounted cash flow techniques of NPW, BCR and IRR were worked out both for DMI and CMI separately and also taking the incremental differences in costs and benefits from both the methods. (Table 5.19). The net present worth for DMI and CMI in Oil palm was Rs. 2, 91,259 and Rs. 98,406 at 13.5 Per cent discount rate. By considering the incremental costs and benefits i.e., taking the difference between costs and benefits under the two sources of irrigation NPW value was Rs. 1, 89,020 which is positive and very high than CMI. The higher NPW of DMI over CMI indicated the soundness of the investment made in DMI in Oil palm plantations.

Table 5.19. Impact in Financial viability of DMI and CMI in Oil palm-Incremental costs and benefits

	PBP	NPW	BCR	IRR (per cent)
Drip method of irrigation	0.67	2,91,259	1.87	50.52
Conventional method of irrigation	1.02	98,406	1.44	41.46
Based on incremental costs and benefits from drip irrigation over conventional irrigation.	0.33	1,89,020	2.74	53.90
Per cent difference of DMI over CMI	+34.31	+70.26	+22.99	+21.85

The benefit-cost ratio of DMI and CMI in Oil palm was worked out to be 1.87 and 1.44. Using the incremental costs and benefits the B-C ratio was 2.74. The discounted benefit-cost ratio indicated that the investment made in DMI is quite profitable and is economically feasible. The IRR was found out to be 50.52 per cent for DMI and 41.46 per cent for CMI. It is interesting to note that with incremental costs and benefits the IRR was 53.90 per cent which was much higher than the values of individual systems of irrigation. The DMI is far superior to CMI in generating the benefits.

5.7 WATER USE EFFICIENCY IN DMI AND CMI

The quantity of water used was low in DMI with 1,310 mm compared to CMI of 1,940 mm. The results of the water use efficiency were presented in table 5.20. It can be observed from the results that higher crop yield coupled with lower quantity of water used resulted in the higher water use efficiency in terms of output per unit of water consumed was 15.35 kg/ha/mm in DMI to that of CMI of 5.03 kg/ha/mm. The water use benefit from DMI was Rs. 1, 26,032. The water use efficiency in terms of water consumed to produce one kg of output was 65.11 mm/kg/ha and 198.77 mm/ha/kg for DMI and CMI respectively.

Table 5.20. Water use efficiency of drip and conventional irrigation systems in oil palm Plantations.

S.No	Particulars	Drip irrigation system	Conventional irrigation system	Difference between DIS and CIS	Per cent differential of DIS over CIS
1	Average yield (t/ha)	20.12	9.76	10.36	+51.49
2	Average water consumption (mm /ha)	1310	1940	630	-32.47
3	Water use efficiency (output per unit of water in Kg/ha/mm)	15.35	5.03	10.32	+67.24
4	Water use efficiency (water consumed per unit of output produced in mm/ha/kg)	65.11	198.77	133.66	-67.24
5	Water use efficiency benefit (Rs/ha/mm)	1,26,031.7	61,136.64	64,895.06	+51.49

5.7.1 Water Saving

In Oil palm plantations through the adoption of drip irrigation significant saving in water was observed. The amount of water saved through DMI compared to CMI was 630 mm/ha/year i.e., 32 per cent. This saved water can be used to irrigate an additional half an hectare of Oil palm if the farmers can shift to DMI.

5.8 CONSTRAINTS IN DRIP IRRIGATION SYSTEM IN OIL PALM CULTIVATION

An opinion survey was conducted to identify the constraints experienced by drip irrigated farmers in the study area.

The constraints faced by the oil palm growers were grouped in the table 5.22. The particulars of the table 5.21. revealed that restricted root zone was the major constraint faced by the farmers and accounted for 58.33 per cent. Next to that sensitivity to clogging of drippers was found in major areas and accounted for (46.66 per cent) followed by the constraints damage to the drip pipe by rats (41.66per cent), high cost compared to conventional methods (35 per cent), subsidy is not sufficient (30 per cent), salt accumulation in root zone (28.33 per cent), high maintenance cost (25 per cent), high skill requirement for design, installation and operations (16.66) , problems of wild pigs in field (8.33per cent) and only diluted fertilizers are used in root zone (8.33per cent).

Table 5.21. Constraints in drip irrigation system

	Particulars	**Percentage of farmers expressing the problem**
(a)	Sensitivity to clogging of drippers	46.66
(b)	High cost compared to conventional methods	35
(c)	High skill is required for design, installation and operations	16.66
(d)	Restricted root zone	58.33
(e)	Salt accumulation in root zone	28.33
(f)	Problems of wild pigs in field	8.33
(g)	Rats may eat or damage the drip pipe	41.66
(h)	High maintenance cost	25
(i)	Subsidy is no sufficient	30
(j)	Only diluted fertilizers are used in root zone	8.33

The major suggestions include timely provision and availability of subsidies and loans; reduction in total initial cost of the drip unit; provision of regular after sales services by the drip set suppliers; and technical training to drip adopters. Additional maintenance and operation burden of filtering and cleaning drippers is

substantial. The suggestions also include assured power supply, financial assistance from banks and increasing the subsidy for cultivation and in installation of drip system. Increase the subsidy and facility on drip irrigation by government and training should be given to the farmers regarding operation, maintenance, repairing and application of water soluble fertilizers. Regular supervision for rats and by underground piping of drip irrigation. Fencing in order to protect wild and stray animals.

5.9 DISCUSSION

5.9.1 Economic Viability of Drip Irrigation with and without Subsidy

The adoption of micro-irrigation cannot be increased without providing subsidy because of its capital-intensive nature. There is no doubt that micro-irrigation is a capital-intensive technology, but it does not mean that its adoption cannot be increased without subsidy. Subsidy can be a necessary condition for encouraging the adoption of micro-irrigation, but cannot be a sufficient condition for sustaining the growth of it, as many other factors determine the adoption of the same. (Narayanamoorthy ,2005)

The results available from INCID (1994) for several vegetable crops, fruit crops and plantation crops show that the investment in DMI is economically viable, even if discounted BCR are estimated without taking into account the subsidy given to farmers. Narayanamoorthy (2005) also estimated that NPW and BCR with and without subsidy under discount rates and concluded that drip investment was economically viable without subsidy in sugarcane, grapes and banana.

In Oil palm under RKVY, Oil Palm Area Expansion Programme GOI is spending Rs. 30,000 lakhs and Rs. 19,200 lakhs i.e., 64per cent is proposed to be spent in Andhra Pradesh alone. A major share of this outlay goes in the form of subsidy component to various activities. The subsidy component on DMI and pump sets for drip system takes a larger share. (Details are presented in Chapter IV table 4.17.).

Therefore to study the economic viability of Oil palm cultivation with different subsidy scenarios and without subsidy components on DMI in the present study BCR and IRR values were estimated. The results of the viability values of BCR and IRR are presented in the table 5.22.

Table 5.22. Economic viability of Oil palm plantations drip irrigation without subsidy and with subsidy at different rates of Drip irrigation.

