IMPACT OF MICRO IRRIGATION SYSTEMS ON CROP PRODUCTIVITY AND WATER USE EFFICIENCY IN NORTHERN KARNATAKA – AN ECONOMIC ANALYSIS

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CERTIFICATE

This is to certify that the thesis entitled "IMPACT OF MICRO IRRIGATION SYSTEMS ON CROP PRODUCTIVITY AND WATER USE EFFICIENCY IN NORTHERN KARNATAKA – AN ECONOMIC ANALYSIS" submitted by Mr. SHREESHAIL RUDRAPUR for the degree of DOCTOR OF PHILOSOPHY in AGRICULTURAL ECONOMICS of College of Agriculture, University of Agricultural Sciences, Dharwad is a record of bonafide research work done by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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CONTENTS

Sl. No.	Chapter Particulars
	CERTIFICATE
	ACKNOWLEDGEMENT
	LIST OF TABLES
	LIST OF FIGURES
	LIST OF APPENDICES
1.	INTRODUCTION
2.	REVIEW OF LITERATURE
	2.1 Socio-economic characters and extent of coverage of area under micro irrigation
	2.2 Extent of private investment and subsidy provided for micro irrigation systems
	2.3 Water use efficiency in major crops under different irrigation systems
	2.4 Profitability of major crops in conventional v/s micro irrigation systems in the study area
	2.5 Financial feasibility of investment in micro irrigation systems in the study area
	2.6 Decomposition analysis of total change in per hectare income between micro irrigation systems and conventional method of irrigation in cultivation of different crops
	2.7 Constraints faced by sample respondents in the study area
3.	METHODOLOGY
	3.1 Description of the study area
	3.2 Sampling procedure
	3.3 Nature and sources of data
	3.4 Analytical tools and techniques
	3.5 Definitions of terms and concepts used
4.	RESULTS
	4.1 Area covered under micro irrigation systems (MIS) in the state
	4.2 Subsidy provided for and private investment on micro irrigation systems in the state and government schemes on micro irrigation
	4.3 General characteristics of sample respondents
	4.4 Water use efficiency in major crops under different irrigation systems
	4.5 Profitability of major crops in conventional v/s micro irrigation systems
	4.6 Financial feasibility of investment on micro irrigation systems and conventional method of irrigation
	4.7 Decomposition analysis of total change in per hectare income between micro irrigation systems and conventional method of irrigation in cultivation of different crops

Contd…..

Sl. No.	Chapter Particulars
	4.8 Constraints faced by sample respondents in the study area
5.	DISCUSSION
	5.1 Area covered under micro irrigation systems in the state
	5.2 Subsidy provided for and private investment on micro irrigation systems in the state and government schemes on micro irrigation
	5.3 General characteristics of sample respondents
	5.4 Water use efficiency in major crops under different irrigation methods
	5.5 Profitability of major crops in conventional v/s micro irrigation systems
	5.6 Financial feasibility of investment on micro irrigation systems and conventional method of irrigation
	5.7 Decomposition analysis of total change in per hectare income between micro irrigation systems and conventional method of irrigation in cultivation of different crops
	5.8 Constraints faced by sample respondents in the study area
6.	SUMMARY AND POLICY IMPLICATIONS
	REFERENCES
	APPENDICES

LIST OF TABLES

Table No.	Title
3.1	Demographic features of the study area
3.2	Land utilization pattern in the study area
3.3	Area under different crops in the study area
3.4	Selection of respondents in the study area
4.1	Compound growth rate and stability of area covered under micro irrigation systems in Karnataka (2005-06 to 2014-15)
4.2	Compound growth rate and stability of subsidy provided for and private investment on micro irrigation systems in Karnataka (2005-06 to 2014-15)
4.3	Different micro irrigation schemes in the state and their achievements
4.4	Socio-economic characteristics of sample respondents of the study area
4.5	Cropping pattern of sample respondents in the study area
4.6	Water use efficiency of sugarcane under drip irrigation and conventional method of irrigation in the study area
4.7	Water use efficiency of maize under sprinkler irrigation and conventional method of irrigation in the study area
4.8	Water use efficiency of groundnut under sprinkler irrigation and conventional method of irrigation in the study area
4.9	Water use efficiency of redgram under sprinkler irrigation and conventional method of irrigation in the study area
4.10	Water use efficiency of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area
4.11	Labour utilisation pattern in sugarcane cultivation under drip irrigation and conventional method of irrigation in the study area
4.12	Input use pattern and output obtained in sugarcane cultivation under drip irrigation and conventional method of irrigation in the study area
4.13	Cost involved in cultivation of sugarcane under drip irrigation and conventional method of irrigation in the study area
4.14	Returns from cultivation of sugarcane under drip irrigation and conventional method of irrigation in the study area
4.15	Labour utilisation pattern in maize cultivation under sprinkler irrigation and conventional method of irrigation in the study area
4.16	Input use pattern and output obtained in maize cultivation under sprinkler irrigation and conventional method of irrigation in the study area
4.17	Cost involved in cultivation of maize under sprinkler irrigation and conventional method of irrigation in the study area

Contd…..

Table No.	Title
4.18	Returns from cultivation of maize under sprinkler irrigation and conventional method of irrigation in the study area
4.19	Labour utilisation pattern in groundnut cultivation under sprinkler irrigation and conventional method of irrigation in the study area
4.20	Input use pattern and output obtained in groundnut cultivation under sprinkler irrigation and conventional method of irrigation in the study area
4.21	Cost involved in cultivation of groundnut under sprinkler irrigation and conventional method of irrigation in the study area
4.22	Returns from cultivation of groundnut under sprinkler irrigation and conventional method of irrigation in the study area
4.23	Labour utilisation pattern in redgram cultivation under sprinkler irrigation and conventional method of irrigation in the study area
4.24	Input use pattern and output obtained in redgram cultivation under sprinkler irrigation and conventional method of irrigation in the study area
4.25	Cost involved in cultivation of redgram under sprinkler irrigation and conventional method of irrigation in the study area
4.26	Returns from cultivation of redgram under sprinkler irrigation and conventional method of irrigation in the study area
4.27	Labour utilisation pattern in *rabi* sorghum cultivation under sprinkler irrigation and conventional method of irrigation in the study area
4.28	Input use pattern and output obtained in *rabi* sorghum cultivation under sprinkler irrigation and conventional method of irrigation in the study area
4.29	Cost involved in cultivation of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area
4.30	Returns from cultivation of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area
4.31	Economics and financial feasibility of investment on different methods of irrigation in cultivation of different crops
4.32	Financial feasibility of investment on micro irrigation and conventional method of irrigation in cultivation of different crops in the study area
4.33	Production function estimates in sugarcane production under drip irrigation and conventional method of irrigation in the study area
4.34	Geometric mean levels of returns and cost involved in the production of sugarcane under drip irrigation and conventional method of irrigation in the study area
4.35	Decomposition analysis of total change in per hectare income between drip irrigation and conventional method of irrigation in cultivation of sugarcane in the study area
4.36	Production function estimates in maize production under sprinkler irrigation and conventional method of irrigation in the study area

Contd…..

Table No.	Title
4.37	Geometric mean levels of returns and cost involved in the production of maize under sprinkler irrigation and conventional method of irrigation in the study area
4.38	Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of maize in the study area
4.39	Production function estimates in groundnut production under sprinkler irrigation and conventional method of irrigation in the study area
4.40	Geometric mean levels of returns and cost involved in the production of groundnut under sprinkler irrigation and conventional method of irrigation in the study area
4.41	Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of groundnut in the study area
4.42	Production function estimates in redgram production under sprinkler irrigation and conventional method of irrigation in the study area
4.43	Geometric mean levels of returns and cost involved in the production of redgram under sprinkler irrigation and conventional method of irrigation in the study area
4.44	Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of redgram in the study area
4.45	Production function estimates in *rabi* sorghum production under sprinkler irrigation and conventional method of irrigation in the study area
4.46	Geometric mean levels of returns and cost involved in the production of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area
4.47	Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of *rabi* sorghum in the study area
4.48	Constraints in adoption and maintenance of micro irrigation systems by the farmer beneficiaries in the study area
4.49	Constraints faced by the farmers in cultivation of different crops under conventional method of irrigation in the study area

LIST OF FIGURES

Figure No.	Title
1.	Map of Karnataka state showing the study area
2.	Compound growth rate and stability of area covered under micro irrigation systems in Karnataka (2005-06 to 2014-15)
3.	Compound growth rate and stability of subsidy provided for and private investment on micro irrigation systems in Karnataka (2005-06 to 2014-15)
4.	Area covered under different micro irrigation schemes in the state
5.	Subsidy provided under different micro irrigation schemes in the state
6.	Water use efficiency of sugarcane under drip irrigation and conventional method of irrigation in the study area
7.	Water use efficiency of maize under sprinkler irrigation and conventional method of irrigation in the study area
8.	Water use efficiency of groundnut under sprinkler irrigation and conventional method of irrigation in the study area
9.	Water use efficiency of redgram under sprinkler irrigation and conventional method of irrigation in the study area
10.	Water use efficiency of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area
11.	Input use pattern and output obtained in sugarcane cultivation under drip irrigation and conventional method of irrigation in the study area
12.	Cost involved in cultivation of sugarcane under drip irrigation and conventional method of irrigation in the study area
13.	Returns from cultivation of sugarcane under drip irrigation and conventional method of irrigation in the study area
14.	Input use pattern and output obtained in maize cultivation under sprinkler irrigation and conventional method of irrigation in the study area
15.	Cost involved in cultivation of maize under sprinkler irrigation and conventional method of irrigation in the study area
16.	Returns from cultivation of maize under sprinkler irrigation and conventional method of irrigation in the study area
17.	Input use pattern and output obtained in groundnut cultivation under sprinkler irrigation and conventional method of irrigation in the study area
18.	Cost involved in cultivation of groundnut under sprinkler irrigation and conventional method of irrigation in the study area
19.	Returns from cultivation of groundnut under sprinkler irrigation and conventional method of irrigation in the study area
20.	Input use pattern and output obtained in redgram cultivation under sprinkler irrigation and conventional method of irrigation in the study area

Contd.…

Figure No.	Title
21.	Cost involved in cultivation of redgram under sprinkler irrigation and conventional method of irrigation in the study area
22.	Returns from cultivation of redgram under sprinkler irrigation and conventional method of irrigation in the study area
23.	Input use pattern and output obtained in *rabi* sorghum cultivation under sprinkler irrigation and conventional method of irrigation in the study area
24.	Cost involved in cultivation of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area
25.	Returns from cultivation of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area
26.	Financial feasibility of investment on drip irrigation and conventional method of irrigation in cultivation of sugarcane in the study area
27.	Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of maize in the study area
28.	Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of groundnut in the study area
29.	Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of redgram in the study area
30.	Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of *rabi* sorghum in the study area

LIST OF APPENDICES

Appendix No.	Title
I.	Financial feasibility of investment on drip irrigation and conventional method of irrigation in cultivation of sugarcane in the study area
II.	Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of maize in the study area
III.	Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of groundnut in the study area
IV.	Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of redgram in the study area
V.	Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of *rabi* sorghum in the study area
VI.	Compound growth rate and instability of area covered under micro irrigation system in Karnataka (2005-06 to 2014-15)
VII.	Compound growth rate and instability of subsidy provided for and private investment on micro irrigation system in Karnataka (2005-06 to 2014-15)

1. INTRODUCTION

Water is gradually becoming a scarce resource worldwide especially in developing countries like India. With the increasing need of providing food and water security for an ever increasing population, the availability, usability and affordability of water is becoming a major challenge. Efficient use of this resource is essential. However, this requires innovation and more precision in its utilisation, especially where it is used in abundance like agriculture. In spite of technological advancements in pressurised irrigation techniques, a substantial amount of land worldwide, especially in countries like India is still irrigated by surface irrigation. Agriculture being the most dominant water user, it is essential to develop and improve existing technologies for better efficient use of this precious resource.

India's irrigated agriculture sector has been fundamental to its development and poverty alleviation. Although plan expenditure on irrigation has increased from ` 441.80 crores in first five year plan to ` 66,448.96 crores (outlay) in the X plan, the share in total plan expenditure decreased from 23 per cent in the I plan to 6.30 per cent in the X plan (Anon, 2007a). An outlay of ` 6,000 crores has been proposed for major and medium irrigation department for 12th five year plan 2012-17 (Anon, 2012). Government of India has recently brought out a Draft National Water Policy (2012) document for formulating a water policy for enhancing the efficiency of utilisation and disposal of water in the country. As India's National Water Policy 2012 observes, irrigation being the largest consumer of fresh water, the aim should be to get optimal productivity per unit of water. At present, India receives on an average annual precipitation of about 4,000 billion cubic meter (BCM), which is the basic water resource. Out of this, after considering the natural evapo-transpiration, only about 1,869 BCM is the average annual natural flow through rivers and aquifers. Of this, only about 1,123 BCM is utilizable through the present plan strategies. Thus, the availability of water is limited but the demand for water is increasing rapidly due to growing population, rapid urbanization, fast industrialization and overall economic development of the country (Anon, 2012a). Of the total irrigation potential for the country, a total of 62.87 million hectares cultivated land has been brought under irrigation from various sources. In this, share of wells, canals, tanks and other sources is 60.70 per cent, 26.50 per cent, 9.60 per cent and 3.20 per cent, respectively (Anon, 2010a).

There are different conventional methods of irrigation being practiced by farmers, such as flood and furrow irrigation. Among these two, flood irrigation is an ancient method of irrigation. It was likely the first form of irrigation used by humans as they began cultivating crops and even today is one of the most commonly used methods of irrigation. While the flood irrigation generally assumed that only half of the water applied actually used by the crop; the other half is lost to evaporation, run off, infiltration in uncultivated areas, transpiration through the leaves of weeds, anaerobic conditions in the soil and around crop root zone and deep percolation below the crop root zone that is unavailable to the plants. In furrow irrigation, the water is applied to the top end of each furrow and flows down the field through gravity. Furrows may range anywhere from less than 100 meter to 300 meter long depending on the soil type, location and crop type. In this method, water can take a considerable period of time to reach the other end, resulting water has been infiltrating for longer period of time at the top end of the field. This results in non uniformity with high application at the top end and lower application at the bottom end. These conventional methods of irrigation not only reduce crop production and soil fertility but also cause ecological hazards like water logging and soil salinity. The application of irrigation water by conventional methods causes upto 30 per cent loss of water through deep percolation depending on the soil type (Anon, 2014a).

To overcome the problems of conventional irrigation methods and to achieve the projected food grain production, Government of India constituted a national task force on micro irrigation in 2004 with an objective to emphasize on all aspects of water conservation and to improve water use efficiency to achieve more crop per drop of water. Later, the government launched a Centrally Sponsored Scheme on Micro Irrigation (CSSMI) in January 2006 with an objective to increase the area under improved methods of irrigation for better water use efficiency to provide stimulus to agricultural growth. The scheme was further up scaled into mission mode in 2010 as the national mission on micro irrigation (NMMI) covering an area of 1.5 million hectares under drip irrigation and 0.5 million hectares under sprinkler irrigation. The main objectives of the National Mission on Micro Irrigation are: to increase the area under micro irrigation through improved technologies, to enhance the water use efficiency in the country, to increase the productivity of crops and farmers' income, to establish convergence & synergy among on-going government programmes, to promote, develop and disseminate micro irrigation technology for agriculture/ horticulture development with modern scientific knowledge and to create employment opportunities for skilled and unskilled person especially unemployed youth. The salient features of the scheme are:

i. All categories of farmers are eligible to avail assistance under this scheme.

ii. Assistance to farmers is limited to a maximum area of five (5.0) hectares per beneficiary.

iii. Assistance for laying down demonstration on farmers field are given 75 per cent subsidy for a maximum area of 0.5 hectare per demonstrate and is met entirely by the central government.

iv. Assistance is available for both drip and sprinkler irrigation for wide spaced as well as close spaced crops. However, assistance for sprinkler irrigation system is available only for those crops where drip irrigation is uneconomical.

v. Assistance is available for irrigation systems for protected cultivation including greenhouses, poly houses and shade nets.

vi. The subsidy amount is calculated taking into consideration cost of fertigation with fertilizer tank / venturi systems, sand filters / media filters, hydro-cyclone filters / sand separators and other different type of filters and valves required for micro irrigation systems.

vii. Panchayati Raj Institutions (PRIs) are involved in promoting the scheme in identification of priority areas, identification of beneficiaries and organizing interactive meetings with the representatives of micro irrigation industry.

viii. At the national level, the executive committee of national mission on micro irrigation reviews the progress and approves the annual action plans of states. At the state level, the state micro irrigation committee (SMIC) oversees the implementation of the mission programme in districts. The district micro irrigation committee (DMIC) coordinates the implementation of national mission on micro Irrigation programme at the district level. National committee on plasticulture applications in horticulture (NCPAH) coordinate and monitor the programme of national mission on micro irrigation in different States.

ix. The scheme is implemented by an implementing agency (IA) at the state level duly appointed by the state government. Funds are released directly to the implementing agency on the basis of approved plans for each year.

x. The implementing agency prepares the annual action plan for the state on the basis of the district plans and gets it forwarded by state micro irrigation committee for approval of the executive committee (EC) of national mission on micro irrigation.

xi. The State level micro irrigation committee (SMIC) undertakes registration of system manufacturers, who are authorized to supply systems to the farmers under the NMMI subsidy scheme. One of the important criteria for registration is that these manufacturers should be able to supply the systems as Bureau of Indian Standards (BIS) marking and provide proper after sales service to the satisfaction of the farmers.

xii. Under the centrally sponsored scheme from 2013-14 out of the total cost of the micro irrigation system, 40 per cent will be borne by the central government, 50 per cent by the state government and the remaining 10 per cent will be borne by the beneficiary, either through his/her own resources or soft loan from financial institutions.

