AN ECONOMIC ANALYSIS OF DRIP IRRIGATION IN COCONUT ORCHARDS IN SRIKAKULAM DISTRICT OF ANDHRA PRADESH

BY

P.GAYATRI DEVI

B.Sc. (Ag.)

**THESIS SUBMITTED TO THE
ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF**

MASTER OF SCIENCE IN AGRICULTURE

(AGRICULTURAL ECONOMICS)

CHAIRPERSON: Dr. N.SUNANDA

DEPARTMENT OF AGRICULTURAL ECONOMICS

AGRICULTURAL COLLEGE, BAPATLA-522101

**ACHARYA N.G.RANGA AGRICULTURAL UNIVERSITY
GUNTUR– 522 507**

2016

AN ECONOMIC ANALYSIS OF DRIP IRRIGATION IN COCONUT ORCHARDS IN SRIKAKULAM DISTRICT OF ANDHRA PRADESH

P.GAYARI DEVI
B.Sc. (Ag.)

MASTER OF SCIENCE IN AGRICULTURE
(AGRICULTURAL ECONOMICS)

2016

CERTIFICATE

This is to certify that the thesis entitled **"AN ECONOMIC ANALYSIS OF DRIP IRRIGATION IN COCONUT ORCHARDS IN SRIKAKULAM 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, Guntur, is a record of the bonafide research work carried out by **Miss. P.GAYATRI DEVI** 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.

Thesis approved by the Student's Advisory Committee

Chairman : **Dr. N.SUNANDA** ______________________
Assistant Professor
Department of Agricultural Economics
Agricultural College, Naira.

Member : **Dr. D.VISHNU SANKAR RAO** ______________________
Honorary director,
Cost of cultivation scheme,
University Head,
ANGRAU, Guntur.

Member : **Dr. V. SRINIVASA RAO** ______________________
Professor and University Head
Department of Statistics and Mathematics
Agricultural College, Bapatla.

Date of final viva-voce:

CERTIFICATE

Miss. P.GAYATRI DEVI has satisfactorily prosecuted the course of research and that thesis entitled **"AN ECONOMIC ANALYSIS OF DRIP IRRIGATION IN COCONUT ORCHARDS IN SRIKAKULAM DISTRICT OF ANDHRA PRADESH"** submitted is the result of original research work and is 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 her for a degree of any university.

Date:
Place:

(N.SUNANDA)
Assistant Professor
Department of Agricultural Economics
Agricultural College, Naira.

DECLARATION

I, **P.GAYATRI DEVI,** hereby declare that the thesis entitled **"AN ECONOMIC ANALYSIS OF DRIP IRRIGATION IN COCONUT ORCHARDS IN SRIKAKULAM 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 original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place : **(P.GAYATRI DEVI)**
Date : **BAM-12-36**

ACKNOWLEDGEMENT

An accomplishment of this thesis is the result of benevolence of ***Almighty,*** *love of my parents and blessing of my teachers and motivation of my friends.*

I am privileged to avail this opportunity to express my deep and heartfelt gratitude and veneration to my major advisor and chairman of the advisory committee ***Dr. N. Sunanda,*** *Assistant Professor, Department of Agricultural Economics, Agricultural College, Naira for her impeccable and highly informative advice and guidance and for her incessant encouragement during the course of the study.*

*I wish to express my deep sense of gratitude to the member of my advisory committee****, Dr. D.Vishnu Sankar Rao,*** *Honorary Director, Cost of Cultivation Scheme, Professor and Univercity Head* ***,*** *Department of Agricultural Economics, ANGRAU, Guntur, Bapatla for his insightful and inspiring guidance, constant encouragement and constructive criticism during the course of my investigation.*

I am extremely greatful to the member of advisory committee ***Dr. V. Srinivasa Rao****, Professor & University Head, Department of Statistics and Mathematics, Agricultural College, Bapatla for his kind cooperation during statistical analysis.*

I avail of this opportunity to express my sincere regards to ***Dr. Y. Radha,*** *Professor & Head,* ***Dr. Uma Devi,*** *Assistant Professor,* ***Dr. K.S.R Paul****, Assistant Research Officer****,*** *Department of Agricultural Economics for their encouraging guidance and transcendent suggestions during the course of investigation.*

My deepest admiration and heartfelt thanks to ***Dr. G. Raghunadha Reddy****, Senior Scientist, Agricultural Economics, RARS, Lam, Guntur his unstinted attention, counsel, moral support and timely guidance which boosted my confidence.*

Even all the good words in the lexicon are not sufficient to describe the care, sacrifices, boundless love, unending encouragement and support given to me by my parents ***Sri P. Ramanayya*** *and* ***Smt P. Saraswathi*** *in shaping my career and future. I am always grateful and indebted to them. My sincere thanks to my caring sister* ***Gowthami*** *for her constant encouragement and inspiration. Diction is not at all enough for express my feelings towards my family members who constantly inspired, educated, guided and moulded me into* *the present position, without whom, I may not have grown to this position. Their boundless affection, meticulous care, admonishing remarks, consistent support and inimitable love acted as impetus on my fortitude during the whole course of my research.*

*Wordy thanks can never repay the help, encouragement and perspiration in rendering ineluctable assistance during my productive education career to my beloved friends **Revathi Reddy, Divya, Swarupa, Jyothsna, Revathi, Triveni, Janaki, Vanaja, Sowmya Laskhmi ,** and **Pushpa, Aruna.***

*With pride I mention my colleagues **Sravani, Sirisha, Priyanka, Lohith** and **Naidu** for their friendly opulence, emotional support rendered, pranks we made, feelings we shared throughout the brighter and clouded phases of post graduation life.*

*It gives me immense pleasure to express my profound thanks to my senior friends **Mrudula, Mayuri, Lavanya, Gowthami, Ramanamma, Faruk, Rambabu**, **Kishore,** and junior friends **Lavanya, Jhansi, Deepthi, Saidhar** and **Manjunath** for their unforgettable help and co-operation during the course of this work.*

*I express my indebtedness to **Acharya N. G. Ranga Agricultural University** for providing financial assistance during the course of my post-graduation.My sincere thanks to **Eswar Digitals,** Bapatla, for neat and meticulous printing of thesis in time.*

Any omission in this brief acknowledgement doesn't mean lack of gratitude.

Date : ***(P.GAYATRI DEVI)***

LIST OF CONTENTS

CHAPTER NO.	TITLE	PAGE NO.
I	INTRODUCTION	
II	REVIEW OF LITERATURE	
III	MATERIAL AND METHODS	
IV	AGRO-ECONOMIC FEATURES	
V	RESULTS AND DISCUSSION	
VI	SUMMARY AND CONCLUSIONS	
	LITERATURE CITED	

LIST OF TABLES

Table No.	Title	Page No
3.1	Plantation age-wise classification of Coconut respondents	
4.1	Population statistics of Srikakulam district (2011 census)	
4.2	Rainfall received during 2013-14 in Srikakulam district	
4.3	Net area irrigated by different sources in Srikakulam district 2013-14	
4.4	Land utilization pattern of Srikakulam district in 2013-14	
4.5	Distribution of land holdings and area operated by different size classes 2013-14.	
4.6	Area under principle crops in Srikakulam district during 2013-14	
4.7	Number of bank branches in Srikakulam district 2013-14	
4.8	Area under Coconut cultivation in India during 2010-11	
4.9	Area under Coconut cultivation in Andhra Pradesh during 2010-11	
4.10	Area under Coconut cultivation in Srikakulam district during 2013-14	
4.11	Area coverage under Drip irrigation in Srikakulam district during 2013-14	
4.12	Area under Coconut cultivation and drip irrigation in Srikakulam district during 2013-14	
4.13	Demographic features of selected mandals (2001 census)	
4.14	Land utilization pattern in selected mandals during 2013-14	
4.15	Distribution of land holdings of selected mandals during 2013-14	
4.16	Rainfall received during 2013-14 in selected mandals	
4.17	Cropping pattern in selected mandals during 2013-14	
4.18	Net area irrigated by different sources and intensity of irrigation in selected mandals 2013-14	
5.1	Farm family particulars of the selected Coconut growers of drip irrigation and conventional methods of irrigation	
5.2	Age-wise classification sample respondents	
5.3	Educational status of the sample respondents	
5.4	Age-wise classification of Coconut plantations in the selected sample and their land holdings	

Table No.	Title	Page No
5.5	Establishment Costs in Coconut Plantations –Drip Method of Irrigation (Rs/ha)	
5.6	Establishment Costs in Coconut Plantations - Conventional Method of Irrigation (Rs/ha)	
5.7	Cost structure of drip irrigation system per hectare of Coconut plantations	
5.8	Maintenance Costs in Coconut plantations during bearing period – Drip Method of Irrigation (Rs/ha)	
5.9	Maintenance costs in Coconut plantations during bearing period – Conventional Method of Irrigation (Rs/ha)	
5.10	Yield and income difference in DMI and CMI in Coconut per hectare	
5.11	Undiscounted cash flow measures of drip method of irrigation and conventional method of irrigation in Coconut	
5.12	NPW of drip method of irrigation in Coconut	
5.13	NPW of conventional method of irrigation in Coconut	
5.14	B-C ratio of drip method of irrigation in Coconut	
5.15	B-C ratio of conventional method of irrigation in Coconut	
5.16	Internal rate of return of drip method of irrigation in Coconut	
5.17	Internal rate of return of conventional method of irrigation in Coconut	
5.18	N/K ratio of drip method of irrigation in Coconut	
5.19	N/K ratio of conventional method of irrigation in Coconut	
5.20	Switching values of drip method of irrigation in Coconut	
5.21	Switching values of conventional method of irrigation in Coconut	
5.22	Economic viability of Coconut plantations under drip irrigation without subsidy and with subsidy at different rates of Drip irrigation.	
5.23	Water use efficiency of Coconut under drip and conventional method of irrigation	
5.24	Impact of DMI over CMI in Coconut per hectare	

LIST OF FIGURES

Figure No.	Title	Page No
3.1	Diagram showing selection of respondents	
4.1	Map of Srikakulam district with the selected mandals	
5.1	Establishment costs in Coconut plantations -Drip Method of Irrigation	
5.2	Establishment costs in Coconut plantations - Conventional Method of Irrigation	
5.3	Maintenance cost of Drip and Conventional methods of Irrigation during Bearing period	
5.4	Yield difference in Drip and Conventional methods of Irrigation	

LIST OF SYMBOLS AND ABBREVIATIONS

et al.	:	and other workers
&	:	and
APMIP	:	Andhra Pradesh Micro Irrigation Project
BPL	:	Below Poverty Line
BCR	:	Benefit- Cost Ratio
cm	:	Centi metre
C.P.O	:	Chief Planning Office
CMI	:	Conventional Method of Irrigation
M^3/ha	:	Cubic per hectare
$	:	Dollar
^{0}C	:	Degree Celsius
$/ha	:	Dollar per hectare
DIS	:	Drip Irrigation System
DMI	:	Drip Method of Irrigation
etc.	:	Etcetra
ET	:	Evapotransoiration
e.g.	:	Exampli gratia
FUE	:	Fertilizer Use Efficiency
FMI	:	Flood Method of Irrigation
FFB	:	Fresh Fruit Bunches
g	:	Gram
>	:	Greater than
ha	:	Hectare
ha-cm	:	Hectare centimertre
ha-m	:	Hectare mertre
HP	:	Horse power
hrs/day	:	Hours per day

IRR	:	Internal rate of return
kg	:	Kilogram
kg/m^3	:	Kilogram per cubic metre
kg/ha	:	Kilogram per Hectare
kg/ha/mm	:	Kilogram per hectare per millimetre
kg/plant	:	Kilogram per plant
kg/m^2	:	Kilogram per square metre
km	:	Kilometer
kwh/ha	:	Kilowatt-hour per hectare
KB	:	Krishik Bandhu
lakh/acre	:	Lakh/ acre
<	:	Less than
l/hour/day	:	Litre per hour per day
lit/second	:	Litres per second
Mg/ha	:	Megagram per hectare
m	:	Metre
MT	:	Metric ton
MIP	:	Micro Irrigation Project
mm	:	Millimeter
mm	:	Millimetre
viz.,	:	Namely
NH	:	National Highway
N/K Ratio	:	Net Benefit-Investment Ratio
NPW	:	Net Present Worth
No.	:	Number
nuts/ha-cm	:	Nuts per hectare centimetre
nuts/palm/year	:	Nuts per palm per year
PE	:	Pan evaporation
PBP	:	Payback period

%	:	Per cent
Rs	:	Rupees
Rs/ha	:	Rupees per hectare
Sq.km	:	Square kilometer
SSDF	:	Subsurface drip fertigation
SDI	:	Surface drip irrigation
i.e.,	:	That is
‘000	:	Thousands
t/ha	:	Tonnes per hectare
USA	:	United States of America
WUE	:	Water use efficiency

ABSTRACT

Name of the Author	:	**P. GAYATRI DEVI**
Title of Thesis	:	**"AN ECONOMIC ANALYSIS OF DRIP IRRIGATION IN COCONUT ORCHARDS IN SRIKAKULAM DISTRICT OF ANDHRA PRADESH "**
Degree	:	MASTER OF SCIENCE IN AGRICULTURE
Faculty	:	AGRICULTURE
Department	:	AGRICULTURAL ECONOMICS
Chair person	:	**Dr. N.SUNANDA**
University	:	ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY
Year of submission	:	2016

The present study was conducted in Srikakulam district of Andhra Pradesh with the major objectives (1) to analyze the cost structure of drip irrigation system in Coconut orchards (2) to appraise the economic viability and financial feasibility of installing drip irrigation system in Coconut cultivation with and without subsidy component (3) to assess water use efficiency of drip method of irrigation in Coconut orchards and (4) to study the possible constraints in installation, execution and maintenance of drip irrigation system in Coconut cultivation and offer relevant suggestions. A total sample of 90 farmers were selected randomly i.e., 45 drip irrigated and 45 conventionally irrigated farmers. The important analytical tools employed in the study were the project evaluation techniques such as PBP, ROR, Average annual returns per rupee of investment, NPW, B-C Ratio, IRR, N/K Ratio and Switching values were used to study the financial feasibility of Coconut plantations with drip method of irrigation and conventional method of irrigation.

The average per hectare total cost with DMI in Coconut was Rs. 1, 33, 377.77 and Rs. 1, 20,058.27 for CMI. The per hectare total establishment cost for DMI in coconut was Rs. 2, 61, 297.20 and Rs. 2, 50,570.32 for CMI. The per hectare total maintenance cost for DMI in Coconut was Rs. 64,07,591.40 and Rs. 61,31,195.95 for CMI. The cost of drip irrigation system in 1 ha of coconut with no subsidy was Rs. 29,435 and with 90 per cent subsidy was Rs. 2943.50 in Andhra Pradesh under APMIP.

The higher water use efficiency of 1024 nuts/ha-cm in DMI to that of 304 nuts/ha-cm in CMI was observed. The amount of water saved through DMI compared to CMI was 4522.39 ha-cm i.e., 62.22 per cent.

The average per hectare yield of coconut was 56244 nuts under DMI and 44325 nuts under CMI. The average income obtained from one ha Coconut under drip irrigation was Rs. 2, 24,976 and Rs 1, 77,301.

The payback period, rate of return, average annual return per rupee of investment, net present worth, benefit-cost ratio, IRR and N/K ratio in the study area for drip method of irrigation were found to be 2.85years, 68.68 per cent, 35.05 per cent, Rs. 5, 37,165.60, 2.18, 26.86 and 4.74 respectively. Similarly for conventional irrigation the payback period, rate of return, average annual return per rupee of investment, net present worth, benefit-cost ratio, IRR and N/K ratio was 4.58 years, 44.58 per cent, 21.82 per cent, Rs. 2, 54,370.60, 1.49, 21.67 and 2.45 respectively. The drip irrigation is found financially viable compared to conventional irrigation.

The results also proved that coconut cultivation under drip irrigation system is economically viable even without subsidy.

The major problems faced by the Coconut farmers in installation, maintenance and execution of drip irrigation system were sensitivity to clogging of drippers, only diluted fertilizers were used in root zone, high skill is required for design, installation and operations, unavailability of cheap locally available spare parts, damage caused to the system by rats and wild pigs in field, high cost compared to conventional methods, inadequate follow up services by the drip agencies, low quality equipment and spare parts, Moisture distributions problems and Salt accumulation in root zone.

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 Coconut cultivation compared to conventional method of irrigation, drip irrigation technology should be expanded to all the Coconut cultivation areas as a mandatory as majority of the farmers are small farmers and is financially viable even without subsidy. Since Coconut 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 DMI in Coconut cultivation.

Chapter I

INTRODUCTION

Irrigation is a basic determinant of agriculture because its inadequacy is the most powerful constraint on the increase of agricultural production. Irrigation is a most important factor for increasing the use and efficacy of yield increasing inputs enhancing cropping intensity as well as productivity of crops. So, it plays a vital role to achieve the food security and sustainable livelihoods. Available water for future irrigation is declining drastically. The intensification of agriculture along with increased demand for water from other sectors viz., industrial and house hold sectors has put tremendous pressure on the limited water resources in recent years in India. 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 requirement of heavy investment on the construction of new irrigation water sources like dams and reservoirs and in addition causes adverse environmental problems. With rapid commercialization of agriculture, exploitation of ground water is increasing at a fast rate. 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). The water use efficiency in the agricultural sector, which consumes over 80 per cent of water, is only in the range of 30-40 per cent in India, indicating that there is considerable scope for improving the water use efficiency.

In this context, efficient use of irrigation water gains priority with reference to short run and long run perspectives of Indian agriculture. With deteriorating surface water infrastructure and rapid decline in ground water tables in large parts of the country and increasing demand for water from all other sectors of the economy, there is a widespread concern for using the available water more efficiently. Micro Irrigation System (MIS), comprising drip and sprinkler technologies, has emerged as an effective tool for water conservation and improving water use efficiency. Micro irrigation in general and Drip irrigation method (DIM) 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.

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 (Indian National Committee on Irrigation and Drainage, 1994). Drip irrigation has helped to bring the crop diversification from rainfed crops to horticultural crops and bringing in cultivable waste lands under horticultural crops. Research suggests that DIM is not only suitable for those areas that are presently under cultivation, but it can also be operated efficiently in undulating terrain, rolling topography, hilly areas, barren land and areas which have shallow soils (Sivanappan, 1994).

Drip irrigation was originally developed as sub irrigation system in Germany in 1860. Since the 1940’s, Israel has been successfully using drip system for cultivation of crops in desert area. Later this 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 as droplets through a network of pipes with the help of emitters at a relatively low pressure. The system applied water at low rate and under pressure to keep the soil moisture within desired range for plant growth. 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 and keeps soil moisture at an optimum level with frequent irrigations. 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, 2001). Besides, increased adoption of DMI also generates many environmental benefits and increases the productivity of crops mainly by reducing moisture stress for crops. In addition to helping conserve water and fertilizers, drip irrigation can also help reduce the problems of salinization and water logging. Additionally, in water scarce environments, drip irrigation may allow for agriculture in areas where furrow or flood irrigation would not be possible. Drip irrigation is easily adopted in perennial crops like coconut, mango, sapota, guava, pomegranate and it is also adopted in grapes in an overhead system.

The coconut palm (*Cocos nucifera*) is one of the most useful plants to the mankind. *Coco* is a Portuguese word for ‘fruit’ and *nucifera* is a Latin word for ‘nut bearing’. It is socially, culturally, and religiously associated with millions of people around the world. In Sanskrit coconut is described as *kalpavriksha* which translates “the tree which provides all the necessities of life”. Coconut supports the livelihood security for millions of small and marginal farmers spread over 93 countries worldwide. Although the coconut is grown mainly for its nuts, it provides many by-products of immense utilities and industrial applications. It is eco-friendly and environmentally sustainable. Coconut is referred as “King of the tropical flora”, “Tree of heaven”, “Tree of life”, “Tree of abundance”, and “King of palms”.

Coconut is grown in more than 93 countries of the world and Indonesia, Philippines, India are the major producing countries of the world. Coconut is grown in more than 18.95 lakh hectares India in with an estimated 16943 million nuts during 2010-11 with an average productivity of 8937 nuts per ha. Four southern states put together account for 92 per cent of the total production in the country with Kerala 45.22 per cent, Tamil Nadu 26.56 per cent, Karnataka 10.85 per cent, Andhra Pradesh 8.93 per cent and other states 8.44 per cent. The coconut palm exerts a profound influence on the rural economy of the many states where it is grown extensively and it provides sustenance to more than 10 million people. Coconut processing sector in India is currently confined to copra production, oil extraction, production of desiccated coconut and manufacture of coir products. The export earnings derived by India from coconut are around Rs.3000 million, mainly through the export trade in coir and coir goods. The contribution of coconut oil to the national edible oil pool is 6%. In addition, the crop contributes Rs.7000 crores annually to the Gross Domestic Product (GDP).

Major area under coconut is in humid tropics where the annual rainfall ranges from 2000 mm to 3500 mm which is about two times higher than the annual evaporation (1500 to 1750 mm). Yet the crop experiences moisture stress from November till May which is rainless months in many coconut growing areas. Coconut has been observed to respond well to irrigation, the increase in yield being over 30 nuts/palm/ year (palanichamy *et al* 2002).

Traditionally, coconut gardens are flood or basin irrigated. In such cases the irrigation efficiency is only 30 to 60 per cent due to the wastage of Water. Besides, there is wastage of labour and energy in adopting these systems. Scarcity of irrigation water and increasing cost of labour and energy are posing serious threat to the economic viability of coconut production. It is therefore imperative that the water use efficiency is increased.

Problem Statement

India currently produces less than 50 per cent of its requirements of edible oils. Almost stagnant domestic production of oil seeds and increased consumption of edible oils has increased dependency on imports in recent years. Between 2000 and 2002, worldwide production of cooking oil rose 72 per cent, that of palm oil increasing the most at 141 per cent, followed by soybean oil and rapeseed oil. But the output of coconut oil declined by a little over one per cent. Compared to most other oil bearing crops, yield and returns from coconut are very low. On the average, one hectare of coconut yields about of a ton as compared to oil palm's four times. The situation is further worsened by the increased hectarage of senile plantations and low and fluctuating prices of coconut products. Natural calamities, numerous pests and diseases, have further reduced productivity. Among all production cost reduction, by-product utilization and product diversification are the effective ways to save the coconut industry.

The subsidy per cent for drip irrigation 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 60 per cent (>10 ha). (APMIP, 2014). Coconut is cultivated in about 1, 03,967 ha of Andhra Pradesh (Coconut Board, 2011-12). Drip irrigation is practiced in Coconut to conserve water, save labour and power, increase water and fertilizer use efficiency, and increase yield. Out of the total drip irrigated area of 5079.17 ha of Srikakulam District, Coconut occupied 1965.97 ha with 38.70 per cent followed by Sugar cane, Banana, Mango, Maize with 14.33 per cent, 9.09 per cent, 6.76 per cent, and 4.86 per cent respectively and the remaining 26.26 per cent distributed to small acreage crops. In Srikakulam district, the area under canals, tanks, tube wells and filter points, other wells, Lift irrigation and other irrigated sources are 52.38 per cent, 27.80 per cent, 1.55 per cent, 2.30 per cent, 0.17 per cent and 1.84 per cent respectively (C.P.O, 2014). In Srikakulam district, the farmers resort for using drip irrigation in Coconut cultivation with 13.45 per cent (1965.97 ha) of total Coconut cultivated area (APMIP, 2014). As Coconut accounted for

38.70 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 Coconut in the district was taken up for the research study.

Objectives

The present study was taken up with the following objectives.

1) To analyze the cost structure of drip irrigation system in Coconut cultivation.
2) To appraise the economic viability and financial feasibility of installing drip irrigation system in Coconut cultivation with and without subsidy components.
3) To assess water use efficiency of drip method of irrigation in coconut orchards
4) To study the possible constraints in installation, execution and maintenance of drip irrigation system in Coconut cultivation and offer relevant suggestions.

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 Coconut cultivation.
2. It was hypothesized that the Coconut cultivation is financially feasible without subsidy in drip irrigation.
3. It was hypothesized that the Coconut cultivation is financially feasible without subsidy on plant material.
4. Drip irrigation was superior in terms of water use efficiency and productivity in Coconut over conventional method of irrigation.

Scope of the Study

The results of the study would be very useful to encourage drip method of irrigation in Coconut cultivation and it would indicate whether there is any scope for expanding drip irrigation in Coconut orchards 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 Coconut cultivation with and without subsidy components. The study gives the scope that investment of drip irrigation is economically viable even without Government subsidy.

The study access the water use efficiency of the drip method of irrigation over conventional method of irrigation in coconut cultivation and 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 Coconut 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 were collected with limited sample of respondents of Coconut cultivation in Srikakulam 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 were collected through survey method by interviewing farmers on the cost and returns of Coconut 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. Further the data collected regarding the calculation of water use efficiency is based on the approximated field level information from the farmers. 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 Coconut 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.

2.1 Establishment and maintenance costs of Coconut cultivation and also cost structure of drip irrigation.

2.2 Economic viability and financial feasibility of installing drip irrigation system in Coconut cultivation.

2.3 Water use efficiency and Comparative economic benefits of drip irrigation system over conventional method of irrigation.

2.4 Studies on drip irrigation system with and without subsidy components.

2.5 Constraints in installation, execution and maintenance of drip irrigation system.

2.1 ESTABLISHMENT AND MAINTENANCE COSTS OF COCONUT CULTIVATION AND ALSO COST STRUCTURE OF DRIP IRRIGATION

Sivanappa (1995) reported that the costs for installing micro irrigation vary from Rs. 15,000/ha for coconut and mango groves to Rs. 45,000-50,000/ha for bananas and sugarcane. Factors influencing the cost include the crop, spacing, quantity of water required and distance from water source.

Shiyani and Kuchhadiya (1996) reported that the cost differences between drip adopters and non-adopters in the study area can mainly be attributed to the cost of hired labour, insecticide/pesticides, depreciation charges, chemical fertilizers *etc.*, The total cost of cotton cultivation was higher in the case of adopters.

Sairam *et al.* (1997) from their study on economics of coconut cultivation under optimum management conditions in North Kerala reported that the cost of cultivation of coconut (based on 1995/96 prices) ranges from Rs. 28,600/ha during the first year of planting to Rs. 23,450/ha during the stabilized bearing period under rainfed conditions. For irrigated conditions, the corresponding figures are Rs. 52,650 and Rs. 27,750/ha. Cost of production was estimated as Rs. 3.30/nut and Rs. 2.60/nut under rain fed and irrigated conditions, respectively.

Nagarajan (1998) from his study on coconut productivity in the Rangasamudram village of the coimbatore district of Tamil Nadu reported that The annual cultivation cost per acre is Rs. 12,000/- Gross revenue is around Rs. 30,000/- and the net income is Rs. 18,000/-.

Anand *et al.* (1999) reported 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 the case of surface irrigation. The cost of production per acre of grapes under drip irrigation was lower by 7.77 per cent (Rs. 1683) when compared to surface irrigation, even with an additional investment on drip irrigation appliances.

Remold (2000) studied on cost benefit analysis of rain fed coconut cultivation in Aralam, in Kerala reported that the annual expenditure per hectare of rainfed coconut was Rs. 46,370 and the annual income derived was Rs. 47,250 and giving a cost-benefit ratio of 1:1.02.

Smajstrla *et al.* (2000) reported that the energy required for irrigation pumping was 70 per cent higher with SDI, despite smaller water applications, because the operating pressure was much higher than with seepage irrigation. Estimated cost to convert an existing seepage system to SDI was $990 per ha.

Malik and Luhach (2002) reported that the average capital cost of drip sets calculated to be Rs. 37964, Rs. 22424 and Rs. 32700 per hectare for grapes, ber and kinnow, respectively. 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. The total annual operational cost per hectare of drip sets was worked to be Rs. 2245, Rs. 4100 and Rs. 3738 for all three fruit crops respectively.

Waykar *et al.* (2003) from their studies on sugarcane crop in Ahmednagar district of Maharashtra reported that the per hectare investment cost on drip irrigation system for sugarcane crop was Rs.46467 in which the share of subsidy provided to the cultivators was 58.19 per cent.

Birari *et al.* (2004) reported that the per hectare total investment for establishing drip method of irrigation for banana was Rs. 42,364. After deducting the subsidy of 40 per cent, a banana grower has to invest Rs. 25,418. The cost of banana cultivation per hectare was Rs. 1,23,758 under drip irrigation and Rs. 1,18,234 under conventional method of irrigation. The gross income per hectare was Rs. 1,73,900 under drip adopters and Rs. 1,54,740 under non-adopters.

Chinnappa and Hippargi (2005) reported that installation cost of drip irrigation in areca nut was Rs. 50,394 per hectare. The maintenance cost of drip irrigated gardens was found to be lower (Rs. 29,109) as compared to surface irrigated gardens (Rs. 37,856). Adoption of drip irrigation in areca nut gardens has resulted in additional output of 5.03 quintals worth Rs. 67,972. There is substantial saving in cost of cultivation (Rs. 8837) of drip-irrigated gardens which is due to decreased use of labour and inputs.

Veeraputhiran and Chinnusamy (2005) concluded that the cost of drip irrigation system was Rs. 77,100/ha with a life period of 5 years (10 seasons), while the seasonalized cost worked out to Rs 9,315/ha only. By incurring this cost, the net additional income could be increased upto Rs. 15,525 in winter and Rs. 20,165 in summer.

Kalathiya *et al.* (2007) studied on holding wise analysis of cost of cultivation of bearing coconut plantations in Valsad district of south Gujarat revealed that the cost of cultivation (including maintenance) was Rs. 7,896.43, Rs. 7,159.37, Rs. 8,220.00, Rs. 6,603.10 and profit was Rs. 14,225.71, Rs. 13,066.06, Rs. 9,372.07, Rs. 13,413.50 per hectare for marginal, small, medium and large farmers respectively. The average total cost of cultivation worked out to Rs. 9,180.50 and profit Rs. 14,205.12/ha. The lowest yield of 5,317 nuts/ha was observed in medium size and highest yield 6,446 nuts/ha in marginal size of holding.

Kalyankar *et al.* (2011) reported that the per acre total cost of Ginger crop production was estimated at Rs. 1,56,294 in the case of drip irrigation method as against Rs. 90,021 in the case of flood irrigation method and it means that per acre cost of Ginger cultivation was higher by 1.74 times under the drip irrigation method in the study region.

Khan *et al.* (2011) revealed that the per hectare total variable cost incurred on furrow, drip and drip with subsidy was Rs. 93,467, Rs. 62,274 and Rs. 62,274, respectively. While the per hectare total cost on furrow and drip irrigation system was Rs. 96,337 and Rs. 77,852 respectively. However, the peasants who availed subsidy at the rate of 50 per cent of the drip irrigation system incurred Rs. 71,552 of total cost, thereby saving an amount Rs. 24,787.

Kakhandaki *et al.* (2012) revealed that in tomato crop the installation cost of sprinkler irrigation was less (Rs. 94225) as compared to the drip irrigation system which shown very high installation cost (Rs. 101891).

Mehendale *et al.* (2013a) reported that the coconut grower incurred Rs. 106014, Rs. 151754 and Rs. 153071 per hectare on cost of cultivation in flood irrigation method, sprinkler irrigation method and drip irrigation structures respectively. In flood, sprinkler and drip irrigation methods total returns worked out to Rs. 121136, Rs. 179600 and Rs. 202400, respectively. The returns are higher to the extent of 50 per cent in sprinkler irrigation method and about 71 per cent in drip irrigation method over the traditional method of irrigation. This showed the superiority of modern method over traditional method in terms of returns.

Sowjanya *et al.* (2013) estimated that the total cost of cultivation, inclusive of direct and indirect costs, was estimated to be Rs. 34, 090.94 per hectare in drip irrigation and Rs. 37, 443.37 per hectare in surface irrigation.

2.2 ECONOMIC VIABILITY AND FINANCIAL FEASIBILITY OF INSTALLING DRIP IRRIGATION SYSTEM IN COCONUT CULTIVATION.

Jadhav *et al.* (1990) reported that yields of tomato cultivar Pusa Rubi were 48 t/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. The drip system showed a 31 per cent saving in irrigation water, the water saved being available to irrigate a further 0.4 ha.

Pitts and Clark (1991) from their study in tomato cultivation in southwest Florida reported that there was a significant reduction in water required by drip irrigation, which averaged 50 per cent of pan evaporation. Reduction in pumping costs compensated to some extent for the additional cost of the drip irrigation system. The seasonal additional cost for drip irrigation (excluding labour) was $328/ha

Minasian *et al.* (1994) reported that drip irrigation was economically attractive in arid or semi-arid regions. Drip systems with injected emitters were more economical than those with extruded emitters, especially when the systems are used for several seasons. For single season use, the biwall pipe system and spiral on-line emitter system were economically preferable. Drip irrigation also had benefits in terms of water conservation, crop productivity and high water use efficiency.

Muralidhara *et al.* (1994) from their studies in the eastern dry zone of Karnataka state concluded that in regions with low moisture holding capacity and scarce availability of water, drip irrigation could play an important role in mulberry cultivation. With its high net present value, cost-benefit ratio above one, and internal rate of return higher than the discount rate, drip irrigation forms a viable alternative technology.

Inamdar *et al.* (1996) from their study in Ankalkhop village of Sangli district in Maharashtra, reported that the per hectare, output and return from sugarcane were 24.32 tonnes and Rs. 13,989 higher when using biwall drip irrigation rather than surface irrigation. This resulted in a benefit: cost ratio of 1.54.