S.No	Subsidy scenario	B-C Ratio	IRR
1	Without subsidy both in Drip irrigation and in plant material	1.57	28.32
2	Without subsidy in Drip irrigation + With subsidy in plant material	1.60	29.09
3	Drip irrigation with 90per cent subsidy+ Without subsidy in plant material	1.74	35.73
4	Drip irrigation with 75per cent subsidy+ Without subsidy in plant material	1.69	33.00
5	Drip irrigation with 50per cent subsidy+ Without subsidy in plant material	1.64	33.53
6	Drip irrigation with 90per cent subsidy+ subsidy in plant material	1.77	37.32
7	Drip irrigation with 75per cent subsidy+ subsidy in plant material	1.74	35.52
8	Drip irrigation with 50per cent subsidy+ subsidy in plant material	1.69	32.97

Note: 90per cent subsidy for the farmers with land holding < 5 ha

75per cent subsidy for the farmers with land holding 5-10 ha

50per cent subsidy for the farmers with land holding >10 ha

Drip irrigation system (DIS) is an expensive technology with an initial capital cost of Rs. 2.60,000. The subsidy is provided to the farmers at different rates based on the land holdings of the farmers. Farmers having < 5ha, 5-10 ha and > 10 ha are provided with subsidy rates of 90 per cent, 75 per cent and 50 per cent respectively. The subsidy is being provided even to the plant material and the cost of subsidized plant material is Rs. 15 per plant.

The table 5.21. revealed that the B-C ratio of drip irrigation without subsidy both to drip irrigation and plant material accounted for 1.57 and the IRR is 28.32. The B-C ratio of drip irrigation without subsidy in drip irrigation and with subsidy in plant material accounted for 1.60 and the IRR is 29.09. The B-C ratio and IRR at 90 per cent, 75 per cent and 50 per cent subsidy rates of drip irrigation and without considering the subsidy in plant material are 1.74, 1.69, 1.64 and 35.73, 33.00, 33.53 respectively. Similarly the B-C ratio and IRR at 90 per cent, 75 per cent and 50 per cent subsidy rates of drip irrigation and with the subsidy in plant material are 1.77, 1.74, 1.69 and 37.32, 35.52, 32.97 respectively.

The analysis of different scenarios with subsidy and without subsidy indicates that drip irrigation is economically viable even without subsidy. Considering different scenarios of subsidy as presented in table 5.21 the B-C ratio and IRR further increases with increase in subsidy rates. But without subsidy both to drip unit and plant material the Oil palm cultivation is also economically viable as revealed by BCR ratio which is greater than one and IRR greater than the market rates of interest extended to Oil palm plantations by banks. The earlier research study results available (INCID 1994, Sivanappan 1995, Narayanamoorthy 2005) also confirmed that the cultivation of several vegetable crops, fruit crops and plantation crops are economically viable without subsidy in drip units.

5.9.2 Impact on Productivity, Returns and viability of Drip Irrigation over Conventional Irrigation Method in Oil Palm.

It was observed that the establishment costs of DMI exceeded CMI by 32 per cent. (Rs. 32, 902). The establishment costs can be paid back after shifting to the drip system within 0.67 years. Though the costs were more it was compensated by the income generated which was 50.40 per cent (Rs. 16, 22,376) higher in DMI over CMI. Similarly the Water use efficiency of DMI exceeded the CMI in Oil palm by 67.23 per cent (10.32 Kg/ha/mm).The NPW, BCR and IRR in DMI exceeded the CMI in Oil palm by 66, 24 and 18 per cent respectively. The analysis of drip system

with different subsidy scenarios and without subsidy showed that the Oil palm cultivation by introduction of DIS is both financially and economically viable even without subsidy component in drip system and plant material.

Table: 5.23. Impact of DMI over CMI in Oil palm Plantations per hectare

S.No	Efficiency impact parameters	Difference between DMI and CMI	Percentage difference between DMI and CMI
1	Establishment costs (upto three years)	Rs. 32,902	38
2	Income gains	Rs. 16,22,376	50.49
3	Water use efficiency	10.32 Kg/ha/mm	67.23
4	PBP	0.35	34.31
5	NPW	192852.76	66.21
6	BCR	0.44	23.53
7	IRR	9.06	17.93

Now the question is whether the huge subsidized the GOI incurring in OPAE under RKVY, i.e., 30,000 lakhs and OPDP to be continued in future or not as the Oil palm cultivation is viable even without subsides.

India imports 50 per cent of its edible oil requirements and their imports are surging year by year from 5.60 million tonnes in 2007-08 to 8.18 million tonnes in 2008-09 in 2009-10. As result there will be huge foreign exchange out go in importing edible oils. India's palm oil production is just 0.2 per cent share in the total world's production. Oil palm is the perennial crop yielding highest edible oil among oil seed crops which produces 4 to 6 tonnes of crude palm oil/ha over its productive life span of 25 years compared to production of less than 1 ton/ha form other oil seeds.

Therefore investment in area expansion under Oil palm plantations in large scale is viable alternative to fore-going huge foreign exchange in volatile global markets in the form of imports of palm oil (crude and RBD palmolein) as the PBP, NPW, BCR and IRR are all positive and are with higher values.

Hence the subsidised programmes can be continued by rationalizing the components of subsidies. The components of subsidies provided under OPAE include subsides for planting materials, cost of cultivation expenses, drip irrigation system, diesel/ electrical pump sets, support for inter cropping, INM, IPM, fertilization, tree guards, vermicompost pits, bore wells, water harvesting etc. Therefore it is suggested that the subsidy components related to drip system, diesel/ electrical pump sets, bore wells, water harvesting can be retained as water is a scarce resource and investing in its saving mechanisms is more valuable. The subsidies on other component can be removed so that the subsidy component can be reduced rationally.

By converting CMI plantations to DMI plantations water saved can be used to expand an half and hectare of land can be brought under DMI. Therefore the subsides on DMI is more productive compared to other subsides in terms of area expansion under DMI Oil palm and achieving reduction of its imports in future.