Karnataka state initiated the micro irrigation scheme as early as 1991 in horticultural crops and for agricultural crops from 2003-04. A centrally sponsored scheme on micro irrigation started being implemented from 2005-06 with a subsidy of 50 per cent sponsored by union and state governments in the ratio of 80:20. The different state governments were found to have supplemented the central subsidy funds with their own resources and improved the scope and coverage of the micro irrigation systems. The unique improvement made by Karnataka government is that it has increased the subsidy to 75 per cent (Anon, 2009) and then to 90 per cent to all the farmers irrespective of farmer category. The state has achieved more than 100 per cent of physical targets (105.03 %) and 98.23 per cent of financial targets. The physical target was 5,10,960 hectares and achievement by the end of 2012-13 was 5,36,680 hectares. The financial target fixed was ` 60,889.32 lakh and target achieved by the end of 2012-13 was ` 59,812.26 lakh (Anon, 2014b). The potential area for micro irrigation in Karnataka is 41.37 lakh hectares and the cumulative area under micro irrigation till 2014-15 is only about 9.93 lakh hectares. Thus there is scope to increase the area under micro irrigation to the extent of 33.87 lakh hectares (76.00 %).

The term “micro-irrigation” describes a family of irrigation systems that apply water through small devices. Micro-irrigation refers to low-pressure irrigation systems that spray, mist, sprinkle or drip. Drip and sprinkler irrigations are two types of micro irrigation systems where the water discharge patterns differ in both methods of irrigation because emission devices are designed for specific applications due to agronomic or horticultural requirements. Micro-irrigation components include pipes, tubes, water emitting devices, flow control equipments, installation tools, fittings and accessories. These devices deliver water onto the soil surface very near the plant or below the soil surface directly into the plant root zone.

Sprinkler irrigation method distributes water to crops by spraying it over the crop area like natural rainfall. Sprinkler irrigation system saves upto 50 per cent of water compared to surface irrigation method and increases productivity by about 15 -25 per cent. It is estimated that the sprinkler irrigation system substantially reduces the use of water and increases crop productivity as well. Fertilizers and pesticides can be effectively applied in split doses through sprinklers at little extra cost. This facilitates uniform fertilizer application and effective pest control. The overall cost of labour is generally reduced. Erosion of soil cover which is common in surface irrigation can be minimised. Until 1970, sprinkler irrigation system in India was mostly used in hilly area for plantation crops like tea and coffee. But thereafter spread to other states like Haryana, Punjab, Rajasthan, Madhya Pradesh, Maharashtra, Uttar Pradesh, Gujarat, Tamil Nadu and Karnataka etc where there was shortage of ground water for irrigation. Today, farmers in almost all states in the country have progressively adopted this system and it is estimated that about 4.84 million hectares and 3.53 lakh hectares can be brought under sprinkler irrigation system in India and Karnataka, respectively (Anon, 2013). Realizing the need for water use optimization in the context of water scarcity and increasing agricultural productivity, the GOI encourages large scale adoption of this system (Anon, 2012b).

Drip irrigation can also help to use water efficiently. A well designed drip irrigation system loses practically no water to run off, deep percolation, or evaporation. Irrigation scheduling can be managed preciously to meet crop demands, holding the promise of increased yield and quality. This method reduces water contact with crop leaves, stems and fruits. Thus conditions might be less favourable for disease development. Though the system was introduced in India in 1970, only recently drip irrigation has become popular among the farmers. At present, around 3.31 million hectares area is under drip irrigation with the efforts of the Government of India, while it was only 40 hectares in 1960. Maharashtra (8.82 lakh ha), Andhra Pradesh (8.24 lakh ha), Gujarat (4.24 lakh ha) and Karnataka (3.93 lakh ha) are some of the states where large areas have been brought under drip irrigation (Anon., 2012b & Anon., 2015). The national committee on plasticulture applications in horticulture (NCPAH), ministry of agriculture and Government of India (GOI) has estimated a total of 27 million hectares area in the country has the potential for adoption of drip irrigation (Anon, 2012b). Potential area for drip irrigation is also expected to increase faster due to rapid decline of irrigation potential in the country.

1.1 Significance of the study

Water is the elixir of life. Every drop of water needs to be used optimally. So much water is being wasted through conventional methods of irrigation even water availability in plenty at the bossom of the earth cannot be extracted at cheap. With every passing day, water is going to become the most critical factor in agriculture and pattern of its use assumes greater importance in the context of its scarcity and huge investment in its creation. Hence, the study is timely and appropriate. The study aims at assessing the impact of micro irrigation in terms of increase in area under micro irrigation, cropping intensity, changes in cropping pattern, crop yield, income and amount of water saved *etc.* In the light of the above and considering the relevance of micro irrigation system in the current agricultural scenario, the study was undertaken with the following specific objectives;

1.2 Specific objectives

1. To study the extent of area coverage under micro irrigation in the state over the years
2. To document the extent of private investment and subsidy provided for micro irrigation systems in the state and to study the government schemes on micro irrigation and provisions thereof
3. To analyse the water use efficiency in major crops under different irrigation systems
4. To estimate profitability of major crops in conventional v/s micro irrigation systems in the study area
5. To evaluate the financial feasibility of investment in micro irrigation systems in the study area
6. To identify constraints in adoption of micro irrigation systems by the farmers in the study area

1.3 Hypotheses

1. Area under micro irrigation systems in the state is increasing over the years.
2. Private investment as well as subsidy provided for the micro irrigation systems in the state is increasing over the years.
3. Yield obtained, water use efficiency achieved and net returns realised in micro irrigation methods are higher than the conventional methods of irrigation.
4. Investment in micro irrigation systems is financially feasible.
5. Farmers are facing many constraints in adopting the micro irrigation methods.

2. REVIEW OF LITERATURE

In this chapter, past studies in the field of area coverage under micro irrigation in the state over the years, extent of private investment and subsidy provided for micro irrigation systems in the state, water use efficiency in major crops under different methods of irrigation, profitability of major crops in conventional v/s micro irrigation systems, financial feasibility of investment in micro irrigation systems and constraints in adoption and maintenance of micro irrigation systems by the farmers are reviewed and compiled to enable better understanding of the issue concerned to the study. The review of literature is presented under the following sub headings:

2.1 Socio-economic characteristics and extent of coverage of area under micro irrigation systems

2.2 Extent of private investment and subsidy provided for micro irrigation systems

2.3 Water use efficiency in major crops under different irrigation systems

2.4 Profitability of major crops in conventional v/s micro irrigation systems

2.5 Financial feasibility of investment in micro irrigation systems

2.6 Decomposition analysis of total change in per hectare income between micro irrigation systems and conventional method of irrigation in cultivation of different crops

2.7 Constraints faced by sample respondents in the study area

2.1 Socio-economic characters and extent of coverage of area under micro irrigation

Narayanamoorthy (2003) conducted a study on potential for drip and sprinkler irrigation in India. His study showed that the advantages of micro irrigation systems were substantial in terms of water savings and productivity gains in contrast to the flood method of irrigation. The other benefits of the micro irrigation systems were reduced electricity consumption, reduced weed and soil erosion problems and reduced cost of cultivation. Investment in micro irrigation was also found to be economically viable even without availing subsidy. In spite of these benefits, the coverage of area under drip (2.13 %) and sprinkler (3.30 %) methods of irrigation was very meagre to its potential which was estimated to be 21.01 million hectares for drip and 50.22 million hectares for sprinkler method of irrigation. The reasons for slow spread were due to less awareness about the economic and revenue related benefits of the micro irrigation systems.

Namara *et al.* (2007) conducted a study on economics, adoption determinants and impacts of micro irrigation technologies in India. The study revealed that micro irrigation technologies led to significant increase in productivity and economic gains. The factors responsible for the adoption of micro irrigation systems were access to ground water, cropping pattern, availability of cash, education level, social status and poverty status of the farmer. The study also indicated that the impact of micro irrigation technologies on the sustainability of ground water resources was depended on the magnitude of overall productivity gain following the shift from conventional method of irrigation to micro irrigation system, pattern of use of the saved water and the type and potential number of adopters.

Muraliraj (2008) conducted a study on micro irrigation in Rayalseema and Telangana regions of Andhra Pradesh. The findings of the study revealed that, in case of drip farmers only 863.50 acres out of 1,097 acres of net irrigated area was brought under micro irrigation.

Yogi (2008) conducted a study on use of drip and sprinkler irrigation in India. It was found from the study that the rate of growth in deep tube well scheme using micro irrigation devices was the highest (346 %) followed by surface flow schemes (194 %). The major states in terms of coverage of area under irrigation were Karnataka (16 %), Madhya Pradesh (16 %), and Rajasthan (9 %). With respect to ownership of micro irrigation devices 81 per cent were owned by individual farmers, 12 per cent by group farmers, two per cent by government and less than one per cent by panchayat.

Barman and Das (2010) conducted a study on socio-economic factors influencing adoption of farm level soil and water conservation practices in Riverine area of north bank plains zone of Assam. The sample size was 110. The results of the study showed that in the riverine, there was a wide variety of rice crop with emphasis shifting towards *rabi* oriented cropping system. About 44.09 per cent respondents had the perception that soil erosion and water degradation would reduce the crop yield to considerable extent and 33.72 per cent respondents had the perception that soil erosion and water degradation would reduce the crop yield moderately.

Palanisami *et al.* (2011) conducted a study on spread and economics of micro irrigation in India: evidence from nine states. His study reported that the micro irrigation area varied between no area in Nagaland to as much as 49.74 per cent in Andhra Pradesh followed by Maharashtra (43.23 %) and Tamil Nadu (24.10 %). An area of around 3.87 million hectares was brought under micro irrigation during the period 2005 to 2009. The results of the study also showed that only about 50.49 per cent of potential area was covered under micro irrigation in the country.

Palanisami and Raman (2012) in their study on potential and challenges in up-scaling micro irrigation in India reported that by 2011, an area of around 5.5 million hectares was brought under micro irrigation in the country. Out of this, the area covered under drip irrigation was 2.2 million hectares and 3.3 million hectares was covered under sprinkler irrigation. Major crops covered under the micro irrigation were some field crops such as cotton, maize, groundnut sugarcane as well as orchard, vegetables, fruit and plantation crops like tomato, banana, papaya, mango, grapes, lemon, tea, coffee and rubber.

Bheemanagouda *et al.* (2014) conducted a study on economic appraisal of drip irrigation system under grape cultivation in Vijayapur district. The area under drip irrigation in Vijayapur district increased from about 232 hectares to 2,593 hectares with a growth rate of about 46 per cent during 2004-05 to 2010-11. The number of beneficiaries covered under the scheme was increased from 49 per cent to 86 per cent. Area covered under drip for grape was also increased from 48 per cent to 87 per cent. The subsidy provided for drip irrigation system was also increased from 52 per cent to 90 per cent for grape cultivation.

Rudrapur *et al.* (2015) conducted a study on socio-economic characteristics of the farmers practicing different methods of irrigation in the malaprabha command area of Karntakata. The results of the study showed that in case of flood method of irrigation, the average age of the farmers was more (45.4 years) compared to farmers under furrow method of irrigation (43.74 years), border strip method of irrigation (37.69 years) and alternate furrow irrigation (38.63 years). The average family size of the farmer under flood method of irrigation was 7.37 where as it was 8.03, 6.74 and 6.11 under furrow method of irrigation, border strip method of irrigation and alternate furrow irrigation method, respectively. The average land holding of them was 4.12 hectares, 5.08 hectares, 5.44 hectares and 4.54 hectares under flood method of irrigation, furrow method of irrigation, border strip method of irrigation and alternate furrow irrigation method, respectively. Majority of the farmers following flood, furrow, border strip and alternate furrow irrigation were literate and it was 57.14 per cent, 54.29 per cent, 91.43 per cent and 88.57 per cent while illiterate range was 42.86 per cent, 45.71 per cent, 8.57 per cent and 11.43 per cent, respectively. The cropping intensity on farms in case of flood method of irrigation was highest (184.47 %), followed by border strip method of irrigation (172.06 %), furrow method of irrigation (166.34 %) and alternate furrow irrigation (158.59 %).

2.2 Extent of private investment and subsidy provided for micro irrigation systems

Anonymous (2000) conducted a study on reform of subsidy regime in respect of all agricultural implements and machinery including drip and sprinkler irrigation. The results of the study revealed that the subsidy provided was for the purpose of mechanisation of agriculture sector under 14 schemes in Karnataka for various components. Among 14 schemes, micro irrigation subsidy was important one which encouraged the small and marginal farmers to invest on micro irrigation.

Narayanamoorthy (2005) conducted a study on economics of drip irrigation in sugarcane cultivation. S. Ramanathan who is a farmer from Okkur village of Sivaganga district was interviewed by the researcher. The results of the study showed that the net present worth of drip irrigation was found to be ` 1,64,938/acre without subsidy and ` 1,72,247/acre with subsidy. Thus the subsidy provided played an important role in gaining an additional return of ` 7,309/acre.

Anonymous (2013) reviewed the micro irrigation in Karnataka. The results revealed that the total expenditure made on micro irrigation was increased from ` 6,728 lakhs in the year 2006-07 to ` 16,683 lakhs during 2010-11. The total area covered under the project was 4.18 lakh hectares of which around 65 per cent of area was covered by the agriculture department and remaining 35 per cent by the horticulture department.

2.3 Water use efficiency in major crops under different irrigation systems

Prabhakar (2000) stated that irrigation studies on gourds and melons showed that trickle irrigation resulted in higher yield and water use efficiency at CAZRI. When compared to furrow irrigation, drip irrigation increased the yield of gourds by 13.50 per cent.

Rahman (2001) conducted a study on water use efficiency of wheat under drip irrigation systems at Al-Maghara area, North Sinai, Egypt to know the water use efficiency of three wheat varieties (Sakha 8, Giza 7 and Giza 69) under four drip irrigation application rates (S1-Irrigation with 4 litre/hour. drippers on one line, S2- Irrigation with 8 litre/hour. drippers on one line, S3-Irrigation with 4 litre/hour. drippers on two lines and S4-irrigation with 8 litre/hour. drippers on two lines). The results of the study highlighted that the water use efficiency was highest under S3 for all three varieties (1.17 q/ ha cm, 1.20 q/ ha cm and 1.13 q/ ha cm, respectively).

Shirahatti *et al.* (2001) reported that the cotton yield increased by 28 and 10 per cent, respectively, by applying same quantity and 50 per cent of water through drip as of surface irrigation. It was observed that, water use efficiency was highest when water applied through drip irrigation and in case of 25 per cent application of water of the control, the yield was reduced by 0.5 per cent.

Dinesh *et al.* (2004) conducted a study on dripping water to a water guzzler: techno economic evaluation of drip irrigation of alfalfa in north Gujarat, India. The findings of the study revealed that water saving from family drip irrigation system was 43 per cent and yield was increased to the extent of 10.80 per cent compared to flood irrigation. The increase in yield per unit of water applied was ranged from 17.5 per cent to 94 per cent. The benefit cost ratio was also increased from 1.05 to 1.29.