Mane and Vijayakumar (1996) reported that the profitability of grape cultivation was Rs. 15,964/ha higher for drip irrigation than for the traditional method of irrigation due to savings in costs of labour, manures, fertilizers and plant protection chemicals. Adoption of drip irrigation resulted in labour displacement of 207 mandays per ha.

Narayanamoorthy (1997a) indicated that drip irrigation contributes to water conservation and water use efficiency, and also reduces cultivation cost per ha and increases yield as compared to conventional irrigation methods. Benefit cost ratios (computed at different discount rates) of 2.07-2.36 for bananas and 1.48-1.8 for grapes show that investment in drip irrigation is economically viable.

Polak *et al.* (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.* (1998b) reported that in the cultivation of grapes, costs of drip irrigation were lower than those of surface irrigation particularly as savings were made when fertilizers and pesticides were applied via the drip system.

Narayanamoorthy and Deshpande (1998) reported that the drip irrigation system reduces cultivation costs and increases crop productivity. The farmers who cultivate grapes and bananas under drip irrigation can achieve full return on their investment on drip in one year.

Raina *et al.* (1998) reported that drip irrigation besides giving a saving of 32 per cent water resulted in 49.5 per cent higher yield as compared to surface irrigation. The benefit: cost ratio of pea cultivation under drip alone, drip plus plastic mulch and surface irrigation was 2.06, 2.11 and 1.93, respectively.

Anand *et al.* (1999) reported that there is a significant increase in net returns of Rs. 6,757.48 under drip irrigation which was 16.13 per cent more than the surface irrigation probably due to considerable saving of Rs. 1,682 in cost of production under drip irrigation. The benefit cost ratios for drip and surface irrigation systems were 3.44 : 1 and 2.94 : 1 respectively. Thus, there was an additional income of Rs. 0.50 for every rupee invested under drip irrigation method.

Berad *et al.* (1999) reported that banana crop performed well in respect of all yield attributes and registered a 15 per cent higher yield (68.5 t/ha) and 7 per cent higher net returns (Rs. 109130/ha) as compared with surface irrigation with normal planting (1.8 m x 1.5 m) with recommended dose of fertilizer application, and only N (urea) applied through the drip system. The drip irrigation was efficient with a 48 per cent saving in water and 30-35 per cent saving in labour, compared with surface irrigation.

Rezende *et al.* (1999) from their studies in Mariga in southern Brazil found that irrigation with the conventional sprinkler system is not profitable. Drip irrigation, due to its low energy consumption, showed higher expected net returns.

Shinde *et al.* (2000) reported that the fertigation of liquid fertilizers through drip irrigation gave 25 per cent fertilizer saving and 20.74 per cent yield increase in sugarcane, although the high cost of liquid fertilizers significantly reduced the net profit margin and B: C ratio. From the economic point of view skipped row planting (0.9-1.8 m x0.3 m) with application of recommended dose of N (urea) by fertigation in four splits, gave better net returns and B: C ratio than applying all liquid fertilizers.

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.

Sharmasarkar *et al.* (2001) reported total variable costs for drip irrigation were lower than those for furrow irrigation. Sugar beet returns were $2080 and $2310 /ha for furrow and drip irrigation practices, respectively. Higher returns and shorter payback time were observed for large conversion areas. For all conversion sizes, ROR increased with system lifetime. Higher profitability was observed for areas with increased water prices and weed control costs. The overall findings indicated that sugar beet production under drip irrigation would be most profitable for a 40 ha area with payback periods ranging from 7 to 10 years.

Malik and Luhach (2002) reported that the net present values of drip sets of discounted returns for per hectare were Rs.18108, Rs. 13912 and Rs. 31011, and IRR values were found at very high rate *i.e.* 33, 37 and 47 per cent and benefit cost ratio were worked out 1:1.737, 1:1.949 and 1:2.570 for grapes, ber and kinnow orchards, respectively. The payback period of drip sets estimated to be five years on grapes and ber orchard, and four years on citrus orchard. He observed that the labour and electricity charges were much lower in drip method of irrigation in comparison to other methods of irrigation. Thus, investment on drip irrigation was found sound and economically viable. Therefore, the cultivators are advised to make use of drip sets.

Sarkar and Hanamashetti (2002) reported that the drip irrigation conserves water and electricity, minimizes conveyance losses, results in higher yield and income and has a higher benefit-cost ratio as compared to conventional (*i.e.* flood) irrigation in the cultivation of sugarcane and grapes in Ahmednagar and Nashik districts of Maharashtra.

Cetin *et al.* (2003) reported that net present values were US$1394.67 for 'J. H. Hale' and US$1796.20 for 'Early Red', respectively, after an initial investment of US$1593 per ha. In the present value terms, a grower could spend up to US$2987.67 for 'J. H. Hale' and US$3389.20 for 'Early Red' per ha for drip irrigation systems and still break even.

Cetin *et al.* (2004a) founded that net present values were US$2584 for 'Granny Smith' and US$909 for 'Golden Delicious', respectively, after an initial investment of US$1415 per ha. In present value terms, a grower could spend up to US$3999 for 'Granny Smith' and US$2324 for 'Golden Delicious' per ha for drip irrigation systems and still break even.

Cetin *et al.* (2004b) reported that the investment cost of the drip irrigation system by the growers was US$ 2244 /ha with 1.6 ha blocks of olives and the net present value was US$ 3464/ ha after an initial investment of US$ 2244/ ha. The benefits of irrigation may include better olive survival, earlier crop production, greater yields, efficient nutrient distribution, less plant stress, reduced yield variability and improved crop quality.

Kumar *et al.* (2004) reported that the extent of water saving achieved through the use of drip system ranged from 7.2 per cent to 43.0 per cent. The extent of yield enhancement obtained through drip system is in the range of 7.4 per cent to 10.80 per cent. As regards economic performance, the private gains from using the drip system were just sufficient to cover installation costs. Drip irrigation of alfalfa is economically viable (B/C ratio: 1.18 to 1.83) from a macro perspective, if we consider the cost of producing the electricity used for groundwater pumping. Economic viability improves (B/C ratio: 1.28 to 2.78) when one considers the price at which water is traded as the economic value of the resource.

Luhach *et al.* (2004) reported that the sprinkler and drip irrigation techniques are water saving, cost effective and efficient in comparison to surface irrigation method. The BCR values were found as 1:1.76, 1:3.73 and 1:3.70 for the drip irrigated grapes, ber and citrus as against BCR values of 1:1.21, 1:2.29 and 1:2.59 for the surface irrigated same crops respectively. The IRR values are 17, 28.5, and 29 for drip irrigated grapes, ber and citrus as against the IRR values of 14, 22 and 24 for the surface irrigated same crops respectively. The higher values of BCR and IRR indicated that the economic viability of the drip irrigation system over conventional method.

Reddy *et al.* (2004) from their study on economic feasibility and prospects of adopting drip irrigation for fruits, vegetables, sugarcane and cotton concluded that 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. The projected capital requirement up to 2005 AD is about Rs. 22687 million to bring an additional 0.76 M ha area under drip irrigation, from the 1998 level. The corresponding net profits are estimated at Rs. 12182 millions per year. This implies that there is a need to accelerate the rate of increase in area under drip irrigation.

Ngigi *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.

Pandey *et al.* (2005) from their study in Chhattisgarh plain agro-climatic region revealed that the drip irrigation with plastic mulching on papaya crop had twin benefits of yield increase and water saving. Seasonal income was also found to be higher with the benefit cost ratio of 1:3.85 under the same treatment.

Sahu and Rao (2005) from their study on vegetable farmer's field in Nardha village of Durg district in Madhya Pradesh reported that the cost of Micro Drip Irrigation System (MDIS) was Rs. 78,000 ha^{-1}. On an average the use of low cost MDIS produced 25-35 per cent higher crop yields and saved 45-48 per cent water, 45 per cent of labour cost and 50 per cent of fertilizer cost. The B:C ratio was higher in case of MDIS (5.34) as compared to basin irrigation (4.14).

Singh *et al.* (2005) reported that the sweet corn can be grown successfully under drip fertigation and 30-40 per cent of saving in water and fertilizers can be obtained through drip fertigation. The cost-benefit ratio of sweet corn planted during the first week of september was 1:4.49 with a net profit of Rs. 85,535/ha.

Mohanty *et al.* (2006) concluded that the additional income from turmeric which is a intercrop in banana orchard was about Rs. 23,700 per ha/year which means that a good part of the investment in drip is recovered back within two years by intercrop alone

Bhatnagar *et al.* (2007) reported that the farmers were satisfied with the refinements and realized advantages of drip irrigation in early shooting and bunch emergence, better finger size and bunch size and better returns. The system was tested with two varieties of banana: *Alpan* and *dwarf Cavendish*. The B:C ratio was 1.01 to 1.87 for var. *Alpan* and 1.61 to 1.75 for var. *dwarf Cavendish*.

Spehia *et al.* (2007) reported that the water use efficiency with sole drip irrigation, drip irrigation with polyethylene mulch and surface irrigation was 3.73, 3.88 and 2.35, respectively. Drip irrigation with polyethylene mulch besides the 55.6 per cent water saving has also resulted to 37 per cent higher yield compared with surface irrigation only. The benefit-cost ratio of capsicum cultivation under drip irrigation, drip irrigation with polyethylene mulch and surface irrigation was 2.66, 2.77 and 2.27 respectively.

Paul *et al.* (2008) reported that the banana crop under drip irrigation with plastic mulch was resulted in the better plant growth, early flowering, more number of fingers and enhancement in the yield. The highest yield of 70.97 t/ha and an increase of 33 per cent in yield, 49 per cent in net seasonal income and also highest benefit-cost ratio (2.24) were recorded in case of 0.8 V drip irrigation with mulch as compared to conventional ring basin irrigation.

Chinnappa and Nagaraj (2009) reported that maintenance of gardens under drip irrigation was found to be less expensive than gardens under flood irrigation due to substantial savings in labour cost and gardens under drip irrigation facility registered an increase in productivity of 25 per cent as compared to gardens with flood irrigation. The benefit cost ratio suggested that gardens under drip irrigation generated higher gross and net returns for every investment (1:3.87). Results of break-even analysis revealed that break-even output for drip irrigation and flood irrigation was in the order of 4.69 q and 3.69 q respectively. By adopting, improved irrigation technology, the arecanut growers were able to cross break even point.

Jalajakshi and Jagadish (2009) demonstrated that the Krishik Bandhu (KB) drip irrigation technology has much higher benefit-cost ratios, of 1.55 and 4.54 in sugarcane and banana in the Erode region of Tamil Nadu, 5.68 in chilli in the Indore region of Madhya Pradesh, 2.75 and 5.46 in cotton and banana in the Jalgaon region of Maharashtra as against 1.12, 1.85, 2.95, 1.44, and 3.69 respectively in case of conventional flood irrigation method. 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.

Okunade *et al.* (2009) from their studies in Nigeria, concluded that the plants irrigated by drip and sprinkler irrigation methods had significantly higher yield than furrow and basin methods for both amaranth and okra. However, basin irrigation had the least cost-benefit ratio and drip had the highest. It is recommended that drip irrigation be used for production of amaranth and okra, especially where labour is neither readily available nor cheap.

Siag *et al.* (2009) reported that the average increase in yield in drip irrigated cotton field was 21 per cent (with a maximum yield of 2812 kg/ha as compared to 2036 kg/ha under flooding) with water savings of 30 per cent, besides early maturity, labour savings. The economic analysis showed that the method of using drip irrigation in cotton was technically feasible and economically viable in canal command area with a benefit cost ratio of (2.03:1) as compared to flooding (1.88:1).

Singh *et al.* (2009) concluded that drip irrigation at 80 per cent ET with polyethylene mulch resulted in significantly highest yield, water use efficiency and maximum benefit: cost ratio in tomato. The drip system besides giving a saving of 39 per cent water resulted in 55 per cent higher fruit yield of tomato as compared to surface irrigation. Hence drip irrigation system is a very effective and efficient method of irrigation for raising tomato crop especially on light texture sandy loam soil.

Albayrak *et al.* (2010) that drip irrigation in sugarbeet production allows for saving in input use more than sprinkler and furrow irrigation systems, and that it increases productivity and profit. The spread of especially drip irrigation in sugarbeet production has increased the economic use of water and profitability, through savings in input and reduction of costs.

Kaltu and Gunes (2010) concluded that the revenue of pressure-drip-irrigation system per hectare was found significantly higher than furrow irrigation. In addition, drip irrigation had more yields than furrow irrigation. Drip irrigation system was extremely easy to operate and its labour during irrigation is minimal than others and also it saves water. At the corn income, it was determined that drip systems had more than that of the other irrigations systems.

Pawar *et al.* (2010) reported that the per-hectare production of banana fruits was 231.46 quintals in the drip-irrigated banana garden followed by 213.89 quintals in the flood-irrigated banana garden. Per-hectare gross return was Rs.1, 26,607.73 in the drip-irrigated banana garden followed by Rs.1, 16,917.80 in the flood-irrigated banana garden. Per-hectare net profit was higher (Rs.45, 499.40) in the drip-irrigated garden compared to Rs.33, 504.67 in the flood-irrigated garden. Per-quintal cost of production was lower in the drip-irrigated garden due to the drip irrigation system.

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

Bhagyawant *et al.* (2012) reported that yield of cauliflower crop (variety-Hunsa) was 187.07 q/ha for drip irrigation and 157.61q/ha for surface irrigation. Drip irrigation system recorded higher water use efficiency than surface irrigation method. It was also observed that the benefit cost ratio of drip irrigation system (1.88) was higher than surface irrigation method (1.62).

Kumar (2012) revealed that the cost of labour significantly reduced under drip method (Rs.11123.4/ha) which is 55.6 per cent less than that of the flood irrigation (Rs.25075.4/ha)in banana cultivation. The drip method of irrigation saves irrigation labour and weeding labour involved in crop production activities. As the drip method saves considerable human labour, the cost of cultivation is significantly less under drip method over the flood method. Though the cost of installation of drip equipment and maintenance is incurred by the drip farms, the reduced cost of cultivation is observed to be 25 per cent.

Sharma *et al.* (2012) concluded that the drip irrigation was economically feasible in guava from the calculated values of the B:C ratios. Higher B:C ratio (2.84) was found in drip irrigated treatment (along with nitrogen fertigation) than that of surface irrigation system.

Singh *et al.* (2012) reported that under drip irrigation system, saving in irrigation water was 45 per cent with 25 per cent saving in fertilizer in guava over the basin irrigation. The yield parameters increased by 28.5 and 32.7 per cent in the number of fruits and average yield per plant in case of guava. The pulp content of guava was 3.3 per cent more than the control. The economic analysis revealed that the drip fertigation technology for guava was feasible with benefit cost ratio 2.48:1.

Chandrakanth *et al.* (2013) reported that the net returns per acre inch of groundwater, net returns per rupee of water cost were Rs. 457, Rs. 2.80 under drip irrigation and Rs. 194, Rs. 1.20 under conventional irrigation methods respectively. It was also found that by adopting the drip irrigation, the net returns per farm increased from Rs. 15,292 to Rs. 25,203 and the marginal productivity of water increased from Rs. 465 to Rs. 1960.

Rajeshkumar *et al.* (2013) reported that economic use of water by drip method of irrigation play a key role in the water management of high water sensitive crops like potato and hence the water saved in drip system of irrigation can be profitably used for increasing area of potato cultivation. In case of potato highest cost benefit ratio (B: C) of 2.33 was recorded in the treatment irrigated every alternative day through drip system, closely followed by 2.25 in the treatment irrigated once in three days by drip irrigation system as compared to conventional furrow irrigation system (1.91).

Silva *et al.* (2013) from their studies in Lavras-state of Minas Gerais (MG), Brazil, reported that the drip irrigation depth with the maximum economic return was estimated in 434.4 mm, with a productivity of 35,160.6 kg ha^{-1}, which is economically viable for the cultivation of asparagus bean, with a expected profitability of R$ 1.70 for every real invested.

Sowjanya *et al.* (2013) reported that the average gross and net income from mango cultivation under surface irrigation was worked out to be Rs.60000 and Rs.22556.55 per hectare respectively, while the same under drip irrigation was Rs.84000 and Rs.49909.77. The capital productivity measures revealed that net present worth of drip and surface irrigated farms was Rs.52532.48 and Rs.24956.26 and Benefit-Cost ratio was 1.40:1 and 1.04:1 respectively. The Internal Rate of Return was 19.76 per cent in drip irrigated farms and 13.65 per cent in surface irrigated farms.

Ndeketeya *et al.* (2014) reported from his studies in the Sugar-cane Estates of Zimbabwe reported that there was a significant difference in the sugar-cane fresh yield and sucrose content of furrow irrigated and drip irrigated plots with the former having better results. According to the financial analysis, both drip and furrow irrigation systems were viable projects except that drip will need more years to bring net returns.

Sharma and Kaushal (2015) reported that drip fertigation in okra saves 20 per cent to 61 per cent of water, increases yield by 13 per cent to 76 per cent, fertilizer saving from 15 per cent to 30 per cent and results in higher water use efficiency from 35.5 per cent to 50.8 per cent as compared with traditional method. It is also economically viable with benefit to cost ratio varying from 1.41 to 2.99.

2.3 WATER USE EFFICIENCY AND COMPARATIVE ECONOMIC BENEFITS OF DRIP IRRIGATION SYSTEM OVER CONVENTIONAL METHOD OF IRRIGATION

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.

Padhye (1990) revealed that the increase in crop yield as compared to flood irrigation was higher in drip irrigation than sprinkler irrigation. The per cent increase in yields of coconut, coffee, sugarcane and vegetables using drip irrigation system was 29 per cent, 39 per cent, 20 per cent and 20-80 per cent respectively, as compared to traditional flood irrigation methods. It was also found that saving in power, water labour & annual cost of maintenance was higher in drip irrigation than flood irrigation method.

Shrestha and Gopalakrishnan (1993) reported that drip irrigation has improved the efficiency of water use and other water amendments such as fertilizers used in the production of sugarcane. The yield increase of about 1.7 tons of sugar per acre or a net gain in revenue of $578 per acre per crop, and considerable savings in water (about 12 per cent) and labour use, were the major contributing factors to the rapid adoption of drip irrigation.

INCID (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. In addition, the saline water could, also be used in this system and the salt is accumulated only at the surface of the periphery of wetting zone. Drip system kept the soil moisture continuously high at-least in the root zone which resulted in a low salt concentration in the root zone due to daily irrigation, which leached away the salts to the outer periphery and hence does not affect the growth of the crop.

Kovatchev *et al.* (1994) reported the pesticide application (0.4% of oxamyl) through drip irrigation system was adequate to remove parasite nematodes and did not affect predatory fauna adversely. The technique also enables the health of the plant to be improved, environmental contamination to be prevented, drip systems to be effectively used and the purchase of costly pesticides to be minimized.

Minasian *et al.* (1994) from their study on an economic analysis of four drip irrigation systems in comparison with a furrow irrigation system was conducted in five plastic greenhouses in Iraq, concluded that drip irrigation was economically attractive in arid or semi-arid regions. Drip irrigation also had benefits in terms of water conservation, crop productivity and high water use efficiency.

Sivanappan (1994) reported that drip irrigation method has increased water use efficiency and water saving is up to 40 to 60 per cent and labour saving up to 90 per cent. Further Drip Method increases the yield by 30 per cent. This method successfully meets the problem of irrigating sandy tracts.

Batchler *et al*. (1996) reported that the micro irrigation can be used to improve the irrigation efficiency of vegetable gardens by reducing evaporation and drainage losses by creating and maintaining soil moisture conditions that are favourable to crop growth.

Shiyani and Kuchhadiya (1996) from their studies in Saurashtra region of Gujarat reported that the drip adopters enjoyed advantages of higher yield, higher product prices, less unit costs of production, higher net profit and higher input-output ratio compared to non-adopters.

Narayanamoorthy (1997b) concluded that the drip method of irrigation helps to reduce the over-exploitation of groundwater that partly occurs because of inefficient use of water under surface method of irrigation. Environmental problems associated with the surface method of irrigation like water logging and salinity are also completely absent under drip method of irrigation.

Subramanian *et al.* (1997) reported that drip irrigation method had a significant effect on the increment in collar height, and nut yield. Drip irrigation at the rate of 40litres/tree gave a saving of 40 per cent of water applied compared with surface irrigation. Drip method of irrigation produced nut yields comparable with or in excess of those produced with surface irrigation.

Behera (1998) reported that the drip method of irrigation conserves a considerable amount of water since losses due to evaporation, deep percolation *etc.*, are completely controlled and also the losses by soil erosion due to surface runoff are eliminated. Crops such as grapes, banana, mango, coconut, guava, citrus, sapota, vegetables and sugarcane are irrigated by the drip irrigation system effectively. The high initial cost of investment for the system is one of the major constraints, but if the benefits are considered, cost is fully compensated by the better returns.

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.

Kapadiyal *et al.* (1998) revealed from their study on coconut plantation in the south Saurashtra region of Gujarat that the drip irrigation system can save 45-50 per cent water over surface irrigation without any significant reduction in yield. With the water thus saved one extra hectare can be brought under irrigation thereby increasing the net income of the farmers.

Raina *et al.* (1998) from their study Himachal Pradesh on pea cultivation concluded that water use efficiency under drip irrigation alone, drip irrigation plus plastic mulch and surface irrigation was 0.188, 0.221 and 0.106 t pod/ha-cm, respectively.

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.

Dawes (2000) concluded that the drip irrigation achieves higher water efficiency than the conventional hand-move sprinkler systems but has higher capital costs. The portable drip system reduces capital costs and increase water use efficiency in tobacco farming in Zimbabwe, where water and financial resources are limited. The amount of tobacco grown with portable drip irrigation has increased to 1225 ha in 1998.

Desai *et al.* (2000) from their study in Junagadh district of Gujarat revealed that the majority of the drip adopted mango farmers had benefited by saving of water, reducing weed control expenses and labour for irrigation and intercropping operations. A little more than one-fourth of the drip adopted farmers availed the benefit in respect of fertilizers economy. In addition to this, the farmers got the benefits of better yields, better fruit size, early maturity of fruits and higher market price of the produce under drip irrigation system.

Muthuchamy *et al.* (2000) reported that after drip irrigation of 112 litres/ day per tree, the highest nut yield of 133 nuts/ tree per year was achieved compared with 124 nuts/ tree per year in conventional basin irrigation. Performance evaluation showed that the basin method of irrigation in coconut requires twice the labour required per day/ha than that of drip 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.

Norton and Silvertooth (2001) reported that the drip irrigated cotton field had more vigorous crop growth and consistently higher fruit retention level. Water use efficiency (WUE) of cotton crop was three times greater under drip (0.33 kg/m3) than under furrow irrigation (0.11 kg/m3).

Ogbuchiekwe and McGiffen (2001) from their studies on celery in California, USA reported that there was a reduction in weed populations under drip and sprinkler irrigation and also increased yield, net returns, and rate of returns were observed. Effective weed control reduced the additional costs of hand-hoeing of the weeds which were not killed by herbicides and finally resulted in greater net return. The net returns of weed control were even greater when celery was drip irrigated than when sprinklers were used.

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.

Palanichamy *et al.* (2002) reported that farmers who adopted drip irrigation increased their net irrigated area from 75 per cent to 92 per cent. The investment in drip system per hectare is Rs. 31,165. Overall water saving of 50 per cent was achieved by adapting drip irrigation in coconut farms. Labour costs can also be declined by Rs. 3,000. Under scarce water conditions, drip irrigation can increase coconut yields by 20-30 per cent.

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.

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.

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.

Hebbar *et al.* (2004) revealed that the total dry matter production and leaf area index of tomato were significantly higher in drip irrigation (165.8 g and 3.12 respectively) over furrow irrigation with the higher fruit yield of 19.9 per cent in drip irrigation (71.9 Mg/ha) over furrow irrigation (59.50 Mg/ha).

Jadhav and Kumbhar (2004) reported that the drip irrigation could offer savings in labour, plant protection charges, irrigation charges, *ect.*, The adoption of drip irrigation method for grape has yielded an additional benefit of Rs. 7000 per hectare. The output-input ratio of drip irrigation method has been worked out as 1.50 against 1.35 for the conventional method of irrigation.

Manjunatha *et al.* (2004) reported that the drip irrigation seemed as a feasible solution in water scarcity areas and the highest fruit yield of Brinjal (26.2 t /ha) was recorded in drip irrigation compared to surface irrigation.

Medagoda *et al.* (2004) reported that the water usage, weed infestation and labour requirement were higher in basin irrigation than the drip system. Hence, drip irrigation may be considered more advantageous than the conventional basin system particularly for commercial scale cultivation, even though the initial cost is higher.

Talathi and Hiremath (2004) from their study in thane district of Maharshtra reported that modern method of irrigation (MMI: drip irrigation) not only contributes to water conservation and provides additional irrigation benefits through increased area under irrigation but also reduces cultivation cost, particularly irrigation cost, and increases crop productivity, as compared to traditional method of irrigation (TMI: flood/check basin irrigation). In the case of vegetable crops, there was an inverse relationship between the quantity of water used and the productivity of a particular crop in the drip method of irrigation, while a positive relationship was observed in the case of fruit crops.

Aujla *et al.* (2005) revealed that when the same quantity of irrigation water and N were applied through drip irrigation system, it increased the cotton yield to 2144 from 1624 kg/ ha (an increase of 32 per cent) compared to check basin irrigation. When the quantity of water through drip was reduced to 75 per cent, the increase in cotton yield was 12 per cent.

Rekha *et al.* (2005) from their studies on okra reported that under drip irrigation there was an increase in yield of 20.69 per cent with the water saving of 44.92 per cent. Drip irrigated okra obtained the high yield of 4188 kg/ha and water use efficiency of 8.23 kg/ha/mm.

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.

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.

Gultas and Erdem (2007) from their study in the cherry orchard of Turkey reported that the seasonal irrigation water requirements were found as 397 and 482 mm for drip and micro-sprinkler irrigation methods, respectively and the system capacities were determined as 3.56 lit/second in drip irrigation method and 5.12 lit/second in micro-sprinkler irrigation method. It is suggested that when irrigation water has been taken from the wells with low dynamic head, micro-sprinkler irrigation method can be applied when water source is adequate, but if water is scarce drip irrigation method should be preferred.

Ibragimov *et al.* (2007) reported that under drip irrigation**,** 18-42 per cent of the irrigation water was saved in comparison with furrow irrigated cotton and irrigation WUE increased by 35-103 per cent compared with that furrow irrigation.

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.

Ngouajio *et al.* (2007) reported that there was an increased tomato yield by 8 - 15 per cent, fruit number by 12 - 14 per cent with reducing amount of irrigation water by 20 per cent in drip irrigation compared to conventional method of irrigation.

Shashidhara *et al.* (2007) from his studies on arecanut and banana in Dharwad reported that majority of drip irrigation farmers had expressed the advantages like saving of water, saving in labour cost for irrigation, uniform application of water and improved quality of the produce respectively. Drip irrigation had shown increased yield in arecanut and banana to the extent of 5.94 and 3.54 per cent, respectively as compared to surface irrigation. The quality parameters of banana crop grown under drip system had shown more number of hands per bunch (12), fingers per bunch (103), length of fruit (4.73 inches) and fruit thickness (2.53inches). The drip irrigation had minimized the days for harvesting (398 days) and also increased self-life (15 days) in banana.

Afshar and Mehrabadi (2008) reported that the total water used for cotton in the drip and furrow irrigation methods were 7002.38 and 11464.9 m^3/ha, respectively. The irrigation water in drip irrigation was 50.4 per cent less than that in furrow irrigation. The most and the least water use efficiency were 0.34 kg/m^3 in drip and 0.21 kg/m^3 in furrow irrigation. Water use efficiency in drip irrigation was 61 per cent more as compared to the furrow irrigation method.

Andal *et al.* (2008) reported that irrespective of crops covered the yields were increased with the installation of micro irrigation systems than the traditional method of irrigation. The increase in yield ranges between 20-40 per cent in different crops and the weighted increase is 39 per cent. Though there was an increased cost of cultivation in view of installation of micro irrigation systems but there is a savings in cost of labour, reduced pest problems, increased yields, more area brought under cultivation with the availability of water, ultimately resulted in increasing the net profit to the farmers.

Halvoson *et al.* (2008) reported that converting from furrow-irrigated to drip-irrigated onion production may reduce N fertilizer needs, water inputs, and NO_3-N leaching potential. Irrigation water use efficiency (IWUE) and Nitrogen use efficiency (NUE) were higher with the drip system than with the furrow system. The drip system had more colossal and jumbo sized onions and less medium sized onions than the furrow system. Adjusted gross economic returns (less the cost of Nitrogen, water, and drip system) were greater with drip irrigation than with furrow irrigation.

Sankar *et al.* (2008) concluded that micro irrigation practices significantly improved growth, yield and water use efficiency of closely spaced crop of garlic (G. 41 variety) under Western Maharashtra conditions. The study indicated that water could be saved to the extent of 37.9 per cent in drip and 36.4 per cent in sprinkler irrigation systems as compared to surface method of irrigation. Among the various methods of irrigation, drip irrigation at 100 per cent PE was superior in terms of improved growth characters, higher marketable bulb yield and water use efficiency than surface irrigation method.

Vermani *et al.* (2008) from their study in Haryana reported that the cultivation under drip irrigation system was found beneficial than traditional method of irrigation owing to saving of 20-30 per cent water, electricity, 40-50 per cent saving of fertilizer, and 200 days of saving of time and labour. Consequently impact of drip irrigation system was found high on the socio-economic status of overwhelming majority of farmers (94 per cent).

Shedeed *et al.* (2009) reported that drip irrigation in tomato recorded significantly higher total dry matter production (3.60 t/ha) and leaf area index (LAI) (3.15) over furrow irrigation (2.86 t/ha and 2.27), respectively. The fruit yield of tomato was 28 per cent higher in drip irrigation (43.87t/ha) over furrow irrigation (34.38 t/ha).

Singh *et al.* (2009) concluded that drip irrigation at 80 per cent ET with polyethylene mulch resulted in significantly highest yield, water use efficiency and maximum benefit: cost ratio in tomato. The drip system besides giving a saving of 39 per cent water resulted in 55 per cent higher fruit yield of tomato as compared to surface irrigation. Hence drip irrigation system is a very effective and efficient method of irrigation for raising tomato crop especially on light texture sandy loam soil.

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.

Al-Amoud (2010) indicated that there is an increase in the yield and a considerable saving of water in subsurface drip irrigation as 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 drip system. The subsurface drip systems prove to be durable and highly efficient for irrigating Date palm trees.

Brahma *et al.* (2010) revealed that plant height, fruit setting percentage, fruit number per plant, individual fruit weight and marketable yield were maximum and also quality parameters like fruit girth, percentage of placenta, edible portion, juice percentage, total soluble solid and ascorbic acid were highest in tomato with cent per cent fertigation of recommended dose of N & K at the rate of 75:60 kg/ha. Economics of cultivation revealed that fertigation with cent per cent recommended dose of N & K was the most efficient treatment with fertigation efficiency of 43.24 per cent and cost: benefit ratio of 1:2.28.

Gufran (2010) reported that the yield of onion crop was higher under drip (trickle) method rather than traditional method and 70 per cent of water saving was found under drip method. Size and test weight of onion bulb, plant growth and benefit cost ratio (BCR) was also more in drip method of irrigation with respect to border method of irrigation.

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.

Jayapiratha *et al.* (2010) from their studies on okra revealed that plant height, flowering index, yield, weed population, water use efficiency, root length and fresh weight were significantly recorded in drip irrigation than the plants under basin irrigation. The water saving was 60 per cent by adopting drip irrigation compared to basin irrigation. The yield obtained for the drip irrigation duration of 15 and 30 minutes and basin irrigation was 1516, 1514 and 1084 kg/1000 m^2 respectively.

Kaltu and Gunes (2010) reported that the revenue of pressure-drip-irrigation system per hectare was found higher than furrow irrigation in corn. In addition, drip irrigation had more yields than furrow irrigation. Drip irrigation system was extremely easy to operate, it lead to water saving and its labour requirement during irrigation is minimal than others.

Kumar 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. The physical water and energy productivity is significantly high in drip over the flood method of irrigation. It is also observed that the drip irrigation has a significant bearing on private costs and benefits and hence profitable to farmers.

Pawar *et al.* (2010) reported that per hectare use of irrigation was higher (20 000 cubic meters) in a flood-irrigated banana garden than in a drip-irrigated garden (13 999.57 cubic meters). It inferred that there are water savings in a drip-irrigated garden due to the drip system.

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.

Palada *et al.* (2011) Compared with traditional practice of hand-watering, drip irrigation increased yield of chili (*Capsicum annuum*), cucumber (*Cucumis sativus*), and eggplant (*Solanum melongena*) by almost 50 per cent, but reduced average net income by 25 per cent. Drip irrigation decreased water use by 33 per cent, and increased water use efficiency by 63 per cent and labour productivity by 74 per cent. Under drip irrigation the use of fertilizer deep placement reduced water use by 48 per cent, increased water use efficiency by 70 v and labour productivity by 78 per cent.

Kumar (2012) reported that the drip method of irrigation is found to have a significant impact on resources saving, cost of cultivation, yield of crops and farm profitability. The adoption of drip irrigation is significantly influenced by experience, farm size, proportion of wider spaced crops and participation in non-farm income activities.