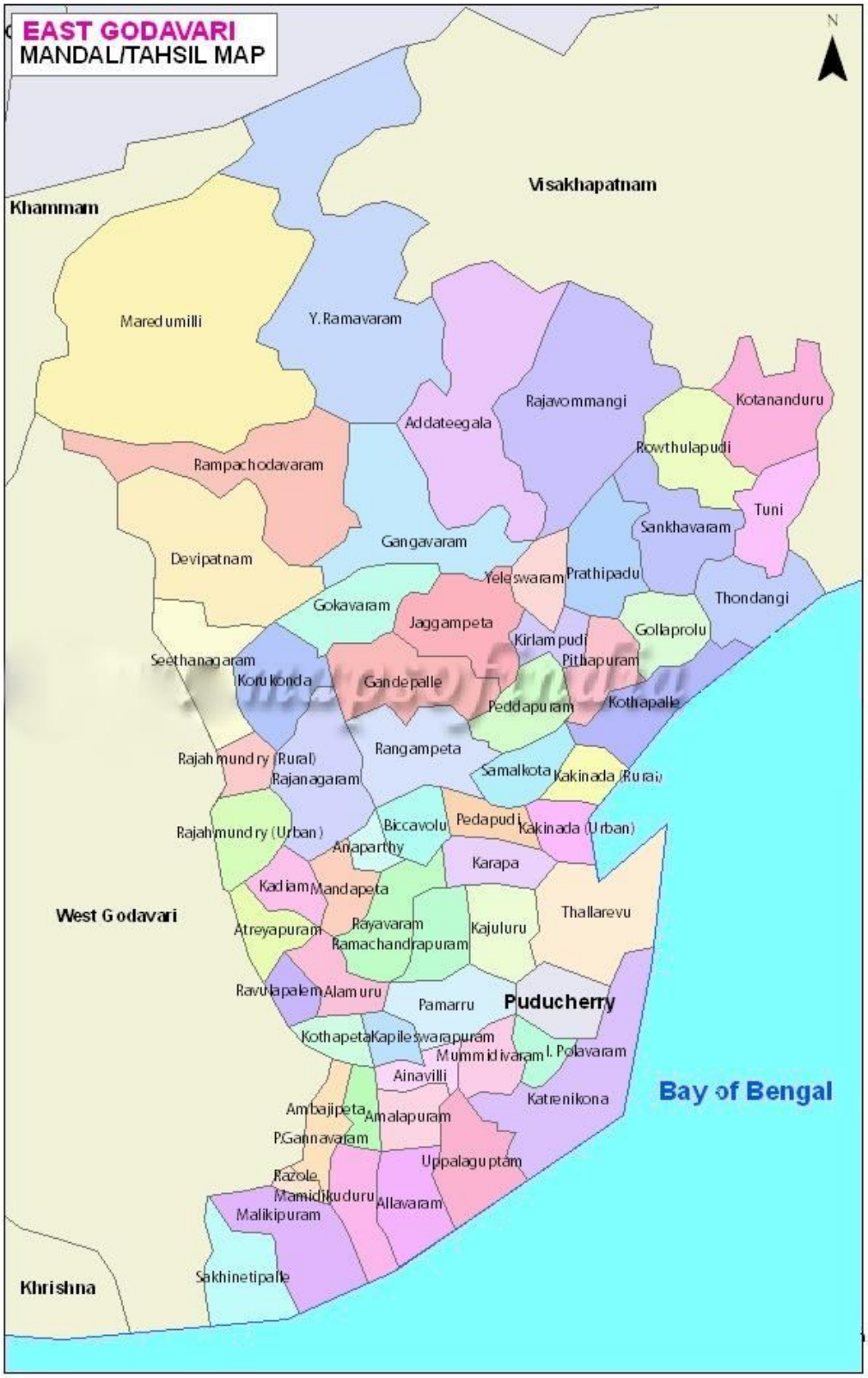


Fig. 4.1. Map of East Godavari district with the selected mandals

Chapter VI

SUMMARY AND CONCLUSIONS

At present, India is importing palm oil to bridge the gap in production and consumption of oil. It is therefore necessary to go for cultivation of oil palm extensively. Besides, it can also contribute substantially to the nutritional and energy requirements of the masses. It is the crop of the future and a source of health and nutrition, enables diversification , import substitution, valued addition, low cost of cultivation, and used for co-generation besides being eco-friendly and sustainable.Despite all the advantages Oil palm requires copious irrigation, as it is a fast growing crop with high productivity and biomass production. For grown up yielding palms of three years age and above a minimum of 250 litres of water per day is must. However, in older plantations during hot summer this amount may be increased up to 300-350 litres. Insufficient irrigation will reduce the rate of leaf production. Water deficiency adversely affects flower initiation, sex differentiation and therefore results in low sex ratio due to production of more male inflorescences.

Drip irrigation provides watering opportunities during any time of the day without being dependent upon wind speed. It increases water efficiency and quality of product from 20-90 per cent .Water loss becomes minimal and water savings increase by 50 per cent via surface flowing and vaporization.

The study was undertaken with the following objectives

1) To analyze the cost structure of drip irrigation system in Oil palm cultivation.
2) To appraise the economic viability and financial feasibility of installing drip irrigation system in Oil palm cultivation with and without subsidy components.
3) To assess the comparative economics and benefits of drip irrigation system over conventional method of irrigation

4) To study the possible constraints in installation, execution and maintenance of drip irrigation system in Oil palm cultivation and offer relevant suggestions.

East Godavari district was purposively chosen for the study as it has considerable area under drip irrigation in Oil palm. Of the total Oil palm area in East Godavari district, 64.5 per cent area is under drip irrigation. All the mandals in East Godavari district practicing drip irrigation in Oil palm were arranged in descending order of the area under the crop and the top three mandals were chosen purposively. Two villages from each selected mandal were chosen randomly making six villages for the study. From each village 10 farmers were chosen and total constituted 60 farmers for the district. Similar method was followed for the conventional irrigation in Oil palm. An ultimate sample of 120 (60 drip irrigated farmers + 60 conventional irrigated farmers) in Oil palm were chosen.

6.1. TOOLS OF ANALYSIS

Tabular analysis was used to analyze the costs and returns of Oil palm. Project appraisal techniques (Pay back period, NPW, B-C ratio, IRR, N/K ratio and Switching values) were used to test the financial feasibility of drip irrigation in Oil palm and for assessing the economic viability of drip irrigation without subsidy and with subsidy under varied subsidy scenarios. Project appraisal techniques with incremental costs and returns were used for comparison of drip method of irrigation and conventional method of irrigation in Oil palm. An opinion survey was conducted to study the constraints in adoption of drip irrigation in Oil palm.

6.2 MAJOR FINDINGS OF THE STUDY

6.2.1 Size of holding

The average size of the holding was 11.42 ha for drip irrigated farmers and 8.63 ha for conventionally irrigated farmers. Area under Oil palm was about 70 per cent to the total operational holding of the selected sample.

6.2.2 Establishment Costs of Oil palm Cultivation

The total establishment costs expended per hectare of Oil palm with drip irrigation during its pre- bearing (1-3 years period) stood at Rs. 1,19,733 of which Rs 40,542 (33.86 per cent) were variable costs and Rs. 79,190 (66.14 per cent) were fixed costs. The total costs expended per hectare of Oil palm with conventional method of irrigation during its pre- bearing period (1-3 years) stood at Rs. 86,831 of which Rs 45,719 (52.65 per cent) where variable costs and Rs. 41,112 (47.35 per cent) were fixed costs. The establishment cost of drip irrigation exceeded the conventional irrigation by 32 per cent (Rs. 32,902) due to the involvement of drip irrigation system cost which stood at Rs. 26,000. It is evident that the cost of cultivation with drip method of irrigation is very high compared to conventional irrigation. The net establishment costs in Oil palm orchards with drip irrigation during the first three years were Rs. 40, 454, Rs. 14, 029 and Rs. 19,375 and with conventional irrigation were Rs. 31,953, Rs. 15,153 and Rs. 19,187

The total costs incurred to establish one hectare of Oil palm during the first year amounted to Rs. 56,708 for drip irrigation and Rs. 30,918 for conventional irrigation. The cost of drip irrigation in first year was very high compared to the second and third year as the drip irrigation system installation was in first year and it accounted for major cost. The cost incurred to maintain one hectare of Oil palm orchard during the remaining years of pre-bearing periods (second and third years) stood at Rs. 30,747 and Rs. 32,205 for drip irrigation and Rs. 29,043 and Rs. 28,869 respectively for conventional irrigation.

6.2.3 Maintenance Costs of Oil Palm Cultivation

The total costs per hectare increased gradually from Rs. 55,905 in fourth year to Rs. 1, 49,802 in 25^{th} year for drip method of irrigation compared to the costs of Rs. 43,901 in fourth year to Rs. 49968 in 25^{th} year for conventional method of irrigation.