Antony and Singandhupe (2004) conducted an experiment on the effect of different irrigation methods and schedules on morphological, biophysical, yield and water use efficiency of capsicum. The plants had more number of branches and plant heights under drip irrigation compared to that of surface irrigation. In drip irrigation, the yield was found to have significant positive correlation with total dry matter (TDM, 0.865) and net photosynthesis (0.840). It was observed that, drip irrigation at 100 per cent CPE is beneficial for capsicum plant in terms of yield, better plant morphological characters, *viz.* plant height number of branches, root finesses and root length.

Aujla *et al.* (2005) conducted a study on effect of various levels of water and nitrogen application through drip irrigation on cotton yield and water use efficiency. The outcome of the experiment showed that when same quantity of irrigation water and nitrogen applied through drip irrigation system compared to check basin method of irrigation, there was increase in the yield to 2,144 kilograms per hectare from 1,624 kilograms per hectare. When the quantity of water applied through drip was reduced to 75 per cent, the increase in cotton yield was 12 per cent than the check basin. However when water was reduced to 50 per cent, there was a reduction in the yield by two per cent than the check basin.

Rekha *et al.* (2005) studied the influence of drip fertigation on yield and resource use efficiency of bhendi. The experiment consisted of 12 treatments: three drip irrigation *i.e.* 0.50, 0.75 and 1.00 (on epan basis), respectively, three fertigation rates *i.e.* 60, 90 and 120 kg nitrogen per hectare, respectively, furrow irrigation with 120 kg nitrogen per hectare, family drip system with 120 kg nitrogen per hectare and a control treatment (drip at 1.00 epan basis + 0 kg N/ha) and was laid in a randomised block design with three replications. Results of the study indicated that yield and water use efficiency differed significantly among the treatments. Highest water use efficiencies were reported when crop was drip irrigated at 1.00 epan and fertigated with 120 kg nitrogen per hectare (8.23 kg/ha mm & 8.10 kg/ha mm, respectively).

Singh and Singh (2005) in their study compared drip irrigation with that of conventional method of irrigation. Results revealed that, there was a saving of water with drip irrigation to the extent of about 50-70 per cent and increase in yield over conventional methods to the extent of about 10-50 per cent. There was about 89 per cent higher yield of grape per unit quantity of water than that of conventional method of irrigation.

Webber *et al.* (2006) compared the water use efficiency of two water saving irrigation technologies for two legumes grown as a second crop. Conventional and alternate furrow irrigation and three irrigation schedules were used. When compared to green gram (0.13 kg m^{-3}) the water use efficiency for root biomass in bean (0.15 kg m^{-3}) was slightly higher. In green gram, water use efficiency was increased when deficit irrigation or alternate furrow irrigation were followed. It was concluded from the study that alternate furrow irrigation and deficit irrigation were appropriate methods to increase water use efficiency.

Isoda *et al.* (2007) conducted a study on effects of three different irrigation methods (drip, porous tube and furrow irrigation) on yield and water use efficiency in sugar beet. The results of the study showed that the amount of water applied by both drip and porous tube irrigation was 63 per cent of that of furrow irrigation.

Singh and Rajput (2007) studied the effect of drip irrigation on okra. The experiment was conducted at Indian Agricultural Research Institute (IARI), New Delhi, India. The okra crop was cultivated in three sub plots with four treatments of drip lateral depths *viz.* on the surface and at depths of 0 m, 0.05 m, 0.10 m and 0.15 m below the soil surface. Laterals used for three sub plots were inline drip laterals having discharge rate of 2.03 X 10^{-6} m^3s^{-1}, 1.53 X 10^{-6} m^3s^{-1} and 1.22 X 10^{-6} m^3s^{-1} per meter length. The findings of the study indicated that water use efficiency of sub surface drip irrigation was highest at 0.10 m depth varying from 43.60 Mg/ha m to 58.80 Mg/ha m.

Harbi *et al.* (2008) conducted an experiment to know the effect of drip irrigation levels and emitters depth on okra under four irrigation rates at 60 per cent, 80 per cent, 100 per cent and 120 per cent of the estimated evapotranspiration and four drip irrigation emitters depth at surface 0 m, 0.15 m, 0.25 m and 0.35 with split plot design. The study showed that the crop water use efficiency was observed to be in range of 1.45 to 2.93 kg/m^3 and 1.29 to 2.43 kg/m^3 in 2005 and 2006, respectively.

Dunage *et al.* (2009) conducted a study on water use efficiency and economics of tomato using drip irrigation under net house conditions. The experiment was conducted at the regional agricultural research station, Raichur during summer 2005. The findings of the experiment revealed that the total water requirements for tomato under net house conditions using 60, 80, 100 and 120 per cent evapotranspiration (ET) levels of drip were 52.72 litre, 61.45 litre, 69.61 litre and 79.52 litre per plant, respectively. The results of the study also showed that the highest water use efficiency was found under drip irrigation at 60 per cent ET (11.90 t/ha cm) and the least water use efficiency was obtained under drip irrigation at 120 per cent ET (7.45 t/h cm). The payback period of the investment in net house cultivation of tomato using drip irrigation was found to be one and half year (three seasons) by the time the drip irrigation system became beneficial.

Tyson and Harrison (2009) reported that drip irrigation is gaining popularity for production of some vegetable crops. The results of their study indicated that drip irrigated vegetables required 40 per cent less water than the sprinkler irrigated vegetables.

Ali *et al.* (2010) evaluated the effects of irrigation method and water quality on sugar beet yield, percentage of sugar content and irrigation water use efficiency (IWUE). Subsurface drip, surface drip and furrow irrigation were the irrigation methods investigated. The results revealed that the highest root yield (79.7 kg ha^{-1}) and highest IWUE (9 kg m^{-3}) were obtained by using surface drip irrigation.

Kader *et al.* (2010) conducted a field experiment to know the effect of irrigation levels and organic compost on okra plants. The split plot experimental design consisted of three irrigation levels 1198.8 m^3 per acre (I-1), 1798.2 m^3 per acre (I-2) and 2397.6 m^3 per acre (I-3) with drip conjunction with two organic fertilisers comprising of composted plant remains and chicken waste manure at the rate of 6 m^3 per acre. It was reported from the study that irrigation water quantity 1798.2 m^3 per acre (I-2) met through drip irrigation along with the two types organic fertilisers resulted the highest yield (3.3 kg/acre) with 104 per cent increase in yield as compared to I-1 and I-3. Highest mean water use efficiency through drip irrigation was reported to be 1.83 under I-2 treatment with 1.38 and 0.58 under I-1 and I-3 treatments, respectively.

Kumar and Palanisami (2010) studied the impact of drip irrigation on farming system in the Coimbatore district of Tamil Nadu. The sample of 50 drip adopters and 50 control farms were studied. Results of the study revealed that, the net sown area increased from 4.51 ha to 5.31 ha in the drip irrigated farms. Markov chain analysis results showed that, the probability of retaining banana and coconut was found to be 57 per cent and 75 per cent, respectively. Probability of shifting the area under maize to banana, maize to coconut and maize to grape was 18 per cent, 18 per cent and 13 per cent, respectively. Water productivity for drip and control farms was worked out to be 7.4 kg/m^3 and 4.9 kg/m^3, respectively.

Anita (2011) conducted a study on drip irrigation in based intercropping system in Tamil Nadu. Nine fertigation levels and four inter crops in sub plots (S1-vegetable coriander, S2-Radish, S3-Beet root and S4-onion) were included in the experiment. The results of the study revealed that crops responded well to higher dose of fertigation in water soluble forms under maize + vegetable coriander intercropping system with yield of 6,522 kg/ha. Drip irrigation at 150 per cent of recommended dose of fertiliser resulted higher water use efficiency. Maize based inter cropping system recorded higher net returns (` 56,858/ha) and B: C ratio (3.24) under drip fertigation at 150 per cent RDF + Radish as inter crop.

Chandrakanth *et al.* (2012) conducted a study on micro irrigation: economics and outreach in Karnataka. The study revealed that the water use efficiency for maize, groundnut, red gram and sorghum under sprinkler irrigation were 62.29 kg/ha cm, 23.11 kg/ha cm, 9.39 kg/ha cm and 56.51 kg/ha cm, respectively and the water use efficiency for sugarcane under drip irrigation was 471.48 kg/ha cm.

Kaushal *et al.* (2012) in their study on drip irrigation in sugarcane reported that drip irrigation in sugarcane increased the water use efficiency to the extent of 60 to 200 per cent, saved water to the extent of 20 to 60 per cent, reduced fertilizer requirement (20 to 33 %) through fertigation and produced better quality crop with increased yield (7 to 25 %) as compared to conventional irrigation.

Mamta (2012) conducted a research study on groundwater use dynamics: analysing performance of micro irrigation system- a case study of Mewat district, Haryana, India. The results of the study highlighted that there was saving in water usage in cultivation of wheat crop to the extent of 63.15 per cent under sprinkler irrigation and 88.89 per cent under drip irrigation over the flood irrigation.

Soomro *et al.* (2012) conducted a research study on effects of marginal quality ground water in comparison to good quality water (tap water) on okra yield and water use efficiency. For T1 marginal quality water (saline water and tap water mixture of equal proportions) and for T2 tap water was supplied through emitters. The results of the study indicated that highest crop yield and water use efficiency was obtained under T_1 (18.93 t/ha and 2.7 gm/$m^{3,}$ respectively) compared to T_2 (17.0t/ha and 2.74 gm/$m^{3,}$ respectively). There was increase in the yield and water use efficiency in T1 over T2 to the extent of 10 per cent in each case.

Chandrakanth *et al.* (2013) conducted a study on economic benefits from micro irrigation for dry land crops in Karnataka. A sample of 45 drip irrigation farmers (DIF) and 45 conventional irrigation farmers (CIF) were selected for the study. Mulberry, grapes and tomato were the major crops selected. The technical efficiency and economic efficiency of water use was analysed in terms of output per acre inch of water and net income per acre inch of water, respectively. In drip irrigation system, 9.05 quintals, 10.50 quintals and 12.45 quintals of yield was produced, respectively in mulberry leaves, grapes and tomato per acre inch of water while in conventional irrigation systems 3.86 quintals, 2.85 quintals and 5.03 quintals of yield was produced, respectively in mulberry, grapes and tomato. The net returns per acre inch of water from mulberry, grapes and tomato were the highest in drip irrigation farmers (` 1,384, ` 4,723 and ` 2,696, respectively) than conventional irrigation farmers (` 525, ` 769 and ` 1040, respectively).

Saxena *et al.* (2013) evaluated the effect of salinity of irrigation water on yield of okra under drip irrigation. The study was performed in randomised block design with four levels of saline irrigation water with EC_{iw} = 0.2, 2.0, 4.0 and 8.0 dS m^{-1} in three replications. Significant change in the yield of okra was observed at 1 per cent level of significance. Highest water use efficiency was found to be with available fresh water of 0.2 dS m^{-1} at 0.49; for the treatments of 2.0 dS m^{-1}, 4.0 dS m^{-1} and 8.0 dS m^{-1} it was reported at 0.49 t/ha cm, 0.46 t/ha cm and 0.38 t/ha cm, respectively.

Sharma *et al.* (2013) conducted a study on influence of drip irrigation and nitrogen fertigation on yield and water productivity of Guava to assess the influence of four irrigation schedules (surface irrigation at IW/CPE 1.0, drip irrigation at 60 %, 80 % and 100 % of crop evapotranspiration) and three nitrogen fertigation levels (80 %, 100 % and 120 % of recommended dose of nitrogen) on the yield and water productivity of guava. The results of the showed that the highest fruit yield of 18.70 t/ha was obtained with drip irrigation at 100 per cent evapotranspiration and lowest yield of 11.00 t/ha was recorded under drip at 60 per cent evapotranspiration. Maximum fruit yield of 16.90 t/ha was registered under at 100 per cent recommended dose of nitrogen. The interaction between irrigation schedules and nitrogen fertigation levels revealed that maximum fruit yield of 21.60 t/ha and water productivity of 17.80 kg/ha mm was observed under drip irrigation at 100 per cent evapotranspiration with 120 per cent of recommended dose of nitrogen.

Ayyanna *et al.* (2014) conducted a study on evaluation of surface and drip irrigation methods for marigold flower under Raichur condition. The experiment was conducted at University of Agricultural Sciences Raichur. The main purpose of the study was to work out the effect of different levels of irrigation on marigold and economics of drip and furrow irrigation (60 %, 80 %, 100 % and 120 % evapotranspiration). The water saved under drip irrigation over furrow irrigation was found to be 74.92 per cent, 68.07 per cent, 61.45 per cent and 54.65 per cent for 60 per cent, 80 per cent, 100 per cent and 120 per cent evapotranspiration, respectively. The highest yield of marigold flower 19.63 t/ha was obtained in 80 per cent evapotranspiration level which was closely followed by 100 per cent evapotranspiration level (17.03 t/ha). All drip irrigation treatments recorded higher benefit cost ratio (4.88 to 2.33) compared to furrow method of irrigation (1.73). It was concluded from the study that 80 per cent evapotranspiration level can be used to achieve higher yield of marigold in sandy loam soils under Raichur (semi arid) conditions.

Vimalendran and Latha (2014) conducted a study on yield, water use and water use efficiency of pigeon pea under drip fertigation system. The results of the study revealed that drip irrigation at 100 per cent water requirement of the crop with fertigation at 125 per cent recommended dose of fertilisers through water soluble fertilisers registered significantly higher grain yield of 2,812 kg/ha and 2,586 kg/ha during 2011-12 and 2012-13, respectively. Surface irrigation with conventional method of fertiliser application recorded lower water use efficiency of 3.70 kg/ha/mm and 3.38 kg/ha/mm during 2011-12 and during second season (2012-13). The highest water use efficiency of 6.72 kg/ha/mm was recorded in drip irrigation at 50 per cent computed water requirement along with fertigation at 125 per cent recommended dose of fertilisers through water soluble fertilisers.

Danso *et al.* (2015) evaluated the effect of different fertilisers and irrigation methods on yield of okra grown in the keta sand Spit of southeast ghana. In their study, four treatments were compared *i.e.* sprinkler irrigation with manure spread fertlilisation, sprinkler irrigation with localised manure fertilisation, drip irrigation with localised manure fertilisation and drip irrigation with fertigation (N-K fertilisers), respectively. The findings of the study indicated that highest water productivity was reported to be 6.5 kg/m^3 with treatment involving drip fertigation with N-K fertilisers.

Malunjkar *et al.* (2015) conducted a study on energy efficiency of banana crop under different irrigation methods. The findings of the study reported that the yield obtained was highest under drip irrigation (67.40 t/ha) compared to conventional method of irrigation (52.50 t/ha). The water use efficiency was also found highest in case of drip irrigation (4.00 kg/m^3) compared to conventional method of irrigation (2.20 kg/m^3).

Omotayo (2015) conducted a study on crop water productivity and economic evaluation of drip irrigated soyabeans in Nigeria. Seasonal crop water use for the treatment in which deficit irrigation was imposed at seed filling stage was 364 mm while for the control treatment with full irrigation, seasonal crop water use was 532 mm. There was reduction in the yield by 18.80 and 21.90 per cent when drip irrigation was imposed during flowering and pod initiation stage, respectively. Similarly, the there was reduction in the yield reduced by 24.40 and 47.90 per cent when drip irrigation was imposed during maturity and seed filling. Water productivity was also reduced by 20.00 and 35.00 per cent during maturity and seed filling stages. Drip irrigation during reproductive stages was also resulted reduction in water productivity by 6.70 to 30 per cent while revenue was reduced by 18.50 to 47.70 per cent.

Sharma and Kaushal (2015) conducted a review study on growing okra with drip fertigation. The findings of the study revealed that there was saving of water in cultivation of okra to the extent of 20 per cent to 61 per cent, yield increased by 13 per cent to 76 per cent, fertiliser saved from 15 per cent to 30 per cent and also resulted in higher water use efficiency from 35.5 per cent to 50.80 per cent as compared to traditional method of irrigation.

2.4 Profitability of major crops in conventional v/s micro irrigation systems in the study area

Cassel *et al.* (2001) conducted a study to know the impact of three drip irrigation regimes corresponding to 20, 35 and 50 per cent water reduction against the flood irrigation. Sugar yield and sugar content under all three drip regimes were higher compared to flood irrigation.