Maddileti (2012) reported that micro irrigation method which included both drip method of irrigation (DIM) and sprinkler irrigation method (SIM) has been proved to be an efficient method in saving water, optimum use of water efficiency, productivity gains, and also reducing energy requirement, weed problems, soil erosion and cost of cultivation. Investment in micro-irrigation also appears to be economically viable, even without availing state subsidies.

Veeraputhiran *et al.* (2012) reported that the adoption of subsurface drip fertigation (SSDF) recorded significantly higher number of internodes per cane and individual cane weight than that of conventional method. Subsurface drip fertigation registered a mean cane yield of 113.9 t/ha which was significantly higher than surface irrigation with conventional fertilizer application (86.8 t/ha). The total water requirement under SSDF was lesser (1730 mm) than conventional method (2499 mm). The higher cane yield coupled with enormous quantity of water saving under SSDF resulted in higher water use efficiency of 65.8 kg/ha/mm but it was only 34.8 kg/ha/mm in conventional method of sugarcane cultivation.

Venkataraman *et al.* (2012) revealed that the key benefits reported by farmers in adopting drip irrigation system are reduced labour cost and higher yields with decreased cost contribution. The drip irrigation system adoption in micro irrigation scheme has enhanced the livelihood of farmers in the study area of vridachalam block in the Cuddalore district of Tamil Nadu.

Kakhandaki *et al.* (2013) revealed that micro sprinkler irrigation was superior to drip irrigation and surface irrigation in terms of tomato yield and cost. However, water use efficiency was found to be high with drip irrigation.

Krishnamoorthy and Rajamani (2013) reported that fertigation with 'Recommended Dose of Fertilizers' (125:50:175 g NPK plant per year) as Water Soluble Fertilizers (WSF) through drip irrigation increased all vegetative growth parameters like trunk girth increment (1.62 cm), canopy spread increment (66.79 cm), leaf fresh weight (3.949 g), leaf dry weight (2.039 g), weight of the pruned branches removed (fresh weight 7.628 kg/plant) and dry weight (4.650 kg/plant) in cocoa.

Mehendale *et al.* (2013b) reported that the water use efficiency (nut yield/ha-m) was found to be more in micro sprinkler irrigation method (43173) followed by drip (38923) and flood irrigation method (22268). Water saved in modern irrigation methods was to the extent of 60 per cent in micro-sprinkler method and 40 per cent in drip irrigation method.

Pandia (2013) reported that drip irrigation is preferable over furrow irrigation in high water-consuming crop such as sugarcane in canal and well conjunctive water use situations due to reduced water availability. The subsurface drip fertigation (SSDF) resulted in energy savings and eliminate anaerobic decomposition of plant materials and thus substantially reduce methane gas production.

Pawar *et al.* (2013) reported that the 100 per cent drip fertigation showed 41.8 per cent increase in yield in sugarcane and the yield increased upto 25.3 per cent by applying only Nitrogen fertilizers through drip as against conventional method (133.4 t/ha). Fertigation also resulted into 40 per cent fertilizer saving. The drip irrigation used less quantity of water (103.7 mm) and saved 57 per cent water over surface irrigation method. Field water use efficiency was also improved considerably under drip fertigation.

Pandey *et al.* (2013) reported that drip irrigation enhanced the fruit yield, net income and minimized the time, weeds and diseases of the chilly crop. Fertigation resulted in maximum yield (10.20 kg/m^2), minimal disease and saved water and total irrigation time as compared to top dressing. The drip irrigation had significantly increased yield (10.50 kg/m^2) and net income (60.30 per cent) as compared to flood irrigation.

Rajeshkumar *et al.* (2013) reported that highest water use efficiency (56.24 kg/ha/mm) in terms of yield per ha-mm of water applied was recorded in the treatment irrigated every alternative day through drip system as compared to conventional furrow irrigation system (14.16 kg/ha/mm).

Thabet (2013) reported from his studies on pepper in Tunisia reported that drip irrigation used 60 per cent less water than surface irrigation whereas production was respectively 17.755 t/ha and 10.715 t/ha for drip and surface irrigations.

Iqbal *et al.* (2014) reported that tomato, cucumber and bell pepper consumed less water under drip irrigation as compared to furrow irrigation system. Average water use efficiency increased by 250 per cent for tomato, 274 v for cucumber and 245 per cent for bell pepper under drip irrigation system as compared to furrow system. On the contrary, the average fruit yield increased only by 2.05 per cent for tomato, 3.32 per cent for cucumber and 2.35 per cent for bell pepper from furrow irrigated plots over those of drip irrigated plots.

2.4 STUDIES ON DRIP IRRIGATION SYSTEM WITH AND WITHOUT SUBSIDY COMPONENTS

Narayanamoorthy (2003) reported that water saving due to drip method of irrigation (DMI) over the flood method irrigation (FMI) is about 47 per cent in sugarcane and 29 per cent in banana. Water required to produce one quintal of sugarcane under DMI is only 1.33 horse power (HP) hours of water against the requirement of 3.17 HP hours of water under FMI. The same trend is observed in the banana crop. It is indicated that drip investment is economically viable even without subsidy.

Waykar *et al.* (2003) reported that the per hectare saving in human labour and electric motor power on drip adoptor farms was 87.07 mandays and 130.37 hours, respectively. Drip irrigation system showed an increase in producing of sugarcane crop by 27.65 percent, per hectare net returns by Rs.20234 over Rs. 17861 under the non-drip category of farmers with B:C Ratio of 1.51 and 1.25 with and without subsidy option showing its economic viability.

Narayanamoorthy (2004) reported from his study on sugarcane in Maharashtra that the productivity was 23 per cent higher than that under the flood method of irrigation, with water saving of about 44 per cent per hectare and electricity saving of about 1059 kwh/ha and also revealed that the investment in drip method of irrigation is economically viable even without subsidy. 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.

Narayanamurthy (2005a) reported that water saving and the water use efficiency of different crops cultivated under drip irrigation are significantly higher when compared with those under flood irrigation. The productivity and profitability of different crops are also found to be higher under drip irrigation. Benefit-cost ratios with different discount rates indicate that drip investment in sugarcane, banana and grape cultivation remains economically viable even without a subsidy.

Narayanamoorthy (2005b) concluded that drip investment in sugarcane cultivation is economically viable even without subsidy and benefit-cost ratio varies from 1.98 to 2.02 under without subsidy condition and the same varies from 2.07 to 2.10 with subsidy (30 per cent) at different discount rates. Further, the results of net present worth indicate that the farmer can recover the entire capital cost of drip set from the income of the very first year itself even without subsidy.

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.

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.

Khalache and Khaire (2007) from their studies in Pune District of Maharashtra recognized that the fig grower's 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.

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.

Brinegar and Ward (2009) from their studies in Upper Rio Grande Basin of Colorado, New Mexico, and Texas, USA reported that the water conservation subsidies for drip irrigation produce several effects which include greater on-farm implementation of water-conserving technology, less water applied to crops, more water consumed by crops, increased farm income, greater crop production, more land irrigated, and increased total water-related economic benefits for the basin.

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.

Narayanamoorthy (2010) concluded that the drip method of irrigation can be used as a tool to conserving resources and achieving most of the objectives of conservation agriculture. 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 and that too without taking into account government subsidy in the same four crops.

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

Khan *et al.* (2011) reported that the net return per hectare on furrow, drip and drip system with subsidy was Rs. 23,661, Rs. 42,148 and Rs. 48,448 based on the average annual water used for irrigation in mulberry production. An additional net return per hectare of Rs. 18,487 and 6,300 was obtained for without and with subsidy in drip irrigation system, which is of Rs. 24,787 that could be used to repay the loan availed for installing the drip irrigation system. Thus, mulberry cultivation under furrow irrigation method, 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 and drip system with subsidy to the peasants respectively.

Dagnino and Ward (2012) reported that subsidies for drip irrigation increase farm income, raise the value of food production, and reduce the amount of water applied to crops. Final findings showed that where water rights exist, water rights administrator will need to guard against increased depletion of the water source in the face of growing subsidies for drip irrigation.

Finger and Lehmann (2012) from their study in Switzerland reported that subsidies may have crowding out effects because they could provide incentives to switch from non-irrigated crops (e.g. wheat) to the production of crops (e.g. potatoes) that require irrigation. This may result in even higher water withdrawal rates. Such an increased competition for water resources may also result in adverse conditions for farmers.

Kaushal *et al.* (2012) reported that the adoption of drip irrigation (surface or subsurface) system in sugarcane is technically feasible and economically viable and the subsidy and technical support to farmers acts as an incentive to adopt this method on a large scale in India.

Ward (2014) reported that an important on-farm drought adaptation mechanism comes by converting from surface irrigation to water conserving irrigation technologies when faced with lower financial costs for conversion. Public subsidies to convert from flood to drip irrigation offset many of the negative impacts of drought on farm income. These subsidies also raise the value of food production, reduce the amount of water applied to crops, but can increase crop water depletions.

Narayanamoorthy *et al.* (2016) reported that farmers cultivating green chilli could reduce the use of water by about twothirds and increase productivity by more than half by adopting the drip irrigation method, compared to the same crop cultivated under conventional flood irrigation. The discounted cash flow analysis shows that the investment in drip irrigation for green chilli cultivation is economically viable even without the state subsidy

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

Narayanamoorthy (1986) reported the constraints faced in adoption of drip irrigation technology highlights that high capital cost, absence or inadequate subsidy, poor drip product quality, lack of farmer awareness and knowledge and relatively expensive drip products mainly targeting large scale farmers are the reasons for the slow spreading of the technology, despite the number of advantages.

Puranik *et al.* (1992) reported that the farmers in the Nagpur district of Maharashtra State faced the major constraints in drip adoption included the heavy initial expenditure required for installation of the system, the lack of technical knowledge support, the lack of availability of subsidies and loans and the cost and time involved in maintenance of the system. Those farmers that had adopted the system identified the major problems as: meeting the installation cost, the frequent clogging of mains and sub-mains, finding the time to attend to minor repairs, the lack of cheap locally available spare parts and the low quality of service by dealers.

Revol *et al.* (1995) concluded that high productivity can be achieved with a properly managed drip irrigation system. Main constraints were maintenance problems, and the control of filtration and rate of flow. The use of tensiometers is recommended.

Saksena (1995) reported the problems in the growth of micro irrigation (drip system and micro sprinklers) in India which include the high capital costs, low irrigation water rates on government canals, lack of technical advice, difficulty in obtaining loans and subsidies, lack of standardized equipment, acute power shortages in parts of the country, and inadequate extension efforts to motivate farmers.

Sivanappa (1995) reported the constraints faced by the micro irrigation adopted farmers were high initial cost, clogging of drippers and cracking of pipes, lack of adequate technical inputs, damaged due to rodents, high cost of spare components and insufficient extension education efforts.

Anand *et al.* (1998a) reported the problems faced by the drip adopted grape growers were the lack of availability of information on water requirements, followed by fertilizer requirements, number of drippers per plant required, and lack of water during heavy cropping. Constraints limiting the extension of drip irrigation were the lack of suitable crops to grow under this system and insufficient water availability.

Reuter (1998) stated that the drip system was very efficient, but it involved high labour costs to install and interfered with other cultivation processes.

Desai *et al.* (1999) reported that the most important economic constraints faced by mango orchard growers in adoption of drip irrigation sets were high cost of spare parts, heavy initial expenses for installation of drip irrigation system and lack of capital for covering entire area under drip irrigation system. The major technological constraints faced by the users of drip sets were frequent clogging of drippers and micro tubes, damage caused to the system by rodents and jackals, lack of technical know-how and lack of awareness among the farmers regarding the benefits of drip irrigation systems.

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) from their experiments in peanut, corn and cotton in Georgia reported that rodent and insect damage occurred with the thin–wall drip tubing but injecting chlorine and pesticides seemed to correct these problems.

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.

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.

Senarathna and Pathmarajah (2007) reported that 44 per cent of the drip irrigation systems are not functioning due to the errors in planning at initial stage. Similarly, another 44 per cent of the farmers faced the problem of system damages caused by animals and rodents like rats, squirrels, porcupines *etc.,* 40 per cent of the drip systems were not functioning due to clogging of emitters. The reasons for clogging are salinity and impurities in water. High cost of maintenance, absence of required pressure for operations, low quality equipment and spares are some other problems reported by the farmers.

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.

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.

Thompson *et al.* (2009) from their studies in USA reported the reasons for the limited adoption of Subsurface Drip Irrigation (SDI) include the high initial capital investment required and the need of intensive management, The major barriers to SDI sustainability in arid regions including the high cost of installation and salt accumulation, which requires periodic leaching, specialized tillage methods, or transplanting of seedlings rather than direct-seeding.

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.

Hussain *et al.* (2010) reported that the major problems faced by surface drip irrigation (SDI) system adopters were blockage/clogging of emitters, damage of T-tapes, filtration obstructions due to high ferrous contents in irrigated water, higher initial cost, which resulted to net economic loss in sugarcane. SDI saved 18 per cent water as compared to flood irrigation system. SDI might be a superior system where water is fit for irrigation, free of ferrous and low installation costs.

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.

Al-Shayaa (2011) reported that about 82 per cent of the farmers faced technical obstacles in adopting the modern irrigation systems including the problems like blockage of drippers, filters, and springs. Lack of funding from banks or the companies remained the most important economic constraints, in getting the modern irrigation systems installed at their farms.

Arun and Singh (2011) reported that clogging and leakage of the drip irrigation system were the most important problems faced by majority (85–100 per cent) in the operation and maintenance of drip irrigation system. For about 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.

Bhingardeve *et al.* (2012) reported that majority of the drip adopted sugarcane growers (93.33 per cent) faced the constraints i.e. the higher initial cost for installation of drip irrigation unit followed by the cracking and clogging of emitters (90.83 per cent) and damage caused by rats/rodents to drip system (81.66 per cent).

Meti (2012) reported that 100.00, 98.86, 87.50, 80.68, 78.41, 73.86, 71.59, 69.32 and 64.77 per cent of drip adopted banana farmers in Dharwad district of Northern Karnataka, were having constraints like complicated procedures in getting loan, delay in sanction of loan, non availability of soluble fertilizers, inadequate supply of electricity, choking of laterals and drippers, high initial investment, inadequate follow up services by drip agencies, non availability of quality materials and rodents damage to the laterals, respectively.

Salhi *et al.* (2012) reported that subsidies, type of crop and educational level have positively affected the drip adoption. However, the investment costs, conditions needed to access and lack of hydraulic structure seem to have a negative effect on adoption of drip irrigation by the farmers.

Friedlander *et al.* (2013) reported that the all drip adopters experienced a wide variety of technical difficulties with their systems. There were certain, very specific difficulties which were good predictors of future drip irrigation abandonment including water storage problems and problems with destructive wildlife.

Patil (2013) from his studies in Sangli District of Maharashtra reported some limitations to the growth of drip irrigation in the region which include clogging of laterals / drippers and micro tubes, damage caused by rodents and rats, reduced life of drip sets, lack of training or extended help to the farmers in respect of this technology by the dealers and manufacturers, insufficient government subsidy and also it not reached to farmers in time, lack of availability of services to farmers after sale from the dealers and still drip sets are not suitable for the use of undiluted or solid fertilizers.

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, an attempt has been made to explain elaborately methodology and other technical aspects adopted while conducting a present research work. The chapter has been divided into following sub-divisions.

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

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

Srikakulam district was selected purposively as it has an area of 14,619 ha of Coconut plantations which occupy 24 per cent area out of the total horticultural crop area of the district and the drip irrigated coconut area is around 1,788 ha. More over in Srikakulam district Coconut consists of 65 per cent of total drip irrigated area in the district under different crops (APMIP, 2012).

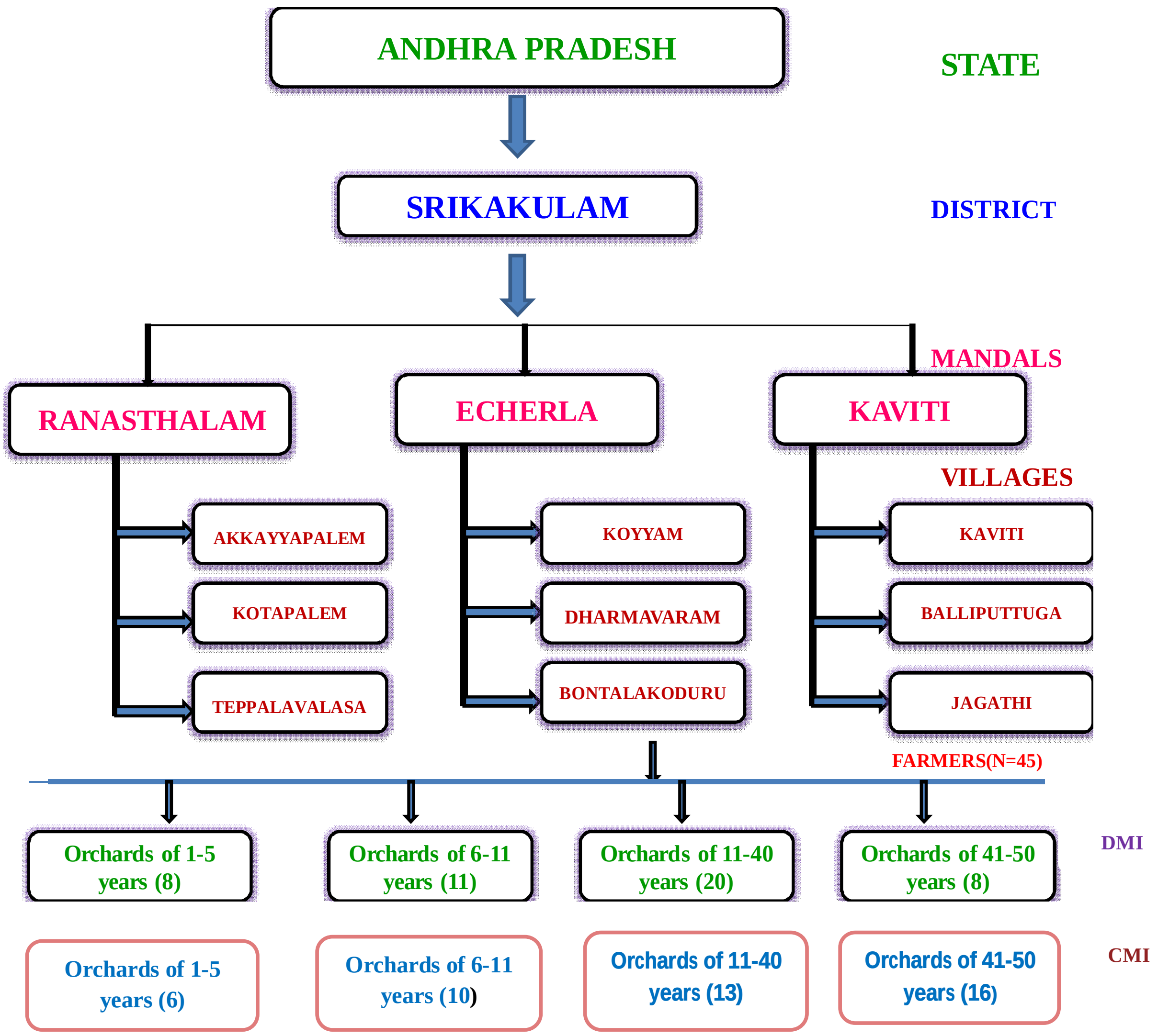

Figure 3.1. Diagram showing selection of sample respondents

3.1.1.2 Selection of mandals

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

3.1.1.3 Selection of villages

From the selected mandals, villages selected where there were more number of drip irrigated coconut orchards. From each mandal three Coconut cultivating villages were randomly selected to make a total of nine villages for the study of drip irrigation.

3.1.1.4 Selection of Respondents

. From the selected villages a sample size of 45 drip adopted coconut farmers selected based on probability proportional to plantation age and coconut area under drip irrigation. The drip irrigated Coconut growers in each village were listed and were stratified into two groups viz., those having pre-bearing orchards (1-5 years) and those having bearing orchard (6-50 years). Farmers having pre- bearing orchards of 1-5 years age constitute six farmers. Farmers having bearing orchard were again stratified into those having orchards of 6-10 years age (11), 11-40 years age (20) and 41-50 years age (8). Total sample sizes of 45 drip irrigated farmers were selected. Another group of 45 conventionally irrigated farmers were selected from the same villages and stratified among the pre-bearing orchards of 1-5 years of age with 6 farmers and bearing orchards were orchards of 6-10 years age (10), 11-40 years age (13) and 41-50 years age (16). According to probability proportion of plantation age, the distribution of the selected growers furnished in the table 3.1.

Table 3.1. Plantation age-wise classification of Coconut respondents

Age of coconut 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
1-5	6	13.33	6	13.33
6-10	11	24.44	10	22,22
11-40	20	44.45	13	28.89
41-50	8	17.78	16	35.56
Total sample	45	100.00	45	100.00

Source: Field survey data

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 Coconut cultivation was obtained through survey method. A pre-tested questionnaire was used prior to the actual data collection. Based on experience gained in pretesting, the interview schedule was modified wherever needed and schedule was finalised for recording the responses of farmers. Farmers in the research area were surveyed according to this well designed questionnaire. The questionnaire was mainly focused on the information related to the details of drip method of irrigation in comparison with the conventional method of irrigation in Coconut. The data collection was carried out during February and March of 2014.

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, Srikakulam. Details regarding the drip irrigation area, subsidy rates were collected from Andhra Pradesh Micro Irrigation Project, Srikakulam.

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 study area. In case of permanent labour payment made in kind like grain, meals and other pre-requisites were 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 actual price paid by the farmers.

3.3.4 Type of Irrigation

In case of conventional method of irrigation water applied to coconut plants through flood method of irrigation and the source of irrigation was ground water and extracted by 5 HP pump sets. In case of drip irrigation method ground water was extracted by 5 HP pump sets and then stored in with storage tank which was included in drip system itself and finally applied to the coconut plants.

3.3.5 Manures and Fertilizers

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

3.3.6 Plant Protection Chemicals

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

3.3.7 Land Revenue

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

3.3.8 Interest on Working Capital

The working capital consists of the expenditure on labour, planting material, manure, fertilizers and plant protection chemicals. Interest on operational capital was calculated at the rate of 11.5 per cent per annum for the life period of the crop which is the prevailing bank rate for Coconut plantations.

3.3.9 Interest on Fixed Capital

Interest on present value of fixed assets (excluding land) has been calculated at 11.5 per cent per annum. The items considered under fixed capital are implements and machinery. Interest was considered on the value of these assets after deducting the depreciation for the year.

3.3.10 Depreciation

The depreciation was worked out for the items like farm machinery and implements. The average life of the assets as indicated by the experts (Agril. Engineers) was used in the computation of the depreciation. Depreciation was calculated by straight line method.

3.3.11 Rental Value of Owned Land

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

3.3.12 Farm Assets

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

3.3.13 Cost of Cultivation

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

3.3.14 Cost of Production

The expenditure incurred in producing a unit quantity of output.

3.3.15 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, manures and fertilizers application, plant protection measures, watch and ward including harvesting, interest on working capital etc.

3.3.16 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.

3.3.17 Computation of Costs and Returns

Coconut is a perennial crop with an approximate bearing life span of up to 50 years. Hence, the cost incurred were classified into two categories viz.,

1. Establishment cost
2. Maintenance cost

3.3.17.1 Establishment cost

The establishment cost included all the expenditure incurred during pre-bearing period of 1- 5 years for the establishment of Coconut 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 Coconut cultivation.

3.3.17.2 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.

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

The annuity of Coconut was distributed over the economic life of 50 years of coconut. 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 for every 10 years upto the economic life of the Coconut plantation. For the remaining period 40 years future worth of annuity was calculated.

$$\text{Present worth of annuity } A = P \times \frac{i(1+i)^n}{(1+i)^n-1}$$

A = annual repayment amount

P = invested fund

i = discount rate = 11.5 per cent

n = number of years = 10

$$\text{Future worth of annuity } A = F \times \frac{i}{(1+i)^n-1}$$

A = annual investment to be made

F = future amount to be realized

i = discount rate = 11.5 per cent

n = number of years = 40 to 50

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 was adopted to compile the general characteristics of the sample farmers, cost structure, returns, profits and total benefits that the farmer received etc. It was also used for comparing the water use efficiency, net present worth, benefit-cost ratio, internal rate of returns, N/K ratio of drip irrigation method with conventional method of irrigation in Coconut. A simple statistical tool like averages, ratios and percentages were computed to interpret results properly.

3.4.2 Water Use Efficiency (WUE)

Water use efficiency is defined as the amount of output produced per unit of water expended for the production. It was calculated by dividing the yield (Y) with the responsive total consumptive use of water for the crop period. The water application to the Coconut crop under conventional method of irrigation was computed by multiplying number of irrigations during the cropping period (*i.e.*, 50 years for coconut), time required to irrigate each time and the water discharged by the source per hour. In this, water discharged from the source (5 HP motor) was measured by considering the time required to fill a container.

In case of drip method of irrigation, the water discharged by each dripper was 8 lit per hour. Hence water applied was calculated by multiplying the number of dripper per hectare, number of irrigations, time required to irrigate the crop per one time irrigation and the water discharged by each dripper per hour.

Then water application was converted from litres per hectare to hectare cm. (1 lakh litres =1 ha-cm).

The following equation was used for calculating the water use efficiency (WUE).

Where

WUE = Y/ W

Y = Yield of Coconut (nuts) per total crop duration

W = Total water applied (lit) per total crop duration.

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 Coconut 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

3.4.3.1.2 Rate of return (ROR) method

ROR method expresses the profits generated by the investment as a percentage of the investment. In other words it is the return per rupee of investment or ratio of earnings to investment. It helps to know the profitability of an investment in the business or generation of returns per rupee of investment and to estimate the profits as percentage of investment.

Rate of Return method (ROR) = $\frac{\text{Average annual profit}}{\text{Average investment}} \times 100$

3.4.3.1.3 Average annual returns per rupee of investment

Average proceeds per year = $\frac{\text{Total receipts}}{\text{Project life span}}$

. Average annual returns per rupee of investment = $\frac{\text{Average proceeds per year}}{\text{Initial investment}}$

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 Coconut 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 11.5 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 = 11.5 per cent

n = number of years = 50 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 = 50 years

i = discount rate = 11.5 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.

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

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 was obtained by simply dividing the present worth of positive net incremental benefits by the present worth of negative net incremental benefits. The selection criterion 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.

3.4.3.2.5.1 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. How much the costs could rise without making the project economically unattractive can be decided by using BCR. Similarly how much benefits could fall making the project economically unattractive. By taking the reciprocal of BCR and subtracting it from one, the net benefit could fall by how much before making the ratio would be driven to one. (Gittenger,1982).

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: Coconut under drip irrigation system

a. with subsidy conditions

b. without subsidy conditions

B: Coconut under conventional methods of irrigation

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

3.4.4. Garret ranking technique

To capture comprehensively the constraints faced by the farmers during installation and maintenance of drip systems in coconut orchards, Garret ranking technique was used. Some major prevailing constraints were highlighted during preliminary survey and the order of the merit given in ascending order was converted into ranks by using the formula. Accordingly, these ranks were converted to scores by referring to Garrets table. Garrett's formula for converting ranks into per cent was given by

$$\text{Per cent position} = \frac{100*(R_{ij}-0.50)}{N_j}$$

Where, R_{ij} = Rank given for i^{th} item by j^{th} farmer

N_j = Number of items ranked by j^{th} farmer

The per cent position of each rank was converted to scores by referring to tables given by Garret and Woodworth (1969). Then for each factor, the scores of individual respondents were summed up and divided by the total number of respondents for whom scores were gathered. The mean scores for all the factors were ranked, following the decision criterion that higher the value the more important is that constrain.

Chapter IV

AGRO-ECONOMIC FEATURES

The success of agriculture and economic growth depends not only on agro-climatic conditions and socio-economic features of the region but also by the demographic features, land holding distribution, cropping pattern and occupational distribution of the people. Since the present study is confined to Srikakulam district, a general view of the agro-economic features of the district and selected mandals will be very useful to have a comprehensive idea of the study area.

4.1 AGRO-ECONOMIC FEATURES OF SRIKAKULAM DISTRICT

4.1.1 Historical Background

Srikakulam district is the extreme northeastern district of the state of Andhra Pradesh in India. Its district headquarters is Srikakulam. It is one of the backward districts of the state, despite its natural resources and other potential, which are yet to be exploited. This district was carved out in 1950 by bifurcating it from Visakhapatnam district. But in November, 1969 the district lost 63 villages from Saluru taluk and 44 villages from Bobbili taluk on account of their transfer to the then newly constituted Gajapathinagaram Taluk of Visakhapatnam District. Again in May, 1979, the district had undergone major territorial changes on account of the formation of new Vizianagaram district which involved transfer of Salur, Bobbili, Parvathipuram and Cheepurupalli taluks to the new district.

4.1.2 Boundaries

Srikakulam district is situated within the geographical co-ordination of 18^0 20' and 19^0 10' of the Northern Latitude and 83^0 50' and 84^0 50' of the Eastern Longitude which extends over an area of 5837 sq. km. with coastal length of 193 km extending from Ranastalam mandal to Itchapuram mandal. The district is bound on the North by Orissa State, on the west and South by Vizianagaram district and on the east by Bay of Bengal.

4.1.3 Administrative Set-up

Administratively, the district is divided into three revenue divisions viz., Srikakulam, Palakonda and Tekkali with38 revenue mandals and it consists of 1865 revenue villages, 1099 gram panchayats. There are 11 urban units in Srikakulam district. Out of these four are municipalities, two are nagar panchayats and three are notified major panchayats and the rest of two are urban areas. Srikakulam, Amudalavalasa, Ichapuram and Palasa-Kasibugga are municipalities, Rajam and Palakonda both are nagar panchayats, Sompeta, Tekkali and Narasannapeta are notified major panchayats, Ponduru and Hiramandalam both are urban areas. Revenue divisions are headed by RDOs whereas mandal and mandal prajaparishads are lead by MROs and MDOs respectively. The district collector is overall administrative head of the district.

4.1.4 Demographic Particulars

The population details of the district are shown in the table 4.1. The total population of the district as per 2011 census is 27, 03,114 lakhs which accounts for 3.20 per cent of the total population of the state. The decennial growth rate of the population from 2001census to 2011 census was 6.50 percent for the district as against 9.21 percent of the State. Out the total population of the district the female and male population of the district was 13, 61,376 and 13, 41,738 respectively. The rural population of the district was 22, 66,411 and it constituted 83.8 per cent of the district population. Similarly, the urban population of the district was 4, 36,703 and forming 16.2 per cent of the district population. The district has a population density of 463 inhabitants per sq. km as against the state average of 308. The sex ratio of the district was 1015 females per 1000 males as against 992 of the state. There are 8, 57,824 male literates and 6, 37,557 female literates. The literacy rate is 71.61 percent among males, 52.08 percent among females and 61.74percent among total population of the district. The number of main workers in Srikakulam district was 9, 36,244forming 34.64 per cent of total population. The number of cultivators in Srikakulam district was 1, 65,317 forming 6.12 per cent of total population. The number of agricultural labour and non-workers in the district were 7, 00,833 and 14, 12,826 respectively.

Table: 4.1. Population statistics of Srikakulam district (2011 census)

S.No.	Item	Unit	Population
1.	Total population	Lakhs	27.03114 \
2.	Male population	Lakhs	13.41738
3.	Female population	Lakhs	13.61376
4.	Total Child Population (0-6 Age)	Lakhs	2.81037
5.	Male Population (0-6 Age)	Lakhs	1.43835
6.	Female Population (0-6 Age)	Lakhs	1.37202
7.	Density of population	Per sq.km.	463
8.	Females per thousands males	No.	1015
9.	Rural population	Lakhs	22.66411
10.	Percentage of rural population to total population	Percentage	83.84 %
11.	Urban population	Lakhs	4.36703
12.	Percentage of urban population to total population	Percentage	16.16 %
13.	Literates	Lakhs	14.95381
14.	Male Literates	Lakhs	8.57824
15.	Female Literates	Lakhs	6.37557
16.	Main workers	Lakhs	9.36244
17.	Marginal workers	Lakhs	3.54044
18.	Non-workers	Lakhs	14.12826
19.	Cultivators	Lakhs	1.65317
20.	Agricultural labour	Lakhs	7.00833

Source: Hand Book of Statistics 2012-13, CPO, Srikakulam district.

4.1.5 Household Indicators

According to a survey made by International Institute for Population Sciences (2007-08), 86.9% had access to electricity, 70.4% had drinking water, 18.5% toilet facilities, and 47.2% lived in a pucca (permanent) home and 90.1% of interviewees carried a BPL card out of 1025 households in 44 villages across the district.

4.1.6 Public Health and Medical

The district has one general hospital, no hospitals for special treatments and 75 PHCs apart from other related wings in allopathy. As many as 582 beds also exits. All the allopathy institutions managed by 125 doctors. In other disciplines of ayurvedic, unani and homeopathy, there are as many as 35 hospitals and dispensaries.

4.1.7 Education

The literacy rate of the district is 61.74 per cent which is lower than the state literacy rate of 67.66 per cent. The only university in the district includes Dr. B. R. Ambedkar University. There are 2763 primary schools, 827 upper primary schools, 132 high schools, 150 junior colleges, 70 degree colleges, 9 engineering colleges, 2 medical colleges, 1 dental college, 1 agricultural college, 1 law college, 2 pharmacy colleges, 1 nursing college, 10 B.ed colleges, 2 M.B.A colleges, 2 M.C.A colleges, 4 polytechnic colleges, 5 I.T.I colleges exist in the district.