6.2.4 Cost of Drip Irrigation System

The cost of total drip system was Rs. 2, 60,000. The drip irrigation system constitutes of mainly three parts i.e., Head control unit cost constitutes of 38.13 per cent, Water carrier system cost constituting of 16.41 per cent and Water distribution system cost constituting of 36.02 per cent. The other charges for drip irrigation system include 9.44 per cent.

6.2.5 Financial Viability of Drip Irrigation in Oil Palm

6.2.5.1 Payback Period

The payback period in the study area for DMI was found to be 0.67 years for drip method of irrigation after establishment of plantations and 1.02 years for CMI. Considering only the drip irrigation system cost i.e., Rs. 2, 60,000 the payback period for its life span of 10 years is 2.03 years.

6.2.5.2 Net Present Worth

The net present worth for DMI in Oil palm was Rs. 2, 91,259 and Rs. 98,406 for CMI at 13.5 Per cent discount rate which is higher than the present costs. Hence the oil palm cultivation with DMI is more financially viable over CMI.

6.2.5.3 Benefit-Cost Ratio

The benefit-cost ratio of DMI in Oil palm was worked out to be 1.87 and 1.43 for CMI. The higher BCR in DMI indicated that DMI in Oil palm cultivation is highly viable over CMI.

6.2.5.4 Internal Rate of Return (IRR)

The IRR was found out to be 50.52 per cent for drip irrigation and 41.46 for CMI. The returns generating capacity of DMI over CMI in Oil palm was 18 per cent higher and hence DMI is profitable.

6.2.5.5 Net Benefit- Investment Ratio (N/K Ratio)

The N/K ratio of drip irrigation is 10.92. The N/K ratio is also sufficiently higher for DMI and the investment is financially viable.

6.2.5.6 Sensitivity Analysis- Switching Values

The costs of Oil palm plantation with drip irrigation could rise by 87 per cent before the B: C ratio would be driven to one and make it viable. Similarly the benefits could fall by 46 per cent before the ratio would be driven to one and still the DMI is viable. The investment costs could rise as much as 58 per cent before the N/K ratio would be driven to one and the benefits could fall by 31 per cent before the ratio become one which indicated the profitability of DMI in Oil palm cultivation.

6.2.6 Financial Viability of Drip Irrigation in Oil Palm Plantations vis-a- vis Conventional Irrigation Method

The payback period with incremental benefits and costs was 0.33 years. The net present worth based on incremental costs and benefit in Oil palm was Rs. 1, 89,020 at 13.5 Per cent discount rate. The benefit-cost ratio with the incremental costs and benefits in Oil palm 2.74. The IRR was found out to be with 53.90 per cent incremental costs and benefits.

6.2.6.1 Water Use Efficiency

The quantity of water used was low in DIS with 1,310 mm compared to conventional irrigation of 1,940 mm. The higher water use efficiency of 15.35 kg/ha/mm in DIS to that of CIS of 5.03 kg/ha/mm. The water use efficiency in terms of water consumed to produce one kg of output was 65.11 mm/kg/ha and 198.77 mm/ha/kg for DMI and CMI respectively. The amount of water saved through drip method of irrigation compared to conventional method of irrigation is 630 mm/ha/year i.e., 32 per cent. With this water saving under DMI over CMI of 630 mm/ha, a half an hectare of extra Oil palm plantation can be brought under cultivation by extending DMI to CMI plantations.

6.2.6.2 Yields and Returns

Oil palm yield starts in fourth year and the total yield per hectare for the entire economic life period was 503 tonnes FFB under drip irrigation and 224 tonnes FFB under conventional irrigation i.e., 55.47 per cent more in DMI. The total income obtained from one ha during the entire life period of oil palm under drip method of irrigation was Rs. 31, 50,792 and Rs.15,28,416 .The yield and income under drip method of irrigation was nearly double to that of conventional method of irrigation. The average yield per hectare in a year for DMI was 20.12 t/ha and for CMI was 9.76 t/ha in which DMI exceed CMI by CMI by 51.49 per cent. Similarly the average returns from Oil palm plantations from DMI were Rs. 97,718 and CMI were Rs. 50,112 and 48.72 per cent more returns were obtained from DMI. The average returns from the intercrops per hectare during pre bearing period were Rs. 22,767 for DMI and Rs. 22,562 for CMI.

6.2.7 Economic Viability of Drip Irrigation with and without Subsidy

The B-C ratio and IRR without subsidy both in drip irrigation system and in plant material was 1.57 and 28.32 respectively. The B-C ratio and IRR with 90 per cent subsidy in drip irrigation and subsidy in plant material is 1.77 and 37.32 respectively. This indicates that the drip irrigation technology is economically viable even without subsidy. For 75 per cent subsidy and 50 per cent subsidy in drip irrigation the B-C Ratio were 1.74 and 1.69 respectively and IRR were 37.32 and 35.52 respectively.

6.2.8 Constraints in Drip Irrigation System in Oil Palm Cultivation

The major problems faced by the farmers in the adoption of drip irrigation were sensitivity to clogging of drippers, damage by rats and high initial investment of drip irrigation system. The major suggestions include timely provision and availability of subsidies and loans; reduction in total initial cost of the drip unit; provision of regular after sales services by the drip set suppliers and technical training to drip system adopters.

6.3 CONCLUSIONS

i. The higher water use efficiency in terms of output produced per unit of water consumed was 15.35 kg/ha/mm in drip irrigation system to that of conventional irrigation system of 5.03 kg/ha/mm.

ii. The water use efficiency in terms of water consumed to produce one unit of output was 65.11 mm/kg/ha and 198.77 mm/kg/ha for DMI and CMI respectively by converting to DMI. Water saving is 32 per cent in drip irrigation compared to conventional irrigation. With this water saving an half an acre of Oil palm plantations can be irrigated by CMI farmers.

iii. The total yield per hectare for the entire economic life period was 503 tonnes under drip irrigation and 224 tonnes under conventional irrigation.ie, 55.47 per cent (279 tonnes) more in DMI. The total income obtained from one ha during the entire life period of Oil Palm under drip irrigation was Rs. 31, 50,792 and Rs.15, 28,416 in DMI 51.49 per cent (Rs. 16, 22,276) more returns were obtained when compared to CMI.

iv. The average yield per hectare in a year for DMI is 20.12 t/ha and for CMI was 9.76 t/ha, where DMI exceed CMI by 51.49 per cent. Similarly the average returns from Oil palm plantations from DMI were Rs. 97,718 and CMI were Rs. 50,112. 48.72 per cent more returns were obtained in DMI. The average returns from the intercrops per hectare during pre bearing period were Rs. 22,767 for DMI and Rs. 22,562 for CMI.

v. Thought the costs incurred in drip method of irrigation is more than conventional drip method of irrigation the returns obtained are double in drip irrigation which compensates the costs incurred.

vi. It is evident from the project evaluation techniques of PBP, NPW, BCR and IRR that the drip irrigation is economically viable and financially feasible.

vii. Drip irrigation is feasible even without subsidy but farmers should be provided loans to adopt DIS in earlier stages as it takes longer duration for the recompensation of the incurred costs.

viii. The major problems faced by the farmers in the adoption of drip irrigation were sensitivity to clogging of drippers, damage by rats and high initial investment of drip irrigation system.