Singandhupe *et al.* (2002) conducted a study on fertigation studies and irrigation scheduling in drip irrigation system in tomato crop. The study was conducted at the Research Farm of Water Management Project, Mahatma Phule Agricultural University, Rahuri (Maharashtra). The results of the study showed that application of nitrogen through the drip irrigation in ten equal splits at 8 days interval saved 20 to 40 per cent nitrogen as compared to the furrow irrigation when nitrogen was applied in two equal splits (at planting and on month thereafter). There was increase in the tomato fruit yield to the extent of 12.50 per cent and water saved to the extent of 37 per cent under drip method compared to furrow method of irrigation. The water use efficiency was also higher under drip irrigation (77 %) over furrow irrigation.

Sunilkumar and Jaikumaran (2002) conducted a study on yield and yield attributes of bhendi as influenced by mulching and methods of irrigation in tropical monsoon climate and sandy clay loam soil. It was reported from the study that drip irrigated crop along with mulch condition produced yield of 12.86 t/ha, whereas mulched and furrow irrigated crop produced 20.95 t/ha and the control produced 122.86 t/ha indicating better yield by suitable water supply through drip irrigation along with mulching than furrow irrigation.

Narendra and Agarawal (2005) conducted an experiment to study the effect of drip irrigation and mulches on the growth and yield of banana. Eight drip-irrigated and two surface irrigated treatments were comprised in the experiment. Results showed that drip irrigation increased the yield of banana compared to surface method of irrigation along with good water saving. A yield of 498.68 q/ha was recorded under 60 per cent water through drip with plastic mulch as compared to the control.

Thamban *et al.* (2006) conducted a study on economic analysis of coconut cultivation under micro irrigation in Kasaragod district of Kerala state. The study revealed that the average plant density in coconut garden varied from 186 to 194 and 181 to 190 in conventional irrigation system and drip irrigation system, respectively. Average cost of coconut ranged from ` 20,619/ha to ` 21,766/ha in conventional irrigation system and Rs18,382/ha to ` 19,786/ha in drip irrigation system. Gross returns varied from ` 28,550/ha to ` 44,890/ha in conventional basin method and ` 29,050/ha to ` 45,667/ha in case of drip method of irrigation.

Jalajakshi and Jagadish (2009) studied economics of krishik bandhu drip irrigation scheme in Tamil Nadu in cultivation of sugarcane and banana. A saving of ` 6,450 and ` 6,313 were found in sugarcane and banana, respectively in krishik bandhu drip irrigation. Benefit cost ratio in sugarcane was observed to be 1.55 in krishik bandhu drip irrigation and 1.12 in conventional flood irrigation method. B:C ratio under krishik bandhu drip irrigation and conventional flood irrigation in banana was 4.58 and 1.85, respectively and in chilli it was 5.68 and 2.95, respectively.

Mishra *et al.* (2009) conducted an experiment on response of okra to drip irrigation and mulching in coastal Orissa. The experiment involved treatments which included irrigation requirements 100 per cent, 80 per cent and 60 per cent under drip irrigation and with 100 per cent irrigation requirement under surface irrigation with and without application of black coloured plastic mulch. The design of experiment was randomised block design with three times replications of each treatment. The results of the study showed that drip irrigation system was observed to be economical and cost effective as compared with conventional surface irrigation. Maximum yield was observed under the treatment with 100 per cent irrigation requirement in combination with black coloured plastic mulch. Drip irrigation system either alone or in combination with mulching increased the yield of okra to the extent of 61 per cent over the surface irrigation method.

Patil *et al.* (2009) conducted an experiment on effect of irrigation methods on yield and water requirement of summer groundnut. The experiment was conducted on the research farm of department of irrigation and drainage engineering, Dr. Deshmukh, Krishi Vidyapeeth, Akola from Jan 2001 to 10th may 2001. The different methods of irrigation studied were drip irrigation, micro sprinkler, drip inline and broad based furrow irrigation. The results of the study showed that the amount of water applied through drip, micro sprinkler, drip inline and broad based furrow irrigation were 58.90 ha cm, 58.90 ha cm, 58.90 ha cm and 81.77 ha cm, respectively. There was increase in the yield under drip, micro sprinkler and drip inline irrigation to the extent of 52.87 per cent, 72.73 per cent and 61.07 per cent over the broad based furrow irrigation, respectively. The net returns was found to be highest under micro sprinkler (` 68,816/ha) followed by drip inline (` 53,915/ha), drip irrigation (` 51,680/ha) and Broad based furrow irrigation (` 37,803/ha). The B:C ratio was also highest under micro sprinkler (2.94) followed by broad based furrow (1.86), drip (1.07) and drip inline (1.06).

Jayapiratha *et al.* (2010) studied the performance of okra crop under drip irrigation. The experiment consisted of six replications of three irrigation treatments applied *i.e.* T1 as 15 minutes duration and T2 as 30 minutes duration through drip irrigation whereas third treatment T3 was applied under basin irrigation with three days irrigation interval as control with randomised block design. Yield for 1000 m^2 area was found to be 1,516 kg, 1,514 kg and 1,084 kg corresponding to 15 minutes irrigation, 30 minutes irrigation and basin irrigation treatment, respectively. The percentage of yield increase was indicated to be 28.12 per cent and 26.00 per cent under 15 minute irrigation and 30 minute irrigation, respectively as compared to control.

Narayanamoorthy (2010) conducted a study on drip method of irrigation be used to achieve macro objectives of conservation agriculture. The study was conducted to know the advantages of drip irrigation over furrow irrigation in cultivation of four major crops *i.e.* sugarcane, grapes, banana and cotton. The results of the study indicated that by adopting drip irrigation there was saving of water to the extent of 44.40 per cent, 37.30 per cent, 29.15 per cent and 45.00 in case of sugarcane, grapes, banana and cotton, respectively. There was increase in the yield of sugarcane, grapes, banana and cotton under drip method of irrigation over furrow irrigation (23.00 %, 19.00 %, 29.00 % and 114.70 %, respectively). The results of the study also showed that there was increase in the net income under drip irrigation over the furrow irrigation in case of sugarcane (74.00 %), grapes (44.00 %), banana (64.50 %) and cotton (3021.00 %).

Birbal *et al.* (2013) conducted a study on effect of irrigation methods and different mulches on yield of okra in ber based vegetable production system. It was reported from the study that highest yield of 83.92 q/ha was obtained under the combination of drip irrigation and plastic mulch as compared to 45.30 q/ha under surface irrigation method, where as it was also indicated that drip irrigation had 14.80 per cent higher yield in comparison to flood irrigation.

Gaurang (2013) in his comparative studies between drip irrigation and furrow irrigation for sugarcane and banana in Navsari region showed that there was increase in the yield of sugarcane under drip irrigation (16.00 %) and net income was also highest under drip irrigation (` 1,96,660/ha) compared to furrow irrigation (` 1,49,950/ha). The water use efficiency was also highest under drip irrigation (74.28 t/ha mm) compared to furrow irrigation (53.33 t/ha mm). Similarly in cultivation of banana under drip irrigation there was increase in the yield (18.00 %) and water saving to the extent of 45 per cent compared to furrow irrigation.

Himanshu *et al.* (2013) conducted an experiment on response of broccoli to irrigation scheduling and methods under drip, sprinkler and surface irrigation. The experiment was carried in Allahabad, India. The results of the study highlighted that the highest yield was observed under drip irrigation (27.65 t/ha) followed by micro sprinkler (27.18 t/ha) and surface irrigation (21.17 t/ha).

Konyeha and Alatise (2013) conducted an experiment on yield and water use of okra grown under micro sprinkler irrigation system during off seasons. Nine micro irrigation plots (2X2 m^2) were established following a 3X3 completely randomized block design. Yield and water use of okra under three different irrigation water managements *i.e.* irrigation water treatment at 20 per cent low irrigation, 50 per cent medium irrigation and 75 per cent high irrigation were measured. Yield response of okra to irrigation reported to show high positive correlation range of 0.9584 to 0.997 while yield increased from 1.08 t/ha at 183.89 mm to 2.78 t/ha at 222.30 mm for the three treatments. It was observed from the study that yield of okra especially in dry areas and during off seasons can be obtained through irrigation water application, but where water is moderately scarce, medium irrigation treatment is recommended to serve as supplement.

Suresh *et al.* (2013) conducted a study on comparative efficiency of sprinkler irrigation over check basin irrigation in groundnut at different irrigation schedules. The experiment was conducted at Agricultural Research Station, Garikapadu in Krishna district of Andhra Pradesh. The results showed that the yield was found to be highest under sprinkler irrigation (2,020 kg/ha) as compared to check basin of irrigation (1,762 kg/ha).

Ramadan *et al.* (2014) evaluated the effect of sprinkler irrigation systems and irrigation frequency on water use efficiency and economical parameters for wheat production. Treatments consisted of two sprinkler irrigation systems, solid set sprinkler (S1) and hand move laterals (S2) and three irrigation frequencies (IF1: once per week; IF2: twice per week; IF3: thrice per week). The results of the study showed that the highest yield was observed in case of S1IF3 (79.59 q/ha) and the least yield was observed in case of S2IF1 (40.84 q/ha).

Abdul and Chand (2014) studied the effect of drip irrigation levels on yield of salad cucumber under naturally ventilated polyhouse. The results of the study showed that maximum fruit number (49), fruit weight (7.19 kg/plant) and fruit yield (88.8 t/ha) were obtained from the drip irrigation level of 65 per cent (1.3 litre per plant per day) and lowest fruit number (35), fruit weight (5.04 kg/plant) and fruit yield (62.26 t/ha) from the drip irrigation level of 50 per cent (1 litre per plant per day). There was increase in water use efficiency to the extent of 35 per cent through 65 per cent drip irrigation level (6,148.31 kg/ha cm) over the control.

Jisnu *et al.* (2014) conducted a study on economics of green chilli cultivation under drip and conventional irrigation methods in Anand and Vadodara districts of Gujarat. Multistage random sampling was followed for the selection of respondents. The sample size was 120 comprising of 60 drip farms and 60 conventional farms. The results of the study revealed that the yield was highest under drip irrigation (402.06 q/ha) compared to conventional method of irrigation (340.52 %). The net return per hectare in drip irrigation system was also highest (` 3,22,265) with benefit cost ratio of 3.58 compared to conventional method of irrigation (` 2,50,111 & 3.15, respectively).

Palanisami *et al.* (2014) conducted a study on enhancing the crop yield through capacity building programs: application of double difference method for evaluation of drip capacity building program in Tamil Nadu State, India. The results of the study highlighted that there was increase in the yield of 2.5 t/ha for banana, 3.3 t/ha for sugarcane and 0.30 t/ha for turmeric through capacity building program. The conventional method using before and after situations had shown an increase in yield of 4.3 t/ha for banana, 40.60 t/ha for sugarcane and 2.60 t/ha for turmeric.

Thirumalaikumar *et al.* (2014) in their study on effect of different irrigation practices on growth parameters of okra reported that average fruit yield under drip irrigation was 22.40 t/ha which was significantly higher than the surface irrigation (18.56 t/ha).

Deepak *et al.* (2015) conducted a study on optimal design to flow rate in drip irrigation system to enhance the tomato cultivation in 5X6 m^2 area. Effect of three flow rates under drip irrigation *i.e.* 2 litre/hour, 4 litre/hour and 8 litre/hour on yield of tomato was studied. The results of the study showed that the highest yield was found under drip irrigation at 2 litre/hour flow rate (8.4 kg) followed by 4 litre/hour (6.1 kg) and 8 litre/hour (5.2 kg).

2.5 Financial feasibility of investment in micro irrigation systems in the study area

Shivakumar *et al.* (2000) studied the economic analysis of drip irrigation system in sunflower in the main research station, University of Agriculture sciences, Bangalore. The average establishment cost of drip layout under normal and paired row planting was found to be ` 35,000/ha and ` 17,500/ha, respectively. B:C ratio, Net present value and Payback period was analysed to be 1.82, ` 14,285 and 0.49 years, respectively which was found economically feasible for the farmers.

Narayanamoorthy and Deshpande (2001) analysed the economic impact of drip method of irrigation. The study revealed that investment in drip irrigation was economically viable for the farmers who own even one hectare of land. Further the results revealed that farmers could regenerate the cost made on drip set from the profit of the first year without availing the subsidy from government schemes.

Cetin *et al.* (2004) analysed the economics of drip irrigation for apple (*Malus domestica*) orchards in Turkey. The results revealed that net present values for ‘Granny Smith’ and ‘Golden Delicious’ were $ 2,584 and $ 909, respectively. Further, it indicated that, a grower spent up to $ 3,999 and $ 2,324 for ‘Granny Smith’ and ‘Golden Delicious’ per hectare for drip irrigation system and was found feasible.

Narayanmoorthy (2008) studied the drip irrigation and rain fed crop cultivation in cotton crop. It was revealed that drip irrigated crop used 228 HP hour/ acre where as in non drip irrigated crop it was 415 HP hour/ acre. There was a profit of ` 21,283/acre and ` 682 / acre under drip and furrow method of irrigation, respectively. At 10 per cent discount rate, NPW was increased from ` 1,08,187/acre without subsidy to ` 1,17,852/acre with subsidy.

Okunade *et al.* (2009) conducted a study on economics of producing okra and amaranth under basin, drip, furrow and sprinkler irrigation. The benefit cost ratios were reported to be 1.24, 1.41, 1.01 and 1.52 (okra) and 1.50, 1.78, 1.22 and 1.55 (amaranth) for sprinkler, drip, basin and furrow irrigation, respectively. It was also reported that the Pay Back Period (PBP) for amaranth and okra were 2.5 and three years, respectively.

Kaur *et al.* (2010) evaluated the economic investment in micro irrigation structures in Kandi area of Punjab. The per hectare returns from irrigation through small dams, lift irrigation and makowal type structures were ` 12,726, ` 15,517 and ` 10,311, respectively. The increase in the returns from micro irrigation through small dams, lift irrigation structure and makowal type structures were 20.56 per cent, 38.54 per cent and 27.95 per cent, respectively.

Gholap *et al.* (2011) conducted a study on economic viability of the micro irrigation system on sugarcane cultivation in Baramati Tehsil of Pune district in Maharashtra. The sample size was 25. The results of the study showed that the investment on drip irrigation in cultivation of sugarcane was found to be economically viable with net present worth of ` 34,754/ha at 15 per cent discount rate. The internal rate of return and benefit cost ratio for the drip irrigation system were found to be 87 per cent and 2.08, respectively.

Maddileti (2012) studied the impact of new methods of irrigation in drought prone areas of Kurnool district. It was found that, there was reduction in energy requirement, weed problems, soil erosion and cost of cultivation due to adoption of micro irrigation. Without availing state subsidies, investment in micro- irrigation was found to be economically viable.

Ndeketeya *et al.* (2014) studied the drip irrigation as a potential alternative to furrow irrigation in sugarcane production in Lowveld Estate, Zimbabwe. The results of the study indicated that the investment on drip irrigation in cultivation of sugarcane was found to be economically feasible with net present value (NPV) of ` 42,620, internal rate of return (IRR) of 7.46 per cent and benefit cost ratio (B:C ratio) of 2.52 compared to furrow irrigation (` 13,946 NPV, 26.26 % IRR & 2.16 B:C ratio).

2.6 Decomposition analysis of total change in per hectare income between micro irrigation systems and conventional method of irrigation in cultivation of different crops

Bisaliah (1977) decomposed the yield difference between the two wheat production technologies in Punjab into its constituent sources. In the study, improved production technology contributed 15 per cent of the total change in output (40.50 %). Under mexican wheat, the increased use of inputs contributed about 25.50 per cent to the total difference in output. The contribution of fertilizer, capital and labour was 15 per cent, eight per cent and two per cent, respectively.

Indusekharan (1982) estimated the contribution of different inputs like labour, chemical fertilizer and capital to cotton productivity under Intensive Cotton District Programme (ICDP). He reported that the decomposition analysis showed about 12.50 per cent of the total increase in cotton output was accounted by these three inputs.

Sisodiya *et al.* (1999) conducted a study on temporal analysis of decomposition of pigeon pea production in different agro climatic regions of Madhya Pradesh. It was observed that the output of pigeon pea increased at higher rate (59.73 %) after introduction of soyabean crop in the state due to high take off of 78.49 per cent productivity of this crop.

Lalwani and Koshta (2000) conducted a decomposition analysis of milk yield in members and non-members of milk producers cooperative societies (MPCS's) in Raipur district of Madhya Pradesh. There was a sample of 30 members and 30 non-members of MPCS's. Milk yield was higher in members of MPCS's than in non-members at the same level of inputs.