4.1.8 Soils

In general the soils of the district are very fertile and they are broadly classified as black soils, red soils, sandy soils and alluvial soils. The major soil types spread among the district are red soils (58.60 %) followed by brown forest soils (14.60 %), alluvial soils (10.3 %), black soils (5.11 %), sandy soils (2.21%) and other soils (9.17 %). Red soils occur mostly along hill slopes. The narrow valleys and low lying areas between the hills are also covered with red loamy soils. Sandy soils are seen occurring in the southern and eastern parts of the district. The deltaic alluvial soil is seen distributed along the banks of the rivers Vamsadhara, Nagavalli and their tributaries. The coastal alluvial soils are seen in the coastal tracts of the district in parts of Ichapuram, Sompeta and Tekkali area. The red sand and lateritic soils are mostly distributed throughout the district.

4.1.9 Rivers

Nagavali, Vamsadhara, Suvarnamukhi, Vegavathi, Mahendratanaya, Gomukhi, Champavathi, Bahuda and Kumbikotagedda are the important rivers which contribute for the economic development of the district. Among these rivers Vamsadhara, Nagavali and Suvarnamukhi are perennial. The Vamsadhara river rises in the Eastern Ghats of Orissa state and enters Srikakulam district in Bhamini mandal and finally falls into the Bay of Bengal near Kalingapatnam. The Nagavali and Suvarnamukhi rivers also originate in the Eastern Ghats while Nagavali in Vangara mandal and the confluence joins the Bay of Bengal at Kallepalli near Srikakulam. The Vegavathi river rises in Pachipenta village and flow from west to east, ultimately joining the river Suvarnamukhi, Gomukhi joins Suvarnamukhi at Sirlam village of Vizianagaram district and Mahendratanaya which is atributory of Vamsadhara joins the later at Komanapalli village in Hiramandalam mandal. The Bahuda river also rises in the Eastern Ghats enters into Srikakulam district at Boddapadu village of Ichapuram mandal and flows through Ichapuram, Kaviti and Mandasa and enters into Bay of Bengal at Donkuru village.

4.1.10 Forests

In the Srikakulam district the area under the forest is 68,641 hectares which constitutes 12% of the total geographical area of the district. The Srikakulam district with one forest division with 3 forest ranges as Palakonda, Pathapatnam and Kasibugga. The important products if the forest is tamarind, timber, turmeric, hill brooms, gum, cashew, pineapple, custard-apple, adda leaves, beedi leaves, nuxvomica, soap nuts, marking nuts etc. The tribes like Savaras, Jatapus, Gadabas and Kons are widely seen in this forest area. They make their lives mostly depending upon the forest while some are involved in cultivation.

4.1.11 Climate and Rainfall

The climate of the district is generally tropical in nature and characterized by high humidity all through the year along with oppressive summer and good seasonal rainfall. April to June months was the hottest months and the temperature runs very high in the month of May. The mean maximum temperature is 30-40 ^{0}C during April-May and the mean minimum temperature is 18 ^{0}C during December-January. The period from December to middle of February is generally the season of fine weather. Since, the area was located nearer to coast where the atmospheric humidity is high. The relative humidity in the district is of the order of 80 percent in the mornings throughout the year, where as in the evenings the relative humidity varies from about 70 to more than 80 percent. Winds in the district are generally light to moderate in speed and during the early part of the southwest monsoon season with directions mostly between south and west.

Month wise rainfall for the selected district is presented in table 4.2 for 2013-14 agricultural year.

Table 4.2. Rainfall received during 2013-14 in Srikakulam district (Rainfall in mm)

S.No	Monsoon Period	Normal Rainfall	Actual Rainfall	Percentage of Deviation
1	South-West (June - September)	705.7	571.0	-19.1
2	North - East (October - December)	276.0	620.0	124.6
3	Winter (January - February)	25.9	0.0	-100.0
4	Hot Weather Period (March - May)	154.0	198.9	5.44
	DIST. TOTAL	**1161.6**	**1389.9**	**19.7**

Source: Hand Book of Statistics 2012-13, CPO, Srikakulam district.

The Southwest monsoon which follows the summer lasts up to the second week of October. The South-West monsoon provides nearly 2/3rd of total annual rainfall, which was evenly spread over the district. The Northwest monsoon starts from mid-October to the end of November.

Srikakulam district receives total normal rainfall of 1161.6 mm per annum. Normal rainfall of the South-West Monsoon season from June to September is 705.7 mm *i.e.,* 60 per cent of annual normal rainfall, and North-East monsoon during October and December months provides 276 mm *i.e.,* 23.8 per cent of annual normal rainfall.

4.1.12 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 Srikakulam district 2013-14

(Area in Hectares)

S.No.	Source	Area	Per cent to gross irrigated area
1	Canals	110699	52.38
2	Tanks	58761	27.80
3	Tube wells & Filter points	3283	1.55
4	Other wells	4861	2.30
5	Lift irrigation	353	0.17
6	Other sources	3893	1.84
7	Gross area irrigated	211351	100.00
8	Area irrigated more than once	29501	13.96
9	Net area irrigated	181850	86.04

Source: *Agricultural Census, Chief Planning Office, Srikakulam district.*

Srikakulam district consists of net irrigated area of 1, 18,850 hectares. Srikakulam channel commands 52.38 per cent under canals, 27.80 per cent under tanks respectively. It is seen from the table that the canal irrigation is the predominant source for the district.

4.1.13 Land Utilization Pattern

The total geographical area of the district is 5, 83,700 hectares. During the year 2013-14 the cultivable land (i.e., net area sown, current fallows and other fallow lands) was 3, 54,859 hectares and it accounted for 60.79 percent of the total geographical area of the district. The area covered by forests is 68,641 hectares which forms 11.76 per cent to the total geographical area.

Land utilization pattern of the district is shown in the table 4.4 so as to have a comprehensive idea regarding the land utilization pattern.

Table 4.4. Land utilization pattern of Srikakulam district in 2013-14.

S.No	Classification of the area	Area (ha)	Per cent to the total area
1	Forests	68641	11.76
2	Barren and uncultivated wastes	48408	8.29
3	Land put to non-agricultural use	102477	17.56
4	Cultivable waste	525	0.09
5	Permanent pastures and other grazing lands	942	0.16
6	Land put under miscellaneous trees	7451	1.28
7	Current fallows	38210	6.55
8	Other fallows	14718	2.52
9	Net cropped area	301931	51.73
10	Fish ponds	397	0.07
11	Total Geographical area	583700	100.00
13	Total cropped area	414006	--
14	Area sown more than once	112075	--

Source: Hand Book of Statistics 2012-13, CPO, Srikakulam district

Land put to non-agricultural uses occupied by buildings, roads and railways or under water i.e., rivers, canals and other land put to uses other than agriculture area is 1, 02,477 hectares accounting for 17.56 per cent of the geographical area. The gross cropped area of the district is 4, 14,006 hectares. Area sown more than once is 1, 12,075 hectares and cultivable waste is 525 hectares. Land put under miscellaneous tree crops and groves not included in the Net area sown occupied an area of 7,451 hectares accounted for 1.28 per cent of the total geographical area.

4.1.14 Land holdings distribution

There are about 5, 25,870 land holdings with an operated area of 8, 62,746.2 ha in the district as per 2010-11world agricultural census (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 or < 2.46 acres)	427437	81.28	388877.69	45.07
2	Small farmer (1 to 2 ha or 2.47 to 4.93 acres)	70894	13.48	240135.11	27.83
3	Semi-medium farmers (2 to 4 ha or 4.94 to 9.87 acres)	21851	4.16	142607.53	16.53
4	Medium farmers (4 to10 ha or 9.88 to 24.70 acres)	5243	1.00	69404.01	8.04
5	Large farmers (>10 ha or 49.42 acres and above)	445	0.08	21721.86	2.52
6	**Total**	**525870**	**100**	**862746.2**	**100.00**

Source: Hand Book of Statistics 2012-13, CPO, Srikakulam district

4.1.15 Agriculture and Cropping Pattern

The role of agricultural sector in district economy is very significant and agriculture is the predominant activity in the district with 75% of the main working population engaged in the agriculture activities. The growth and development of the district is therefore, closely linked with development of agriculture, which needs to be increased substantially. Agriculture in Srikakulam district is mostly rainfall dependent; monsoon and seasonal conditions play a major role in the agriculture production.

There is a gradual change from cultivating traditional varieties to high yielding varieties in the district which has resulted in increased production and productivity. The district is endowed with 146 seed depots, 378 fertilizer depots and 59 pesticide depots. The district has 100 rural godowns with a total capacity of 90,000 MT and 10 cold storages for supporting the agriculture activity. The crop grown and their area of production in the district were shown in the table 4.6.

Table 4.6. Area under principle crops in Srikakulam district during 2013-14

(Area in hectares)

Sl. No.	Crop Name	*Kharif*	*Rabi*	Total	Per cent to total area
1	Paddy	199717	3425	203142	49.07
2	Jowar	39	21	60	0.01
3	Bajra	210	0	210	0.05
4	Maize	5752	4985	10737	2.59
5	Ragi	331	712	1043	0.25
6	Horsegram	0	5215	5215	1.26
7	Greengram	1158	31662	32820	7.93
8	Blackgram	640	42445	43085	10.41
9	Redgram	706	16	722	0.17
10	Chillies	48	1937	1985	0.48
11	Sugarcane	5682	5122	10804	2.61
12	Mango	9164	0	9164	2.21
13	Plantain(Banana)	2422	0	2422	0.59
14	Cashew Nut	23214	0	23214	5.61
15	Oil Palm	312	0	312	0.08
16	Tapioca	41	0	41	0.01
17	Cotton	9846	0	9846	2.38
18	Ground Nut	9945	6065	16010	3.87
19	Sesamum	1199	4037	5236	1.26
20	Coconut	14480	0	14480	3.50
21	Tobacco	2	0	2	0.00
22	Flowers	3	5	8	0.00
23	Other Crops	17020	6428	23448	5.66
Gross Area Sown		**301931**	**112075**	**414006**	**100.00**

The table 4.6 revealed that, as per 2013-14 in Srikakulam major cropped area was occupied by paddy with an area of 2, 03,142 hectares followed by cashew nut and coconut.

The predominant crops grown in the district are paddy (49.07 per cent), and maize (2.59 per cent) among cereals, blackgram (10.41 per cent), greengram (7.93 per cent) and horsegram (1.26 per cent) among pulses, ground nut (3.87 per cent) and sesamum (1.26 per cent) among oil seeds, cashew nut (5.61 per cent) and coconut (3.50 per cent) among plantation crops, sugar cane (2.61 per cent), cotton (2.38 per cent), mango (2.21 per cent) and chillies (0.48 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, cauliflower, cabbage *etc.*, and these vegetable crops are grown in all three seasons of the year. In Srikakulam district greengram, blackgram, groundnut, maize, horsegram, sugarcane, paddy, and sesamum are major crops during Rabi season.

4.1.16 Animal husbandry

The district has total livestock population of 17, 58,523 according to 2007 livestock census. There are 8,07,235 cattle, 1,25,958 buffaloes, 5,00,692 sheep, 1,87,995 goat, 10,350 pigs and 17,19,950 poultry population in the district. There are 195 veterinary institutions, 13 veterinary hospitals and 99 rural livestock units catering to veterinary services in the district. The marginal formers, who are large in number, are habituated to possess many milch animals. Four milk-chilling centers have come up so far. Dairy product units can be encouraged. Poultry, eggs, meat & meat products are also having good potential.

4.1.17 Fisheries

There is a lot of scope for fisheries since the district has got long coastal length, which is the highest among the nine coastal districts of Andhra Pradesh. The fishermen population reported to be 45,589 living in 98 villages and there are about 123 fishermen co-operative societies in the district.

4.1.18 Banks

Production credit is an essential input for development of agriculture. The particulars pertaining to number of bank branches established in the district were represented by table 4.7. It is evident from the Table 4.8 that in the district number of nationalized banks are more (125) followed by regional rural banks (73), private banks (18) & others and co-operative banks (12) respectively.

Table 4.7 Number of bank branches in Srikakulam district 2013-14

S.No.	Banks	Number
1	Nationalized banks	125
2	Regional Rural Banks	73
3	Co-operative banks	12
4	Private banks & others	18
	Total	228

Source: Hand book of statistics 2012-13, Srikakulam district

4.1.19 Road/Railway/Air/Water Transport net work

The important Howrah – Chennai main line passes through the district by means of both broad gauge (156 km) and meter gauge (37 km) length of railway line and thus given access for reaching both the ends in the East and South of the Country. The district has 26 railway stations connecting important places like Ponduru, Amadalavalasa, Naupada, Palasa, Ichapuram*etc.,* in the district.

The Chennai – Howrah high way *i.e,* NH5 – passes through, the district for the length of 173.4 km while the State high way & Zilla parishad roads are 133.82 km & 1995.43 km respectively. Besides, the mandal perished roads are covering the district to an extent of 1137.31kms. The Andhra Pradesh State Road and Transport Committe is maintaining a fleet of buses for providing transport facilities even to the interior corners of the district.

The nearest airport is Visakhapatnam which is about 100 km away from the district head quarters. It connects to all important places in the country.

Fishing harbour is being established at Bhavanapadu village. About 200 mechanised boats are providing berthing facilities at this harbour. The district has long coastal line with 193 km length but sufficient water transport is not being carried out for fishing purpose. There is natural harbour at Visakhapatnam which is 100 km from Srikakulam.

4.1.20 Agro-Industrial Scenario

The district offers tremendous potential for establishment of large, medium and small scale industries and the cost of the land and labour are also cheap and other natural resources are also available in the district. The major activities of the industries in the district are pharmacy, cashew, jute, coir, pesticide, pistons, ammonium nitrate, rice mills, granite, stone crushers, beach sand minerals and power & sugar. There are 35 large and medium scale industries in the district were established with an investment of Rs. 3,136.04 crores and provided employment around 16,358 persons and 5,922 micro and small scale industries were established with an investment of Rs. 318.85 crores and provided 51,104 employments to the unemployed persons. In addition to the above 42 large and medium scale industries are under implementation with an investment of Rs.47, 431.80 crores for providing 17,697 employment to the unemployed youth and 3,482 micro and small scale industries are also under implementation with an investment of Rs.1, 255.90 crores for providing 19,317 employment to the unemployed persons and the major activities of these industries are power, pharma, textiles, granite, cashew, beach sand minerals, sugar & ferro alloys *etc.*,

4.2 DETAILS OF COCONUT AND DRIP IRRIGATION

4.2.1 Coconut Cultivation in India

From Table 4.8 it can be represented that in India, Kerala stands first in the area of Coconut occupying 41.56 per cent *i.e.*, 788000 ha followed by Karnataka, Tamilnadu and Andhra Pradesh occupying 22.10 per cent, 20.10 per cent and 5.48 per cent consisting of 419000 ha, 390000 ha and 103945 ha respectively.

Table 4.8. Area under Coconut cultivation in India during 2010-11

S.No	State	Area in hectares	Per cent to total area
1	Kerala	788000	41.56
2	Karnataka	419000	22.10
3	Tamil Nadu	390000	20.57
4	Andhra Pradesh	103945	5.48
5	Orissa	50945	2.69
6	West Bengal	28600	1.51
7	Goa	25600	1.35
8	Andaman and Nicobar Islands	21700	1.14
9	Maharashtra	21000	1.11
10	Assam	18800	0.99
11	Gujarat	16000	0.84
12	Tripura	5800	0.31
13	Lakshadweep	2700	0.14
14	Pondicherry	2100	0.11
15	Nagaland	900	0.05
16	Chhattisgarh	700	0.04
17	**Total**	**1895900**	**100.00**

Source: Technology Mission of Oilseeds, Department of Agriculture & Cooperation Ministry of Agriculture (2010-11)

4.2.2 Coconut Cultivation in Andhra Pradesh

Table 4.9 represented that in Andhra Pradesh, East Godavari stands first in the area of Coconut occupying 48.86 per cent *i.e.*, 50789 ha followed by West Godavari, Srikakulam and Visakhapatnam occupying 19.66 per cent, 14.06 per cent and 7.47 per cent consisting of 20437 ha, 14619 ha and 7763 ha respectively.

Table 4.9. Area under Coconut Cultivation in Andhra Pradesh during 2010-11

S. No.	District	Area in hectares	Per cent to total area
1	East Godavari	50789	48.86
2	West Godavari	20437	19.66
3	Srikakulam	14619	14.06
4	Visakhapatnam	7763	7.47
5	Chittoor	3837	3.69
6	Vijayanagaram	1909	1.84
7	Krishna	1897	1.83
8	Nellore	788	0.76
9	Anantapuram	786	0.76
10	Khamam	707	0.68
11	Guntur	142	0.14
12	Cuddapah	131	0.13
13	Prakasam	73	0.07
14	Kurnool	51	0.05
15	Other Districts	16	0.02
17	**Total**	**109365**	**100.00**

Source: Technology Mission of Oilseeds, Department of Agriculture & Cooperation Ministry of Agriculture (2010-11)

4.2.3 Coconut Cultivation in Srikakulam District

Table 4.10 represented that Coconut occupies a total of 14480 ha in Srikakulam district. Kaviti mandal stands first in Coconut area in Srikakulam with 35.03 per cent (5072 ha) followed by the VajrapuKotturu, Mandasa, Kanchili, Ransthalam and Sompeta mandals with 12.89 per cent, 12.17 per cent, 11.24 per cent, 9.13 per cent and 6.08 per cent respectively.

Table 4.10. Area under Coconut cultivation in Srikakulam district during 2013-14

S. No.	Mandal	Area in hectares	Per cent to total area
1	Kaviti	5072	35.03
2	VajrapuKotturu	1866	12.89
3	Mandasa	1762	12.17
4	Kanchili	1628	11.24
5	Ransthalam	1322	9.13
6	Sompeta	881	6.08
7	Etcherla	359	2.48
8	Ichapuram	350	2.42
9	Gara	315	2.18
10	Laveru	219	1.51
11	Santhabommali	210	1.45
12	Polaki	190	1.31
13	Palasa	125	0.86
14	Other Mandals	181	1.25
17	**Total**	**14480**	**100.00**

Source: Department of Horticulture, Srikakulam District (2013-14).

4.2.3 Area Coverage under Drip Irrigation in Srikakulam District

Adoption of drip irrigation is prominent in Srikakulam district covering an area of 5079.17 ha. Coconut occupied a significant position in the district by occupying 38.70 per cent to the total drip irrigated crops covering an area of 1965.97 ha. It is followed by sugar cane, banana, mango, maize with 14.33 per cent, 9.09 per cent, 6.76 per cent, and 4.86 per cent respectively and the remaining 26.26 per cent distributed among the remaining crops in the district. Details of area coverage under drip irrigation in Srikakulam district during 2013-14 was represented by Table 4.11.

Table 4.11. Area coverage under drip irrigation in Srikakulam district during 2013-14

S.No	Crop	Area(ha)	Per cent to total
1	Coconut	1965.97	38.70
2	Sugarcane	728.20	14.33
3	Banana	461.81	9.09
4	Mango	343.10	6.76
5	Maize	246.23	4.86
6	Other crops	1333.86	26.26
7	**Total**	**14156.13**	**100.00**

Source: Andhra Pradesh Micro Irrigation Project (APMIP), Srikakulam, 2013-14.

4.2.3 Area Coverage under Coconut with Drip Irrigation in Srikakulam District

Area under different mandals in Coconut and the area under drip irrigation in Coconut are given in the table 4.10.

Table 4.12 Area under Coconut cultivation and drip irrigation in Srikakulam district during 2013-14.

S.No	Mandal	Total area under Coconut (ha)	Coconut area under drip irrigation (ha)	Per cent of Coconut area under drip irrigation in the mandal
1	Kaviti	5072.00 (35.03)	490.99 (24.96)	9.68
2	VajrapuKotturu	1866.00 (12.89)	125.41 (6.37)	6.72
3	Mandasa	1762.00 (12.17)	41.97 (2.13)	2.38
4	Kanchili	1628.00 (11.24)	64.42 (3.28)	3.96
5	Ranastalam	1332.00 (9.13)	834.77 (42.44)	62.67
6	Etcherla	359.00 (2.48)	195.10 (9.92)	54.35
7	Gara	315.00 (2.18)	63.27 (3.22)	46.91
8	Laveru	219.00 (1.51)	61.72 (3.14)	2.82
9	Santhabommali	210.00 (1.45)	29.80 (1.52)	14.19
10	Other mandals with less coverage of Coconut area	1727.00 (11.93)	59.46 (3.02)	3.44
	TOTAL	**14480.00 (100.00)**	**1966.91 (100.00)**	**13.58**

Note: Figures in parenthesis indicate the percentage to total

Source: Andhra Pradesh Micro Irrigation Project (APMIP). Srikakulam, 2014

Ranastalam mandal stands first for the adoption of drip irrigation in coconut in Srikakulam district with 42.44 per cent followed by the Kaviti and Echerla mandals with 24.96 per cent and 9.92 per cent respectively.

4.3 AGRO-ECONOMIC FEATURES OF THE SELECTED MANDALS

The three mandals selected for the study are Ranastalam, Echerla and Kaviti. Six villages from these three mandals were selected as Akkayyapalem, Kotapalem, Teppalavalasa from Ranastalam mandal, Koyyam, Dharmavaram, Bonthalakoduru from Echerla mandal and Kaviti, Balliputtuga, Jagathi from Kaviti mandal for the present study in Srikakulam district.

4.3.1 Demographic Features

Details of population, literacy rate, labour force and cultivators are important in influencing the economy.

The population of Ranastalam mandal as per 2001 census is 85,872 of which 50.99 per cent *i.e.,* 43,787is males and the remaining 49.01 per cent *i.e.,* 42,085 is females. The population density is 407 per sq. km. and the percentage of literacy is 46.11 per cent. The population of Echerla mandal as per 2001 census is 87,847 of which 50.84 per cent *i.e.,* 44,660 is males and the remaining 49.16 per cent *i.e.,* 43,187 is females. The population density is 488 per sq. km. and the percentage of literacy is 50.35 per cent. The population of Kaviti mandal as per 2001 census is 75,974 of which 47.87 per cent *i.e.,* 36,365 is males and the remaining 52.13 per cent *i.e.,* 39,609 is females. The population density is 644 per sq. km. and the percentage of literacy is 56.07 per cent.

The number of main workers in Ranastalam mandal was 33,281 forming 38.76 per cent of total population. The number of cultivators in Ranastalam mandal was 5,301forming 6.17 per cent of total population. The number of agricultural labour and non-workers in the mandal were 21,447 and 44,185 respectively. The number of main workers in Echerla mandal was 31,839 forming 36.24 per cent of total population. The number of cultivators in Echerla mandal was 4,432 forming 5.05 per cent of total population. The number of agricultural labour and non-workers in the mandal were 20,958 and 45,988 respectively. The number of main workers in Kaviti mandal was 22,621 forming 29.77 per cent of total population. The number of cultivators in Echerla mandal was 2,466 forming 3.25 per cent of total population. The number of agricultural labour and non-workers in the mandal were 20,437 and 40,117 respectively.

The details of population of selected mandals were presented in the table 4.9.

Table 4.13. Demographic features of selected mandals (2001 census)

S. No.	Particulars	Unit	Ranastalam		Echerla		Kaviti	
			2001	Per cent to total population	2001	Per cent to total population	2001	Per cent to total population
1	Total population	No	85872	100.00	87847	100.00	75974	100.00
	a) Male	No	43787	50.99	44660	50.84	36365	47.87
	b) Female	No	42085	49.01	43187	49.16	39609	52.13
2	Density of population	Per sq.km	407	-	488	-	644	-
3	Females per 1000 males	No	961	-	967	-	1089	-
4	Literates	No	39597	46.11	44235	50.35	42600	56.07
	a) Male	No	23415	27.27	25996	29.59	24307	31.99
	b) Female	No	16182	18.84	18239	20.76	18293	24.08
5	Total main workers	No	33281	38.76	31839	36.24	22621	29.77
	a) Cultivators	No	5301	6.17	4432	5.05	2466	3.25
	b) Agricultural labour	No	21447	24.98	20958	23.86	20437	26.90
6	Total non-workers	No	44185	51.45	45988	52.35	40117	52.80
7	Marginal workers	No	8406	9.79	10020	11.41	13236	17.42

Source: Hand Book of Statistics 2013-14, Chief Planning Office, Srikakulam District.

4.3.2 Land Utilization Pattern

Land utilization pattern of the selected mandals is shown in the table 4.14 so as to have a comprehensive idea regarding the land utilization pattern.

Table 4.10 reveals that in Ranastalam mandal total cropped area was 12,949. Net sown area was 11,736 which occupies 55.64 per cent of the total geographical area of the mandal followed by barren and uncultivated land, land put to non-agricultural use and forests with 6.97 per cent, 19.88 per cent and 3.30 per cent respectively. This table also reveals that in Echerla mandal total cropped area was 13,511. Net area sown was 11,276 which occupies prime place with 62.60 per cent of the total geographical area of the mandal followed by barren and uncultivated land, land put to non-agricultural use and forests by 3.81 per cent, 23.57 per cent and 4.15 per cent respectively.

Table 4.14. Land utilization pattern in selected mandals during 2013-14

(Area in hectares)

S.No.	Classification of the area	Ranastalam	Echerla	Kaviti
1	Forests	696 (3.30)	747 (4.15)	914 (7.75)
2	Barren and uncultivated land	1471 (6.97)	686 (3.81)	874 (7.41)
3	Land put to non-agricultural use	4193 (19.88)	4246 (23.57)	2045 (17.33)
4	Cultivable waste	17 (0.08)	4 (0.02)	10 (0.08)
5	Permanent pastures and other grazing lands	17 (0.08)	2 (0.01)	4 (0.03)
6	Miscellaneous tree crops & grooves not included in net area sown	739 (3.50)	48 (0.27)	-- (0.00)
7	Current fallows	1887 (8.95)	982 (5.45)	509 (4.31)
8	Other fallows	337 (1.60)	12 (0.07)	105 (0.89)
9	Net area sown	11736 (55.64)	11276 (62.60)	7338 (62.19)
10	Total cropped area	12949 (61.39)	13511 (75.01)	7544 (63.94)
11	Fish Ponds	-- (0.00)	10 (0.06)	-- (0.00)
12	Area sown more than once	1213 (5.75)	2235 (12.40)	206 (1.75)
	Total geographical area	**21093 (100.0)**	**18013 (100.0)**	**11799 (100.0)**

Note: Figures in parenthesis indicate the percentage to total
Source : Hand book of statistics (2013-14), Srikakulam District.

In Kaviti mandal the total cropped area was 7,544. Net area sown was 7,338 which occupies prime place with 62.19 per cent of the total geographical area of the mandal followed by barren and uncultivated land, land put to non-agricultural use and forests by 7.41 per cent, 17.33per cent and 7.75 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 4.15.

Table 4.15 reveals that Ranastalam mandal consists of 3,100 marginal farmers followed by 495 small farmers and 162 semi–medium farmers. Echerla mandal consists of 3,265 marginal farmers followed by 280 small farmers and 115 semi–medium farmers. Kaviti mandal consists of 12,170 marginal farmers followed by 1,492 small farmers and 697 semi–medium farmers.

Table 4.15. Distribution of land holdings of selected mandals during 2013-14

(Area in hectares)

S.No.	Type of Farmer	Ranastalam		Echerla		Kaviti	
		No	**Area**	**No**	**Area**	**No**	**Area**
1	Marginal farmer (< 1 ha)	3100	2776.75	3265	2631.1	12170	9009.80
2	Small farmer (1-2 ha)	495	1678.29	280	929.88	1492	5407.46
3	Semi-medium farmers (2-4 ha)	162	1040.28	115	752.89	697	4617.44
4	Medium (4-10 ha)	47	668.71	64	826.58	306	4096.34
6	Large (>10 ha)	6	196.20	3	81.02	19	644.10
	Total	**3810**	**6360.23**	**3727**	**5221.47**	**14684**	**23775.14**

Source: *Hand book of statistics 2013-14, Chief Planning Office, Srikakulam District.*

4.3.4 Rainfall Pattern

Month wise rainfall for the selected mandals is presented in Table 4.16. Table 4.16 revealed that most of the rainfall in Ranastalam mandal was distributed in May, August, September and October months and less rainfall in June, July, November months and nil rainfall in December, January, February, March and April during year of 2013-14.

In Echerla mandal, most of the rainfall was received in the months of May, June, July, August and October and less rainfall received during September and November months. There is no rainfall during December, January, February, March and April months of the year 2013-14.

Table 4.16 reveals that most of the rainfall in Kaviti mandal was received during the months of May, June, July and October and very less rainfall during August, November and March months. There is no rainfall during September, December, January, February and April months of the year 2013-14.

Table 4.16. Rainfall received during 2013-14 in selected mandals

(Rainfall in mm)

S. No.	Months	Ranastalam			Echerla			Kaviti		
		Actual	**Normal**	**% of Dev.**	**Actual**	**Normal**	**% of Dev.**	**Actual**	**Normal**	**% of Dev.**
1	June-13	79.2	118.9	-33.4	116.0	113.2	2.5	224.4	172.0	30.5
2	July-13	78.8	145.8	-46.0	117.0	159.0	-26.4	151.4	201.6	-24.9
3	August-13	132.6	171.9	-22.9	200.6	170.0	18.0	13.6	204.9	-93.4
4	September-13	188.8	161.4	17.0	45.0	159.2	-71.7	0.0	203.8	-100.0
5	October-13	791.9	193.5	309.3	663.1	177.8	272.9	738.6	235.9	-100.0
6	November-13	50.0	90.1	-44.5	21.2	100.4	-78.9	31.4	145.7	-78.4
7	December-13	0.0	3.9	-100.0	0.0	1.8	-100.0	0.0	3.3	-100.0
8	January-14	0.0	10.3	-100.0	0.0	5.7	-100.0	0.0	4.1	-100.0
9	February-14	0.0	12.8	-100.0	0.0	15.6	-100.0	0.0	16.3	-100.0
10	March-14	0.0	13.1	-100.0	0.0	13.0	-100.0	10.6	17.6	-39.8
11	April-14	0.0	26.3	-100.0	0.0	22.2	-100.0	0.0	16.9	-100.0
12	May-14	105.8	98.0	8.0	131.6	104.1	26.4	109.2	99.2	10.1
	Total	**1427.1**	**1046.0**	**36.4**	**1294.5**	**1042.0**	**24.2**	**1279.2**	**1321.3**	**-3.2**

Source:*Hand book of statistics 2013-2014, CPO, Srikakulam District.*

4.3.5 Cropping Pattern

The predominant crops grown in the selected mandals are paddy and maize among cereals, greengram and blackgram among pulses, sugarcane, mango, cashew nut, coconut, cotton and groundnut among non-food and commercial crops. Among vegetable crops grown in these mandals 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 Ranastalam mandal. This table reveals that maize occupied prime place in Ranastalam mandal by 2800 hectares with 23.53 per cent of the total cropped area followed by banana, cashew nut, coconut, ground nut, mango, paddy and cotton by 17.31 per cent, 14.51 per cent, 11.20 per cent, 8.48 per cent, 8.00 per cent, 4.62 per cent and 3.78 per cent respectively.

Table 4.17 revealed that in Echerla mandal, paddy occupied prime place by 3,088 hectares with40.80 per cent to total gross sown area of the mandal followed by cashew nut, blackgram, mango, maize, coconut and sesamum with 18.72 per cent, 12.06 per cent, 5.52 per cent, 4.96 per cent, 4.74 per cent, and 3.26 per cent respectively.

Table 4.17 revealed that coconut occupied a prime place in Kaviti mandal by 5,072 hectares with 59.31 per cent of the total gross sown area of the mandal followed by paddy, Cashew nut, greengram, blackgram and mango with 28.48 per cent, 5.39 per cent, 3.30 per cent, 1.57 per cent and 1.54 per cent respectively.

The cropping pattern of the selected mandals is given in the table 4.17.

Table 4.17. Cropping pattern in selected mandals during 2013-14

(Area in hectares)

S.No.	Crop name	Ranastalam		Echerla		Kaviti	
		Area	per cent to total area	Area	per cent to total area	Area	per cent to total area
1	Paddy	550	4.62	3088	40.80	2435	28.48
2	Maize	2800	23.53	375	4.96	0	0.00
3	Greengram	282	2.37	412	5.44	282	3.30
4	Blackgram	235	1.98	913	12.06	134	1.57
5	Redgram	9	0.08	5	0.07	7	0.08
6	Other pulses	0	0.00	0	0.00	0	0.00
7	Chillies	233	1.96	53	0.70	1	0.01
8	Sugarcane	148	1.24	84	1.11	16	0.19
9	Mango	952	8.00	418	5.52	132	1.54
10	Banana	2060	17.31	29	0.38	0	0.00
11	Cashew nut	1726	14.51	1417	18.72	461	5.39
12	Tapioca	0	0.00	0	0.00	0	0.00
13	Cotton	450	3.78	88	1.16	0	0.00
14	Oil Palm	27	0.23	0	0.00	0	0.00
15	Ground nut	1009	8.48	80	1.06	5	0.06
16	Sesamum	85	0.71	247	3.26	6	0.07
17	Coconut	1332	11.20	359	4.74	5072	59.31
18	Tobacco	0	0.00	0	0.00	0	0.00
19	**Total**	**11898**	**100.00**	**7568**	**100.00**	**8551**	**100.00**

Source: *Hand Book of Statistics (2013-14), CPO, Srikakulam district*

4.3.6 Irrigation sources

Ranastalam mandal has gross irrigated area of 2076 hectares and net irrigated area of 1654 hectares. Echerla mandal has 4555 hectares and 1589 hectares of gross and net irrigated areas respectively. Gross and net irrigated areas of the Kaviti mandal were 4546 hectares and 3025 hectares respectively.