6.4 POLICY IMPLICATIONS

Some policy recommendations, which may be useful for expanding the adoption of drip method of irrigation in India.

i. It is understood from the study that capital cost required to install drip irrigation is relatively high. Therefore, measures can primarily be taken to reduce the cost of drip irrigation equipment by promoting production and supply of low cost drip systems.

ii. Research on drip irrigation should be given necessary priority to produce low cost drip systems.

iii. Considering the high yield per hectare through drip method of irrigation in Oil palm cultivation compared to conventional method of irrigation, drip irrigation technology should be expanded to all the Oil palm cultivation areas as a mandatory as majority of the farmers are large farmers and is financially viable even without subsidy.

iv. Subsides related to plant material, cost of cultivation, INM, IPM, fertilization, tree guards, vermicompost pits, intercrops etc can be reduced.

v. Subsidy related to drip systems, diesel/electric pumps, bore wells land water harvesting methods can be continued to bring entire Oil palm area under drip irrigation methods as it is more productive and viable.

vi. Since Oil palm plantations with DMI are viable financially and economically even without subsidy in drip. Subsidies can be rationally reduced. As an alternative for reduction of subsidies loans from banks shall be provided for adoption of DIS in Oil palm cultivation.

vii. Special package schemes can be introduced where priority can be given in providing bank loan for digging wells and electricity connection (pump-set) for those farmers who is ready to adopt drip method of irrigation for cultivating any crop as electricity is fully subsidized in Andhra Pradesh.

viii. Drip sets manufacturers should be asked to involve intensively in promoting drip irrigation by introducing frequent demonstrations regarding maintenance, servicing and adoption of drip systems at farmer's fields.

LITERATURE CITED

Al-Amoud, A. I. 2010. Subsurface Drip Irrigation for Date Palm Trees to Conserve Water. *Acta Horticulturae*. 882:103-114.

Almas,L. K., Vimlesh., Girase,J., Amosson, S., New, L., Bretz, F and Marek, T. 2010. Selected Paper prepared for presentation at the Southern Agricultural Economics Association. Annual Meetings. Orlando. February 6-9, 2010.

Anand, T. N., Lakshminarayan, M. T., Manjunatha, B. N and Kumar, G. T. P. 1998. Comparison of Economics of Drip and Surface Irrigation Systems in Grapes. *Financing Agriculture* 30: 3-6.

Arun,K and Singh, G. 2011. Field Evaluation of Drip Irrigation for Kinnow Crop. *Progressive Horticulture*. 43(2): 302- 306.

Assouline,S., Coben, S., Merbadh,D., Harodil,T and Rochneo,M. 2002. Micro Drip Irrigation of Field Crops: Effect on Yield, Water Uptake and Drainage in Sweet Corn. *Soil Science Society American Journal.* 66:228-235.

Barse, K.N., Gohad, V.V and Lunge, M.R. 2010. Adoption of Drip Irrigation System by Orange Growers in Amravati Taluka. *http://www.hindagrihorticulturalsociety.co.in.html*

Belder, P and Rohrbach, D and Twomlow, S J and Senzanje, A (2007) *Can drip irrigation improve the livelihoods of smallholders? Lessons learned from Zimbabwe:Global Theme on Agroecosystems Report no. 33*. Research Report. International Crops Research Institute for the Semi-Arid Tropics, Bulawayo, Zimbabawe.

Berrada, A. 2009. Assessment of Drip Irrigation in Morocco with Particular Emphasis on the Plain of Tadla. *Research Grant Report*. Southwestern Colorado Research Centre.

Bobojonov, I., Franz, J., Berg, E., Lamers, J. P. A and Martius, C. 2010: Improved Policy Making For Sustainable Farming: A Case Study on Irrigated Dryland Agriculture in Westernuzbekistan. *Journal of Sustainable Agriculture.* 34(7): 800-817.

Boesen, J. E.,Orum, M. V., Jovanovic, Z and Pedersen, S. M. 2010. Farmers' Incentives to Save Water with New Irrigation Systems and Water Taxation - A Case Study of Serbian Potato Production. (Special Issue: SAFIR - Safe And High Quality Food Production Using Low Quality Waters And Improved Irrigation Systems And Management.).*Agricultural Water Management.* 98 (3): 465-471.

Brinegar,H.R and Ward,F.A., 2009. Basin Impacts of Irrigation Water Conservation Policy. *Ecological Economics.* 69 (2):414-426.

Camp,C. R. 1998. Subsurface Drip Irrigation: A Review. *Transaction of the ASAE.* 41 (5): 1353-1367.

Cetin, B., Ozer, H and Kuscu, H. 2004. Economics of Drip Irrigation for Apple (*Malus Domestica*) Orchards in Turkey. *New Zealand Journal of Crop and Horticultural Science.*32 (4): 349-354.

Çetin, B., Tipi,T., Ozer, H and Yazgan,S. 2010 Economics of Drip Irrigation for Peach*(Prunus Persica)* Orchards in Turkey. *New Zealand Journal of Crop and Horticultural Science.* 31(2): 85-90.

Chinnappa, B and Hippargi,K. 2005. An Economic Impact Assessment of Drip Irrigation Technology in Arecanut Plantations: An Empirical Evidence from Karnataka. *Journal of Plantation Crops.* 33(2): 130-134.

Chinnappa, B and Nagaraj, R. 2009. Establishment and Maintenance of Arecanut Plantations under Different Water Management Regimes. *Environment and Ecology*. 27(4):2112-2122.

Daniel, C. 1992. Drip Irrigation (Typhoon), In Indian Petrochemical Corporation Ltd. *National Seminar on Drip Irrigation,* Oxford and IBH Publishing Company Private Limited. New Delhi. 66-68.

Dash, N.K. 1998. Drip Irrigation and Micro-Irrigation Potential and Prosperity for Sugarcane Cultivation With Reference to Orissa. VSI. 3:7 -12.

Deshmukh, A.S., Shinde, P.P. and Katake, S.S. 1998. Role of Drip Irrigation in Increasing Water Use Efficiency for Sugarcane Crop. National Seminar on Irrigation Water Management at VSI. 1998. 34 -46.

Devasirvatham,V. 2009. A Review of Subsurface Drip Irrigation in Vegetable Production. Research Report. *CRC for Irrigation Futures Irrigation Matters.*[*http://www.irrigationfutures.org.au/imagesDB/news/CRCIF-IM0309-web.pdf*](http://www.irrigationfutures.org.au/imagesDB/news/CRCIF-IM0309-web.pdf)*.html*

Dhanapal R., Maheswarappa H.P and Subramanian P. 2004. Influence of Drip Irrigation on Nut Characters and Yield of Coconut (*Cocos Nucifera*) in Laterite Soil.Research Report. Division of Crop Production. Central Plantation Crops Research Institute. Kasaragod. Kerala.

Dhawan ,B. D., 2000. Drip Irrigation: Evaluating Returns. *Economic and Political Weekly*. 35 (42): 3775-3780

Dhawan, B.D. 2002. Technological Change in Indian Irrigated Agriculture: A Study of Water Saving Methods. *Common Wealth Publishers*. New Delhi.