Gaddi *et al.* (2002) estimated contribution of different sources to yield gap in cotton using output decomposition model. The variables which were included in the model explained more than 87 per cent of the variation in cotton production in demonstration field. The most important variables governing production were human labour, bullock labour and seeds. Capital input did not exert any significant influence in cotton production, while the plant nutrients were excessively used. The study revealed that the production elasticities of all inputs on all the fields were invariably lower than unity implying diminishing marginal productivity with respect to each of these inputs.

Kunnal *et al.* (2004) studied the effects of technical change in cotton production on output and employment generation in Karnataka using production function analysis and decomposition analysis. The important inputs conditioning cotton output were bullock labour, machine labour and capital in case of hybrids and seeds, farm yard manure and capital in local varieties. Cultivation of hybrids resulted in 121 per cent more cotton output than under local varieties. The contribution from the increased input use was 99.28 per cent and that of technology was 21.72 per cent.

Radha and Chowdry (2005) conducted a study on comparative economics of seed production *vis-a-vis* commercial production of cotton in Andhra Pradesh. About 64.5 per cent of the change in gross returns was purely due to technical change as revealed by the study.

Ravichandran *et al.* (2006) studied the economics of bio-inputs usage in paddy cultivation in Tamil Nadu. The study compared the use of chemical and biological inputs in rice production. There was a difference of 12.30 per cent in gross return per hectare of paddy crop between adopters and non-adopters of bio-inputs.

Mohan (2009) conducted a study on the impact of integrated pest management (IPM) technology in cotton and paddy production in Haveri district, Karnataka. As revealed by the decomposition analysis, the total difference in the output between IPM and non-IPM was 26.47 per cent in cotton and 17.59 per cent in paddy. IPM technology component alone contributed 29.86 and 28.32 per cent in cotton and paddy, respectively.

Vinod (2010) studied the comparative economics of vegetable production under organic and inorganic farming in Belagavi district. The total difference in income between organic and inorganic farming was found to be 14.88 per cent and 27.07 per cent in tomato and chilli, respectively. Organic farming alone contributed 23.82 per cent and 33.91 per cent, respectively in case of tomato and chilli.

2.7 Constraints faced by sample respondents in the study area

Batta and Singh (2000) conducted a study on drip irrigation in Rahuri district of Maharashtra. High initial cost of the system and procedural difficulty in availing the subsidy by the government were the major socio-economic constraints. The major field related constraints were clogging of micro tubes, clogging of drippers, leakage of drippers from lateral jointing, leakage from lateral sub main jointing, non uniform discharge from drippers, biting of laterals/micro tubes by rodents and difficulty in inter cultural operations and taking out the drip system laterals during crop harvest.

Zenebe (2000) conducted a temporal analysis on the economic impact of irrigation on crop production in malaprabha command area. During 1998-99 resources like, land, seed, fertilisers and manures were used less efficiently compared to 1991-92. Inadequate water availability was the major problem as opined by the farmers.

Kulecho (2005) studied the reasons for smallholder farmers discontinuing with low-cost micro-irrigation. Lack of maintenance, irrelevant cultural background and unreliable water supply were the major constraints in discontinuing the micro irrigation by the farmers.

Uday *et al.* (2007) conducted an investigation on drip irrigation system installed for grape orchards in Nasik district of Maharashtra. The major constraints were clogging of emitters, irregular water supply and irregular electricity supply and high initial cost as opined by 85 per cent, 87.5 per cent, 91.66 per cent and 75 per cent of the farmers, respectively. The other problems faced were material transport facilities, lack of technical knowledge and high cost of spare parts.

Navaneeth *et al.* (2008) conducted economic analysis on performance of minor irrigation in Krishna basin of Karnataka. The major constraints observed in the development of minor irrigation were encroachment and siltation of tank bed, poor maintenance, inadequate power and lack of institutional support.

Balasubramanaiam *et al.* (2009) conducted a study on irrigation system in groundnut: Advantages and disadvantages. The study was conducted in Erode district of Tamil Nadu. Majority of the respondents opined that easy intercultural operations (75 %), less labour cost (74 %), maintenance and conservation of soil moisture (68 %), application of fertilisers and fungicides through irrigation water (63 %) and suitability to undulating topography (56 %) were the advantages of sprinkler irrigation; whereas they also reported that non-suitability to areas with high wind velocity (65 %), high cost (61 %) and leakage from coupler or fittings were the major constraints associated with the sprinkler irrigation.

Muruganantham *et al.* (2009) conducted a study on micro irrigation in a drought prone district in Tamil Nadu. In his study the constraints were grouped into (i) farmer level constrains and (ii) service provider level constrains. financial constraints, resources constraints, operation and maintenance constraints and lack of awareness were the farmer level constraints. The major service provider level constraints were financial constraints, availability of equipments and skilled labour shortage. Clogging, theft and damage by the animals were the other constraints faced by the farmers in adoption and maintenance of micro irrigation.

Nogues and Herrero (2009) studied the adoption status of family drip irrigation system in Tigray state. His study showed that the lower growth of the adoption of drip irrigation was only associated with the technology itself but also with the lack of awareness among the farmers and development agents on the technical and operational requirement of the drip irrigation system to operate effectively and to utilise the technology at the household level.

Kumar *et al.* (2012) conducted a study on the extent of adoption of sprinkler irrigation system by the farmers in Jhunjhunu district of Rajasthan. The major reason for medium level adoption was the low level knowledge of the respondents. Among different practices adopted, adoption of distance between nozzles and adoption of the area under sprinkler system were ranked first and last, respectively.

Mostafa (2013) conducted a study to evaluate the low pressure drip irrigation system for smallholders. The study was conducted in Germany. The results of the study showed that the reused drip lines leads to a decrease in distribution uniformity and an increase in costs when the distribution uniformity decreased by 10.50 per cent and 21.60 per cent for reusing the laterals for second and third year, respectively. Moreover, the cost of repairing laterals was more than five and 6.5 times higher for both the second and third season.

3. METHODOLOGY

This chapter comprises of the description of the study area, sampling technique adopted, method of survey, nature and sources of data and various tools and techniques employed in analyzing the data. At the end of the chapter, the terms and concepts used for the study are also defined and explained to facilitate a clear understanding of the important issues with which the present study is concerned.

The methodology followed in the study is presented under the following sub headings.

3.1 Description of the study area

3.2 Sampling procedure

3.3 Nature and sources of data

3.4 Analytical techniques/tools employed

3.5 Definitions of terms and concepts used

3.1 Description of the study area

The Karnataka state lies between 11°30' and 19°25' North latitudes and between 74°07' and 78°35' East longitudes. It is the eighth largest state in India in both area and population with an area of 190.50 lakh hectares and the population of about 610.95 lakh according to 2011 census. Of the total population of Karnataka, 309.67 lakh (50.69 %) are male and 301.29 lakh (49.31 %) are female and 374.69 lakh (61.33 %) are staying in rural area and 236.26 lakh (38.67 %) are staying in urban area. The literacy rate is 75.60 per cent (Table 3.1). The state is bordered by the Arabian Sea to the West, Goa to the North West, Maharashtra to the North, Andhra Pradesh to the East, Tamil Nadu to the East and South East, and Kerala to the South West.

Karnataka state is situated in tropical zone and enjoys warm climate throughout the year. The mean temperature ranges from 21.5 °C to 31.7 °C, the maximum and minimum temperature being 42 °C and 14 °C, respectively. The normal rainfall of the state ranges from as low as 569 mm to as high as 4,029 mm. Average actual annual rainfall of the state is 1,409 mm. The major part of the rainfall of the state is received from the south west monsoon, which commences in the first week of June and continues till the end of September. Major part of the state has red soils. Laterite soils are found in the hilly and coastal regions of the Western Ghats. The northern part of the state has black soils with high moisture holding capacity.

The net irrigated area in the state is 35.56 lakh hectares. Of the total net irrigated area, the area irrigated from tube wells is 13.22 lakh hectares, 4.11 lakh hectares from open wells, 12.53 lakh hectares from canals, 0.93 lakh hectares from lift irrigation, 1.54 lakh hectares from tanks and 3.22 lakh hectares from other sources (Table 3.1).

The land utilization pattern of the Karnataka (Table 3.2) during the year 2012-13 is presented in the Table 3.2. Out of the total geographical area of the state (190.50 lakh ha) the area under forest was 30.73 lakh hectares, with net sown area of 99.23 lakh hectares and fallow land around 22.25 lakh hectares. Area which is not available for cultivation was 22.30 lakh hectares and other uncultivable land excluding fallow land was 15.98 lakh hectares.

The cropping pattern (Table 3.3) in the state during 2013-14 indicated that out of the gross cropped area, cereals formed the important component with 45.48 per cent followed by pulses (22.68 %), commercial crops (13.10 %), oil seeds (12.86 %) and fruits and vegetables (5.88 %). Major cereal crops grown are maize, paddy, jowar, wheat and bajra. Major pulses grown are redgram, horse gram, black gram and bengal gram. Major oil seeds grown are groundnut, sunflower and sesame. Major commercial crops grown are sugar cane, cotton and tobacco.

The present study is conducted in four districts of Northern Karnataka and presented in Fig. 1. The detailed description of these districts, namely Belagavi, Viyayapur, Bidar and Kalaburgi is presented in the following sub headings.

3.1.1 Belagavi district

Belagavi district falls in the Northern part of Karnataka between 15°23' and 16°58' North latitude and 74°10' and 75°28' Eastern longitude. It is comprised of ten taluks *viz*; Belagavi, Athani, Bailahongal, Chikkodi, Gokak, Hukkeri, Khanapur, Raibhag, Ramdurga and Saundatti. The population of the Belagavi district is 47.80 lakh (2011 census) of which the total population 64.45 per cent of the population was literate. The district has a normal rainfall of 825 mm per annum. The net irrigated area in the district is 4,93,307 hectares. Of the total net irrigated area, the area irrigated from tube wells is 1,67,684 hectares, 1,48,276 hectares from open wells, 77,670 hectares from canals, 17,640 hectares from lift irrigation, 307 hectares from tanks and 81,730 hectares from other sources (Table 3.1).

The predominant type of soil in the district is black soil. Total geographical area of Belagavi district is 13.44 lakh hectares, out of this 1.90 hectares is under forest, 1.14 lakh hectares land is not available for cultivation and total net sown area is 6.57 lakh hectares and other uncultivable land excluding fallow land was 0.39 lakh hectares (Table 3.2).

The cropping pattern in Belagavi district during 2013-14 indicated that out of the net cultivated area, cereals formed the important component with 41.83 per cent followed by commercial crops (30.96 %), oilseeds (12.85 %), pulses (10.10 %) and fruits and vegetables (4.27 %). Major cereal crops grown are maize, paddy, jowar, wheat and bajra. Major pulses grown are tur, horse gram, black gram and bengal gram. Major oil seeds grown are groundnut, sunflower and sesame. Major commercial crops grown are sugar cane, cotton and tobacco (Table 3.3).

3.1.2 Viyayapur district

Viyayapur district falls in the Northern part of Karnataka between 15^0 20^1 N latitude and 74^0 28^1 E longitude. It consists of five taluks viz; Viyayapur, Basavanabagewadi, Indi, Muddebihal and Sindagi. The population of the Viyayapur district is 21.77 lakh (2011 census) and out of the total population 67.13 per cent of the population is literate. The district generally has a normal rainfall of 632 mm per annum and the actual rainfall during 2013 was 564 mm per annum. The net irrigated area in the district is 51,036 hectares. Of the total net irrigated area, the area irrigated from tube wells is 93,018 hectares, 82,520 hectares from open wells, 1,15,939 hectares from canals, 1,638 hectares from lift irrigation, 236 hectares from tanks and 13,475 hectares from other sources (Table 3.1).

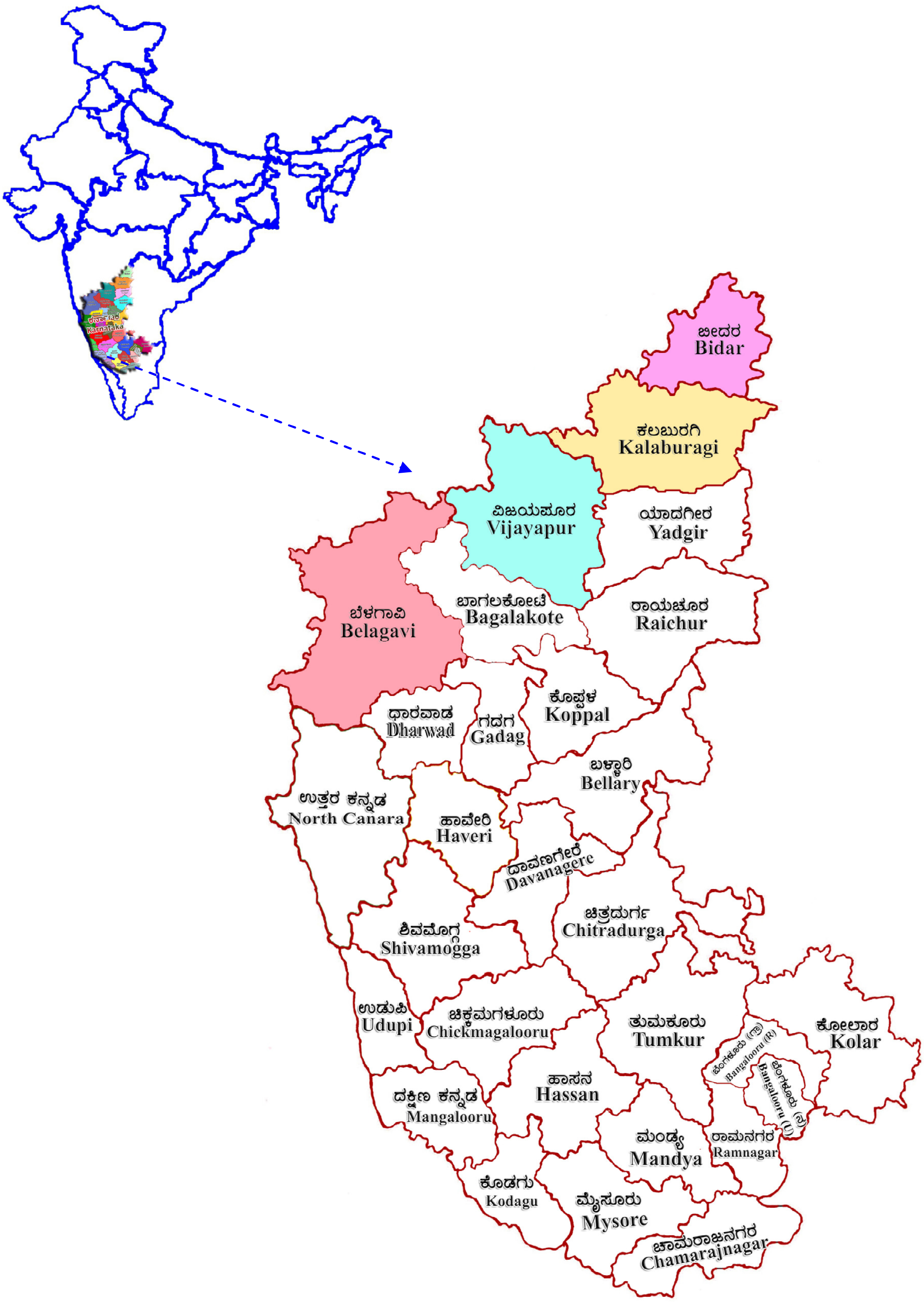

Fig. 1: Map of Karnataka state showing the study area

The predominant type of soil in the district is black and red loamy soil. Total geographical area of Viyayapur district is 10.53 lakh hectares out of this 0.02 lakh hectare is under forest, 0.65 lakh hectares land is not available for cultivation, 0.16 lakh hectares land is other uncultivated land excluding fallow land, 1.24 lakh hectare is under fallow land and total net sown area was 8.46 lakh hectares (Table 3.2).

The cropping pattern in Viyayapur district during 2013-14, indicated that out of the net cultivated area, cereals formed the important component with 39.67 per cent followed by pulses (36.92 %), oil seeds (10.43 %), commercial crops (8.71 %) and fruits and vegetables (4.27 %). The major cereal crops grown are, maize, jowar and bajra. Major pulses grown are tur, horse gram, black gram and bengal gram. Major oil seeds grown are groundnut, sunflower, safflower and sesame. Major commercial crops grown are sugar cane, cotton and tobacco (Table 3.3).