Area irrigated by different sources and intensity of irrigation in this mandals is included in the table 4.18.

Table 4.18. Net area irrigated by different sources and intensity of irrigation in selected mandals 2013-14 (Area in Hectares)

S.No.	Source	Ranastalam	Echerla	Kaviti
1	Canals	0 (0.00)	0 (0.00)	2233 (49.12)
2	Tanks	900 (43.35)	447 (9.81)	210 (4.62)
3	Tube wells	726 (34.97)	92 (2.02)	98 (2.15)
4	Dug wells	28 (1.35)	1050 (23.05)	484 (10.65)
5	Lift irrigation	0 (0.00)	0 (0.00)	0 (0.00)
6	Other sources	0 (0.00)	0 (0.00)	0 (0.00)
7	Net irrigated area	1654 (79.67)	1589 (34.88)	3025 (66.54)
8	Area irrigated more than once	422 (20.33)	2966 (65.12)	1521 (33.46)
9	Gross irrigated area	2076 (100.00)	4555 (100.00)	4546 (100.00)

Note : Figures in parenthesis indicate the percentage to total

Source : Hand book of statistics (2013-14), Srikakulam District..

Table 4.18 reveals that highest proportion of 43.35 per cent is irrigated under tanks in Ranastalam mandal, followed by 34.97 percent under tube wells. This table also reveals that highest proportion of 23.05per cent is irrigated under dug wells Echerla mandal followed by 9.81 percent under tanks.

In Kaviti mandal the highest proportion of 49.12 per cent is irrigated under canals followed by 10.65 and 4.62 percent area under dug wells and tanks respectively.

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 Coconut cultivation in Srikakulam 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 Coconut plantations in Drip and Conventional methods of irrigation.
3. Cost structure of Drip Irrigation System.
4. Maintenance costs of Coconut cultivation in Drip and Conventional methods of irrigation.
5. Yields and returns of Coconut cultivation with Drip and Conventional methods of irrigation.
6. Financial viability of Drip method of irrigation in Coconut plantations vis-a-vis Conventional methods of irrigation.
7. Water Use Efficiency in Drip irrigation and Conventional methods of irrigation in Coconut cultivation.
8. Constraints in Drip irrigation system in Coconut cultivation.
9. Impact on productivity, returns and viability of drip irrigation over conventional irrigation in coconut.

5.1 CHARACTERISTICS OF SELECTED HOLDINGS

5.1.1Farm 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 4.67 with 38.12 per cent males, 33.83per cent females and 28.05 per cent children. Total number of farm workers in the family was 36.19 per cent of which 24.84 per cent male and 11.35 per cent female members

Table 5.1. Farm family particulars of the selected Coconut growers of drip irrigation and conventional methods of irrigation

S.No.	Particulars	Drip method of irrigation		Conventional method of irrigation	
		Average members per family	Percent to total family members	Average members per family	Per cent to total family members
1	Size of the family				
	(a)Males	1.78	38.12	1.96	39.92
	(b)Females	1.58	33.83	1.82	37.07
	(c)Children	1.31	28.05	1.13	23.01
	Total	4.67	100	4.91	100
2	Farm working members				
	(a)Males	1.16	24.84	1.18	24.03
	(b)Females	0.53	11.35	0.60	12.22
	Total	1.69	36.19	1.78	36.25

Source: Field survey data

Similarly it could be observed from table 5.1that the average size of the family of conventionally irrigated farmers was 4.91 with 39.92 percent males, 37.07per cent females and 23.01per cent children. Total number of farm workers in the family constituted 36.25 per cent of which 24.03 per cent male and 12.22 per cent female were working on the farm.

5.1.2. Age of sample respondents

The distribution of sample farmers according to their age group is shown in table 5.2. The Coconut farmers with age group of 30-40 years were more in number with 36.67 per cent in the total sample of 90 farmers. Among the categories, the farmers with age group of 30-40 years were more in number with 42.22 per cent under drip method of irrigation, whereas under conventional method of irrigation farmers with age group of 41-50 years were dominant with 35.56 per cent. The average age of the sample farmers was 45.34 years. Most of the farmers belong to middle age group and the research studies shown that they adopt new ideas in cultivation.

Table 5.2 Age-wise classification of sample respondents

S.No.	Age of the Coconut farmers (years)	Drip method of irrigation	Conventional method of irrigation	Total Farmers
1	30-40	19 (42.22)	14 (31.11)	33(36.67)
2	41-50	12(26.67)	16(35.56)	28(31.11)
3	51-60	10(22.22)	13(28.89)	23(25.55)
4	> 60 years	4 (8.89)	2(4.44)	6 (6.67)
	Total	45 (100)	45 (100)	90 (100)
	Mean Age	45.58	45.11	45.34

Note: Figures in parentheses indicate percentage to the total

Source: Field survey data

5.1.3. Educational Status

The education status of the sample farmers is presented in table 5.3. It indicates the educational progressiveness of drip adopted Coconut farmers. If people are educated, they are more exposed to different sources of knowledge and access to information and thus, they would be more innovative in accepting the new practices like drip method of irrigation.

Table 5.3. Educational status of the sample respondents

S.No.	Particulars	Farmers with Drip irrigation method	Farmers with conventional irrigation method	Total farmers
1	Illiterate	8 (17.78)	18 (40.00)	26 (28.89)
2	Primary Education	10 (22.22)	9 (20.00)	19 (21.11)
3	Secondary Education	15 (33.33)	12 (26.67)	27 (30.00)
4	College Education	12 (26.67)	6 (13.33)	18 (20.00)
	Total	45 (100)	45 (100)	90 (100)
	Mean Education level	7^{th} standard	5^{th} standard	6^{th} standard

Note: Figures in parentheses indicate percentage to the total

Source: Field survey data

Out of the total sample of 90 Coconut farmers, 71.11 per cent of the farmers were literates and among them 21.11 per cent studied up to primary level, 30.00 per cent studied up to secondary school level and 20.00 per cent up to college level, while the remaining 28.89 per cent farmers were illiterates. Among the Drip adopted coconut farmers, 82.22 per cent of farmers were literates and only the remaining 17.78 per cent farmers were illiterates. The numbers of illiterates were still more among the Coconut farmers with conventional irrigation and accounting for 40.00 per cent. It was concluded that majority of the farmers are literates. The mean educational level of sampled farmers was 6^{th} standard.

5.1.2 Pattern of Land Holdings

The average size of the holding was 4.54 ha for drip irrigated farmers and 3.84 ha for conventionally irrigated farmers. Area under Coconut was about 55.70 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 5.4. In the sample, majority of drip irrigated Coconut plantations were in the age group of 11-40 years which constituted 44.45 per cent of the total number of drip farmers and it occupied with 33.32 per cent of the drip irrigated area of the sample. Among the conventional farmers sample, older age plantations *i.e.*, 41-50 years constituted 34.79 per cent of the sample farmers. Because of older age plantations these groups of farmers have not gone for the adoption of drip method of irrigation.

Table 5.4. Age-wise classification of Coconut plantations in the selected sample and their land holdings

Age of Coconut plantation	Drip method of irrigation				Conventional method of irrigation centre			
	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
1-5	6	13.33	2.32	12.75	6	13.33	2.34	15.24
6-10	11	24.44	5.90	32.44	10	22.22	4.21	27.43
11-40	20	44.45	6.06	33.32	13	28.89	3.46	22.54
41-50	8	17.78	3.91	21.49	16	35.56	5.34	34.79
Total	45	100.0	18.19	100.00	45	100.00	15.35	100.00

Source: Field survey data

5.2 ESTABLISHMENT COSTS OF COCONUT PLANTATIONS

Coconut is a perennial plantation crop and once established the crop can be economically cultivated for about 50 years. The gestation period of Coconut orchard is about five years. The economic yield starts from sixth year onwards. Therefore the cost incurred in establishing the orchard during the pre-bearing period was considered as establishment cost. The establishment cost included all the expenditure incurred on land preparation, digging and filling of pits, plant material and planting, manures, fertilizers and plant protection etc. The maintenance costs included were the expenditure incurred on manures and fertilizers application, plant protection, irrigation, weeding, intercultural operations, harvesting, and transportation.

The study of costs and returns of Coconut cultivation and comparing with and without drip irrigation helps the farmers to improve future Coconut 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, and annuity of drip irrigation system in case of drip method of irrigation.

5.2.1 Establishment Costs in Coconut plantations during pre-bearing period (1-5 years)

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 fifth year can also be termed as pre-bearing costs.

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

Coconut requires evenly distributed annual rainfall of 1000 to 2000 mm; good irrigated and well drained soils. Water deficiency adversely affects the plantation and leads to reduced flowering, more dropping of nuts and yield, size and quality of nuts will be reduced. Hence to meet the requirements of Coconut plantations, DMI is adopted.

The details of establishment costs in the first five years of Coconut plantation were presented in the table 5.5.

Establishment costs have been divided into variable costs and fixed costs. The total establishment costs expended per hectare of Coconut with drip method of irrigation (DMI) during its pre- bearing period (1-5 years) stood at Rs. 2,61,297.20 of which Rs 90, 695.22 (34.71 per cent) were variable costs and Rs. 1,70,601.98 (65.29 per cent) were fixed costs.

During the pre-bearing period i.e., in the first five years, rental value of owned land (38.75 per cent) accounted for major share in total establishment cost of Coconut under DMI followed by human labour (13.87 per cent), interest on fixed capital (13.21 per cent), depreciation charges (9.81 per cent), machine labour (5.74 per cent), manures (4.38 per cent), fertilizers (3.63 per cent), interest on working capital (3.58 per cent), plant material (2.32 per cent), annuity of drip irrigation system (1.80 per cent), plant protection chemicals (1.20 per cent), Drip irrigation system cost (1.13 per cent), and land revenue (0.60 per cent).

During the pre-bearing period of Coconut, the drip irrigation system installed in the first year and the actual cost for installation of drip irrigation system in one hectare of Coconut plantation was Rs. 29,435. 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. Hence the cost incurred by the farmers for drip irrigation system with 90 per cent subsidy in one hectare of Coconut plantation was Rs. 2943.5 which constituted for 4.59 per cent of the total cost incurred during the first year of Coconut plantation.

The total costs incurred to establish one hectare of Coconut plantation during the first year amounted to Rs. 64,194.15 out of which Rs. 28,661.08 (44.65 per cent) was spent on variable resources and the remaining Rs. 35,533.07 (55.35 per cent) pertained to fixed costs. Among the fixed costs, rental value of owned land occupied a major share with Rs. 20.250 which accounted for 31.54 per cent followed by interest on working capital with Rs. 6901.02 (10.75 per cent), depreciation with Rs. 5126.55 (7.99 per cent) Drip irrigation system with Rs. 2943.50 (4.59 per cent) and land revenue with Rs. 312 (0.49 per cent) of total costs incurred during the first year of establishing coconut plantation with drip irrigation

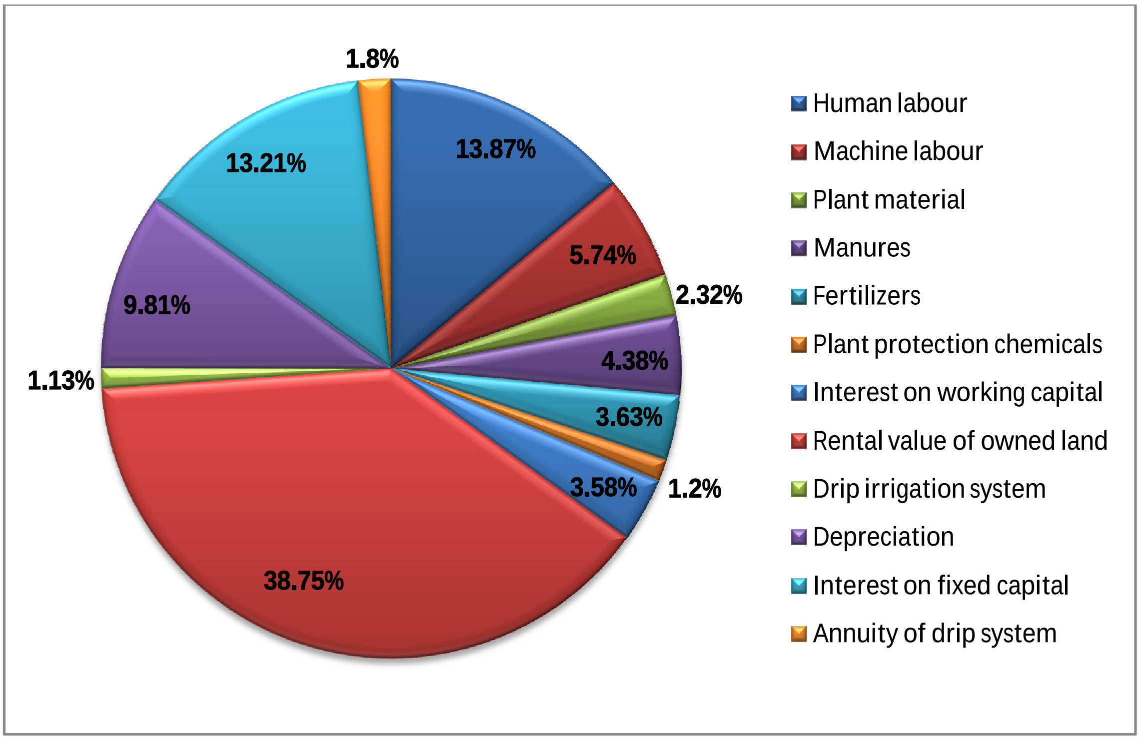

Fig. 5.1. Establishment Costs in Coconut Plantations -Drip Method of Irrigation

Table 5.5. Establishment Costs in Coconut plantations during pre-bearing period – Drip Method of Irrigation (Rs/ha)

S.No.	Cost Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	Total establishment cost/ha
I	**Variable costs**						
1	Human labour	12371.00 (19.27)	6257.00 (12.73)	5632.00 (11.74)	5976.00 (12.09)	6007.00 (11.88)	36243 (13.87)
2	Machine labour	3000.00 (4.67)	3000.00 (6.11)	3000.00 (6.25)	3000.00 (6.07)	3000.00 (5.93)	15000 (5.74)
3	Plant material	5500.00 (8.57)	550.00 (1.12)	--	--	--	6050 (2.32)
4	Manures	3150.00 (4.91)	1600.00 (3.26)	2000.00 (4.17)	2350.00 (4.75)	2350.00 (4.65)	11450 (4.38)
5	Fertilizers	1059.00 (1.65)	1256.00 (2.56)	1453.00 (3.03)	2303.00 (4.66)	3402.00 (6.73)	9473 (3.63)
6	Plant protection chemicals	625.00 (0.97)	625.00 (1.27)	625.00 (1.30)	625.00 (1.26)	625.00 (1.24)	3125 (1.20)
7	Interest on working capital	2956.08 (4.60)	1528.12 (3.11)	1461.65 (3.05)	1639.21 (3.32)	1769.16 (3.50)	9354 (3.58)
8	Subtotal of variable costs (1 to7)	28661.08 (44.65)	14816.12 (30.15)	14171.65 (29.54)	15893.21 (32.15)	17153.16 (33.93)	90695 (34.71)

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

Cont'd

S. No.	Cost Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	Total establishment cost/ha
II	**Fixed costs**						
9	Land revenue	312.00 (0.49)	312.00 (0.63)	312.00 (0.65)	312.00 (0.63)	312.00 (0.62)	1560 (0.60)
10	Rental value of owned land	20250.00 (31.54)	20250.00 (41.21)	20250.00 (42.21)	20250.00 (40.96)	20250.00 (40.06)	101250 (38.75)
11	Drip irrigation system	2943.50 (4.59)	--	--	--	--	2943.50 (1.13)
12	Depreciation	5126.55 (7.99)	5126.55 (10.43)	5126.55 (10.69)	5126.55 (10.37)	5126.55 (10.14)	25632.75 (9.81)
13	Interest on fixed capital	6901.02 (10.75)	6901.02 (14.04)	6901.02 (14.38)	6901.02 (13.96)	6901.02 (13.65)	34505.10 (13.21)
14	Annuity of drip system	--	1730.23 (3.52)	1215.01 (2.53)	958.92 (1.94)	806.47 (1.60)	4710.63 (1.80)
I5	Subtotal of fixed costs (1 to 6)	35533.07 (55.35)	34319.80 (69.85)	33804.58 (70.46)	33548.49 (67.85)	33396.04 (66.07)	170601.98 (65.29)
III	**Total costs (I+ II)**	**64194.15 (100)**	**49135.92 (100)**	**47976.23 (100)**	**49441.70 (100)**	**50549.20 (100)**	**261297 (100)**

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

2. Drip irrigation system cost at subsidized rate of Rs. 2943.50 per unit/ha against the actual cost of Rs. 29,435 per unit/ha

Among the variable costs, human labour occupied the first place constituting 19.27 per cent of total costs with an amount of Rs. 12,371 followed by plant material with Rs. 5,500 (8.57 per cent), manures with Rs. 3,150 (4.91 per cent), machine labour with Rs. 3,000 (4.67 per cent), interest on working capital with Rs. 2,956.08 (4.60 per cent), fertilizers with Rs. 1,059 (1.65 percent) and plant protection chemicals (1.41 per cent). 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 Coconut orchard.

The cost incurred to maintain one hectare of Coconut plantations during the remaining years of pre-bearing periods (second to fifth years) stood at Rs. 49,135.92, Rs. 47, 976.23, Rs. 49,441.70, and Rs. 50,549.20 respectively. The respective total variable cost on an average per hectare during the above said years were Rs. 14,816.12, Rs. 14,171.65, Rs. 15,893.21 and Rs. 17,153.16 which accounted for 30.15 per cent, 29.54 per cent, 32.15 per cent and 33.71 per cent respectively and the fixed costs for the same years of pre- bearing period were Rs. 34,319.80, Rs. 33,804.58, Rs. 33,548.49, and Rs. 33,396.04 which accounted for 69.85 per cent, 70.46per cent, 67.85per cent and 66.07per cent respectively.

Among the variable costs from second year to fifth year of pre-bearing period, human labour cost turned out to be the major item and worked out to be Rs. 6,257.00 (12.73 per cent), Rs.5,632.00 (11.74), Rs. 5,976.00 (12.09 per cent) and Rs. 6,007 (11.88 per cent) respectively. The cost of human labour decreased from first year to second year and increased from second year to fifth year.

Next to the cost of human labour, machine labour were found to be the second major item of the variable cost followed by manures cost and fertilizers cost from second to fourth year of pre-bearing period. During the fifth year of pre-bearing, cost of fertilizers was the second major item of variable cost followed by machine labour and manures cost.

The cost of machine labour was same from second to fifth year which stood around Rs. 3,000 and accounted for 6.11 per cent, 6.25 per cent, 6.07 per cent and 5.93 per cent to the total cost incurred during those respective years of pre-bearing.

The cost of fertilizers and manures increased from second year to fifth year of pre-bearing period of Coconut plantation. In coconut cultivation, the reason for increased dosage of fertilizers application increased with age of Coconut plantation upto 5th year and also Coconut demands a balanced and adequate supply of fertilizers during the initial stages of its life i.e., pre-bearing period.

The cost of manures applied during the second year to fifth year of pre-bearing period stood at Rs. 1,600, Rs. 2,000, Rs. 2,350, and Rs. 2,350 respectively and accounted for 3.26 per cent, 4.17 per cent, 4.75 per cent and 4.65 percent of the total cost incurred in those respective years of pre-bearing.

The cost of fertilizers from second year to fifth year stood at Rs. 1,256.00 (2.56 percent), Rs. 1,453.00 (3.03 per cent), Rs. 2303.00 (4.66 per cent) and Rs. 3,402 (6.73 percent) respectively.

The other important items of variable costs from second year to fifth year of pre-bearing period were interest on working capital amounting to Rs. 1,528.12 (3.11 per cent), Rs. 1,461.65 (3.05 per cent), Rs. 1,639.21 (3.32 per cent) and Rs. 1,769.16 (3.50 per cent) followed by plant protection chemicals Rs. 625stood same and constituting 1.27 per cent, 1.30 per cent, 1.26 per cent and 1.24 per cent respectively. Plant materials accounted for Rs.550 for gap filling and constituting 1.12 per cent of the total cost incurred during the second year of pre-bearing period.

Rental value of owned land formed the major part of fixed costs during the second to fifth year of pre-bearing period and it accounted for 41.21 per cent, 42.21 per cent, 40.96 per cent and 40.06 per cent of the total costs respectively. Next to the Rental value of owned, interest on fixed capital was the second major item of fixed cost from second to fifth year of pre-bearing followed by depreciation charges, annuity of dip system and land revenue formed other important items of fixed costs in the order.

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

The details of establishment costs in the first five years of Coconut plantation in conventional method of irrigation (CMI) are presented in the table 5.6.

The total costs expended per hectare of Coconut plantation with CMI during its pre- bearing period (1-5 years) stood at Rs. 2,50,570.32 of which Rs. 1,30,685.82 (52.16 per cent) was variable costs and Rs. 1,19,884.50 (47.84 per cent) were fixed costs.

During the pre-bearing period i.e., in the first five years of Coconut plantation under CMI, rental value of owned land (40.41 per cent) accounted for major share followed by human labour (27.37 per cent), machine labour (5.99 per cent), interest on working capital (5.38 per cent), fertilizers (5.19 per cent), manures (4.57 per cent), interest on fixed capital (4.01), depreciation charges (2.81 per cent), plant material (2.41 per cent),and plant protection chemicals (1.25 per cent), and land revenue (0.62 per cent).

The total costs incurred to establish one hectare of Coconut plantation under CMI during the first year amounted to Rs. 57, 286.41 out of which Rs. 33,309.51 (58.15 per cent) was spent on variable resources and the remaining Rs. 23,976 (41.85 per cent) pertained to fixed costs. Among the fixed costs, rental value of owned land took a major share with Rs. 20, 250 which accounted for 35.35 per cent of total costs incurred during first year of establishing Coconut with CMI. Next to the rental value of owned land, interest on fixed capital was the second major item of fixed costs constituting 3.51 per cent of the total costs with an amount of Rs. 2008.41 followed by depreciation (2.46 per cent) and land revenue (0.54 per cent).

Among the variable costs, human labour occupied the first place constituting 28.07 per cent of total costs with an amount of Rs. 16,083 followed by plant material (9.60 per cent), interest on working capital (6.00 per cent), manures (5.50 per cent), machine labour (5.24 per cent), fertilizers (2.65 per cent), and plant protection chemicals (1.09 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 Coconut plantations.

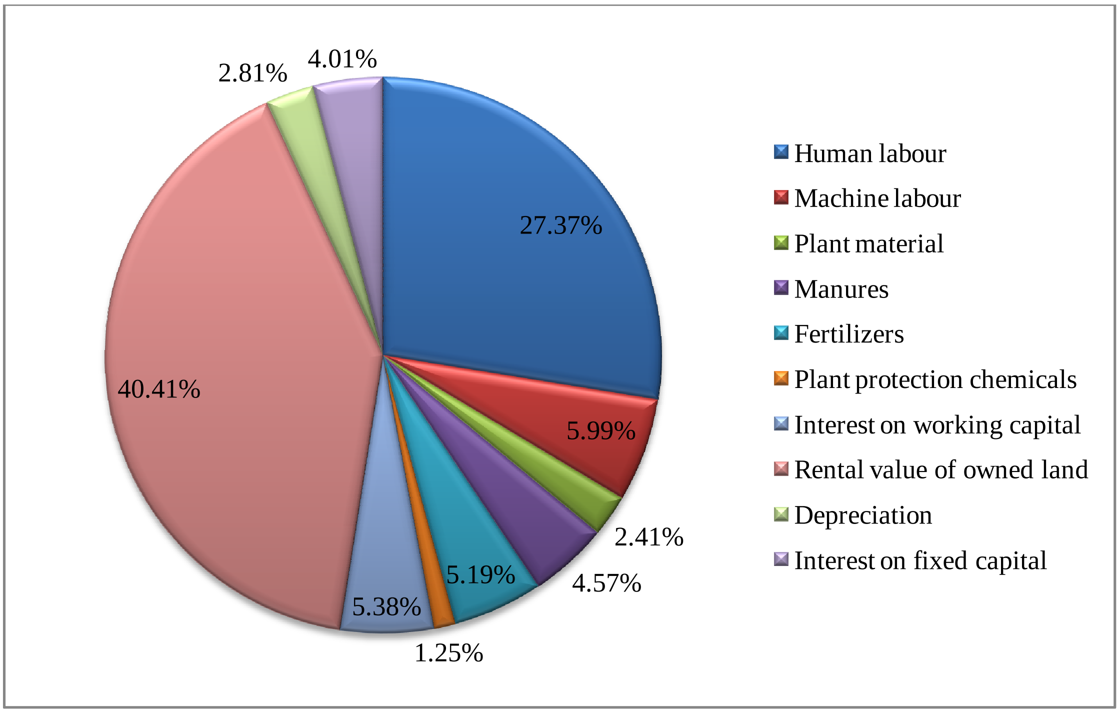

Figure 5.2. Establishment Costs in Coconut Plantations -Conventional Method of Irrigation

Table 5.6. Establishment Costs in Coconut Plantations - Conventional Method of Irrigation (Rs/ha)

S.No	Cost Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	Total establishment cost/ha
I	**Variable costs**						
1	Human labour	16083.00 (28.07)	13208.00 (28.07)	12300.00 (26.55)	13302.00 (26.99)	13679.00 (27.03)	68572.00 (27.37)
2	Machine labour	3000.00 (5.24)	3000.00 (6.38)	3000.00 (6.48)	3000.00 (6.09)	3000.00 (5.93)	15000.00 (5.99)
3	Plant material	5500.00 (9.60)	550.00 (1.17)	--	--	--	6050.00 (2.41)
4	Manures	3150.00 (5.50)	1600.00 (3.40)	2000.00 (4.32)	2350.00 (4.77)	2350.00 (4.64)	11450.00 (4.57)
5	Fertilizers	1516.00 (2.65)	1713.00 (3.64)	2118.00 (4.57)	3426.00 (6.95)	4237.00 (8.37)	13010.00 (5.19)
6	Plant protection chemicals	625.00 (1.09)	625.00 (1.33)	625.00 (1.35)	625.00 (1.27)	625.00 (1.23)	3125.00 (1.25)
7	Interest on working capital	3435.51 (6.00)	2380.04 (5.06)	2304.95 (4.98)	2610.85 (5.30)	2747.47 (5.43)	13478.82 (5.38)
8	Subtotal of variable costs (1 to7)	33309.51 (58.15)	23076.04 (49.04)	22347.95 (48.24)	25313.85 (51.36)	26638.47 (52.63)	130685.82 (52.16)

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

Cont'd

S. No.	Cost Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	Total establishment cost/ha
II	**Fixed costs**						
9	Land revenue	312.00 (0.54)	312.00 (0.66)	312.00 (0.67)	312.00 (0.63)	312.00 (0.62)	1560.00 (0.62)
10	Rental value of owned land	20250.00 (35.35)	20250.00 (43.04)	20250.00 (43.71)	20250.00 (41.08)	20250.00 (40.01)	101250.00 (40.41)
11	Depreciation	1406.49 (2.46)	1406.49 (2.99)	1406.49 (3.04)	1406.49 (2.85)	1406.49 (2.78)	7032.45 (2.81)
12	Interest on fixed capital	2008.41 (3.51)	2008.41 (4.27)	2008.41 (4.34)	2008.41 (4.07)	2008.41 (3.97)	10042.05 (4.01)
13	Subtotal of fixed costs (1 to 4)	23976.90 (41.85)	23976.90 (50.96)	23976.90 (51.76)	23976.90 (48.64)	23976.90 (47.37)	119884.50 (47.84)
III	**Total costs** (I+ II)	**57286.41 (100)**	**47052.94 (100)**	**46324.85 (100)**	**49290.75 (100)**	**50615.37 (100)**	**250570.32 (100)**

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

.

The cost incurred to maintain one hectare of Coconut plantations during the remaining years of pre-bearing periods (second to fifth years) stood at Rs. 47,052.94, Rs. 46,324.85, Rs. 49, 290.75 and Rs. 50,615.37 respectively. The respective total variable costs on an average per hectare during second to fifth years of pre-bearing period were Rs. 23,076.04, Rs. 22,347.95, Rs. 25,313.85, and Rs. 26,638.47 which accounted for 49.04 per cent, 48.24 per cent, 51.36 per cent, and 52.63 per cent respectively. Fixed costs for the second to fifth years of pre- bearing period stood at Rs. 23,976.90 which accounted for 50.96 per cent, 51.76per cent, 48.64per cent and 47.37per cent of the total cost incurred during those particular years respectively.

In second to fifth years of pre-bearing period human labour turned out to be the major item of variable cost which worked out to Rs. 16,083 (28.07 per cent), Rs. 13,208 (28.07), Rs. 12,300(26.55 per cent), Rs. 13,302 (26.99) and Rs. 13,679 (27.03 per cent) respectively. The cost of human labour was decreased from second year to third year and hen increased from third year to fifth year.

Next to the human labour, machine labour was the second major item followed by interest on working capital during the second and third years. The cost of machine labour stood at Rs. 3,000 and it constituted 6.38 per cent, 6.48 of the total cost of the concern years respectively..

In second and third years, interest on working capital was the third major item followed by manures cost and fertilizers cost. Interest on working stood at Rs. 2,380.04 and Rs. 2304.95 which constituting 5.06 per cent, 4.98 per cent for second and third years respectively.

The cost of manures and fertilizers increased from second year to third year. The cost of manures was stood at Rs. 1,600 (3.40 per cent) and Rs. 2,000 (4.32 per cent) followed by cost of fertilizers which accounted to Rs.1,713 (3.64 per cent) and Rs. 2,118 (4.57 per cent) during second and third years respectively. During the second year plant materials accounted for Rs.550 (1.17 per cent) for the gap filling.

In fourth and fifth years of pre-bearing period fertilizer cost was the second major item followed by machine labour. Fertilizer cost stood at Rs. 3,426 and Rs. 4,237 which constituting 6.95per cent and 8.37per cent followed by machine labour cost of Rs. 3,000 which accounting for 6.09 per cent, 5.93 per cent for fourth and fifth years respectively.

Next to the machine labour, interest on working capital was the major item followed by cost of manures in fourth and fifth years. Interest on working capital stood at Rs. 2,610 (5.30 per cent) and Rs. 2,747 (5.43 per cent) followed by manures cost of Rs. 2,350 which stood same and constituted for 4.77 per cent and 4.64 per cent of the total cost incurred during fourth and fifth years.

The other important item of variable costs from second to fifth years of pre-bearing period was plant protection chemicals Rs. 625which accounts for 1.33 per cent, 1.35 per cent, 1.27 per cent and 1.23 per cent respectively.

Rental value of owned land formed the major part of fixed costs during second to year of pre-bearing. It accounted for 43.04 per cent, 43.71 per cent, 41.08 per cent and 40.01 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 Coconut plantations with DMI (Rs. 2,61,297.20) exceeded the establishment cost of Coconut with CMI (Rs. 2,50,570.32) by 4.28 per cent only. Considerable change was observed in the variable costs for drip method of irrigation and conventional method of irrigation which stood at Rs. 90,695.22 and Rs. 1,30,685.82 respectively i.e., 30.60 per cent less in DMI to that of CMI. The human labour in the CMI was greater by 89.20 per cent and compared to DMI as the labour requirement for conventional irrigation, fertilizer application and other operations were more in case of CMI. The fertilizer cost in the CMI was greater by 37.33 per cent compared to DMI as fertigation method was followed in DMI, less amount of fertilizer required. The cost of plant material, manures, plant protection chemicals remained same in both the methods of irrigation as the requirement for Coconut plantation remained same. The interest on fixed capital for the drip irrigation system exceeded the conventional irrigation system by 79 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. 2943.50 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. 25,632.75 compared to Rs. 7,032.45 of CMI i.e., 72.56 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. 4,710.63. Land revenue and rental value of owned land remain same in both the methods of irrigation systems. Contrary to the case with the fixed costs, the variable costs were less in case of DMI (Rs. 90,695.22) than CMI (Rs. 1,30,685.82) by 44.09 per cent.

To sum up the establishment cost for drip method of irrigated Coconut plantations were higher by 4.28 per cent over conventionally irrigated plantations due to the capital intensive technology of drip irrigation.

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.