Dhonde, R.M and Banger, A.R. 1998. Peoples Participation in Drip Irrigation System for Suru Sugarcane in Kukadi and Krishna Commands of Maharashtra: An Overview. 25 -33

DiGeorge G., Heather A., 1994.Drip Irrigation, An Adaptive Strategy. Thesis. University of Nevada. Las Vegas. *http://digitalcommons.library.unlv.edu/cgi/viewcontent.cgi?article=1258&context=thesesdissertations.html*

Dineshkumar, M., Madar S., Upali Aand Singh, O.P.2009. How Far can they contribute to Water Productivity Enhancement in Indian Agriculture? *http://nrlp.iwmi.org/PDocs/pres/oth/09-WATER SAVINGS-DINESH .html*

Duncan, J.V. 1986. Subsidies to Promote Technology Adoption in Trinidad and Tobago.West Indies Agricultural Economics.Conference. Kingston. Jamaica.7-10April. *http://www.ibe.unesco.org/fileadmin/user_upload/Inclusive_Education/Reports/kingston_07/trinidad_tobago_inclusion_07.pdf. html*

Dursun, M and Ozden, S. 2011. A Wireless Application of Drip Irrigation Automation Supported By Soil Moisture Sensors. *Scientific Research and Essays.* 6, 7:1573-1582.

Francois M., Jeanphilippe V. and Youssef H. 2008. Irrigation in the Jordan Valley: Are Water Pricing Policies Overly Optimistic? *Agricultural Water Management.* 95 (1) 427- 438.

Frank C., Patrick B and Richard W.1998. The Economic Feasibility of Automated Sub-Drip Irrigation for Potato Production in Florida: A Synthesis Report. *http://www.sjrwmd.com/technicalreports/pdfs/SP/SJ97-SP9.pdf.html*

GOI, 1994. Report of Task Force on Microirrigation, (Chairman: N. Chandrababunaidu), Ministry Of Agriculture, Government of India. January.

Goldhamer, D. A., Michailides, T. J and Morgan, D. P. 2002. Buried drip irrigation reduces fungal disease in pistachio orchards. *California Agriculture.* 56(4): 133-138.

Gupta, A. J., Ahmad, M. F and Bhat, F. N. 2010. Studies on Yield, Quality, Water and Fertilizer Use Efficiency of Capsicum under Drip Irrigation and Fertigation. *Indian Journal of Horticulture.* 67(2): 213-218.

Gurav, B. S., Sadaphal, S. S., Chavai, A. M and Khot, B. B. 2003. Constraints Experienced By the Sugarcane Growing Farmers in Adoption of Drip Irrigation System and their Suggestions for Enhancing the Rate of Adoption of Drip Irrigation System. *Cooperative Sugar*. 34(8): 647-649.

INCID. 1994. Drip Irrigation in India. Indian National Committee on Irrigation and Drainage. New Delhi.

Jadhav,S.S., Gutal,G.B and Chougule,A.A.1990.Cost Economics of the Drip Irrigation System for Tomato Crop. Proceedings of the 11th International Congress on the Use of Plastics in Agriculture. New Delhi. India. 26th February-2nd March 1990.Conference Paper.

Jalajakshi C.K and Jagadish N. 2009. Economics of Krishik Bandhu Drip Irrigation: An Empirical Analysis. *Agricultural Economics Research Review.*22 (1):161-164.

Kandaswamy, P. 1990. Drip Irrigation Need for More Scientific Research for Large Scale Adoption. *Kisan World*. 17: 31-32.

Khalache, P. G and Khaire, P. R. 2007. Socio-personal and socio-economic characteristics of the fig growers and information sources used by them in fig cultivation technology.*International Journal of Agricultural Sciences.* 3(1): 258-260.

Kulecho, I. K and Weatherhead, E. K. 2005. Reasons for Smallholder Farmers Discontinuing With Low-Cost Micro-Irrigation: A Case Study from Kenya. *Irrigation and Drainage Systems.* 19(2): 179-188.

Kumar, G. K. V .1992. Economics of Oil Palm Cultivation and its Profitability in Bhadra Area of Shimog. *Indian Oil Palm Journal* 2 (9): 13-21.

Landge, V.V., Pawar B.R., Yeware, P.P and Deshmukh, D.S. 2010.Constraints and Suggestions of Banana Growers in Drip and Flood Irrigated Systems. *Agriculture Update*.5(1): 155-157

Liu, L., YaoZe, L. G., Xu T. L., HaiSheng R., ShuMei, Y and Yang P. 2012. Emitters. *Irrigation Science*. 30(1): 43-56.

Luquet, D., Vidal, A., Smith, M and Dauzat, J. 2005. 'More Crop Per Drop': How to make it Acceptable for Farmers? *Agricultural Water Management.* 76(2):108-119.

Magar, S.S., Firke, N.N and J.R. Kadam. 1988. Importance of Drip Irrigation. *Sinchan*.7 (2): 61-62.

Maisiri,N., Senzanje, A., Rockstrom, J and Twomlow, S. 2005. On Farm Evaluation of the Effect Of Low Cost Drip Irrigation on Water and Crop Productivity Compared to Conventional Surface Irrigation System. *Physics and Chemistry of the Earth Parts*. 11-16: 783-791.

Malik, D .P and Luhach. 2002.Economic Dimensions of Drip Irrigation in Context of Fruit Crops. *http://departmetns.agrijuji.ac.il/economics/keynes-mallika.pdf.html*

Moezzi, A. A., Torfi, K., Albaji, M and Mahjoobi, A. 2009. Optimal Application of Irrigation Water with Drip-Tape Method for Pashmineh Zar Croplands. *Journal of Food, Agriculture & Environment.* 7(2):646-650.

Mohanty, S., Srivastava R. C., Behera M. S and Singandhupe R. B. 2006. Evaluation of Intercrops in Drip Irrigated Banana. *Journal of Agricultural Engineering.* 43 (4):15-21.

Morita, S., Takakura, M., Fujii, M., Nagata,S.and Hayashi, M. 1990 . The Method of Drip Irrigation to the Sugar Cane. *Bulletin of the Kagoshima Agricultural Experiment Station.* 18:21-32.

Motilal, V. S. 1996 .Oil Palm- Sunshine for Bleak Edible Oil Scenario .*National Bank News Review.* 12 (3): 42-44.

Muralidhara, H.R., Gundurao, D.S., Sarpeshker, A.M. and Ramaiah, R. 1994.Is Drip Irrigation Viable for Mulberry Cultivation- An Economic Analysis. *Mysore Journal of Agricultural Sciences.* 28 (3): 256-260.

NABARD.Technical Service Department.1995. Oil Palm The Highest Edible Oil Yielding Crop. *Horticulture and Plantation Discipline.* Mumbai.

Nagaraj, N., Venkataram, J. V., Narayanaswamy, P and Reddy, T. R. K. 1989.An Economic Evaluation of Drip Irrigation for Coconut Plantation. *Financing Agriculture.* 21(1): 3-5.

Najafi, P and Tabatabaei, S. H. 2007. Effect of Using Subsurface Drip Irrigation And ET-HS Model to Increase WUE in Irrigation of Some Crops. *Irrigation and Drainage.* 56 (4):477-486.

Namara, R. E., Upadhay, Bhawana and Nagar R.K. 2005. Adoption and Impacts of Micro Irrigation Technological Emperical Results from Selected Localities of Maharashtra and Gujarat States of India. Research Report 93, International Water Management Institiute . Columbo. Srilanka.

Narayanamoorthy, A and Deshpande, R.S, 2005. Where Water Seeps! Towards A New Phase in India's Irrigation Reforms. Academic Foundation. New Delhi.

Narayanamoorthy, A. 1995. Electric Pumpset and Groundwater Management: Macro and Micro Evidence. *The Asian Economic Review.* 37(1): 87-110.