3.1.3 Bidar district

Bidar district falls in the Northern part of Karnataka between 17^0 53^1 N latitude and 77^0 53^1 E longitude. It consists of five taluks viz; Bidar, Basavakalyan, Homnabad, Aurad and Bhalki. The population of the Bidar district is 17.03 lakh (2011 census) of which male population was 8.71 lakh and female population was 8.33 lakh. The district generally has a actual rainfall of 970 mm per annum which was eight per cent more than the normal rainfall of 886 mm. The net irrigated area in the district is 51,036 hectares. Of the total net irrigated area, the area irrigated from tube wells is 27,101 hectares, 21,552 hectares from open wells, 1,140 hectares from canals, 124 hectares from lift irrigation, 507 hectares from tanks and 612 hectares from other sources (Table 3.1).

The predominant type of soil in the district is black soil. Total geographical area of Bidar district is 5.42 lakh hectares of which 0.28 lakh hectares is under forest, 0.42 lakh hectares land is not available for cultivation, 0.44 lakh hectares land is other uncultivated land excluding fallow land, 0.78 lakh hectare is under fallow land and total net sown area was 3.50 lakh hectares (Table 3.2).

The cropping pattern in Bidar district during 2013-14, indicated that out of the net cultivated area, pulses formed the important component with 43.67 per cent followed by oilseeds (29.10 %), pulses (17.55 %), commercial crops (8.49 %) and fruits and vegetables (1.19 %). The major cereal crops grown are jowar, wheat and paddy. Major pulses grown are tur, green gram and black gram. Major oil seeds grown are soyabean, safflower and sunflower. Major commercial crops grown are sugar cane and cotton (Table 3.3).

3.1.4 Kalaburgi district

Kalaburgi district falls in the Northern part of Karnataka between 17^0 31^1 N latitude and 76^0 87^1 E longitude. It consists of ten taluks viz;. Afzalpur, Aland, Chincholi, Chitapur, Kalaburgi, Jevargi, Sedam, Shahapur, Surpur and Yadgiri. The population of the Kalaburgi district is 25.66 lakh (2011 census) of which 61.10 per cent of the population is literate. The district generally has an actual rainfall of 776 mm per annum which was 7.84 per cent less than the normal rainfall of 842.00 mm.

Table 3.1: Demographic features of the study area

Sl. No.	Particulars	Belagavi		Viyayapur		Bidar		Kalaburgi		Karnataka	
1	**Geographical area (lakh ha)**	**13.44**		**10.53**		**5.42**		**10.94**		**190.50**	
2	**Population**	**Lakh No.**	**%**	**Lakh No.**	**%**	**Lakh No.**	**%**	**Lakh No.**	**%**	**Lakh No.**	**%**
	Rural	35.68	74.57	16.75	76.94	12.77	75.00	17.31	69.02	374.69	61.33
	Urban	12.12	25.43	5.02	23.06	4.26	25.00	8.36	30.98	236.26	38.67
	Total	**47.80**	**100.00**	**21.77**	**100.00**	**17.03**	**100.00**	**25.66**	**100.00**	**610.95**	**100.00**
	Male	24.23	50.69	11.11	51.03	8.71	51.15	13.02	50.74	309.67	50.69
	Female	23.57	49.31	10.66	48.97	8.33	48.85	12.65	49.26	301.29	49.31
	Total	**47.80**	**100.00**	**21.77**	**100.00**	**17.03**	**100.00**	**25.66**	**100.00**	**610.95**	**100.00**
	Literate	30.81	64.45	14.61	67.13	9.57	56.17	15.68	61.10	461.88	75.60
	Illiterate	16.99	35.55	7.16	32.87	7.46	43.83	9.98	38.90	149.07	24.40
	Total	**47.80**	**100.00**	**21.77**	**100.00**	**17.03**	**100.00**	**25.66**	**100.00**	**610.95**	**100.00**
3	**Net irrigated area**	**Hectare**	**%**	**Hectare**	**%**	**Hectare**	**%**	**Hectare**	**%**	**Hectare**	**%**
	Canals	77,670	15.74	1,15,939	37.79	1,140	2.23	28,204	27.99	12,53,141	35.24
	Tanks	307	0.06	236	0.08	507	0.99	490	0.49	1,53,972	4.33
	Open well	1,48,276	30.06	82,520	26.89	21,552	42.23	25,868	25.67	4,11,452	11.57
	Tube well	1,67,684	33.99	93,018	30.32	27,101	53.10	38,471	38.18	13,21,601	37.17
	Lift irrigation	17,640	3.58	1,638	0.53	124	0.24	4,353	4.32	93,356	2.63
	Others	81,730	16.57	13,475	4.39	612	1.20	3,373	3.35	3,22,170	9.06
	Total	**4,93,307**	100.00	**3,06,826**	100.00	**51,036**	100.00	**1,00,759**	100.00	**35,55,692**	100.00
4	**Rainfall**	**Mm**		**mm**		**mm**		**mm**		**mm**	
	Normal	844		632		886		842		1,220	
	Actual	825		564		970		776		1,409	

Source: District at a glance 2013-14, District statistical office, Belagavi, Viyayapur, Bidar and Kalaburgi
Karnataka state at a glance, 2013-14

Table 3.2: Land utilization pattern in the study area

Sl. No.	Particulars	Belagavi		Viyayapur		Bidar		Kalaburgi		Karnataka	
		Area (lakh ha)	%	Area (lakh ha)	%	Area (lakh ha)	%	Area (lakh ha)	%	Area (lakh ha)	%
1	Total Geographical Area	13.44	100.00	10.53	100.00	5.42	100.00	10.94	100.00	190.50	100.00
2	Area under forest	1.90	14.14	0.02	0.19	0.28	5.17	0.35	3.20	30.73	16.13
3	Area not available for cultivation	1.14	8.48	0.65	6.17	0.42	7.75	0.74	6.76	22.30	11.71
4	Other uncultivable land excluding fallow land	0.39	2.90	0.16	1.52	0.44	8.12	0.36	3.29	15.98	8.39
5	Fallow Land	3.44	25.60	1.24	11.78	0.78	14.39	0.84	7.68	22.25	11.68
6	Net sown area	6.57	48.88	8.46	80.34	3.50	64.58	8.65	79.07	99.23	52.09

Source: District at a glance 2013-14, District statistical office, Belagavi, Viyayapur, Bidar and Kalaburgi
Karnataka state at a glance, 2013-14

Table 3.3: Area under different crops in the study area

Sl. No.	Crops	Belagavi		Viyayapur		Bidar		Kalaburgi		Karnataka	
I	**Cereals**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**
1	Paddy	58,674	6.18	52	0.01	3,572	0.80	5,277	0.52	13,37,253	12.16
2	Jowar	1,25,747	13.25	1,65,998	17.55	62,706	13.99	2,04,504	20.09	11,02,833	10.03
3	Bajra	12,444	1.31	69,992	7.40	2,938	0.66	14,897	1.46	2,82,117	2.57
4	Maize	1,57,839	16.64	81,785	8.65	2,771	0.62	6,027	0.59	13,73,744	12.49
5	Ragi	1,223	0.13	0	0.00	0	0.00	0	0.00	6,71,855	6.11
6	Wheat	39,362	4.15	57,511	6.08	6,657	1.48	13,506	1.33	2,09,133	1.90
7	Others	1,536	0.16	0	0.00	38	0.01	22	0.00	25,298	0.23
	Total cereals	**3,96,825**	**41.83**	**3,75,338**	**39.67**	**78,682**	**17.55**	**2,44,233**	**24.00**	**50,02,233**	**45.48**
II	**Pulses**										
1	Redgram	3,836	0.40	1,80,625	19.09	73,267	16.34	3,69,534	36.31	8,23,313	7.49
2	Horsegram	3,250	0.34	3,961	0.42	16	0.00	388	0.04	1,71,151	1.56
3	Blackgram	4,377	0.46	192	0.02	32,927	7.34	40,904	4.02	1,02,151	0.93
4	Greengram	16,257	1.71	6,811	0.72	36,356	8.11	35,950	3.53	3,18,861	2.90
5	Avare	1,020	0.11	11	0.00	1,041	0.23	257	0.03	67,082	0.61
6	Cowpea	1,988	0.21	444	0.05	203	0.05	326	0.03	80,055	0.73
7	Bengalgram	64,072	6.75	1,54,574	16.34	50,943	11.36	1,53,027	15.04	9,26,355	8.42
8	Others	981	0.10	2,657	0.28	1,039	0.23	34	0.00	5,324	0.05
	Total pulses	**95,781**	**10.10**	**3,49,275**	**36.92**	**1,95,792**	**43.67**	**6,00,420**	**59.00**	**24,94,292**	**22.68**

Contd……

Sl. No.	Crops	Belagavi		Viyayapur		Bidar		Kalaburgi		Karnataka	
I	**Cereals**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**
III	**Oilseeds**										
1	Groundnut	39,522	4.17	34,306	3.63	937	0.21	7,171	0.70	6,53,012	5.94
2	Sunflower	10,723	1.13	58,952	6.23	4,289	0.96	45,193	4.44	4,16,171	3.78
3	Safflower	2,388	0.25	3,257	0.34	11,513	2.57	4,979	0.49	43,284	0.39
4	Castor	531	0.06	0	0.00	8	0.00	0	0.00	12,185	0.11
5	Sesamum	321	0.03	395	0.04	2,544	0.57	5,418	0.53	41,775	0.38
6	Nigerseed	896	0.09	321	0.03	1,178	0.26	532	0.05	17,925	0.16
7	Soyabean	66,769	7.04	0	0.00	1,09,392	24.40	6,052	0.59	2,18,907	1.99
8	Linseed	635	0.07	1,345	0.14	440	0.10	208	0.02	5,576	0.05
	Others	0	0.00	0	0.00	0	0.00	0	0.00	450	0.00
	Total oilseeds	**1,21,923**	**12.85**	**98,676**	**10.43**	**1,30,460**	**29.10**	**69,557**	**6.83**	**14,14,224**	**12.86**
IV	**Commercial crops**										
1	Cotton	31,365	3.31	10,419	1.10	319	0.07	47,204	4.64	6,61,162	6.01
2	Sugarcane	2,52,921	26.66	71,989	7.61	37,735	8.42	50,056	4.92	6,70,516	6.10
3	Tobacco	9,492	1.00	0	0.00	0	0.00	0	0.00	1,08,795	0.99
	Total commercial crops	**2,93,778**	**30.96**	**82,408**	**8.71**	**38,054**	**8.49**	**97,260**	**9.56**	**14,40,473**	**13.10**
V	**Fruits**	9,641	1.02	20,136	2.13	2,005	0.45	3,699	0.36	3,53,313	3.21
VI	**Vegetables**	30,798	3.25	20,205	2.14	3,304	0.74	2,536	0.25	2,93,620	2.67
	Gross cropped area	**9,48,746**	**100.00**	**9,46,038**	**100.00**	**4,48,297**	**100.00**	**10,17,705**	**100.00**	**1,09,98,155**	**100.00**

Source: District at a glance 2013-14, District statistical office, Belagavi, Viyayapur, Bidar and Kalaburgi
Karnataka state at a glance, 2013-14

The net irrigated area in the district is 1,00,759 hectares. Of the total net irrigated area, the area irrigated from tube wells is 38,471 hectares, 25,868 hectares from open wells, 28,204 hectares from canals, 4,353 hectares from lift irrigation, 490 hectares from tanks and 3,373 hectares from other sources (Table 3.1).

The predominant type of soil in the district is deep black clayey soil. Total geographical area of Kalaburgi district is 10.94 lakh ha out of this 0.35 lakh hectares is under forest, 0.74 lakh hectares land is not available for cultivation, 0.36 lakh hectares land is other uncultivated land excluding fallow land, 0.84 lakh hectare is under fallow land and total net sown area was 8.65 lakh hectares (Table 3.2).

The cropping pattern in Kalburgi district during 2013-14, indicated that out of the net cultivated area, pulses formed the important component with 59.00 per cent followed by cereals (24.00 %), commercial crops (9.56 %), oilseeds (6.83 %) and fruits and vegetables (0.61 %). The major cereal crops grown are jowar, bajra and wheat. Major pulses grown are tur, bengal gram and black gram. Major oil seeds grown are sunflower, groundnut and safflower. Major commercial crops grown are sugar cane and cotton (Table 3.3).

3.2 Sampling procedure

The purposive multistage random sampling was followed for the selection of districts, taluks, villages and micro irrigation scheme beneficiary farmers. The farmers practicing conventional methods of irrigation were also selected from the selected villages randomly.

3.2.1 Selection of districts

For detailed study, four major districts in terms of number of beneficiaries covered (both drip & sprinkler) under the project entitled "Evaluation of micro irrigation scheme implemented in Karnataka" were selected. Hence, Belagavi, Viyayapur, Bidar and Kalaburgi districts were selected purposively.

3.2.2 Selection of taluks

From each selected district one major taluk in terms of number of beneficiaries covered (both drip & sprinkler) under the project were selected purposively. The taluks selected were Gokak from Belagavi district, Indi from Viyayapur district, Bhalki from Bidar district and Afzalpur from Kalaburgi district.

3.2.3 Selection of villages

Three villages from each taluk based on the availability of beneficiaries practicing both drip and sprinkler irrigation systems for raising the field crops were selected purposively for the study. Hence, Kalloli, Naganur and Mudalagi from Gokak taluk, Salatagi, Havinal and Jigajinagi from Indi taluk, Kesarjavalga, Saiganv and Telwad from Bhalki taluk and from Afzalpur taluk, Gour B, Ballurgi and Afzalpur villages were selected purposively.

3.2.4 Selection of respondents

From each selected village ten farmers practicing sprinkler irrigation, ten farmers practicing drip irrigation and ten farmers practicing conventional methods of irrigation (flood/furrow) were selected purposively. Thus village wise sample size was 30, district wise sample size was 90 and irrigation method wise sample size was 120 and thus making the total sample size of 360 (Table 3.4).

3.2.5 Selection of crops

Since the main objective of the study is to know the impact of drip and sprinkler irrigation systems on water use efficiency and farm income over the conventional methods of irrigation, the major crops which were common under both micro irrigation and conventional methods of irrigation were selected for the study. The crop which was common under both drip irrigation and conventional method of irrigation in all the four selected districts was sugarcane. In case of sprinkler and conventional method of irrigation, the common crops were maize and groundnut in Belagavi and Viyayapur districts, redgram and *rabi* sorghun in Bidar and Kalaburgi district. Hence the crop wise sample size for the analysis of water use efficiency, profitability and financial feasibility of investment on micro irrigation in cultivation of particular crop varied.

The total sample size for sugarcane was 120 drip irrigation farmers (DIF) and 120 conventional irrigation farmers (CIF) since the crop is common under both the methods of irrigation in all the districts (30 DIF and 30 CIF from each district), where as sample size for maize and groundnut was 60 sprinkler irrigation farmers (SIF) and 60 CIF since the crops were common in Belagavi and Viyayapur districts (30 SIF and 30 CIF from each district). Similarly, the sample size for redgram and *rabi* sorghum was 60 SIF and 60 CIF since the above crops were common in Bidar and Kalaburgi districts (30 SIF and 30 CIF from each district).

3.3 Nature and sources of data

The required primary data was elicited from sample farmers through personal interview method with the help of well structured and pre tested schedules. The data so collected pertained to the agriculture year 2013-14. The data on socio economic characteristics of the farmers, cropping pattern, cost of cultivation and water applied in cultivation of major crops under different methods of irrigation, and constraints faced by the respondents in adoption and maintenance of different irrigation methods *etc.*, were collected.

Secondary data on area covered under and subsidy provided for micro irrigation in the state and list of farmer beneficiaries etc were collected from the department of agriculture and department of horticulture, Bangalore. General features of the study area and land revenue *etc* were collected from the district statistical offices of each selected district. Efforts were also made to gain the secondary data required for the study from the joint director of agriculture and horticulture offices of respective districts and important websites like www.planninigcommission.nic.in, www.indiastat.com, www.karnatakastat.com and des.kar.nic.in *etc.*

Table 3.4: Selection of respondents in the study area

Sl. No	Districts	Talukas	Villages	Respondents			
				Drip irrigation farmers (DIF)	Sprinkler irrigation farmers (SIF)	Conventional irrigation farmers (CIF)	Total
1	Belagavi	Gokak	Kalloli	10	10	10	30
			Nagnur	10	10	10	30
			Mudalagi	10	10	10	30
			Sub total	**30**	**30**	**30**	**90**
2	Viyayapur	Indi	Salatagi	10	10	10	30
			Havinal	10	10	10	30
			Jigajinagi	10	10	10	30
			Sub total	**30**	**30**	**30**	**90**
3	Bidar	Bhalki	Kesarajavalga	10	10	10	30
			Saiganv	10	10	10	30
			Telawad	10	10	10	30
			Sub total	**30**	**30**	**30**	**90**
4	Kalaburgi	Afzalpur	Gour B	10	10	10	30
			Ballurgi	10	10	10	30
			Afzalpur	10	10	10	30
			Sub total	**30**	**30**	**30**	**90**
Total				**120**	**120**	**120**	**360**

3.4 Analytical tools and techniques

For the purpose of achieving the objectives and to draw meaningful interpretations and inferences of the study, the data were analysed using the following analytical tools and techniques.