5.3.1Cost components of Drip Irrigation System

Drip irrigation system was expensive which accounted for Rs. 29,435 per 1 ha of Coconut plantation. 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. The detailed cost components of Drip irrigation system under Coconut plantation are presented in the table 5.7

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

S.No.	Cost component	Cost in Rupees (Rs.)	Percentage share to total
I	**Head control unit**		
1	Filtration unit-screen filter	2337.00	7.94
2	Throttle valve	832.00	2.82
3	Air release valve	376.00	1.28
4	Pressure cork	66.00	0.22
6	Pressure gauge	170.00	0.58
7	Hydro cyclone	3090.00	10.50
	Sub total	**6871.00**	**23.34**
II	**Water carrier system**		
1	PVC pipes for main pipe line	5236.20	17.79
2	PVC pipes for sub main pipe line	4937.40	16.77
3	PP Ball valve/control 40mm	356.00	1.21
4	PP Ball valve/control 63mm	575.00	1.95
5	Flush valve	102.00	0.35
	Sub total	**11206.60**	**38.07**
III	**Water distribution system**		
1	Plain laterals	5800.00	19.70
2	Emitters	1656.00	5.63
4	Grommet	78.60	0.27
5	Start connector	73.50	0.25
6	Nipple	7.70	0.03
7	End cap	67.00	0.23
8	Spaghetti/Micro tube	402.00	1.36
9	Micro tube Barbed	185.35	0.63
	Sub total	**8270.40**	**28.10**
IV	**Other Charges**		
1	Fittings and accessories	720.00	2.45
2	Transportation	425.00	1.44
3	Installation charges	483.00	1.64
4	VAT on system cost	1399.00	4,75
5	Service tax on installation	60.00	0.20
6	**Sub total**	**3087.00**	**10.49**
I+ II+ III +IV	**Total**	**29435.00**	**100** **100.00**

Source: Andhra Pradesh Micro Irrigation Project (APMIP). Srikakulam District, 2015.

Online DIS will be used in wide spaced orchard crops like coconut, mango and banana. In this type of DIS, a minimum of four drippers has to be placed for each palm. If each dripper discharges eight litres of water per hour, four hours of irrigation per day will be sufficient to discharge 128 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. 29, 435 for 1 ha of Coconut plantation. The DIS mainly constitutes three parts i.e., Head control constituting 23.34 per cent, Water carrier system constituting 38.07 per cent and Water distribution system constituting of 28.10 Per cent. The other charges included 10.49 per cent.

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, 75 per 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.

5.4 MAINTENANCE COSTS OF COCONUT PLANTATIONS DURING BEARING PERIOD

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

The cost of maintenance of Coconut per hectare from 6th to 50th year for DMI is presented in the table 5.8. It is revealed from the results that the total costs per hectare decreased gradually from Rs. 1, 20,200.09 in sixth year to Rs. 1, 06,802 in 10thyear. During the starting stage of bearing the variable costs increased from sixth year (Rs. 24,247.91) to 10th year (Rs. 27,615.21) and then remained constant during the peak period of bearing (Rs. 62,634.01) and then decreased to Rs. 43,148 from 41st year to 50th year. The fixed cost decreased from Rs. 95,952.18 in sixth year to Rs. 72,542.70 in 11th year. It is interesting to note that the share of fixed costs in total costs increased from 53.67 per cent in 11th year to 54.66 per cent in 20th year which was decreased to 51.07 per cent 21st year. Again from 21st year to 30th year of plantation, share of fixed costs in total costs increased from 51.07 per cent to 53.48 per cent which was again decreased to 50.34 per cent. Again from 41st year to 50th year of plantation, share of fixed costs in total costs increased from 51.56 per cent to 54.44 per cent of the total cost of Coconut plantations due to increased annuity value of drip system as it needs replacement after 10 years of installation of drip system.

The human labour accounted for maximum expenditure in variable costs during the starting stage of bearing period from sixth year to 10th year and increased from 9.41per cent (Rs. 11,309) to 14.12 per cent (Rs. 14,975) of total costs. During the starting stage of bearing (6th year to 10th year) the remaining components of variable costs like machine labour (Rs. 4,000), fertilizers cost (Rs. 3,402), manures cost (Rs. 2,350), and plant protection chemicals (Rs. 686) stood constant and the interest on working capital increased during from 2.08 per cent to 2.69 percent of the total cost which was the result from increased human labour from 6th year to 10th year.

During the starting stage of bearing, annuity of Coconut accounted for major share and it decreased from 52.13 per cent (Rs. 62,656.78) to 42.73 per cent (Rs. 45,302.98) followed by rental value of owned land which increased from 16.85 per cent to 19.10 per cent of the total cost from sixth year to 10th year. Next to the rental value of owned, interest on fixed capital, depreciation, annuity of drip system, land revenue formed other important items of fixed costs in order. Annuity of drip irrigation was decreased from Rs. 705.83 (0.59 per cent) to Rs. 510.34 (0.48 per cent) from 6th year to 10th year of bearing.

During the peak bearing period of 11th year to 40th year of Coconut human labour cost accounted for major expenditure among the variable costs and it was mainly due to increased human labour requirement for operation like harvesting, collection and handling of nuts during peak bearing stage. The human labor required stood constant accounted to Rs. 45,672. Next to the human labour, interest on working capital (Rs. 6,460.01) was second major item followed by machine labour (Rs. 4,000), fertilizers cost (Rs. 3,402), manures cost (Rs. 2,350), and plant protection chemicals (Rs. 750) stood constant and formed other important items of variable costs in the order during peak bearing period of 11th year to 40th year.

During the last stage of bearing from 41st year to 50th year also human labour was the major component of variable cost and it stood constant at Rs. 43,148 which followed interest on working capital (Rs. 6126.06), machine labour (Rs. 4,000), fertilizers cost (Rs. 2,960), manures cost (Rs. 2,350), and plant protection chemicals (Rs. 540) which stood constant from 41st year to 50th year of bearding. It can be observed that there was a decrease in human labour requirement, fertilizer cost, and plant protection chemicals from peak bearing period (11th to 40th year) to last stage of bearing (41st year to 50th year) due to decreased returns comparatively.

Among fixed costs, annuity of Coconut plantation took a lion's share in the range of 52.13 per cent to 22.11 per cent and decreased from Rs. 62,656.78 in sixth year to Rs. 30,213 in last period of bearing (46th t0 50th year). Next to the annuity of Coconut, rental value of owned land was the second important component of fixed costs and it stood constant at Rs. 20,250 from 6th year to 10th year of bearing.

Next to the rental value of owned land, interest on fixed capital was the third major item it stood constant for Rs. 6901.02 during 6th year to 10th year of bearing. During remaining period of bearing from 11th year to 50th year, annuity of drip system stood third after interest on fixed capital.

The annuity of drip irrigation system accounts for Rs. 705.83 in sixth year and gradually decreased to Rs. 510 in 10th year *i.e.,* from 0.59 to 0.48 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 11th year, 21st year, 31st year and 41st year of bearing because the actual life span of the drip system is 10 years. The present value of annuity was calculated upto 10th year and from 11th year to 20th year, 21st year to 30th year, 31st year to 40th year and 41st year to 50th year future value of annuity was calculated and hence it gradually increased from Rs. 6,911.45 (11th year to 15th year) to Rs. 14,753.88 (16th year to 20th year).

Depreciation charges (Rs.5,126.55) and Land revenue (Rs.312) formed other important items of fixed costs in the order and stood constant from 6th to 50th year of bearing period of Coconut plantation.

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

S.No.	Cost particulars	Year 6	Year 7	Year 8	Year 9	Year 10
I	**Variable costs**					
1	Human labour	11309.00 (9.41)	11375.00 (9.99)	12250.00 (11.12)	13329.00 (12.37)	14975.00 (14.12)
2	Machine labour	4000.00 (3.33)	4000.00 (3.51)	4000.00 (3.63)	4000.00 (3.71)	4000.00 (3.77)
3	Manures	2350.00 (1.96)	2350.00 (2.06)	2350.00 (2.13)	2350.00 (2.18)	2350.00 (2.22)
4	Fertilizers	3402.00 (2.83)	3402.00 (2.99)	3402.00 (3.09)	3402.00 (3.16)	3402.00 (3.21)
5	Plant protection chemicals	686.00 (0.57)	686.00 (0.60)	686.00 (0.62)	686.00 (0.64)	686.00 (0.65)
6	Interest on working capital	2500.91 (2.08)	2508.50 (2.20)	2609.12 (2.37)	2733.21 (2.54)	2848.21 (2.69)
7	Subtotal of variable costs (1 to 6)	24247.91 (20.17)	24321.50 (21.35)	25297.12 (22.97)	26500.21 (24.60)	27615.21 (26.05)
II	**Fixed costs**					
8	Land revenue	312.00 (0.26)	312.00 (0.27)	312.00 (0.28)	312.00 (0.29)	312.00 (0.29)
9	Rental value of owned land	20250.00 (16.85)	20250.00 (17.78)	20250.00 (18.38)	20250.00 (18.79)	20250.00 (19.10)
10	Depreciation	5126.55 (4.27)	5126.55 (4.50)	5126.55 (4.65)	5126.55 (4.76)	5126.55 (4.84)
11	Interest on fixed capital	6901.02 (5.74)	6901.02 (6.06)	6901.02 (6.26)	6901.02 (6.41)	6901.02 (6.51)
12	Annuity of drip system	705.83 (0.59)	634.78 (0.56)	582.22 (0.53)	541.97 (0.50)	510.34 (0.48)
13	Annuity of coconut	62656.78 (52.13)	56350.06 (49.48)	51684.33 (46.92)	48111.60 (44.65)	45302.98 (42.73)
14	Subtotal of fixed costs (1 to 6)	95952.18 (79.83)	89574.41 (78.65)	84856.12 (77.03)	81243.14 (75.40)	78402.89 (73.95)
III	**Total costs** (I+ II)	**120200.09 (100)**	**113895.91 (100)**	**110153.24(100)**	**107743.35 (100)**	**106018.10 (100)**

Note: Figures in parentheses indicate percentages to total costs

Cont'd

S.No.	Cost particulars	Year 11-15	Year 16-20	Year 21-25	Year 25-30
I	**Variable costs**				
1	Human labour	45672.00 (32.15)	45672.00 (31.49)	45672.00 (33.86)	45672.00 (32.27)
2	Machine labour	4000.00 (2.82)	4000.00 (2.76)	4000.00 (2.97)	4000.00 (2.83)
3	Manures	2350.00 (1.65)	2350.00 (1.62)	2350.00 (1.74)	2350.00 (1.66)
4	Fertilizers	3402.00 (2.39)	3402.00 (2.35)	3402.00 (2.52)	3402.00 (2.40)
5	Plant protection chemicals	750.00 (0.53)	750.00 (0.52)	750.00 (0.56)	750.00 (0.53)
6	Interest on working capital	6460.01 (4.55)	6460.01 (4.45)	6460.01 (4.79)	6460.01 (4.56)
I	Subtotal of variable costs (1 to 6)	62634.01 (44.08)	62634.01 (43.18)	62634.01 (46.43)	62634.01 (44.25)
II	**Fixed costs**				
1	Land revenue	312.00 (0.22)	312.00 (0.22)	312.00 (0.23)	312.00 (0.22)
2	Rental value of owned land	20250.00 (14.25)	20250.00 (13.96)	20250.00 (15.01)	20250.00 (14.31)
3	Depreciation	5126.55 (3.61)	5126.55 (3.53)	5126.55 (3.80)	5126.55 (3.62)
4	Interest on fixed capital	6901.02 (4.86)	6901.02 (4.76)	6901.02 (5.12)	6901.02 (4.88)
5	Annuity of drip system	6911.45 (4.86)	14753.88 (10.17)	6911.45 (5.12)	14753.88 (10.42)
6	Annuity of coconut	39942.70 (28.11)	35070.71 (24.18)	32766.66 (24.29)	31566.87 (22.30)
II	Subtotal of fixed costs (1 to 6)	79443.72 (55.92)	82414.16 (56.82)	72267.68 (53.57)	78910.32 (55.75)
	Total costs (I+ II)	**142077.73 (100)**	**145048.17 (100)**	**134901.69 (100)**	**141544.33 (100)**

Note: Figures in parentheses indicate percentages to total costs

Cont'd

S.No.	Cost particulars	Year 31-35	Year 36-40	Year 41-45	Year 46-50
I	**Variable costs**				
1	Human labour	45672.00 (34.33)	45672.00 (32.50)	43148.00 (33.46)	43148.00 (31.57)
2	Machine labour	4000.00 (3.01)	4000.00 (2.85)	4000.00 (3.10)	4000.00 (2.93)
3	Manures	2350.00 (1.77)	2350.00 (1.67)	2350.00 (1.82)	2350.00 (1.72)
4	Fertilizers	3402.00 (2.56)	3402.00 (2.42)	2960.00 (2.30)	2960.00 (2.17)
5	Plant protection chemicals	750.00 (0.56)	750.00 (0.53)	540.00 (0.42)	540.00 (0.40)
6	Interest on working capital	6460.01 (4.86)	6460.01 (4.60)	6126.05 (4.75)	6126.05 (4.48)
7	Subtotal of variable costs (1 to 6)	62634.01 (47.08)	62634.01 (44.57)	59124.05 (45.85)	59124.05 (43.26)
II	**Fixed costs**				
8	Land revenue	312.00 (0.23)	312.00 (0.22)	312.00 (0.24)	312.00 (0.23)
9	Rental value of owned land	20250.00 (15.22)	20250.00 (14.41)	20250.00 (15.70)	20250.00 (14.82)
10	Depreciation	5126.55 (3.85)	5126.55 (3.65)	5126.55 (3.98)	5126.55 (3.75)
11	Interest on fixed capital	6901.02 (5.19)	6901.02 (4.91)	6901.02 (5.35)	6901.02 (5.05)
12	Annuity of drip system	6911.45 (5.19)	14753.88 (10.50)	6911.45 (5.36)	14753.88 (10.79)
13	Annuity of coconut	30911.10 (23.23)	30543.23 (21.74)	30333.85 (23.52)	30213.69 (22.11)
I4	Subtotal of fixed costs (1 to 6)	70412.12 (52.92)	77886.68 (55.43)	69834.87 (54.15)	77557.14 (56.74)
III	**Total costs** (I+ II)	**133046.13 (100)**	**140520.69 (100)**	**128958.92 (100)**	**136681.19 (100)**

Note: Figures in parentheses indicate percentages to total costs

5.4.2 Maintenance Costs in Coconut Plantations during Bearing Period Conventional Method of Irrigation (CMI)

The cost of maintenance of Coconut plantations under CMI per hectare from sixth to 50th year was presented in the table5.9. The results revealed that the total costs per hectare decreased gradually from Rs. 1, 23,486.76 in 6thyear to Rs. 1, 13,809.31 in 10th year. From 10th year to 11th year total cost increased due in increase in variable cost. During the 11th year to 50th year of total cost decreased from Rs. 1, 31,869.23 to Rs.1, 19,388.64. The variable costs increased Rs. 39,425.29 (31.93 per cent) to Rs. 46,386.23 (40.76 per cent) during 6th year to 10th year of bearing. It remaining constant at Rs. 69,589.38 from 11th year to 40th year and then decreased as constant at Rs. 66,438.39 from 41st to 50th year.

Among the variable costs the human labour accounted for maximum expenditure (19.41 per cent to 26.55 per cent) in total costs during the bearing period of 6th year to 10th year. It remained constant throughout the peak bearing period of 11th year to 40th year i.e., Rs. 50,875and the increase in labour cost was mainly due to increasing human labour requirement for irrigation, harvesting operation and for weeding operations. During the last stage of bearing of 41st year to 50th year human labour decreased to Rs. 48,560 due to reduced returns.

Fertilizer cost was the next major item of operational costs and their share constituted 3.43 to 3.59 per cent followed by interest on working capital (3.29 to 3.59 per cent), machine labour (3.24 to 3.39 per cent), manures (1.90 t0 1.99 per cent) and plan protection chemicals (0.65 o 0.68 per cent) in total costs during 6th year to 7th year.

During the 8th year to 50th year, interest on working capital was the next major item after human labour and increased from 3.79 per cent to 5.84 per cent of the total cost for the concern years. During the last stage of bearing (41st year to 50th year) it decreased from 5.73 to 5.74 per cent. Next important component of variable cost was fertilizer cost (Rs. 4,237), followed by machine labour (Rs. 4,000), manures cost (Rs 2,350) and plant protection chemicals (Rs. 950) which stood constant during upto 40th year. .

From 41st to 50th year machine labour cost and manures cost stood constant at Rs. 4,000 and Rs. 2,350 and fertilizers cost, and plan protection cost decreased comparatively and stood at Rs. 3, 956 and Rs. 720 respectively.

Among fixed costs, annuity of Coconut plantations took lion's share andthe present value of annuity was calculated for Coconut orchard which accounted for Rs. 60,084.57 (68.07 per cent) in sixth year and gradually decreased to Rs. 28,973.35 (24.27 per cent) in 50th year.

Next to the annuity of Coconut, rental value of owned land was the major component of fixed cost and it remaining constant from 6th year to 50th year of bearing period. Interest on fixed capital, depreciation charges, land revenue formed other important components of fixed costs in the order.

The per hectare total cost for the life period of 50 years with DMI in Coconut was Rs. 66, 68, 888.60and Rs. 60, 02, 913.85 for CMI. Per hectare total establishment cost for DMI in Coconut was Rs.2, 61, 297.20 and Rs. 2, 50,570.32 for CMI. The per hectare total maintenance cost for DMI in Coconut was Rs. 64,07,591.40 and Rs. 61,31,195.95 for CMI.

Coconut grower incurred Rs. 106014, Rs. 151754 and Rs. 153071 per hectare on cost of cultivation in flood irrigation method, sprinkler irrigation method and drip irrigation structures respectively (Mehendale *et al.*2013)

The maintenance cost of drip irrigated gardens was found to be lower (Rs. 29,109) as compared to surface irrigated gardens (Rs. 37,856). Adoption of drip irrigation in areca nut gardens has resulted in additional output of 5.03 quintals worth Rs. 67,972. There is substantial saving in cost of cultivation (Rs. 8837) of drip-irrigated gardens which is due to decreased use of labour and inputs (Chinnappa and Hippargi, 2005)

The cost of cultivation of coconut (based on 1995/96 prices) ranges from Rs. 28,600/ha during the first year of planting to Rs. 23,450/ha during the stabilized bearing period under rain fed conditions. For irrigated conditions, the corresponding figures are Rs. 52,650 and Rs. 27,750/ha (Sairam *et al.*1997).

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

S.No.	Cost particulars	Year 6	Year 7	Year 8	Year 9	Year 10
I	**Variable costs**					
1	Human labour	23972.00 (19.41)	24383.00 (20.68)	26861.00 (23.12)	26995.00 (23.91)	30215.00 (26.55)
2	Machine labour	4000.00 (3.24)	4000.00 (3.39)	4000.00 (3.44)	4000.00 (3.54)	4000.00 (3.51)
3	Manures	2350.00 (1.90)	2350.00 (1.99)	2350.00 (2.02)	2350.00 (2.08)	2350.00 (2.06)
4	Fertilizers	4237.00 (3.43)	4237.00 (3.59)	4237.00 (3.65)	4237.00 (3.75)	4237.00 (3.72)
5	Plant protection chemicals	800.00 (0.65)	800.00 (0.68)	800.00 (0.69)	800.00 (0.71)	800.00 (0.70)
6	Interest on working capital	4066.29 (3.29)	4113.55 (3.49)	4398.52 (3.79)	4413.93 (3.91)	4784.23 (4.20)
7	Subtotal of variable costs (1 to 6)	39425.29 (31.93)	39883.55 (33.83)	42646.52 (36.71)	42795.93 (37.90)	46386.23 (40.76)
II	**Fixed costs**					
8	Land revenue	312.00 (0.25)	312.00 (0.26)	312.00 (0.27)	312.00 (0.28)	315.00 (0.28)
9	Rental value of owned land	20250.00 (16.40)	20250.00 (17.18)	20250.00 (17.43)	20250.00 (17.93)	20250.00 (17.79)
10	Depreciation	1406.49 (1.14)	1406.49 (1.19)	1406.49 (1.21)	1406.49 (1.25)	1406.49 (1.24)
11	Interest on fixed capital	2008.41 (1.63)	2008.41 (1.70)	2008.41 (1.73)	2008.41 (1.78)	2008.41 (1.76)
12	Annuity of coconut	60084.57 (48.66)	54036.75 (45.83)	49562.26 (42.66)	46136.50 (40.86)	43443.18 (38.17)
II	Subtotal of fixed costs (1 to 5)	84061.47 (68.07)	78013.65 (66.17)	73539.16 (63.29)	70113.40 (62.10)	67423.08 (59.24)
III	**Total costs** (I+ II)	**123486.76 (100)**	**117897.20 (100)**	**116185.68 (100)**	**112909.33 (100)**	**113809.31 (100)**

Note: Figures in parentheses indicate percentages to total costs

Cont'd

S.No.	Cost particulars	Year 11-15	Year 16-20	Year 21-25	Year 25-30
I	**Variable costs**				
1	Human labour	50875.00 (38.58)	50875.00 (40.00)	50875.00 (40.70)	50875.00 (41.08)
2	Machine labour	4000.00 (3.03)	4000.00 (3.14)	4000.00 (3.20)	4000.00 (3.23)
3	Manures	2350.00 (1.78)	2350.00 (1.85)	2350.00 (1.88)	2350.00 (1.90)
4	Fertilizers	4237.00 (3.21)	4237.00 (3.33)	4237.00 (3.39)	4237.00 (3.42)
5	Plant protection chemicals	950.00 (0.72)	950.00 (0.75)	950.00 (0.76)	950.00 (0.77)
6	Interest on working capital	7177.38 (5.44)	7177.38 (5.64)	7177.38 (5.74)	7177.38 5.80)
7	Subtotal of variable costs (1 to 6)	69589.38 (52.77)	69589.38 (54.71)	69589.38 (55.68)	69589.38 (56.19)
II	**Fixed costs**				
8	Land revenue	312.00 (0.24)	312.00 (0.25)	312.00 (0.25)	312.00 (0.25)
9	Rental value of owned land	20250.00 (15.36)	20250.00 (15.92)	20250.00 (16.20)	20250.00 (16.35)
10	Depreciation	1406.49 (1.07)	1406.49 (1.11)	1406.49 (1.13)	1406.49 (1.14)
11	Interest on fixed capital	2008.41 (1.52)	2008.41 (1.58)	2008.41 (1.61)	2008.41 (1.62)
12	Annuity of coconut	38302.95 (29.05)	33630.97 (26.44)	31421.51 (25.14)	30270.98 (24.44)
13	Subtotal of fixed costs (1 to 5)	62279.85 (47.23)	57607.87 (45.29)	55398.41 (44.32)	54247.88 (43.81)
III	**Total costs** (I+ II)	**131869.23 (100)**	**127197.25 (100)**	**124987.79 (100)**	**123837.26 (100)**

Note: Figures in parentheses indicate percentages to total costs

Cont'd

S.No.	Cost particulars	Year 31-35	Year 36-40	Year 41-45	Year 46-50
I	**Variable costs**				
1	Human labour	50875.00 (41.29)	50875.00 (41.41)	48560.00 (40.63)	48560.00 (40.67)
2	Machine labour	4000.00 (3.25)	4000.00 (3.26)	4000.00 (3.35)	4000.00 (3.35)
3	Manures	2350.00 (1.91)	2350.00 (1.91)	2350.00 (1.97)	2350.00 (1.97)
4	Fertilizers	4237.00 (3.44)	4237.00 (3.45)	3956.00 (3.31)	3956.00 (3.31)
5	Plant protection chemicals	950.00 (0.77)	950.00 (0.77)	720.00 (0.60)	720.00 (0.60)
6	Interest on working capital	7177.38 (5.83)	7177.38 (5.84)	6852.39 (5.73)	6852.39 (5.74)
I	Subtotal of variable costs (1 to 6)	69589.38 (56.48)	69589.38 (56.64)	66438.39 (55.60)	66438.39 (55.65)
II	**Fixed costs**				
1	Land revenue	312.00 (0.25)	312.00 (0.25)	312.00 (0.26)	312.00 (0.26)
2	Rental value of owned land	20250.00 (16.44)	20250.00 (16.48)	20250.00 (16.95)	20250.00 (16.96)
3	Depreciation	1406.49) (1.14)	1406.49 (1.14)	1406.49 (1.18)	1406.49 (1.18)
4	Interest on fixed capital	2008.41 (1.63)	2008.41 (1.63)	2008.41 (1.68)	2008.41 (1.68)
5	Annuity of coconut	29642.13 (24.06)	29289.36 (24.13)	29088.57 (24.51)	28973.35 (24.27)
II	Subtotal of fixed costs (1 to 5)	53619.03 (43.52)	53266.26 (43.64)	53065.47 (44.57)	52950.25 (44.35)
	Total costs (I+ II)	**123208.41 (100)**	**122855.64 (100)**	**119503.86 (100)**	**119388.64 (100)**

Note: Figures in parentheses indicate percentages to total costs

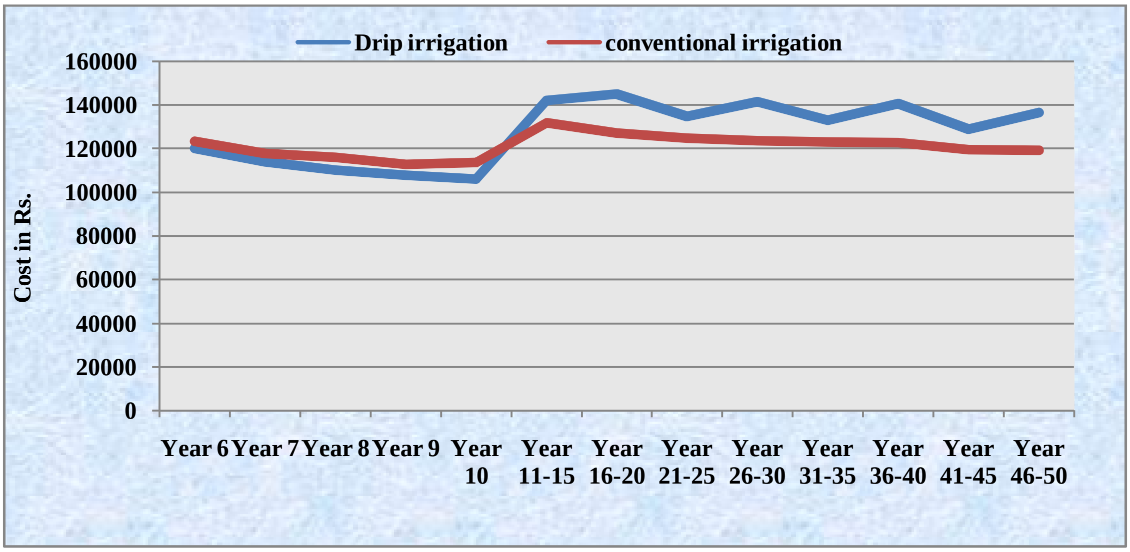

Figure 5.3. Maintenance cost of drip and conventional methods of irrigation during bearing period

From the above discussion it was observed that the maintenance cost for DMI was lower during 6th year to 10th year and decreased gradually compared to CMI from 2.66 per cent in sixth to 6.85 per cent in 10th year. During the 11th to 15th year of bearing period maintenance cost for DMI was higher as compared to CMI by 7.74 per cent which was increased to 14.48 per cent in 46th to 50th year of bearing period. The major role was played by the annuity of drip irrigation and annuity of Coconut in case of fixed costs of DMI. There is a variation in total variable costs between the two systems of irrigations which was mainly due to more human labour requirement, fertilizers usage in CMI as compared to DMI.

5.5 YIELDS AND RETURNS OF COCONUT CULTIVATION WITH DRIP AND CONVENTIONAL METHODS OF IRRIGATION

5.5.1 Harvesting

The coconut palm has a unique character that once it attains bearing stage it continues to bear a bunch of nuts at every leaf axil almost at monthly intervals all the year round and throughout its life extending over its economical life period of upto 50 years. The yield is expressed as number of nuts per hectare per year. Most of the farmers harvest the tender nuts which are in great demand as a delicious soft drink particularly in north costal Andhra Pradesh are best harvested at the age of six to seven months.

In lean period of production, harvesting can be made less frequent and it should be more frequent in peak periods. Generally, harvesting is done once in every 45 to 60 days interval. Then Coconut farmer can get the yield in 7 to 9 pickings per year. In that study area harvesting can be done manually by climbing the coconut tree.

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

Coconut yields start from sixth year and continues upto its economic lifetime of 50 years and the particulars are given in table 5.10. In coconut 6 to 10 years is the lean period and 11 to 40 years is the peak period of production and during 41 to 50 years, yield of coconut tend to decrease. After 50 years the yields shows a very declining trend and at this stage coconut palms respond very little to cultural and other practices, since the vigour and capacity of the palm to yield has lost. The particulars of table 5.10., indicated that the yield per hectare increased gradually from 8,190 nuts in sixth year to 68,970 nuts during11th to 40th year and then decreased to 61,760 nuts during 41st to 50th year when practiced under DMI. Accordingly the gross incomes also increased from Rs 32,760 sixth year to Rs. 2, 75,880 in peak bearing period of 11th year to 40th year and then decreased to Rs. 2, 47, 040 during the period of 41st year to 50th year. The yield and income increased gradually from starting year of bearing i.e., sixth year to peak bearing period (11th year to 40th year) in DMI over CMI.

Table 5.10. Yield and income difference in DMI and CMI in Coconut per hectare

S. No.	Year	Yield in nuts/ha				Income in Rs			
		Drip irrigation	Conventional Irrigation	Yield difference	per cent difference	Drip irrigation	Conventional Irrigation	Income difference	per cent difference
1	6	8190	6910	1280	15.63	32760	27640	5120	15.63
2	7	15650	12680	2970	18.98	62600	50720	11880	18.98
3	8	21295	17150	4145	19.46	85180	68600	16580	19.46
4	9	35185	28175	7010	19.92	140740	112700	28040	19.92
5	10	45190	36150	9040	20.00	180760	144600	36160	20.00
6	11-40	68970	53790	15180	22.01	275880	215160	60720	22.01
7	41-50	61760	50150	11610	18.80	247040	200600	36440	18.80

Note: Income valued at the average price of Rs.4 /nut of Coconut

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

Coconut yields start from sixth year and continues upto its economic lifetime of 50 years. The particulars of table 5.10. indicated that the yield per hectare increased gradually from 6,910 nuts in sixth year to 53,790 nuts during 11^{th}year to 40th year and then decreased to 50,150 nuts during 41^{st} year to 50^{th} year when practiced under CMI. Accordingly the gross incomes also increased from Rs 27,640 sixth year to Rs. 2, 15,160 in peak bearing period of 11^{th} year to 40^{th} year and then decreased to Rs. 2, 00, 600 during the period of 41^{st} year to 50^{th} year.

Muthuchamy *et al.* (2000) reported that Coconut Water applied through drip irrigation of 112 litres per day per tree, the highest nut yield of 133 nuts per tree per year was achieved compared with 124 nuts per tree per year in conventional basin irrigation

There was an increase of 29 per cent in yields of coconut by using drip irrigation system as compared to traditional flood irrigation methods (Padhye,1990).

From the results obtained it can be concluded that the yield in DMI was on an average around 20 per cent higher to CMI in Coconut and drip irrigation helps in achieving greater yield compared to CMI and thereby results in higher income.

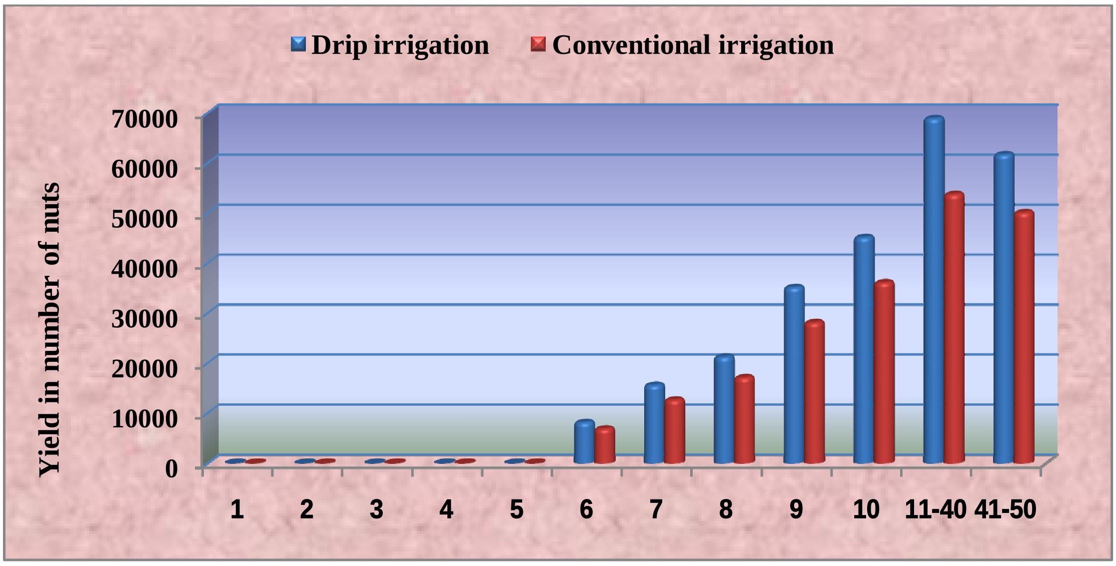

Figure 5.4. Yield difference in drip and conventional methods of irrigation

5.6 FINANCIAL VIABILITY OF DMI VIS-A VIS CMI IN COCONUT 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 Coconut 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 Coconut plantations. In this study, project evaluation techniques were employed to study the financial feasibility of Coconut plantations with DMI and CMI. Undiscounted cash flow techniques such as payback period, rate of return method and average annual returns per rupee of investment 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 Coconut cultivation.

5.6.1.1 Undiscounted Cash Flow Techniques

The results of undiscounted cash flow techniques of both DMI and CMI are presented in table 5.11.

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 2.85 years and 4.58 years for CMI. Therefore, it can be concluded that the period required to repay the initial investment is less for DMI.