Narayanamoorthy, A. 1996. Impact of Drip Irrigation on Consumption of Water and Electricity. *The Asian Economic Review.* 38(3):350-364.

Narayanamoorthy, A. 1997. Economic Viability of Drip Irrigation : An Empirical Analysis from Maharashtra. *Indian Journal of Agriculture Economics*. 52 (4): 728-739.

Narayanamoorthy, A. 2001(a). Impact of Drip Irrigation on Sugarcane cultivation in Maharashtra. Agro-Economic Research Centre. Conference paper. Gokhale Institute of Politics and Economics. Pune.

Narayanamoorthy, A. 2001(b). Irrigation and Rural Poverty Nexus -A Statewise Analysis. *Indian Journal of Agricultural Economics*. 56(1): 40-56.

Narayanamoorthy, A. 2003. Averting Water Crisis by Drip Method of Irrigation: A Study of Two Water-Intensive Crops: A Study of Two Water Intensive Crops. *Indian Journal of Agricultural Economics.* 58 (3): 504-511.

Narayanamoorthy,A. 2004. Impact Assessment of Drip Irrigation in India: The Case of Sugarcane. *Development Policy Review.* 22 (4):443-462

Narayanamoorthy,A. 2005(a) . Efficiency of Irrigation: A Case of Drip Irrigation. Ocassional Paper-45. *http://www.nabard.org/fileupload/DataBank/OccasionalPapers/OC 45.pdf.html*

Narayanamoorthy, A. 2005(b). Economics of Drip Irrigation in Sugarcane Cultivation: Case Study of a Farmer from Tamil Nadu. *Indian Journal of Agricultural Economics*. 60(2): 235-248.

Narayanamoorthy, A. 2006(a). Micro Irrigation and Electricity Consumption Linkages in Indian Agriculture: A Field Based Study. *http://www.iwmi.cgiar.org/EWMA/files/papers/Drip-energy-AN-paper%20(2).pdf.html*

Narayanamoorthy, A. 2006(b).Potential for Drip and Sprinkler Irrigation in India. *http://nrlp.iwmi.org/PDocs/DReports/Phase_01/12. Water Savings Tech*

Narayanamoorthy, A. 2007. Drip and Sprinkler Irrigation in India: Benefits, Potential and Future Directions. *http://www.iwmi.cgiar.orgpenance passion.html*

Narayanamoorthy, A. 2008.Drip Irrigation and Rainfed Crop Cultivation Nexus: The Case of Cotton Crop. *Indian Journal of Agricultural Economics*. 63 (3): 487-501.

Narayanamoorthy, A . 2010. Can Drip Method of Irrigation be used to achieve the Macro Objectives of Conservation Agriculture? *Indian Journal of Agricultural Economics.* 58 (1):428-437.

Ngigi, S. N., Savenije, H. H., G. Thome, J. N., Rockstrom, J and Vries, F. W. T. P. 2005. Agro-Hydrological Evaluation of On-Farm Rainwater Storage Systems for Supplemental Irrigation in Laikipia District of Kenya. *Agricultural Water Management.* 73(1):21-41.

O'Brien, D. M., Rogers, D. H., Lamm, F. R and Clark, G. A. 1998. An Economic Comparison of Subsurface Drip and Center Pivot Sprinkler Irrigation Systems. *Applied Engineering in Agriculture.* 14(4): 391-398.

Panigrahi,P., Srivastava, A. K and Huchche, A. D. 2012. Effects of Drip Irrigation Regimes and Basin Irrigation on Nagpur Mandarin Agronomical and Physiological Performance. *Agricultural Water Management.* 104: 79-88.

Pemberton, C.A. Proceedings of the 18th West Indies Agricultural Economics Conference. Kingston. Jamaica. 7-10 April 1986.- St. Augustine (Trinidad and Tobago). 1989. *http://sta.uwi.edu/fsa/ documents/ 1.1.5fsaannualreport20052006final. pdf.html*

Phene Claude. 2004. Subsurface Drip Irrigation and Fertigation. Netafim University. *www.netafim.com/articles.html*

Polak, P., Nanes, B and Adhikari, D. 1997. The IDE Low Cost Drip Irrigation System. *Zeitschrift fur Bewasserungswirtschaft.* 32 (1): 105-112.

Postal, S., Polak, P., Gonzales, F., and Keller, J. 2001. Drip Irrigation for Small Farmers: A New Initiative to Alleviate Hunger and Poverty. *Water Institute.* 26 (1):3-13.

Prasad R.N., Bankar G.J and Vashishtha B.B. 2003. Effect of Drip Irrigation on Growth, Yield and Quality of Pomegranate in Arid Region. *Indian Journal of Horticulture.* 60 (2):140-142.

Prasad, M. V and Kumar, P. S. 2009. Adoption of Oil Palm Package of Practices and Yield Obtained by the Farmers in Karnataka, India - A Survey. *International Journal of Oil Palm*. 6(1): 61-66.

Prasilova, M., Severova, L and Chromy, J. 2011. Subsidies of Agricultural Production in the Czech Republic and Their Economic Context. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis.*59 (7): 293-300.

Radhika, K. 1995. Economics of Oil Palm in India with Particular Relation to Andhra Pradesh . *Agricultural Banker*. 19 (2): 16-20.

Rajbir Singh., Satyendra Kumar, Nangare and Meena. 2009. Drip Irrigation and Black Polyethylene Mulch Influence on Growth, Yield and Water-Use Efficiency of Tomato. *African Journal of Agricultural Research.* 4(12):1427-1430.

Ramah, K., Santhi, P and Ponnuswamy,K. 2010. Economic Viability of Drip Fertigation in Maize (*Zea mays* L.) based Cropping System. *Madras Agricultural Journal.* 97 (1-3): 12-16.

Rangachary, P. U .B. P. 1995. An Economic Analysis of Oil Palm Cultivation in West Godavari District of Andhra Pradesh. *M.Sc. (Ag) Thesis*. Acharya N G Ranga Agricultural University. Hyderabad.

Rao, K. R and Rajasekhar .1992. Oil Palm for Oil Thirsty India. *Yojana*. 34 (11): 10-12

Ravibhat and Sujatha, S. 2006. Cost-Benefit Analysis of Ferti-Drip Irrigation in Arecanut (*Areca Catechu* L.). *Journal of Plantation Crops*. 34 (3): 263-267.

Reddy, P. S., Reddy, B. K and Raju, C. S. 2010. A Comparative Study on Economics of Mulberry with Other Commercial Crops Of Andhra Pradesh. *Agricultural Science Digest*. 30 (1):37-41.

Reddy,K.S., Singh, R.M., Rao, K.V.R and Bhandarkar, D.M. 2004. Economic Feasibility of Drip Irrigation Systems in India. *Agricultural Engineering Today*. 2004.28(1, 2):65-69,

Ren Gao Yang, ZhiBin Duan RuiPing, Zhuang WeiMin Huang and JianGuo Wang RongDong. 2010. Planting Technique for Spring Wheat with Saving Water, High Yield and High Efficiency under Drip Irrigation System. *Xinjiang Agricultural Sciences.* 47(2): 281-284.

Rolbiecki,S and Rzekanowski, C.2001. Influence Of Sprinkler Irrigation And Drip Irrigation On The Yield Of Carrot (*Daucus Carota* L.) Grown in the Very Light Soil. *Inzynieria Rolnicza.* 5(13): 397-402.