3.4.1 Growth rate analysis

3.4.2 Instability analysis

3.4.3 Tabular analysis/ Budgeting technique

3.4.4 Financial feasibility analysis

3.4.5 Decomposition analysis

3.4.6 Garrett ranking technique

3.4.1 Growth rate analysis

For computing compound annual growth rate of area under micro irrigation and subsidy provided for micro irrigation system in the state, the exponential function of the following form was used.

$$Y = a\, b^t e^{U_t} \quad \text{.......................} \quad (1)$$

Where,

Y = Area (ha) / subsidy (` lakh)

a = Intercept

b = Regression coefficient

'a' and 'b' are the parameters to be estimated

t = Time period

U_t = Disturbance term in year 't'

The equation (1) was transformed into log linear form and written as;

$$\log Y = \log a + t \log b + U_t \quad \text{.......................} \quad (2)$$

Equation (2) was estimated by using Ordinary Least Squares (OLS) technique.

Compound annual growth rate (g) was then computed by using the formula;

$$g = (b - 1)\, 100 \quad \text{.......................} \quad (3)$$

Where,

g: Compound growth rate in per cent per annum

b: Antilog of log b

The standard error of the growth rate was estimated and tested for its significance with 't' statistic.

3.4.2 Instability analysis

The coefficient of variation was used to measure the variability in area covered under and subsidy provided for micro irrigation systems in the state. The coefficient of variation or index of instability was computed by using the following formula;

$$CV = \frac{\text{Standard Deviation } (\sigma)}{\text{Mean } (\bar{X})} \times 100 \quad \cdots\cdots(4)$$

Linear trend was fitted to the original data of area covered under and subsidy provided for micro irrigation system in the state for a period of ten years from 2005-06 to 2014-15. The trend coefficients were tested for their significance. Whenever the trend of series found to be significant; the variation around the trend rather than the variation around mean was used as an index of instability. The formula suggested by Cuddy and Della was used to compute the degree of variation around the trend. That is Coefficient of variation was multiplied by the square root of the difference between the unity and coefficient of multiple determinations (R^2) in the cases where R^2 was significant to obtain the instability index (II).

$$\text{Instability index} = \frac{\text{Standard Deviation } (\sigma)}{\text{Mean } (\bar{X})} \times 100 \times \sqrt{1-r^2} \quad \cdots\cdots(5)$$

3.4.3 Tabular analysis/ Budgeting technique

Budgeting technique was followed for estimating the cost and returns in the production of field crops under different irrigation methods and tabular analysis was used to analyse the averages and percentages pertaining to socio economic of characteristics of the farmers and their cropping pattern *etc.*

3.4.4 Financial feasibility analysis

The techniques used for the financial feasibility analysis of investment on micro irrigation system were:

1. Net Present Value (NPV)
2. Internal Rate of Return (IRR)
3. Benefit-Cost Ratio (B: C Ratio)
4. Pay Back Period (PBP)

3.4.4.1 Net Present Value (NPV)

The net present value represents the discounted value of the net cash inflows to the project. In the present study, a discount factor of 12 per cent was used to discount the net cash inflows representing the opportunity cost of capital. It can be represented by,

$$NPV = \sum_{i=1}^{n} Y_n (1 + r)^{-n} - I \quad \text{..........(6)}$$

Where,

Y_n = Net cash inflows in the year n

r = Discount factor

I = Initial investment

The decision rule associated with the net present value is, the investment on micro irrigation will be feasible if its value is positive and is infeasible if its value is negative (if the net present value is zero, it is a matter of indifference).

3.4.4.2 Internal Rate of Return (IRR)

The rate at which the net present value of returns from investment on micro irrigation is equal to zero is internal rate of return (IRR). The net cash inflows were discounted to determine the present worth following the interpolation technique. The method of interpolation followed is as under;

$$IRR = \left(\text{Lower discount rate} \right) + \left(\text{Difference between two discount rates} \right) X \left(\frac{\text{Present worth of cash flow at lower discount rate}}{\text{Sum of absolute values of present worth of cash flows at the two discount rates}} \right) \quad \text{..........(7)}$$

Internal rate of return is a relative measure. The investment on micro irrigation will be feasible if the calculated IRR is greater than the ongoing opportunity cost of capital.

3.4.4.1 Benefit Cost Ratio (B:C Ratio)

The benefit cost ratio (BCR) was worked out at 12 per cent discount rate by using following formula;

$$\text{B:C ratio} = \frac{\text{Discounted cash inflow}}{\text{Discounted cash outflow}} \quad \text{..........(8)}$$

It measures the present value of returns per rupee of investment and it is a relative measure. The decision rule is that, the investment on micro irrigation is feasible when BCR is greater than one, when BCR is less than one, it is infeasible and if BCR is zero, it is a matter of indifference.

3.4.4.4 Pay Back Period (PBP)

Payback period represents the length of time required for the stream of cash proceeds produced by the investment to be equal to the original cash outlay *i.e.* the time required for the project to pay for itself. In the present study, payback period was calculated by successively deducting the initial investment from the net returns until the initial investment is fully recovered.

$$\text{Payback period} = \frac{\text{Initial investment}}{\text{Average annual net cash inflow}} \quad \cdots\cdots(9)$$

According to the payback criterion, the shorter the payback period, the more desirable is the investment on micro irrigation.

For financial feasibility analysis the cost of digging open well which was the main source of irrigation in the study area, cost of motor set, cost of pipeline and cost incurred for electricity sanction was taken as the initial investment under conventional method of irrigation and along with this cost the cost of micro irrigation system was taken as initial investment under micro irrigation system. For the analysis of financial feasibility of investment under drip/conventional method of irrigation in cultivation of sugarcane crop the total cost of irrigation structure was converted into per hectare initial investment by dividing the total investment by average size of land holding. Similarly for maize, groundnut, redgram and *rabi* sorghum the per hectare initial investment irrigation was taken as initial investment per crop season. The other part of the financial feasibility analysis was cash flow estimation. The cash flows were assumed to be same throughout the life period of micro irrigation system (10 years) and were discounted at 12 per cent.

3.4.5 Output decomposition model

3.4.5.1 Structural break in production relation

Before going to the decomposition analysis of the income difference of major crops between the Micro Irrigation Farmers (MIF) and Conventional Irrigation Farmers (CIF) one must ensure whether there is structural break or not in the production relations between MIF and CIF. To identify the structural break, if any, in the production relations with the adoption of micro irrigation systems (drip and sprinkler), output elasticities were estimated by ordinary least square method by fitting a log linear regression separately for MIF and CIF. The pooled regression was run in combination with MIF and CIF including dummy variable for farmers practicing micro irrigation systems. The dummy variable was quantified as one for farmers practicing micro irrigation systems and zero for farmers practicing conventional method of irrigation.

For identifying the structural break in production with the introduction of drip irrigation (new technology) in sugarcane and sprinkler irrigation (new technology) in maize, groundnut, redgram and *rabi* sorghum, the Cob-Douglas type of production function was used. Production function with technology dummy variable was fitted for identifying structural break in production relations between the MIF and CIF. Production function with one for MIF and zero for CIF was estimated.

The following log linear estimable forms of equations were used for examining the structural break in production relation.

$\ln y_1 = \ln A_1 + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \alpha_4 \ln X_4 + \alpha_5 \ln X_5 + \alpha_6 \ln X_6 + \alpha_7 \ln X_7 + U_i$ ……… (10)

$\ln y_2 = \ln A_2 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + U_{i\ldots.}$… (11)

$\ln y_3 = \ln A_3 + \lambda_1 \ln X_1 + \lambda_2 \ln X_2 + \lambda_3 \ln X_3 + \lambda_4 \ln X_4 + \lambda_5 \ln X_5 + \lambda_6 \ln X_6 + \lambda_7 \ln X_7 + e3d + U_i$ … (12)

Where,

Y = Gross return in `/hectare

a = Intercept

x_1 = Seed cost/ hectare

x_2 = FYM cost/ hectare

x_3 = Fertiliser cost/ hectare

x_4 = Human labour cost/ hectare

x_5 = Bullock and Machine labour cost/ hectare

x_6 = Plant protection chemicals cost/ha

x_7 = Irrigation water applied in ha cm

e_i = Error term

b_i = Elasticity coefficients of respective inputs and summation of these gives returns to scale

Equations 10, 11 and 12 represent farmers following conventional method of irrigation, farmers following micro irrigation systems and pooled regression function with farmers following micro irrigation systems as dummy variables, respectively.

$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \lambda 1, \lambda_2, \lambda_3, \lambda_4, \lambda_5, \lambda_6, \lambda_7$

represent individual output/income elasticity of respective input variable in equation (10) (11) and (12). ‘d’ in equation (12) represents dummy variable. If the regression coefficient of dummy variables is significant, then there is structural break in production relations with the adoption micro irrigation systems (drip & sprinkler).

3.4.5.2 Output decomposition model

For any production function, the total change in income is affected by the change in the factors of production and in the parameters that define the function. This total change in per hectare output/income is decomposed to reflect on adoption of micro irrigation systems. The output decomposition model developed by Bisaliah (1977) is used in the study, which is depicted below.

The output decomposition equation used in this study can be written as

$$\ln Y\ MIF - \ln Y\ CIF = [\text{intercept MIF} - \text{intercept CIF}] +$$

$$[(\beta_1-\alpha_1) \times \ln X_1\ CIF + \ldots\ldots\ldots\ldots\ldots + (\beta_7-\alpha_7) \times \ln X_7\ CIF] +$$

$$[\{ (\beta_1 (\ln X_1\ MIF - \ln X_1\ CIF + \ldots\ldots\ldots + (\beta_7 (\ln X_7\ MIF - \ln X_7 CIF) \}] \ldots.(13)$$

The decomposition equation (13) is approximately a measure of percentage change in output/income with the adoption of micro irrigation systems. The first bracketed expression of the right hand side is the measure of percentage change in output/income due to shift in scale parameter (A) of the production function. The second bracketed expression is the difference between output elasticities each weighted by natural logarithms of the volume of that input used under non adopter category, a measure of change in output/income due to shift in slope parameters (output elasticities) of the production function. The third bracketed expression is the sum of the natural logarithms of the ratio of each input of adopters to non-adopters, each weighted by the output elasticity of that input. This expression is a measure of change in output due to change in the per hectare quantities of seeds, FYM, fertilizers, human labour, bullock and machine labour and water applied.

3.4.6 Garrett Ranking Technique

To know the constraints in adoption and maintenance of different irrigation systems Garrett's ranking technique was used. Basically it gives the change of orders of constraints and advantages into numerical scores. The major advantage of this technique as compared to simple frequency distribution is that the constraints and advantages are arranged based on their importance from the point of view of respondents. Hence the same number of respondents on two or more constraints may have been given different rank.

Garrett's formula for converting ranks into per cent was given by

$$\text{Per cent position} = 100^* (R_{ij} - 0.5) / N_j$$

Where,

R_{ij}= rank given for i^{th} factor by j^{th} individual

N_j= number of factors ranked by j^{th} individual

The per cent position of each rank then converted into scores referring to the table given by Garret and Woodswordh (1969). For each factor, the scores of individual respondents were added together and divided by the total number of the respondents for whom scores were added. These mean scores for all the factors were arranged in descending order, ranks were given and most important factors were identified.

3.5 Definitions of terms and concepts used

3.5.1 Cost of cultivation

3.5.1.1Variable costs

3.5.1.1.1 Seeds: The cost of seeds was calculated at the local market price for the farm produced seeds and actual expenditure incurred in the case of purchased seeds.

3.5.1.1.2 Farm yard manure: The quantity of farm yard manure used in the cultivation of crops was measured in terms of tractor load. The cost was imputed at the market price prevailing in the village.

3.5.1.1.3 Fertilizer and Plant protection chemicals: Cost of fertilizer and Plant protection chemicals were measured based on the actual price paid by the sample farmers.

3.5.1.1.4 Human labour: Human labour was estimated in terms of six hours of work per day. The women labour days were converted in to man days on the criterion that one women day was equal to 0.60 man days on the bases of market wage rate equivalent.

3.5.1.1.5 Bullock labour: Bullock labour was estimated in terms of bullock pair days. Both owned and hired bullock labours were charged at the prevailing market rate paid per day of six hours in the study area.

3.5.1.1.6 Machine labour: The cost of machine labour both owned and hired was calculated at the different rates for different operations prevailed in the study area.

3.5.1.1.7 Interest on working capital: This was calculated on the entire working cost of the enterprise at the prevailing bank rate of interest (@ 07.00 per cent per annum) and was charged for half of the cropping period for seasonal crops (maize, groundnut, redgram and *rabi* sorghum) and was charged for whole cropping period for perennial/ annual crops like sugarcane.

3.5.1.2 Fixed costs: Fixed costs include land revenue, rental value of the land, depreciation on farm implements and micro irrigation system, and interest on fixed capital investment. The explanation on the measurement of different items of fixed costs is as follows.

3.5.1.2.1 Land revenue: The land revenue was accounted at the rates fixed by the government for the field crops.

3.5.1.2.2 Rental value of the land: The prevailing land rents for agricultural enterprises were imputed for the sample, as all land holdings were observed to be owner operated.

3.5.1.2.3 Depreciation: The depreciation rates based on purchase value, life span and junk value for various agricultural implements, machinery and micro irrigation systems were decided in consultation with respondents and was calculated using straight line method. The average life of micro irrigation system was assumed to be 10 years and the junk value was taken as 20 per cent of the initial cost.

Original value – Junk value

Depreciation = --……………………(14)

Years of useful life

3.5.1.2.4 Interest on fixed capital: This was calculated at the rate of 12 per cent per annum.

3.5.1.3 Returns: The gross returns were calculated by taking the actual output prices obtained by the farmer in the market. The same was used for imputing the value of the produce retained for home consumption. Gross returns include values of both the main product and by-product. Net returns were calculated by deducting the total cost of cultivation from gross returns.

3.5.2 Cropping pattern: The proportion of the area under various crops at a point of time (*kharif*, *rabi* and *summer*) represented the cropping pattern.

3.5.3 Cropping Intensity (CI) : Cropping intensity was computed as the ratio of gross cropped area to the net cropped area and expressed in percentage.

$$\text{Cropping Intensity (\%)} = \frac{\text{Gross cropped area}}{\text{Net cropped area}} \times 100 \quad \cdots\cdots(15)$$

3.5.4 Conventional methods of irrigation: Flood and furrow methods of irrigation were the conventional methods of irrigation used by the respondents where water is allowed from the source into the field without much control on either side of the flow and covers the entire field and moves almost unguided (flood irrigation) and irrigates only one fifth to one half the top surface therefore loses water by evaporation (furrow irrigation).

3.5.5 Drip irrigation: Drip irrigation is the slow, even application of low-pressure water to soil and plants using plastic tubing placed near the plants' root zone. Or it is a low pressure system that delivers water slowly and accurately to plant roots, drop by drop.

3.5.6 Sprinkler irrigation: Sprinkler irrigation is the method of irrigation by which water is sprayed on the land surface in the form of artificial rain. To create the precipitation, water under pressure is ejected through the nozzle of a device called a sprinkler.

3.5.7 Water use efficiency: Water use efficiency is defined as the amount of output produced per unit of water expended.

3.5.8 Water application: Water application to the respective crops under conventional methods of irrigation was computed by multiplying the number of irrigations during the cropping period, time required to irrigate each time and the water discharged by the source per hour. In case of conventional method of irrigation, water discharged from the source (5 HP motor) was measured by considering the time required to fill a container.

In case of drip irrigation, the water discharged by each dripper was four litres per hour. Hence water applied to each crop through drip irrigation was calculated by multiplying the number of drippers per hectare, number of irrigations, time required to irrigate the crop per time and the water discharged by each dripper per hour.