5.6.1.1.2 Rate of return method (ROR)

ROR method expresses the profit generated by the investment as a percentage of the investment. In other words it is the ratio of average annual profit to average investment. The rate of return in the study area for DMI was found to be 68.68 per cent and 44.59 per cent for CMI. Therefore it can be concluded that the return per rupee of investment was higher for DMI as compared to CMI.

5.6.1.1.3 Average annual returns per rupee of investment

It is the ratio of average annual net profit to initial investment of the project. The average annual returns per rupee of investment were found to be 35.05 per cent for DMI and 21.82 per cent for CMI. Therefore it can be concluded that the average annual returns per rupee of investment was higher for DMI as compared to CMI.

Table 5.11. Undiscounted cash flow measures of drip method of irrigation and conventional method of irrigation in Coconut

S.No.	Undiscounted cash flow measures	Drip method of irrigation	Conventional method of irrigation	Difference (%)
1	Pay Back period	2.85 years	4.58 years	60.70
2	Rate of return	68.68 per cent	44.58 per cent	54.06
3	Average annual return per rupee of investment	35.05 per cent	21.82 per cent	37.74

5.6.1.2 Discounted Cash Flow Techniques

The costs and benefits from Coconut plantations were discounted at the rate of 11.5 per cent discount rate as it is the rate at which the commercial banks normally lend to Coconut plantations development in the study area.

5.6.1.2.1 Net Present Worth (NPW)

It is observed from tables 5.12 and 5.13 that the net present worth for DMI in Coconut was Rs. 5, 37,165.60 and CMI was Rs. 2, 54,370.60 at 11.5 Per cent discount rate. The higher NPW of drip irrigation indicated the soundness of the investment made in drip irrigation in Coconut plantations. The investment in Coconut plantation with DMI is worthwhile from the sixth 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 (Table 5.14) in Coconut was worked out to be 2.18 and for CMI (Table 5.15) it was 1.49. 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 Coconut cultivation is financially feasible.

5.6.1.2.3 Internal Rate of Return (IRR)

The IRR was found out to be 26.86 per cent for DMI (Table 5.16) which was nearly two times higher than the bank rate of interest on long term loan. The IRR for CMI (Table 5.17) was 21.67 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 Net benefit investment ratio of DMI was found to be 4.74 (Table 5.18) and for CMI it was 2.45 (Table 5.19). Hence it is worthwhile to invest in DMI which has higher net benefit investment ratio as compared to CMI.

Table 5.12. NPW of drip method of irrigation in Coconut

Year	Costs	Gross returns	Net returns	df @11.5%	NPW
1	49210.50	0	-49210.50	0.8969	-44135.00
2	33850.00	0	-33850.00	0.8044	-27227.60
3	33272.00	0	-7246.91	0.7214	-24002.40
4	34816.00	0	-34816.00	0.6470	-22525.80
5	35946.00	0	-35946.00	0.5803	-20858.20
6	42309.00	32760.00	-9549.00	0.5204	-4969.45
7	42375.00	62600.00	20225.00	0.4667	9439.84

8	43250.00	85180.00	41930.00	0.4186	17551.97
9	44329.00	140740.00	96411.00	0.3754	36195.35
10	45975.00	180760.00	134785.00	0.3367	45382.97
11-40	2310910.50	8276400.00	5965489.50	2.8161	559523.67
41-50	741719.50	2470400.00	1728680.50	0.0741	12790.10
				NPW	**537165.58**

Note: Replacement cost of drip system for every 10th year has been included

Table 5.13. NPW of conventional method of irrigation in Coconut

Year	Costs	Gross returns	Net returns	df @11.5%	NPW
1	50436.00	0	-50436.00	0.8969	-45234.08
2	41258.00	0	-41258.00	0.8044	-33186.27
3	40605.00	0	-40605.00	0.7214	-29292.40
4	43265.00	0	-43265.00	0.6470	-27992.21
5	44453.00	0	-44453.00	0.5803	-25794.48
6	55921.00	27640.00	-28281.00	0.5204	-14717.89
7	56332.00	50720.00	-5612.00	0.4667	-2619.35
8	58810.00	68600.00	9790.00	0.4186	4098.11
9	58944.00	112700.00	53756.00	0.3754	20181.49
10	62167.00	144600.00	82433.00	0.3367	27755.72
11-40	2489310.00	6454800.00	3965490.00	2.8161	372242.66
41-50	801510.00	2006000.00	1204490.00	0.0741	10628.23
				NPW	**254370.58**

Table 5.14. B-C ratio of drip method of irrigation in Coconut

Year	Costs	Gross returns	df @11.5%	PW Cost	PW Benefit
1	49210.50	0	0.8969	44134.98	0
2	33850.00	0	0.8044	27227.57	0
3	33272.00	0	0.7214	24002.38	0
4	34816.00	0	0.6470	22525.76	0
5	35946.00	0	0.5803	20858.17	0
6	42309.00	32760.00	0.5204	22018.29	17048.83
7	42375.00	62600.00	0.4667	19778.15	29217.98
8	43250.00	85180.00	0.4186	18104.53	35656.50
9	44329.00	140740.00	0.3754	16642.33	52837.68
10	45975.00	180760.00	0.3367	15480.08	60863.04
11-40	2310910.50	8276400.00	2.8161	217386.42	776910.09
41-50	741719.50	2470400.00	0.0741	5523.79	18313.89
				B-C Ratio	**2.18**

Note: Replacement cost of drip system for every 10th year has been included

Table 5.15. B-C ratio of conventional method of irrigation in Coconut

Year	Costs	Gross returns	df @11.5%	PW Cost	PW Benefit
1	50436.00	0	0.8969	45234.08	0
2	41258.00	0	0.8044	33186.27	0
3	40605.00	0	0.7214	29292.40	0
4	43265.00	0	0.6470	27992.21	0
5	44453.00	0	0.5803	25794.48	0
6	55921.00	27640.00	0.5204	29102.19	14384.30
7	56332.00	50720.00	0.4667	26292.45	23673.10
8	58810.00	68600.00	0.4186	24617.97	28716.08
9	58944.00	112700.00	0.3754	22129.20	42310.69
10	62167.00	144600.00	0.3367	20932.02	48687.74
11-40	2489310.00	6454800.00	2.8161	233672.86	603150.06
41-50	801510.00	2006000.00	0.0741	5941.86	17636.60
				B-C Ratio	**1.49**

Table-5.16. Internal rate of return of drip method of irrigation in Coconut

Year	Costs	Gross returns	Net returns	df @22%	NPW at 22%	df @27%	NPW at 27%
1	49210.50	0	-50436.00	0.8197	-40336.50	0.7874	-38748.40
2	33850.00	0	-41258.00	0.6719	-22742.50	0.6200	-20987.00
3	33272.00	0	-40605.00	0.5507	-18323.10	0.4882	-16243.10-
4	34816.00	0	-43265.00	0.4514	-15715.90	0.3844	-13383.30
5	35946.00	0	-44453.00	0.3700	-13300.00	0.3027	-10880.10
6	42309.00	32760.00	-28281.00	0.3033	-2896.00	0.2383	-2275.81
7	42375.00	62600.00	-5612.00	0.2486	5027.70	0.1877	3795.44
8	43250.00	85180.00	9790.00	0.2038	8543.70	0.1478	6195.77
9	44329.00	140740.00	53756.00	0.1670	16102.31	0.1164	11217.42
10	45975.00	180760.00	82433.00	0.1369	18451.99	0.0916	12348.22
11-40	2310910.50	8276400.00	3965490.00	0.6207	5965489.50	0.3391	67286.39
41-50	741719.50	2470400.00	1204490.00	0.0014	1728680.60	0.0002	40.78
	Total				58270.68		-1633.71
					IRR		**26.83**

Note: Replacement cost of drip system for every 10th year has been included

Table 5.17. Internal rate of return of conventional method of irrigation in Coconut

Year	Costs	Gross returns	Net returns	df @15 %	NPW at 15%	df @20 %	NPW at 20%
1	50436.00	0	-50436.00	0.8696	-43857.4	0.8333	-42030
2	41258.00	0	-41258.00	0.7561	-31197	0.6944	-28651.4
3	40605.00	0	-40605.00	0.6575	-26698.4	0.5787	-23498.3
4	43265.00	0	-43265.00	0.5718	-24736.9	0.4823	-20864.7
5	44453.00	0	-44453.00	0.4972	-22101	0.4019	-17864.7
6	55921.00	27640.00	-28281	0.4323	-12226.7	0.3349	-9471.25
7	56332.00	50720.00	-5612	0.3759	-2109.76	0.2791	-1566.21
8	58810.00	68600.00	9790	0.3269	3200.368	0.2326	2276.841
9	58944.00	112700.00	53756	0.2843	15280.81	0.1938	10418.27
10	62167.00	144600.00	82433	0.2472	20376.18	0.1615	13313.39
11-40	2489310.00	6454800.00	3965490.00	1.6230	214534.30	0.8041	106291.79
41-50	801510.00	2006000.00	1204490.00	0.0187	2256.77	0.0029	343.58
	Total				92721.29		-11302.60
					IRR		**21.67**

Table 5.18. N/K ratio of drip method of irrigation in Coconut

Year	Incremental Costs	Incremental Benefits	Net Benefits	df @11.5%	PW of incremental net benefit
1	49210.50	0	-49210.50	0.8969	-44135.00
2	33850.00	0	-33850.00	0.8044	-27227.60
3	33272.00	0	-7246.91	0.7214	-24002.40
4	34816.00	0	-34816.00	0.6470	-22525.80
5	35946.00	0	-35946.00	0.5803	-20858.20
6	42309.00	32760.00	-9549.00	0.5204	-4969.45
7	42375.00	62600.00	20225.00	0.4667	9439.84
8	43250.00	85180.00	41930.00	0.4186	17551.97
9	44329.00	140740.00	96411.00	0.3754	36195.35
10	45975.00	180760.00	134785.00	0.3367	45382.97
11-40	2310910.50	8276400.00	5965489.50	2.8161	559523.67
41-50	741719.50	2470400.00	1728680.50	0.0741	12790.10
PW of negative net incremental benefits					-143718.00
PW of positive net incremental benefits					680883.90
				N/K ratio	**4.74**

Note: Replacement cost of drip system for every 10th year has been included

Table 5.19. N/K ratio of conventional method of irrigation in Coconut

Year	Incremental Costs	Incremental Benefits	Net Benefits	df @11.5%	PW of incremental net benefit
1	50436.00	0	-50436.00	0.8969	-45234.08
2	41258.00	0	-41258.00	0.8044	-33186.27
3	40605.00	0	-40605.00	0.7214	-29292.40
4	43265.00	0	-43265.00	0.6470	-27992.21
5	44453.00	0	-44453.00	0.5803	-25794.48
6	55921.00	27640.00	-28281.00	0.5204	-14717.89
7	56332.00	50720.00	-5612.00	0.4667	-2619.35
8	58810.00	68600.00	9790.00	0.4186	4098.11
9	58944.00	112700.00	53756.00	0.3754	20181.49
10	62167.00	144600.00	82433.00	0.3367	27755.72
11-40	2489310.00	6454800.00	3965490.00	2.8161	372242.66
41-50	801510.00	2006000.00	1204490.00	0.0741	10628.23
PW of negative net incremental benefits					-174739.00
PW of positive net incremental benefits					429109.10
				N/K ratio	**2.45**

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. As presented in table 5.20 the costs of Coconut plantation with drip irrigation could rise by 118 per cent before the B: C ratio would be driven to one. Similarly the benefits could fall by 54 per cent before the ratio would be driven to one.

Table 5.20. Switching values of drip method of irrigation in Coconut

S.No.	Switching values	Per cent
Based on B:C Ratio		
1	Increased total costs	118
2	Decrease in total incremental benefits	54

The costs of Coconut plantation with conventional irrigation could rise by 49 per cent before the B: C ratio would be driven to one. Similarly the benefits could fall by 33 per cent before the ratio would be driven to one (Table 5.21).

Table 5.21. Switching values of conventional method of irrigation in Coconut

S.No.	Switching values	Per cent
Based on B:C Ratio		
1	Increased total costs	49
2	Decrease in total incremental benefits	33

It is evident from the above switching values that the investment on drip irrigation in Coconut is a profitable proposition and is economically viable even if the costs could raise by 118 per cent and benefits could fall by 54 per cent in future period.

5.8. ECONOMIC VIABILITY OF DRIP IRRIGATION WITH AND WITHOUT SUBSIDY

Drip irrigation system (DIS) is an expensive technology with an initial capital cost of Rs. 29,435 per ha of Coconut plantation. The subsidy is provided to the farmers at different rates based on the land holdings of the farmers. Farmers having < 5 ha, 5-10 ha and > 10 ha are provided with subsidy rates of 90 per cent, 75 per cent and 50 per cent respectively.

To study the economic viability of Coconut cultivation with different subsidy scenarios and without subsidy components on DMI in the present study NPW, BCR, IRR and N/K ratio values were estimated. The results of the viability values of theses discounted techniques were presented and compared to conventional method of irrigation in the table 5.22.

Table 5.22. Economic viability of Coconut plantations under drip irrigation with and without subsidy

S.No.	Discounted Cash flow technique	Drip method of irrigation				Conventional method of irrigation
		Drip irrigation Without subsidy	Drip irrigation with 90 per cent subsidy	Drip irrigation with 75 per cent subsidy	Drip irrigation with 50 per cent subsidy	
1	**NPW (Rs.)**	501500.60	537165.58	531221.40	521314.50	254370.58
2	**BCR**	2.02	2.18	2.16	2.11	1.49
3	**IRR(Per cent)**	24.59	26.86	26.54	25.93	21.67
4	**N/K Ratio**	3.99	4.74	4.60	4.38	2.46

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

The table 5.22. revealed that the NPW of drip irrigation without subsidy, drip irrigation with 90 per cent subsidy, drip irrigation with 75 per cent subsidy and drip irrigation with 50 per cent subsidy accounted for Rs. 5,01,500.60, Rs. 5, 37,165.58, Rs. 5,31,221.40, and Rs. 5,21,314.50 and for conventional method of irrigation it was Rs. 2,54,370.58.

B-C ratio of drip irrigation without subsidy, drip irrigation with 90 per cent subsidy, drip irrigation with 75 per cent subsidy and drip irrigation with 50 per cent subsidy was accounted for 2.02, 2.18, 2.16 and 2.11 as against conventional method of irrigation with 1.49.

IRR for drip irrigation without subsidy, drip irrigation with 90 per cent subsidy, drip irrigation with 75 per cent subsidy and drip irrigation with 50 per cent subsidy was worked out to be 24.59 per cent, 26.86 per cent, 26.54 per cent, and 25.93 per cent while it was 21.67 per cent for conventional irrigation.

Similarly the N/K Ratio for drip irrigation without subsidy, drip irrigation with 90 per cent subsidy, drip irrigation with 75 per cent subsidy and drip irrigation with 50 per cent subsidy was accounted for 3.99, 4.74, 4.60 and 4.38 while conventional method of irrigation accounted to 2.46.

The analysis of different scenarios with subsidy and without subsidy indicated that drip irrigation is economically viable even without subsidy in Coconut cultivation. Considering different scenarios of subsidy as presented in table 5.21 the NPW, B-C ratio, IRR and N/K ratio further increased with increase in subsidy rates. But without subsidy drip irrigation system in Coconut cultivation was also economically viable as revealed by BCR ratio which is greater than one and IRR greater than the market rates of interest extended to Coconut plantations by banks and also N/K ratio with greater than one.

Narayanamoorthy (2005b) 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.

Drip irrigation system showed an increase in production of sugarcane crop by 27.65 per cent, per hectare net returns by Rs. 20,234 over Rs. 17,861 under the non-drip category of farmers with B:C Ratio of 1.51 and 1.25 with and without subsidy option showing its economic viability (Waykar, 2003).

The earlier research study results available (INCID 1994, Sivanappan 1995, Narayanamoorthy 2005b) also confirmed that the cultivation of several vegetable crops, fruit crops and plantation crops was economically viable without subsidy in drip units.

It can be concluded that the adoption of drip irrigation in Coconut is economically viable even without subsidy as there is a significant amount of saving in irrigation water, electricity, cost of cultivation and a substantial increase in the productivity

5.7 WATER USE EFFICIENCY IN DMI AND CMI

The quantity of water used was low in DMI with 2745.60 ha-cm compared to 7267.99 ha-cm in CMI. The results of the water use efficiency (WUE) are presented in table 5.22.

Table 5.23. Water use efficiency of Coconut under drip and conventional method of irrigation systems.

S. No.	Particulars	Drip method of irrigation	Conventional method of irrigation
1	Number of irrigations/50 years	13750	2000
2	Time required per irrigation (hour)	4	16
3	Total hours of irrigation	55000	32000
4	Water applied per hour (l)	4992	22712.47
5	Total water applied (l)	274560000	726799040
6	Water applied in ha-cm	2745.60	7267.99
7	Yield (nuts/ha)	2812210	2216265
8	Water use efficiency (water consumed per unit of output produced in nuts/ha-cm)	1024	305
9	Gain in WUE in of Coconut under drip irrigation over conventional method of irrigation.	70.21 per cent	

The highest water use efficiency of 56.24 kg ha^{-1} mm^{-1} in terms of yield per ha-mm of water applied was recorded in the treatment irrigated every alternative day through drip system as compared to conventional furrow irrigation system 14.16 kg ha^{-1} mm^{-1}(Rajeshkumar *et al.*2013).

It can be observed from the results that higher crop yield coupled with lower quantity of water used resulted in higher water use efficiency in terms of output per unit of water consumed that was recorded at 1024 nuts/ha-cm in DMI as against 305 nuts/ha-cm in CMI.

5.7.1 Water Saving

In Coconut cultivation, drip irrigation system can save 45-50% water over surface irrigation. With the water thus saved, one extra hectare can be brought under irrigation thereby increasing the net income of the farmers (Kapadiyal *et al.*,1998).

In Coconut plantations, through the adoption of drip irrigation, significant saving in water was observed. From Table 5.22 concluded that the amount of water saved through DMI compared to CMI was 4522.39 ha-cm *i.e.,* 62.22 per cent. This saved water can be used to irrigate an additional one hectare of Coconut if the farmers can shift to DMI.

5.8 CONSTRAINTS IN DRIP IRRIGATION SYSTEM IN COCONUT CULTIVATION

An opinion survey was conducted to identify the constraints experienced by drip irrigated farmers in the study area. There are various constraints faced by coconut farmers while adopting drip irrigation system and sample respondents were allowed to rank their constraints and this was explained by Garrett Ranking Method.

The constraints faced by the Coconut growers under Drip irrigation and their garrett scores were are presented in the table 5.24. The particulars presented in the table 5.24, revealed that sensitivity to clogging of drippers was the major constraint faced by majority of the farmers. Next to that only diluted fertilizers were used in root zone was another constraint followed by the some other constraints like high skill is required for design, installation and operations, unavailability of cheap locally available spare parts, damage caused to the system by rats and wild pigs in field, high cost compared to conventional methods, inadequate follow up services by the drip agencies, low quality equipment and spare parts, Moisture distributions problems and Salt accumulation in root zone.

Table 5.24 Garrett score of constraints faced by drip adopted coconut farmers

Particulars	Garrett score	Average score	Rank
Sensitivity to clogging of drippers	3555	79.00	I
Only diluted fertilizers are used in root zone	3154	70.09	II
High skill is required for design, installation and operations	2469	54.87	III
Unavailability of cheap locally available spare parts	2408	50.84	IV
Damage caused to the system by rats and wild pigs in field	2288	47.96	V
High cost compared to conventional methods	2158	46.20	VI
Inadequate follow up services by the drip agencies	2079	44.00	VII
Low quality equipment and spare parts	1980	60.91	VIII
Moisture distributions problems	1507	33.49	IX
Salt accumulation in root zone	1052	23.38	X

Source: Field survey data

Shivanappan (1995) expressed that the constraints faced by the micro irrigation adopted farmers in Coconut were high initial cost, clogging of drippers and cracking of pipes, lack of adequate technical inputs, damage due to rodents, high cost of spare components and insufficient extension education efforts.

Similar results were also presented by Desai *et al.*, 1999 that the major technological constraints faced by the users of drip sets were frequent clogging of drippers and micro tubes, damage caused to the system by rodents and jackals, lack of technical know-how and lack of awareness among the farmers regarding the benefits of drip irrigation systems.

The major suggestions include regular cleaning of drippers and filters, timely provision of regular after sales services by the drip set suppliers; and technical training to drip adopters, provision and availability of subsidies and loans; reduction in total initial cost of the drip unit.. The suggestions also include regular supervision for rats and underground piping of drip irrigation, laying fencing in order to protect from wild and stray animals, assured power supply, financial assistance from banks and increasing the subsidy for cultivation and in installation of drip system. In addition to these training should be given to the farmers regarding operation, maintenance, repairing and application of water soluble fertilizers.

5.9 IMPACT ON PRODUCTIVITY, RETURNS AND VIABILITY OF DRIP IRRIGATION OVER CONVENTIONAL IRRIGATION METHOD IN COCONUT

It is observed from table 5.24 that the establishment costs of DMI exceeded CMI by Rs. 10, 726.88 accounting to 4.28 per cent. The establishment costs can be paid back after shifting to the drip system within 2.85 years. Though the costs were more it was compensated by the income generated which was 53.91 per cent (Rs. 27, 28,828.50) higher in DMI over CMI. Similarly the Water use efficiency of DMI exceeded the CMI in Coconut by 70.21 per cent (719 nuts/ha-cm). The NPW, BCR and IRR in DMI exceeded the CMI in Coconut by 53, 32 and 20 per cent respectively.

Table 5.24. Impact of DMI over CMI in Coconut Plantations per hectare

S.No.	Efficiency impact parameters	Difference between DMI and CMI	Percentage difference between DMI and CMI
1	Establishment costs (upto five years)	Rs. 10, 726.88/ha	4.28
2	Income gains	Rs. 27, 28,828.50/ha	53.91
3	Water use efficiency	719 nuts/ha-cm	70.21
4	PBP	1.73 years	60.70
5	NPW	282795.01/ha	52.64
6	BCR	0.70	31.99
7	IRR	5.19	19.32

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 coconut 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. It enables diversification, import substitution, valued addition, low cost of cultivation, and is used for co-generation besides being eco-friendly and sustainable. Despite all the advantages, coconut requires copious irrigation, and it required 280 litres of water per day per tree. Water deficiency resulted in wilting of lower leaves, reduced flowering, and more dropping of nuts, besides affecting adversely the yield, size and quality of nuts.

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 through drip irrigation.

The study was undertaken with the following objectives

1) To analyze the cost structure of drip irrigation system in coconut cultivation.
2) To appraise the economic viability and financial feasibility of installing drip irrigation system in coconut cultivation with and without subsidy components.
3) To assess water use efficiency 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 coconut cultivation.

Srikakulam district was purposively chosen for the study as it has considerable area under drip irrigation in coconut. Of the total coconut area in Srikakulam district, 65 per cent area is under drip irrigation. All the mandals in Srikakulam district practicing drip irrigation in coconut were arranged in descending order of the area under the crop and the top three mandals were chosen purposively. Three villages from each selected mandal were chosen randomly making the selection of nine villages for the study. Five farmers were chosen from each village thus constituting the total sample of 45 farmers for the district. Similar method was followed for the conventional irrigation in Coconut. An ultimate sample of 90 (45 drip irrigated farmers +45 conventional irrigated farmers) in coconut were chosen.

6.1.TOOLS OF ANALYSIS

Tabular analysis was used to analyze the costs and returns of coconut cultivation. Project appraisal techniques (Pay back period, ROR method, Average annual returns per rupee of investment, NPW, B-C ratio, IRR, N/K ratio and Switching values were used to test the financial feasibility of drip irrigation in coconut and for assessing the economic viability of drip irrigation without subsidy and with subsidy under varied subsidy scenarios. Water use efficiency of coconut under drip and conventional method were assessed. An opinion survey was conducted to study the constraints in execution, installation and maintenance of drip irrigation in Coconut.

6.2 MAJOR FINDINGS OF THE STUDY

6.2.1 Size of Holding

The average size of the holding was 5.85 ha for drip irrigated farmers and 2.31 ha for conventionally irrigated farmers. Area under coconut was about 56.41 per cent to the total operational holding of the selected sample.

6.2.2 Establishment Costs of Coconut Cultivation

The total establishment costs expended per hectare of coconut with drip irrigation during its pre- bearing (1-5 years period) stood at Rs. 2,61,297 of which Rs 90,695 (34.71 per cent) were variable costs and Rs. 1,70,602 (65.29per cent) were fixed costs. The total costs expended per hectare of coconut with conventional method of irrigation during its pre- bearing period (1-5 years) stood at Rs. 2,50,570 of which Rs 1,30,686 (52.16 per cent)were variable costs and Rs. 1,19,885 (47.84 per cent) were fixed costs. The establishment cost of drip irrigation exceeded the conventional irrigation by 4.28 per cent (Rs. 10,727) due to the involvement of drip irrigation system cost which stood at Rs. 2944. It is evident that the cost of cultivation with drip method of irrigation is high compared to conventional irrigation.

The total costs incurred to establish one hectare of coconut plantations during the first year amounted to Rs. 64,194for drip irrigation and Rs. 33,310 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. The cost incurred to maintain one hectare of coconut orchard during the remaining years of pre-bearing periods (second to fifth years) stood at Rs. 49,136, Rs. 47,976, Rs. 49,442 and Rs. 50,549for drip irrigation respectively. The cost incurred to maintain one hectare of coconut orchard during the remaining years of pre-bearing periods (second to fifth years) stood at and Rs. 23,076, Rs. 22,348, Rs. 25,314 and Rs. 26,639respectively for conventional irrigation.

6.2.3 Maintenance Costs of Coconut Cultivation

The per hectare total maintenance cost of coconut for entire life period bearing stage under DMI was Rs.64, 07,591and Rs. 61, 31,196 for CMI. The total costs per hectare decreased gradually from Rs. 1, 20,200.09 in sixth year to Rs. 1, 06,018 in 10thyear for drip method of irrigation compared to the costs of Rs. 1, 23,487in sixth year to Rs. 1, 13,809 in 10th year for conventional method of irrigation. Maintenance cost in drip method of irrigation was fluctuating between the years of 11th year to 50th year due to replacement of drip system for every 10th year as the life span of drip system is 10 years only. As in case of conventional method of irrigation maintenance cost decreased from Rs.1, 31,869 (11th year to 15th year) to Rs. 1, 19,388.64 (45th year to 50th year).

6.2.4 Cost of Drip Irrigation System

The cost of total drip system was Rs. 29,435. The drip irrigation system constitutes mainly three parts i.e., Head control unit cost constituting of 23.34 per cent, Water carrier system constituting of 38.07 per cent and Water distribution system constituting of 28.10 per cent. The other charges for drip irrigation system include 10.49 per cent.

6.2.5 Yield and Returns of coconut under DMI and CMI

Coconut yield starts in sixth year and extends upto 50 years. Bearing stage started at 6 to 10 years, while 11 to 40 years was the peak bearing stage and after that yields tended to decrease. The yield and income under drip method of irrigation was nearly 20 per cent higher to that of conventional method of irrigation. The total yield per hectare for the entire economic life period was 2812210 nuts under DMI and 2216265 nuts under CMI. The total income obtained from one ha during the entire life period of Coconut under drip irrigation was Rs. 1, 12,48,840 and Rs. 88, 65,060. The average yield per hectare in a year during peak bearing period of 11th to 40th year of Coconut for DMI was 68970 nuts/ha and for CMI was 53790 nuts/ha, in which DMI exceeds CMI by CMI by 22.01 per cent. Similarly the average returns from Coconut plantations from DMI were Rs. 275880 and CMI were Rs. 215160 and 22.01 per cent more returns were obtained from DMI.

6.2.6 Financial Viability of Drip Irrigation in Coconut

6.2.6.1 Payback Period

The payback period in the study area for Coconut plantation was found to be 2.85 years for drip method of irrigation after establishment of plantations and 4.58 years for CMI.

6.2.6.2 Rate of return method (ROR)

The rate of return in the study area for Coconut under DMI was found to be 68.68 per cent and 44.59 per cent for CMI.

6.2.6.3 Average annual returns per rupee of investment

The average annual returns per rupee of investment were found to be 35.05 per cent for DMI and 21.82 per cent for CMI in Coconut.

6.2.6.4 Net Present Worth

The net present worth for DMI in Coconut was Rs. 5, 37,166and Rs. 2, 54,371 for CMI at 11.5 per cent discount rate which is higher than the present costs. Hence the Coconut cultivation with DMI is more financially viable over CMI.

6.2.6.5 Benefit-Cost Ratio

The benefit-cost ratio of Coconut was worked out to be 2.18 in DMI and 1.49in CMI. The higher BCR in DMI indicated that DMI in Coconut cultivation is highly viable over CMI.

6.2.6.6 Internal Rate of Return (IRR)

The IRR was found out to be 26.86 per cent for drip irrigation and 21.67 for CMI. The returns generating capacity of DMI over CMI in Coconut was 5.19 per cent higher and hence DMI is profitable.

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

The Net benefit investment ratio of DMI was found to be 4.74 and for CMI it was 2.45. Hence it is worthwhile to invest in DMI, which has higher Net benefit investment ratio as compared to CMI.

6.2.6.8 Sensitivity Analysis- Switching Values

The costs of Coconut plantation with drip irrigation could rise by 118 per cent before the B: C ratio would be driven to one and make it viable. Similarly the benefits could fall by 54 per cent before the ratio would be driven to one and still the DMI is viable.

6.2.7 Economic Viability of Drip Irrigation with and without Subsidy

The NPW, B-C ratio, IRR and N/K ratio without subsidy in drip irrigation system was Rs. 5,01,500.60, 2.02, 24.59 and 3.99 respectively. The NPW, B-C ratio, IRR and N/K ratio with 90 per cent subsidy in drip irrigation was Rs. 5,37,165.58, 2.18, 26.86 and 4.74 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 NPW values were Rs. 5,31,221.40 and Rs. 521315, B-C Ratios were 2.16 and 2.1, IRRs were 26.54 and 25.93 respectively.

6.2.8 Economic Viability

The quantity of water used was low in DMI with 2745.60 ha-cm compared to CMI with7267.99 ha-cm. The higher water use efficiency of 1024.26 nuts/ha-cm in DMI over that of CMI with 304.94 nuts/ha-cm was recorded. The amount of water saved through DMI compared to CMI was 4522.39 ha-cm i.e., 62.22 per cent. With this, water saving under DMI over CMI can be brought under cultivation by extending DMI to CMI plantations.

6.2.9 Constraints in Drip Irrigation System in Coconut Cultivation

The major problems faced by the farmers in the adoption of drip irrigation were sensitivity to clogging of drippers was the major constraint faced by majority of the farmers. Next to that only diluted fertilizers were used in root zone was another constraint followed by the some other constraints like high skill is required for design, installation and operations, unavailability of cheap locally available spare parts, damage caused to the system by rats and wild pigs in field, high cost compared to conventional methods, inadequate follow up services by the drip agencies, low quality equipment and spare parts, moisture distributions problems and salt accumulation in root zone. The major suggestions include regular cleaning of drippers and filters, timely provision of regular after sales services by the drip set suppliers; and technical training to drip adopters, provision and availability of subsidies and loans; reduction in total initial cost of the drip unit.

6.3 CONCLUSIONS

i. The higher water use efficiency in terms of output produced per unit of water consumed was 1149.86 nuts/ha-cm in drip irrigation system to that of conventional irrigation system of341.94 nuts/ha-cm.

ii. The water use efficiency in terms of water consumed to produce one unit of output was 1149.86 nuts/ha-cm and 341.94 nuts/ha-cm for DMI and CMI respectively. By converting to DMI, water saving was 62.22 per cent in drip irrigation compared to conventional irrigation. With this water saved another half acre of Coconut plantation can be irrigated by CMI farmers.

iii. The total yield per hectare for the entire economic life period was 3157060 nuts under drip irrigation and 2485215 nuts under conventional irrigation *i.e.,* 27.03 per cent (671845 nuts) more in DMI. The total income obtained from one ha during the entire life period of Coconut under drip irrigation was Rs. 1,26,28,240 and Rs. 99, 40,860 in CMI with 27.03 per cent (Rs. 26, 87,380) more returns obtained over CMI.

iv. The average yield per hectare in a year for DMI is 63141nuts/ha and for CMI it was 49704 nuts/ha, where DMI exceeded CMI by 27.03 per cent. Similarly the average returns from Coconut plantations from DMI were Rs.2, 52,565 and CMI were Rs. 1,98,817, with Rs. 53,748 of more returns obtained in DMI. Though 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.

v. It is evident from the project evaluation techniques of PBP, ROR, average annual returns per rupee of investment, NPW, BCR, IRR and N/K ratio that the drip irrigation is economically viable and financially feasible.

vi. The major problems faced by the farmers in the adoption of drip irrigation were sensitivity to clogging of drippers, damage by rats use of only diluted fertilizers in root zone.

6.4 POLICY IMPLICATIONS

Some policy recommendations, which may be useful for expanding the adoption of drip method of irrigation in the state are:

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. By adopting the drip irrigation system, production costs will be reduced mainly due to less labour requirement and fertigation technique and also returns will be high due to sufficient and timely water management. It is required to create awareness among the farmers about the economic benefits and usage of drip irrigation system.

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

iv. Since coconut plantations with DMI are viable financially and economically even without subsidy in drip irrigation system. Subsidies can be rationally reduced. As an alternative for reduction of subsidies, loans from banks shall be provided for adoption of DIS in coconut cultivation, especially for the small farmers.

v. 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.

vi. Drip sets manufacturers should supply good quality spare parts of the system for the maintenance of the system without any fail in the functioning of the system. It is also necessary to provide sufficient training regarding the cleaning and maintenance of drippers.