Rosario, G.A.,Cruz,R.S.,Ganotisi, N.D., Pegaranda, H.D., Cosico, V.B.and Rosario, M.R. 2000. Drip Fertigation for Cotton Production. Philippines. *PCARRD Highlights.* 3: 16-18.

Rosegrant, W. Mark. 1997. Water Resources in the Twenty-First Century: Challenges and Implications for Action, Food and Agriculture, and the Environment.Discussion Paper. *International Food Policy Research Institute.*Washington D.C., U.S.A.

Roy, Tuhin Narayan, Ray and Jhilam. 2009. Fertilizer Subsidy in India- Status and Future.*Journal of Interacademicia*. 13 (2):235-244.

Saini, A. K., Singh, K. G. Siag Mukesh. 2006.Economics of Using Drip Irrigation System Round the Year for Different Crop Sequences. *http://www.indianjournals.com/ijor.aspx?target=ijor:joae&volume.html*

Sankaranarayanan, K., Nalayini,P., Sabesh, M., Usha Rani, S., Nachane., R. P and Gopalakrishnan, N. 2011. Low Cost Drip – Cost Effective and Precision Irrigation Tool in Bt Cotton. *Technical Bulletin.*

Sankpal, V.Y., Danawale, N.J.,Khade, K.K and Bhoite, D.S. 1998. Response of Sugarcane Varieties to Drip Irrigation during Suru Season. *Agricultural Water Management.* 5 :3-8.

Satyendrakumar,, Ashwanikumar and Rajbirsingh. 2007. Microirrigation for Onion Cultivation in a Canal Command Area. *Journal of Agricultural Engineering (New Delhi).* 44(1): 33-37.

Scheierling, S. M. ,Young, R. A and Cardon, G. E. 2006. Public Subsidies for Water-Conserving Irrigation Investments: Hydrologic, Agronomic and Economic Assessment. *Water Resources Research*. 42: 3-6.

Seckler, D., Amarasinghe, U., Molden D., De Silva, R and Barker, R. 1998. World. Response of Sugarcane Varieties to Drip Irrigation During Suru Season. VSI. 13- 24.

Senzanje, A. Motsi, K.and Rwakatiwana, P. 2004. Assessment of the Technical Performance and Operational Limits of a Low Cost Drip Irrigation System for Peri-Urban and Smallholder Farmers. *Discovery and Innovation*. 16: (1,2): 85-97.

Shashidhara, K.K., Bhemappa, A., Hirevenkanagoudar, L.V and Shashidhar, K.C. 2007. Benefits and Constraints in Adoption of Drip Irrigation among the Plantation Crop Growers. *Karnataka Journal of Agricultural Sciences.* 20 (1):82-84.

Shedeed , I. Shaymaa., Sahar M. Zaghloul, A. A. Yassen. 2009. Effect of Method and Rate of Fertilizer Application under Drip Irrigation on Yield and Nutrient Uptake by Tomato. *Ozean Journal of Applied Sciences.* 2(2):8-16.

Shikhamany S.D., and Srinivas, K. 1999. Growth, Yield and Water Use of Thompson Seedless Grapes under Basin and Drip Irrigation. *Indian Journal of Horticulture*.56 (2): 117-123.

Shrivastava, P.K., Parikh M.M., Savani N.G and Raman S.2000. Response of Banana to Drip Irrigation, Mulches and Irrigation Scheduling in South Gujarat. *Agricultural Engineering Today*. 2000.24 (3): 63-69.

Shukla, K. N., Singh, P. K and Chauhan, H. S. 2000. Yield, water applied and economics of drip irrigated mango orchard in India.6th International Micro-irrigation Congress (Micro 2000), Cape Town, South Africa, 22-27 October. 2000. 1-6.

Simonne Eric., Robert Hochmuth., Jacque Breman., William Lamont., Danielle Treadwell., and Aparna Gazula . 2008. Publication. Drip-Irrigation Systems for Small Conventional Vegetable Farms and Organic Vegetable Farms. University Of Florida.

Sivanappan, R. K. 1995. Present Status and Future of Micro Irrigation in India, in ASAE, Micro Irrigation for a Changing World: Conserving Resources, Preserving Environment, Proceedings of the Fifth International Micro Irrigation Congress. . Orlando. Florida. April 2-6.

Sorensen, R. B., Wright F. S and Butts C. L. 2001. Subsurface Drip Irrigation System Designed for Research in Row Crop Rotations. *Applied Engineering in Agriculture.*17(2): 171.

Sreedhar, G and Babu, R. N. 2007.An enquiry into the Working and Benefits of Micro Irrigation Systems in Andhra Pradesh. *Journal of Rural Development.* 26(1):99-119.

Srilatha, Ch. 2000. Economic Analysis of Production and Processing of Oil palm in Nellore District of Andhra Pradesh. *M.Sc (Ag). Thesis.* Acharya N G Ranga Agricultural University. Hyderabad.

Srinivas, I .K 1989. An Economic Analysis of Production and Marketing of Coconut in East Godavari District of Andhra Pradesh. *M.Sc (Ag). Thesis.* Acharya N G Ranga Agricultural University, Hyderabad.

Sumbwanyambe and Nel. 2012. Subsidy and Revenue Maximization in Developing Countries. Proceedings of the International Multi Conference Engineers and Computer Scientists. March 14-16,2012 , Hongkong.

Sureshkumar, D and Palanisami, K. 2010. Impact of Drip Irrigation on Farming System : Evidence From Southern India. *Agricultural Economics Research Review.* 23:265-272.

Surve U.S., Shinde S.H and Dusane S.M. 2002.Efficacy of Liquid Fertilizer through Drip Irrigation on Growth and Yield of Cucumber . *Agricultural Science Digest.* 22(4):228-231.

The Times of India. 2009. 90% subsidy for big farmers going for drip irrigation. February 22, 2009. *http://articles.timesofindia.indiatimes.com/keyword/drip-irrigation.html*

Thompson., C and Kansas. 2010. Proceedings of the 22nd Annual Central Plains Irrigation Conference, Kearney.February 23-24.

Venugopal, R. and Rajkumar, M. 1998. Drip Irrigation System – New Concept in Sugarcane Culture at Baramba of Orissa state. VSI. 3:7 –12.

Ward, A. F.2010.Financing Irrigation Water Management and Infrastructure: A Review. *International Journal of Water Resources Development*. 26(3): 321-349.

Ward, F. A., Michelsen, A.M and Leeann D. 2007. Barriers to Water Conservation in the Rio Grande Basin. *Journal of the American Water Resources Association.*43 (1): 237-253.

Westarp, S and von Chieng SieTan Schreier, H. 2004. A Comparison between Low-Cost Drip Irrigation, Conventional Drip Irrigation, and Hand Watering In Nepal. *Agricultural Water Management*. 64(2):143-160.

Wilson, C and Bauer, M.2004. Drip Irrigation for Home Gardens. Gardening Series. Basics. *http://www.ext.colostate.edu/pubs/garden/04702.pdf.html*

Wu, P. T., Zhu, D. L., Jin, J and Niu, W. P. 2010. Design of Drip Irrigation Lateral for Optimum Capital and Operating Cost. *Water Science and Technology: Water Supply.* 10(6): 943-952.

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