LITERATURE CITED

Afshar, H and Mehrabadi, H.R. 2008. Investigation on yield and yield components of cotton in drip and furrow irrigation methods (Persian). *Seed and Plant.* 23 (4): 557-570.

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

Albayrak, M., Gunes, E and Gulcubuk, B. 2010. The effects of irrigation methods on input use and productivities of sugar beet in central Anatolia, Turkey. *African Journal of Agricultural Research.* 5 (3): 188-195.

Al-Shayaa, M.S. 2011. Barriers of adopting the modern irrigation systems in the Medina in Saudi Arabia (Arabic). *Bulletin of Faculty of Agriculture, Cario University.* 62 (3): 261-273.

Anand, T.N., Lakshminarayana, M.T and Manjunatha, B.N. 1998(a). Problems of drip irrigation system as perceived by the grape growers. *Karnataka Journal of Agricultural Sciences.* 11 (4): 1106-1108.

Anand, T.N., Lakshminarayana, M.T and Manjunatha, B.N. 1998(b). Comparison of input utilization in grape cultivation under drip and surface irrigation systems. *Current Research – University of Agricutural Sciences (Bangalore).* 27 (9/10): 164-165.

Anand, T.N., Lakshminarayana, M.T., Manjunatha, B.N and Prasanna Kumar, G.T. 1999. Comparision of economics of drip and surface irrigation systems in grapes. *Financing Agriculture.* 30 (31): 3-6.

Andal, G., Rao, V.P and Bindu, H. 2008. Analysis of impact of adoption of micro irrigation technology on crop yield, water saving and economics in farmer’s fields of Andhra Pradesh. *Journal of Soils and Crops.* 18 (2): 266-272.

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

Aujla, M.S., Thind, H.S and Buttar, G.S. 2005. Cotton yield and water use efficiency at various levels of water and nitrogen through drip irrigation under two methods of planting. *Journal of Agricultural Water Management.* 71: 167-179.

Barse, K.N., Gohad, V.V and Lunge, M.R. 2010. Adoption of drip irrigation system by orange growers in amaravati taluka. *Agriculture Update*. 5: 346-348.

Batchler, C., Lovell, C and Murata, M. 1996. Simple micro irrigation technique for improving irrigation efficiency on vegetable gardens. *Journal of Agricultural Water Management.* 32: 37-48.

Behera, B.P and Sahoo, N. 1998. Economic evaluation of a drip irrigation system in orissa. *Environment and Ecology.* 16 (2):297-299.

Berad, S.M., Shinde, S.H and Dahiwalkar, S.D. 1999. Effects of drip fertigation and paired planting on productivity and economics of banana. *Journal of Maharashtra Agriculture Universities.* 23 (3): 288-290.

Bhagyawant, R.G., Khedkar, D.D., Popale, P.G and Jadhav, S.B. 2012. Yield response and economic feasibility of cauliflower under drip irrigation. *Engineering and Technology In India.* 3 (1): 34-38.

Bhatnagar, P.R., Sikka, A.K., Gautam, U.S., Singh, S.S., Kumar, U and Rajan, K. 2007. Microtube irrigation for banana cultivation in South Bihar: participatory assessment and refinement. *Journal of Agricultural Engineering*. 44 (2): 109-115.

Bhingardeve, S.D., Patil, S.S and Tale, N.N. 2012. Drip irrigation system followed by the sugarcane growers. *Cooperative Sugar.* 43 (10): 35-38.

Birari, K.S., Desale, P.G and Patil, M.R. 2004. An economic evaluation of drip irrigation technique for banana in Western Maharashtra. *Agricultural Economics Research Review.* 17 (Conference issue): 226.

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.

Brahma, S., Phookan, D.B., Barua, P and Saikia, L. 2010. Effect of drip-fertigation on performance of tomato under Assam conditions. *Indian Journal of Horticulture.* 67 (1): 56-60.

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 American Society of Agricultural Engineering.* 41 (5): 1353-1367.

Cetin, B., Ozer, H and Kuscu, H. 2004 (a). Economics of drip irrigation for apple (*Malus domestica*) orchards in turkey. *New Zealand Journal of Crop and Horticultural Science*. 32 (4): 349-354.

Cetin, B., Yazgan, S and Tipi, P. 2004(b). Economics of drip irrigation of olives in Turkey. *Agricultural Water Management.* 66 (2): 145-151.

Çetin, B., Tipi, T., Ozer, H and Yazgan, S. 2003. Economics of drip irrigation for peach (*Prunus Persica*) orchards in turkey. *New Zealand Journal of Crop and Horticultural Science.* 31 (2): 85-90.

Chandrakanth, M.G., Priyanka, C.N., Mamatha, P and Patil, K. K. 2013. Economic benefits from micro irrigation for dry land crops in Karnataka. *Indian Journal of Agricultural Economics.* 68 (3): 326-337.

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.

Dagnino, M and Ward, F.A. 2012. Economics of agricultural water conservation: empirical analysis and policy implications. *International Journal of Water Resources Development.* 28 (4): 577-600.

Dawes, M.A. 2000. Low cost portable drip for irrigated tobacco production in Zimbabwe. 6th international micro-irrigation congress (Micro 2000), Cape Town, South Africa, 22-27 october, 2000. 1- 6.

Desai, C.P., Patel, A.A and Patel, M.R. 1999. Constraints faced by mango growers in adoption of drip irrigation system. *Gujarat Agricultural University Research Journal*. 24 (2): 52-57.

Desai, C.P., Patel, M.R., Patel, A.A and Trivedi, J.C. 2000. Economic gain through adoption of drip irrigation system in mango orchards. *Gujarat Agricultural University Research Journal.* 25 (2):46-52.

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.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.

Finger, R and Lehmann, N. 2012. Policy reforms to promote efficient and sustainable water use in swiss agriculture. *Water Policy.* 14 (5): 887-901.

Friedlander, L., Tal, A and Lazarovitch, N. 2013. Technical considerations affecting adoption of drip irrigation in sub-saharan africa. *Agricultural Water Management.* 126: 125-132.

Gittinger J. P. 1982. Economic analysis of Agricultural Projects. EDI series in Economic Devolopment. World Bank publications.

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.

Gufran, M. 2010. Field evaluation of onion crop under trickle irrigation system in U.P. *New Agriculturist.* 21 (1/2): 93-98.

Gultas, H.T and Erdem, Y. 2007. Comparison of drip and micro sprinkler irrigation methods for dwarf cherry orchards in the aspect of investment and operational costs. (Turkish). *Tarim Bilimleri Dergisi*. 13 (1): 38-46.

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.

Halvoson, A.D., Bartolo, M.E., Reule, C.A and Berrade, A. 2008. Nitrogen effects on onion yield under drip and furrow irrigation. *Agronomy Journal.* 100 (4): 1062-1069.

Hebbar, S.S., Ramachandrappa, B.K., Nanjappa, H.V and Prabhakar, M. 2004. Studies on NPK drip fertigation in field grown tomato. *European Journal of Agronomy.* 21: 117-127.

Hussain, K., Majeed, A., Nawaz, K., Afghan, S., Ali, K., Feng, L., Zafar, Z and Raza, G. 2010. Comparative study of subsurface drip irrigation and flood irrigation systems for quality and yield of sugarcane. *African Journal of Agricultural Research.* 5 (22): 3026-3034.

Ibragimov, N., Evett, S.R., Esanbekov, Y., Kamilov, B.S., Mirzaev, L and Lamers, J.P. A. 2007. Water use efficiency of irrigated cotton in Uzbekistan under drip and furrow irrigation. *Agricultural Water Management.* 90 (1-2): 112-120.

Inamdar, P.P., Pawar, J.R and Sale, D.L. 1996. Economic efficiency of biwall drip irrigation in sugarcane production – a case study in Anakalkhop village in Sangli district of Maharashtra. *Bharatiya Sugar*. 22 (3): 13-18.

INCID 1994. Drip irrigation in India. Indian national committee on irrigation & drainage, ministry of water resources, Govt., of India, New Delhi.

Iqbal, M., Sahi, F.H., Hussain, T., Aadal, N.K., Azeem, M.T and Tariq, M. 2014. Evaluation of comparative water use efficiency of furrow and drip irrigation systems for off-season vegetables under plastic tunnel. *International Journal of Agriculture and Crop Sciences.* 7 (4): 185-190.

Jadhav, M.S. and Kumbhar, J.S. 2004. Impact of drip irrigation to conventional method of irrigation in grapes in maharashtra. *Agricultural Economics Research Review.* 17 (1-2): 228.

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. 171-176.

Jalajakshi, C.K and Jagadish, N. 2009. Economics of krishik bandhu drip irrigation: An empirical analysis. *Agricultural Economics Research Review.* 22 (1):161-164.

Jayapiratha, V., Thushyanthy, M and Sivakumar, S. 2010. Performance evaluation of okra (*Abelmoschus esculentus*) under drip irrigation system. *Asian Journal of Agricultural Research.* 4 (3): 139-147.

Kakhandaki, S.H., Padmakumari, O and Patil, R.H. 2013. Performance of drip and micro sprinkler irrigation systems in tomato crop. *Karnataka Journal of Agricultural Sciences.* 26 (3): 419-420.

Kakhandaki, S.H., Padmakumari, O., Madhusudhan, M.S. and Ramappa, K.T. 2012. Study on cost economics of drip and micro sprinkler irrigation systems for tomato crop. *International Journal of Agricultural Engineering.* 5 (1): 95-97.

Kalathiya, K.V., Dave, S.K and Mehta, D.R. 2007. Cost and returns in different sizes of coconut holding in Valsad district (South Gujarat). *Indian Journal of Agricultural Research.* 41 (3): 228-231.

Kaltu, S and Gunes, E. 2010. Effect of different irrigation systems on yield and income of corn (*Zea mays* L.). (Turkish). *TABAD. Tarm Bilimleri Arastrma Dergisi.* 3 (2): 27-31.

Kaltu, S., and Gunes, E. 2010. Effect of different irrigation systems on yield and income of corn (*Zea mays* L.). *TABAD, Tarm Bilimleri Arastrma Dergisi.* 3 (2): 27-31.

Kalyankar, P.M., Takle, S.R and Bhise, V.B. 2011. Drip irrigation technique and productivity of ginger. *International Journal of Management Research and Technology.* 5 (2): 359-370.

Kapadiyal, P.K., Koradiya, U.A., Sarvaiya, R.B., Gandhi, A.P., Bhambhaniya, L.B., Lad, A.N and Raman, S. 1998. Drip irrigation for coconut in south Saurashtra. Developments in plantation crops research. Proceedings of the 12th Symposium on Plantation Crops, PLACROSYM XII, Kottayam, India, 27-29 November 1996. 157-159.

Kaushal, A., Patole, R and Singh, K.G. 2012. Drip irrigation in sugarcane: a review. *Agricultural Reviews.* 33 (3): 11-219.

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 Agricultiral Sciences.* 3 (1): 258-260.

Khan, M., Somashekhar, H., Naik, R.G and Sadathulla, F. 2011. Comparative economic analysis of irrigation methods for sustainable quality mulberry leaf production. *Environment and Ecology*. 29 (1):86-88.

Kovatchev, V., Tcholeva, B and Tzvetkov, I. 1994. Investigation of the application of some pesticides through drip irrigation. 17^{th} ICID European Regional Conference on Irrigation and Drainage, Varna, Bulgaria, 16-22 May, 1994. Measures for mitigation of non-beneficial ecological effects of irrigation. 3: 247-251.

Krishnamoorthy, C and Rajamani, K. 2013. Effect of fertigation through drip and micro sprinkler on plant biometric characters in cocoa (*Theobroma cacao* L.). *Pakistan Journal of Biological Sciences.* 16 (24): 1950-1956.

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, D.S. 2012. Adoption of drip irrigation system in India: some experience and evidence. *Bangladesh Development Studies.* 35 (1): 61-78.

Kumar, D, S. and Palanisami, K. 2010. Impact of drip irrigation on farming system: evidence from southern India. *Agricultural Economics Research Review.* 23: 265-272.

Kumar, M.D., Shah, T., Bhatt, M and Kapadia, M. 2004. Dripping water to a water guzzler: techno economic evaluation of drip irrigation of alfalfa in north Gujarat, India.http://rwes.dpri.kyotou.ac.jp/~tanaka/ APHW/ APHW2004/proceedings/TWM/56-TWM-A257/56-TWM-A257.pdf

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.

Luhach, M.S., Khatkar, R.K., Singh, V.K and Khatry, R.S. 2004. Economic analysis of sprinkler and drip irrigation technology in Haryana. *Agricultural Economics Research Review.*17: 107-113.

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.

Maddileti, S. 2012. Micro irrigation impact of new methods of irrigation in drought prone areas of Kurnool district. *International Research Journal of Agricultural Economics and Statistics***.** 3 (2): 373-377.

Malik, D.P and Luhach, M.S. 2002. Economic dimensions of drip irrigation in context of fruit crops. *http://departmetns.agri.huji.ac.il/economics/keynes-mallika.pdf.html*

Mane, K.M and Vijayakumar, H.S. 1996. Comparitive economics of cultivation of grapes by different methods of irrigation. *Karnataka Journal of Agricultural Sciences*. 9 (1):129-134.

Manjunatha, M.V., Rajkumar, G.R., Hebbara, M and Ravishankar, G. 2004. Effect of drip and surface irrigation on yield and water production efficiency of brinjal in saline vertisols. *Indian Journal of Agricultural sciences.* 74: 583-587.

Medagoda, I., Tennakoon, T.M.S.K and Roonage, M.A. 2004. Growth, flowering and yield performance of papaya (*Carica papaya* L.) under drip and basin irrigation. *Tropical Agriculturist.* 155: 29-32.

Mehendale, M.M., Deorukhakar, A.C., Perke, D.S. and Talathi, J.M. 2013(a). Cost, returns and profitability under coconut based different irrigation methods. *Internationl Research Journal of Agricultural Economics and Statistics***.** 4 (2): 143-147.

Mehendale, M.M., Deorukhakar, A.C., Perke, D.S. and Talathi, J.M. 2013(b). Water use efficiency under coconut based different irrigation methods. *International Research Journal of Agricultural Economics and Statistics***.** 4 (1): 60-64.

Meti, C.B. 2012. Studies on factors influencing the drip irrigation adoption, constraints and remedial measures to increase area under drip irrigation. *International Journal of Agricultural Engineering.* 5 (2): 236-239.

Minasian, A.N., Al-Karaghouli, A.A., and Habeeb, S.K. 1994. An economic analysis of drip irrigation systems: a choice among alternatives. *Plasticulture.* 101: 23-27.

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.

Muhuchamy, I., Subramanian, K., Kannan, B., Vel, S.S. 2000. Hydraulic design and performance evaluation of subsurface drip irrigation for coconut in coimbatore district. *Madras Agricultural Journal.* 87: 640-644.

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.

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.

Nagarajan S.S. 1998. Improving coconut farm productivity with silt. *Kisan World*. 25 (5): 19-20.

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.

Narayanamoorthy, A. 1986. Micro irrigation. *Kisan World*. 23(1): 51-53.

Narayanamoorthy, A. 1997(a). Economic viability of drip irrigation: An empirical analysis from Maharashtra. *Indian Journal of Agricultural Economics*. 52 (4): 728-739.

Narayanamoorthy, A. 1997(b). Drip irrigation: A viable option for future irrigation development. *Productivity*. 38 (3): 504-511.

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

Narayanamoorthy, A. 2003. Averting water crisis by drip method of irrigation: a study of two water-intensive crops. *Indian Journal of Agricultural Economics.* 58 (3): 427-437.

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.

Narayanamoorthy, A and Deshpande, R.S. 1998. Efficient water management through drip irrigation: some evidence for western India. Water and land resources development and management for sustainable use. Vol. II-B. The tenth ICDI Afro-Asian regional conference on irrigation and drainage, Denpasar, Bali, Indonesia, 19-26 July, 1998: B38,12.

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., Devika, N and Bhattarai, M. 2016. More Crop and Profit per Drop of Water: Drip Irrigation for Empowering Distressed Small Farmers. *IIM Kozhikode Society and Management Review.* 5(1): 83-90.

Ndeketeya, A., Rusere, F., Svubure, O., Gwatibaya, S., Soropa, G. and Mashonganyika, J. 2014. Drip irrigation as a potential alternative to furrow irrigation in sugar-cane production-A case of the Lowveld Estate, Zimbabwe. *International Journal of Agricultural Policy and Research.* 2 (1): 26-32.

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.

Ngouajio, M., Wang, G and Goldy, R. 2007. Withholding of drip irrigation between transplanting and flowering increases the yield of field-grown tomato under plastic mulch. *Journal of Agricultural Water Management.* 87: 285-291.

Norton, E.R., Silvertooth, J.C. 2001. Evaluation of a drip versus furrow irrigated cotton production system**.** *http://ag.arizona.edu/pubs/crops/az1224/az12245b.pdf.*

Ogbuchiekwe, E.J and McGiffen, M.E. 2001. Efficacy and economic value of weed control for drip and sprinkler irrigated celery. *HortScience.* 36 (7):1278-1282.

Okunade, D.A., Olanusi, O.A and Adekalu, K.O. 2009. Growth, yield, and economics of okra and amaranth production under irrigation. *International Journal of Vegetable Science.* 15 (1): 28-43.

Padhye, A.H. 1990. Micro & Sprinkler Irrigation in India. Proc. Int., Congress on the Use of Plastics in Agriculture, New Delhi.

Palada, M.C., Bhattarai, S.P., Roberts, M.S., Bhattarai, M., Baxter, N., Kimsan, R and Wu, D.L. 2011. Improving smallholder dry season vegetable production through increased water productivity with low cost drip irrigation technology in Cambodia. *Acta Horticulturae.* 922:133-140.

Palanichamy, N.V., Palanisami, K and Shanmugam, T.R. 2002. Economic performance of drip irrigation in coconut farms in Coimbatore. *Agricultural Economics Research Review.* Conference Issue, 40-48.

Pandey, A.K., Singh, A.K., Kumar, A and Singh, S.K. 2013. Effect of drip irrigation, spacing and nitrogen fertigation on productivity of chilli (*Capsicum annuum* L.). *Environment and Ecology.* 31 (1): 139-142.

Pandey, V.K., Sharma, H.G and Agarwal, N. 2005. Evaluation of drip irrigation and plastic mulching on papaya cultivation. *Drainage and Irrigaion Water Management*. 136-144.

Pandia, B.J. 2013. Role of micro irrigation technology in sugarcane crop – an overview. *Cooperative Sugar.* 45 (4): 23-29.

Patil, P.V. 2013. Drip irrigation technology in agriculture of Sangli district (Maharashtra): A geographical study. *Journal of Current Sciences*. 1 (1): 36-40.

Paul, J.C., Mishra, J.N and Pradhan, P.L. 2008. Response of banana to drip irrigation and mulching in coastal Orissa. *Journal of Agricultural Engineering.* 45 (4): 44-49.

Pawar, B.R., Landge, V.V., Deshmukh, D.S and Yeware, P.P. 2010. Economics of banana production in drip irrigated and flood irrigated gardens. *International Journal of Commerce and Bussiness Management.* 3 (1): 88-91.

Pawar, D.D., Dingre, S.K and Surve, U.S. 2013. Growth, yield and water use in sugarcane (*Saccharum officinarum*) under drip fertigation. *Indian Journal of Agronomy*. 58 (3): 396-401.

Pitts, D.J and Clark, G.A. 1991. Comparison of drip irrigation to subirrigation for tomato production in southwest Florida. *Applied Engineering in Agriculture*. 7 (2): 177-184.

Polak, P., Nanes, B and Adhikari, D. 1997. A low cost drip irrigation system for small farmers in developing countries. *Journal of the American Water Resources Association.* 33 (1): 119-124.

Postel, 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, 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.

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.

Puranik, R.P., Khonde, S.R., Ganorkar, P.L. 1992. Constraints and problems perceived by non adopters and adopters of drip irrigation system. *Agricultural Situation in India*. 47 (1): 33-34.

Raina, J.N., Thakur, B.C and Bhandari, A.R. 1998. Effect of drip irrigation and plastic mulch on yield, water use efficiency and benefit-cost ratio of pea cultivation. *Journal of the Indian Society of Soil Science.* 46 (4):562-567.

Rajeshkumar, N.K., Raghavendra, K., Veeresh, J.M., Chowdareddy, M and Chowdegowda, M.G. 2013. Evaluation of drip irrigation over conventional furrow irrigation on yield and economics of potato (*Solanum tuberosum* L.) crop. *International Agricultural Engineering Journal.* 22 (3): 15-25.

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*. 28(1,2): 65-69.

Rekha, K.B., Reddy, G.M and Mahavishnan, K. 2005. Nitrogen and water use efficiency of okra as influenced by drip fertigation. *Journal of Tropical Agriculture.* 43: 43-46.

Remold, M. 2000. Cost benefit analysis of coconut cultivation (rainfed). *Indian Coconut Journal*. 31 (3): 7-9.

Reuter, C. 1998. Water saving irrigation systems. *Gemuse (Munchen)*. 34 (6): 21-24.

Revol, P., Belluau, E., Kosuth, P and Ledore, F. 1995. Orchard irrigation. Drip irrigation in question? (French). *Arboriculture Fruitiere.* 481: 22-25.

Rezende, R., Cardoso, C.O., Goncalves, A.C.A., Peres, F.C., Frizzone, J.A. and Folegatti, M.V. 1990. Economic viability of supplementary irrigation in citrus in northeast Parana (Portuguese). *Acta Scientiarum*. 21 (3): 591-598.

Sahu, R.K and Rao, V.N. 2005. Development and evaluation of micro drip irrigation system in farmer's field. *Drainage and Irrigation Water Management.* 118-135.

Saini, A. K., Singh, K. G and Mukesh Siag. 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*

Sairam, C.V., Gopalasundaram, P., Muralidharan, K., George, M.V., Hedge, M.R and Umamaheswari, L. 1997. Estimation of cost of production of coconut under optimum management conditions in North Kerala. *Journal of Plantation crops*. 25 (2):163-168.

Saksena, R.S. 1995. Microirrigation in India – achievements and perspective. Microirrigation for a changing world: conserving resourses/preserving the environment. Proceedings of the Fifth International Microirrigation Congress, Orlando, Florida, USA, 2-6 April, 1995. 353-358.

Salhi, S., Imache, A., Tonneau, J.P and Ferfera, M.Y. 2012. Determinants of conversion to drip irrigation system by farmers: the case of the Mitidja plain in Algeria. *Cahiers Agriculture.* 21 (6): 417-426.

Sankar, V., Lawande, K.E and Tripathi, P.C. 2008. Effect of micro irrigation practices on growth and yield of garlic (*Allium sativum* L.) var. G. 41. *Journal of Spices and Aromatic Crops.* 17 (3): 230-234.

Sarkar, A.N and Hanamashetti, J.S. 2002. Financial viability of drip irrigation system for sugarcane and grape cultivation in Maharashtra. *Asia-Pacific Journal of Rural Development.* 12 (1): 1-31.

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): 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.

Senarathna, W.A.S and Pathmarajah, S. 2007. Evaluation of the status of drip irrigation systems installed under subsidy schemes of Coconut Cultivation Board in Kurunegala district in Sri Lanka. *http://www.researchgate.net/publication/237149655.*

Sharma, P and Kaushal, A. 2015. Growing Okra with Drip Fertigation- A Review. *International Journal of Engineering Science Invention.* 4 (9): 1-5.

Sharma, S., Halder, A., Patra, S.K and Ray, R. 2012. Effect of drip irrigation and nitrogen fertigation on water use efficiency (WUE) and cost economics of guava cv. Khaja. *Progressive Horticulture.* 44 (1): 134-139.

Sharmasarkar, F.C., Sharmasarkar, S., Held, L.J., Miller, S.D., Vance, G.F and Zhang Ren Duo. 2001. Agroeconomic analyses of drip irrigation for sugarbeet production. *Agronomy Journal.* 93 (3): 517-523.

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, S.I., Zaghloul, S.M., Yassen, A.A. 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): 139-147.

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.

Shinde, S.H., Dahiwalkar, S.D and Berad, S.M. 2000. Influence of planting technique and fertigation through drip on yield, quality and economics of sugarcane. *Journal of Maharashtra Agricultural Universities.* 24 (3):276-278.

Shiyani, R.L and Kuchhadiya, D.B. 1996. Impact of drip irrigation system on cotton growers of Saurashtra region. *Impact of drip irrigation system on cotton growers of Saurashtra region.* Gujarat Agricultural University, Department of Agricultural Economics. 46.

Shrestha, R.B and Gopalakrishnan, C. 1993. Adoption and diffusion of drip irrigation technology: an econometric analysis. *Economic Development and Cultural Change.* 41 (2): 407-418.

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.* 23 (3,4): 29-38.

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.

Siag, M., Chawla, J.K., Vashisht, A and Bhushan, I. 2009. Efficient use of canal water through drip irrigation in cotton (*Gossypium hirsutum*). *Indian Journal of Agricultural Sciences.* 79 (10):794-797.

Silva, W.G., Carvalho, J.A., Oliveira, E.C., Lima Junior, J.A and Silva, B.M. 2013. Technical and economic analysis of irrigation of asparagus bean in protected environment. *Engenharia Agricola.* 33 (4):658-668.

Simonne Eric., Hochmuth, R., Breman, J., Lamont, W., Treadwell, D and Gazula, A. 2008. Drip-irrigation systems for small conventional vegetable farms and organic vegetable farms. University Of Florida.

Singh, B., Kumar, M., Mehto, S.P and Singh, A. 2005. Winter sweet corn cultivation under drip fertigation: a profitable crop for peri-urban areas of Delhi. *Indian Journal of Fertilisers.* 1 (8): 37-38.

Singh, R., Kumar, S., Nangare, D.D and Meena, M.S. 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.

Singh, R.M., Bhandarkar, D.M., Singh, D.K., Reddy, K.S., Rao, K.V.R and Mathankar, S.K. 2012. Techno-economic feasibility of drip fertigation in guava (*Psidium guajava* L.). *Environment and Ecology*. 30 (2): 271-274.

Sivanappan, R.K. 1995. Present status and future of microirrigation in India. Microirrigation for a changing world: conserving resources/preventing the environment. Proceedings of the Fifth International Microirrigation Congress, Orlando, Florida, USA, 2-6 April, 1995. 740-744.

Sivanappan, R.K. 1994. Prospects of micro Irrigation in India. *Irrigation and Drainage System.* 8 (1): 49-58.

Smajstrla, A.G., Locascio, S.J., Weingartner, D.P and Hensel, D.R. 2000. Subsurface drip irrigation for water table control and potato production. Applied Engineering in Agriculture. 16 (3): 225-228.

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.

Sowjanya, B., Kumari, R.V., Reddy, P.R and Kulkarni, B.S. 2013. Economic feasibility of drip irrigation in mango cultivation: a study in Andhra Pradesh, India. *Indian Journal of Social Research.* 54 (3): 199-210.

Spehia, R. S., Thakur, B. C and Sharma, I. P. 2007. Drip irrigation water requirement of capsicum under sub-humid sub-temperate region of Himachal Pradesh. *International Journal of Agricultural Sciences*. 3 (1): 124-128.

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.

Subramanian, P., Krishnasamy, S and Devagayam, M.M. 1997. Studies on the evaluation of drip irrigation in comparison with surface irrigation (basin) in Coconut. *South Indian Horticulture.* 45: 255-258.

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.

Talathi, J.M and Hiremath, G.K. 2004. Ground water use efficiency in different methods of irrigation in Thane District (M.S). *Indian Journal of Soil Conservation.* 32 (3):194-197.

Thabet, M. 2013. Drip irrigation systems and water saving in arid climate: A case study from South Tunisia. *International Journal of Water Resources and Arid Environments.* 2 (4): 226-230.

Thompson, T.L., Cheng, P.H and Yi, L.Y. 2009. The potential contribution of subsurface drip irrigation to water saving agriculture in the western USA. *Agricultural Sciences in China.* 8 (7):850-854.

Veeraputhiran, R. and Chinnusamy, C. 2005. Economic feasibility of drip irrigation and nitrogen fertigation in hybrid cotton. *Journal of Cotton Research and Development.* 19 (1): 69-73.

Veeraputhiran, R., Balasubramanian, R., Pandian, B.J., Chelladurai, M., Tamilselvi, R and Renganathan, V.G. 2012. Effect of subsurface drip fertigation on cane yield, water use efficiency and economics of sugarcane. *Madras Agricultural Journal*. 99 (4/6): 255-258.

Venkataraman, R., Velmurugan, D and Prakash, K.A. 2012. Service delivery of drip irrigation system (DIS) among farmers in selected areas of Tamil Nadu. *Agricultural Economics Research Review*. 25 (1-2): 550.

Vermani, S., Kaur, S and Punia, D. 2008. Impact of drip irrigation on rural communities of Haryana. *Haryana Journal of Horticultural Sciences.* 37 (1/2):198-200.

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. 2014. Economic impacts on irrigated agriculture of water conservation programs in drought. *Journal of Hydrology* (Amsterdam). 508: 114-127.

Waykar, K.R., Shinde, H.R., Sale, Y.C., Kasar, D.V. 2003. Economics of drip irrigation system for sugarcane crop in ahmednagar district of Maharashtra State. *Indian sugar.* 53(4): 251-259.

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.

Note : The pattern of literature cited presented above is in accordance with the guidelines for thesis presentation, Acharya N.G. Ranga Agricultural University, Guntur.

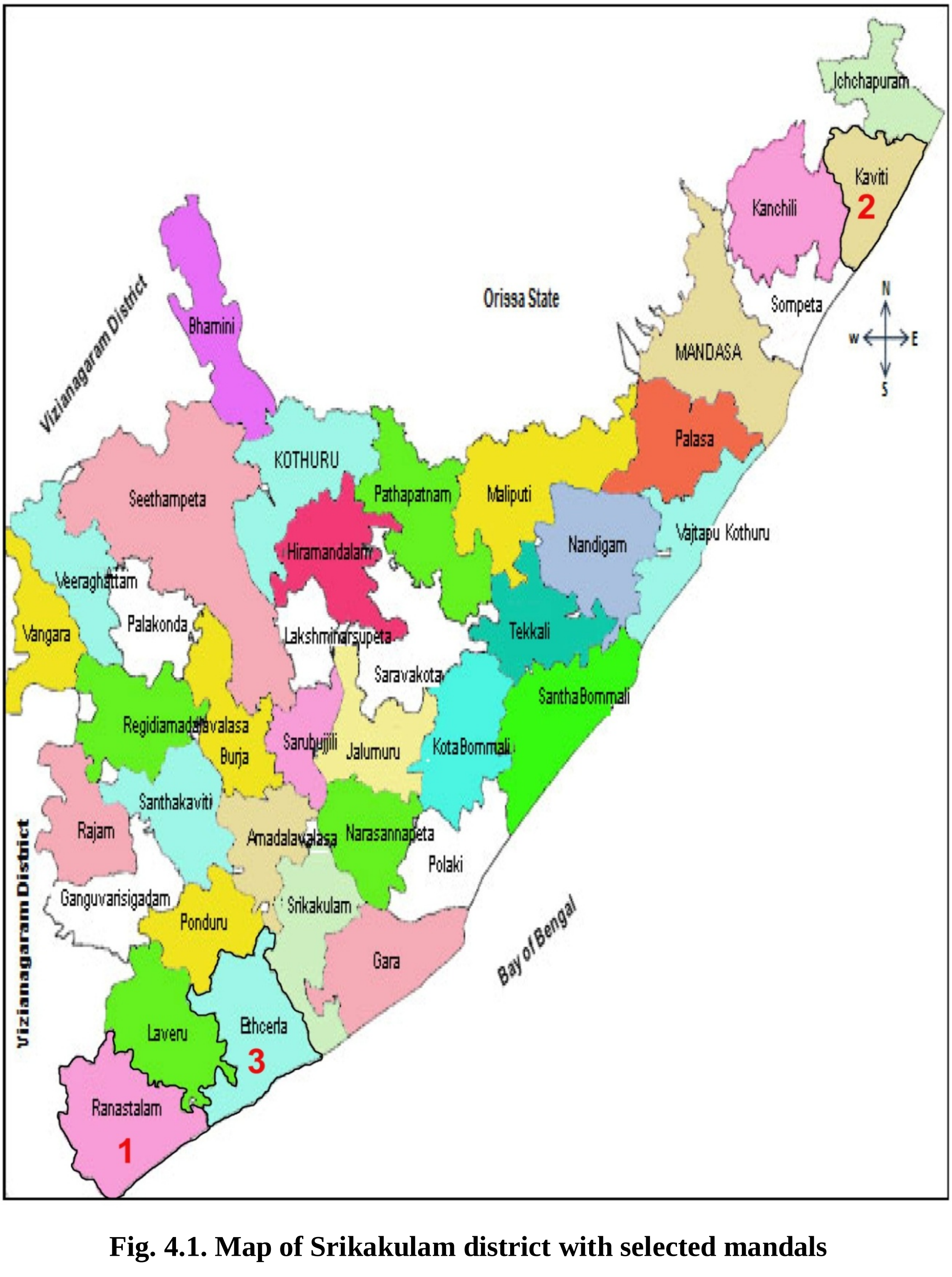

Fig. 4.1. Map of Srikakulam district with selected mandals