In case of sprinkler irrigation the water discharged by each nozzle was 1500 litres per hour. Hence water applied to each crop through sprinkler irrigation was calculated by multiplying the number of nozzles per sprinkler set, number of turns to cover an area of one hectare, total number of irrigations, time required to irrigate the crop per time and the water discharged by each nozzle per hour.

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

4. RESULTS

The results obtained from the analysis of both primary and secondary data pertaining to the study are presented in this chapter under the following subheadings.

4.1 Area covered under micro irrigation system in the state

4.2 Subsidy provided for and private investment on micro irrigation system in the state and government schemes on micro irrigation

4.3 General characteristics of sample respondents

4.4 Water use efficiency in major crops under different irrigation systems

4.5 Profitability of major crops in conventional v/s micro irrigation systems

4.6 Financial feasibility of investment on micro irrigation system and conventional method of irrigation

4.7 Decomposition analysis of total change in per hectare income between micro irrigation systems and conventional method of irrigation in cultivation of different crops

4.8 Constraints faced by sample respondents in the study area

4.1 Area covered under micro irrigation systems (MIS) in the state

The compound growth rate and stability in area under micro irrigation systems in the state for the period from 2005-06 to 2014-15 is depicted in Table 4.1 and Fig. 2. The area under micro irrigation system in the state was growing at the rate of 20.33 per cent per annum and is significant at 5 per cent level. The instability index was high *i.e.*, 35.23 per cent. The average area covered under MIS per year in the state was 74,963.26 hectares.

4.2 Subsidy provided for and private investment on micro irrigation systems in the state and government schemes on micro irrigation

The extent of subsidy provided for and private investment on micro irrigation for the period from 2005-06 to 2014-15 are presented in Table 4.2 and Fig. 3. The extent of total subsidy provided for micro irrigation was growing at the rate of 25.92 per cent annually and is significant at one per cent. The subsidy for micro irrigation in the state by the state government was growing at the higher rate (28.06 %) compared to subsidy given by central government (23.71 %) and were significant at one per cent level. The farmer's share was growing at the rate of 13.19 per cent annually and was found to be significant at 5 per cent level where as the total investment on micro irrigation was increasing at the rate of 23.71 per cent per annum and significant at one per cent. The instability index was highest in case of farmers share (33.93 %) followed by state share (28.24 %), total subsidy share (25.20 %), central share and total investment (23.73 % in each case). The per year average investment on micro irrigation system in the state was ` 26,403.19 lakh, of which total subsidy provided and farmer's share was ` 21,315.34 lakh (` 10,754.06 lakh state share & ` 10,561.28 lakh central share) and ` 5,087.85 lakh, respectively.

Table 4.1: Compound growth rate and stability of area covered under micro irrigation systems in Karnataka (2005-06 to 2014-15)

Sl. No.	Year	Area in hectares
Average area covered under micro irrigation per year		74,963.26
CGR (%)		20.33**
Instability Index (%)		35.23

Source: Centre for budget and policy studies, 2013
www.indiastat.com
www.karnatakastat.com
Note: ** Significance at 5% level

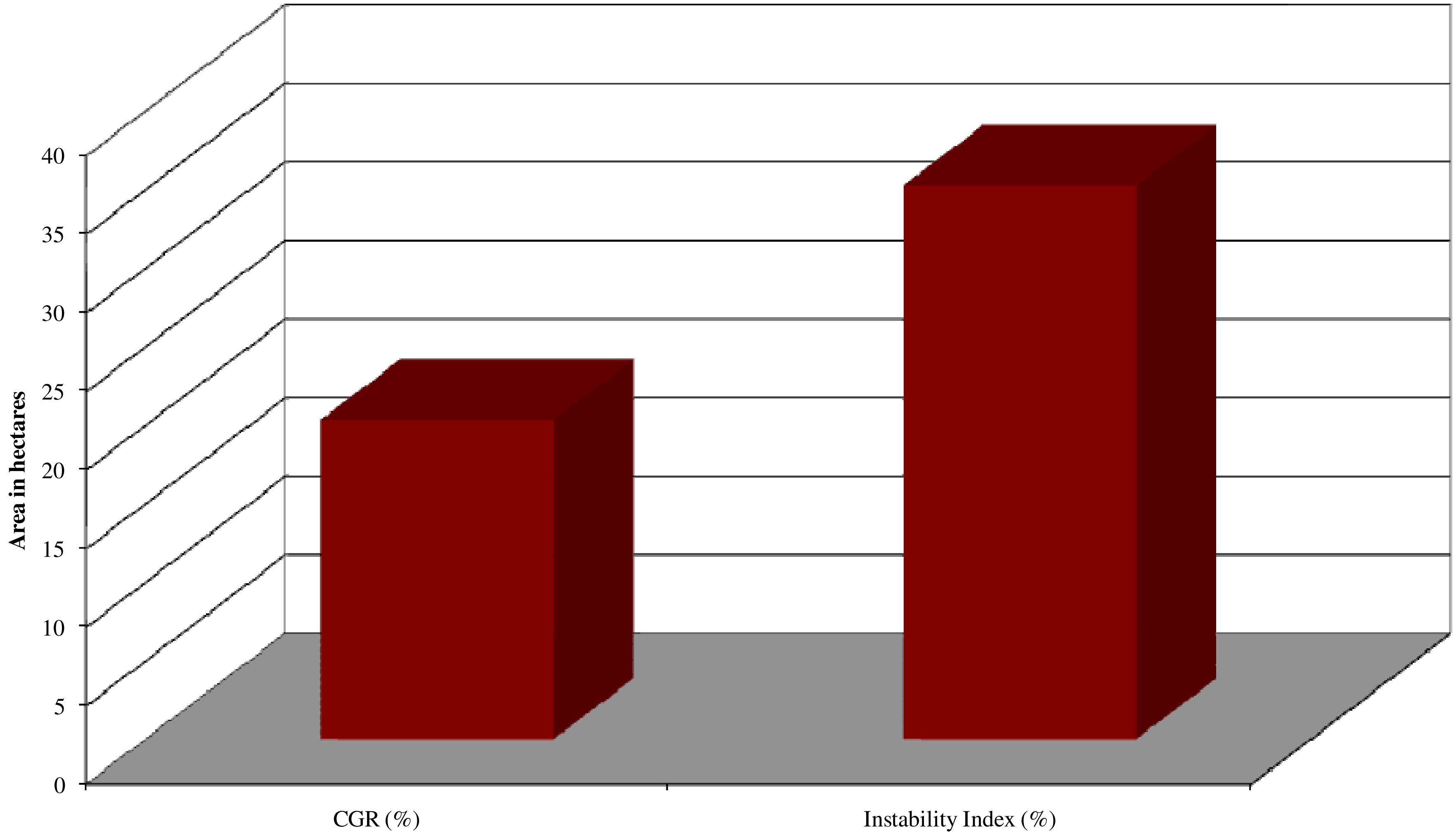

Fig. 2:Compound growth rate (CGR) and stability of area covered under micro irrigation systems in Karnataka (2005-06 to 2014-15)

Table 4.2: Compound growth rate and stability of subsidy provided for and private investment on micro irrigation system in Karnataka (2005-06 to 2014-15)

Sl. No.	Year	(` in lakhs)				
		State Subsidy	Central subsidy	Total subsidy	Farmers share	Total investment
Average per year		10754.06 (40.73)	10561.28 (40.00)	21315.34 (80.73)	5087.85 (19.27)	26403.19 (100.00)
CGR (%)		28.06***	23.71***	25.92***	13.19**	23.71***
Instability Index (%)		28.24	23.73	25.50	33.93	23.73

Source: Centre for budget and policy studies, 2013
www.indiastat.com
www.karnatakastat.com
Note: *** Significance at 1% level
** Significance at 5% level
Figures in the parentheses indicate percentage to total

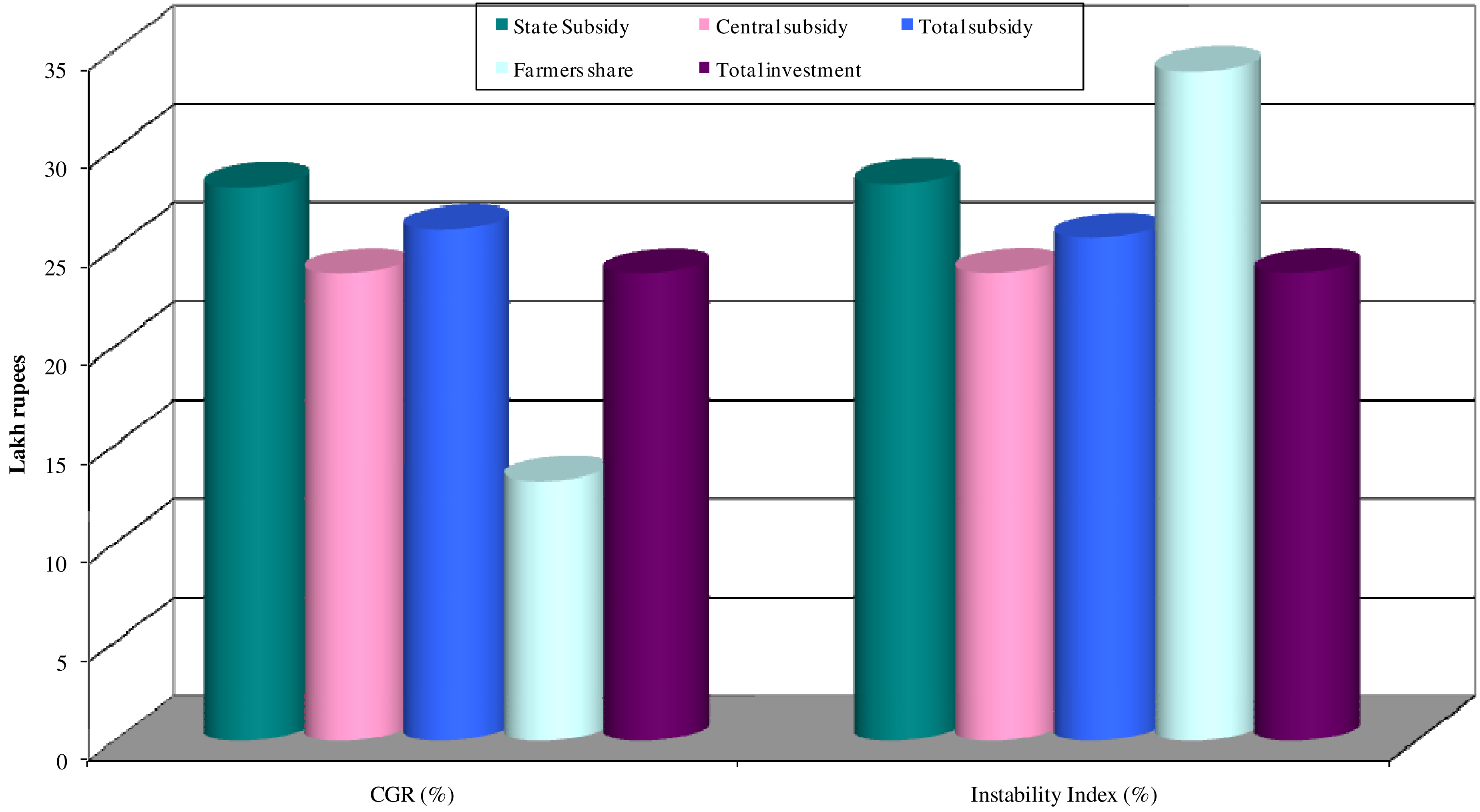

Fig. 3: Compound growth rate (CGR) and stability of subsidy provided for and private investment on micro irrigation systems in Karnataka (2005-06 to 2014-15)

Table 4.3: Different micro irrigation schemes in the state and their achievements

Sl. No.	Schemes	Area covered (lakh ha)	Subsidy provided (` in crores)
1	Drip irrigation scheme (1991-92 to 2004-05)	2.27 (22.86)	450.00 (17.21)
2	Micro irrigation scheme (2003-04 to 2004-05)	0.17 (1.71)	33.70 (1.29)
3	Centrally sponsored scheme on micro irrigation (2005-06 to 2009-10)	2.43 (24.47)	575.73 (22.01)
4	National mission on micro irrigation (2009-10 to 2014-15)	5.06 (50.96)	1,555.80 (59.49)
	Total	9.93 (100.00)	2,615.23 (100.00)

Source: Centre for budget and policy studies, 2013
www.indiastat.com
www.karnatakastat.com
Note: Figures in the parentheses indicate percentage to total

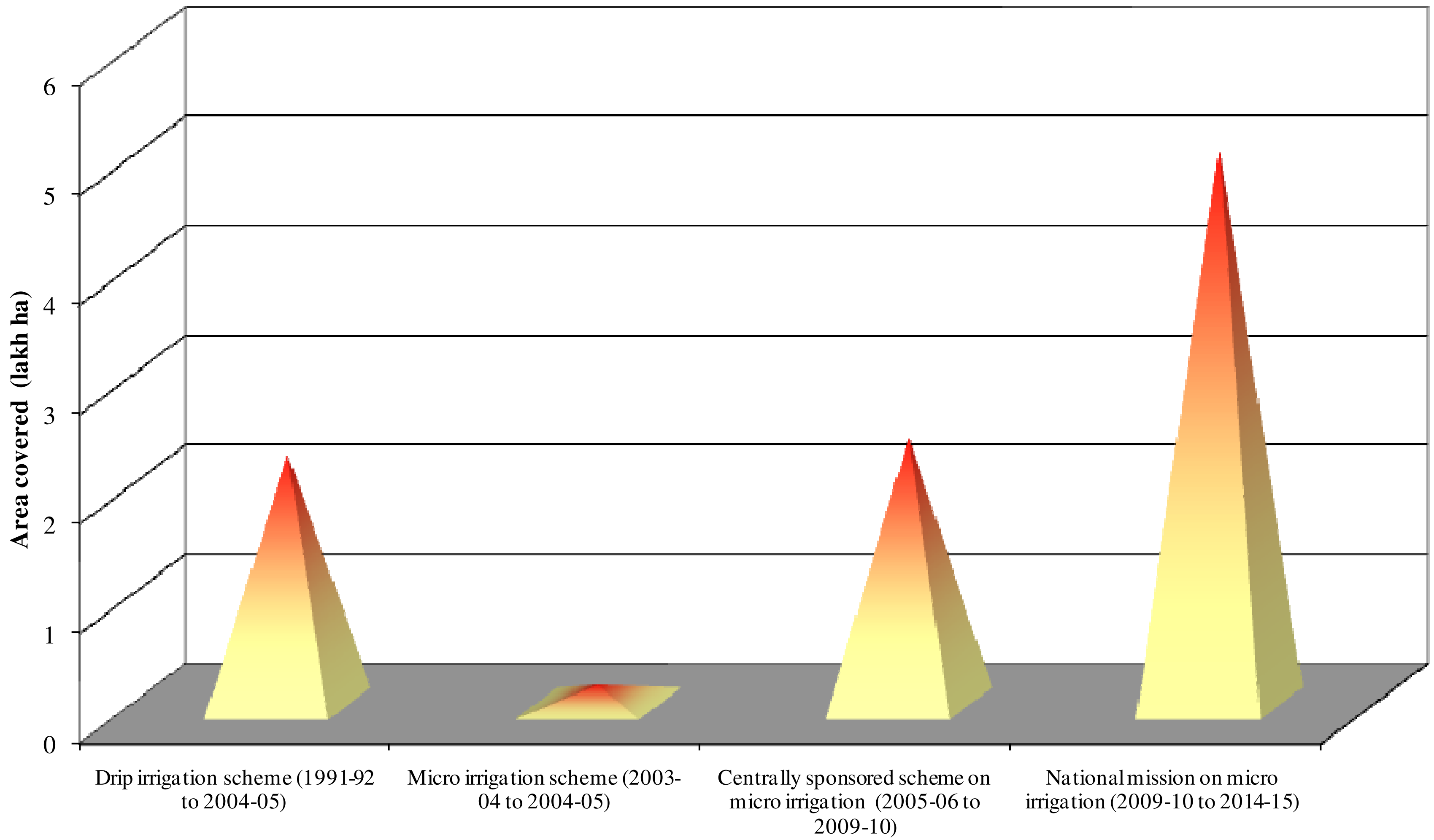

Fig. 4: Area covered under different micro irrigation schemes in the state

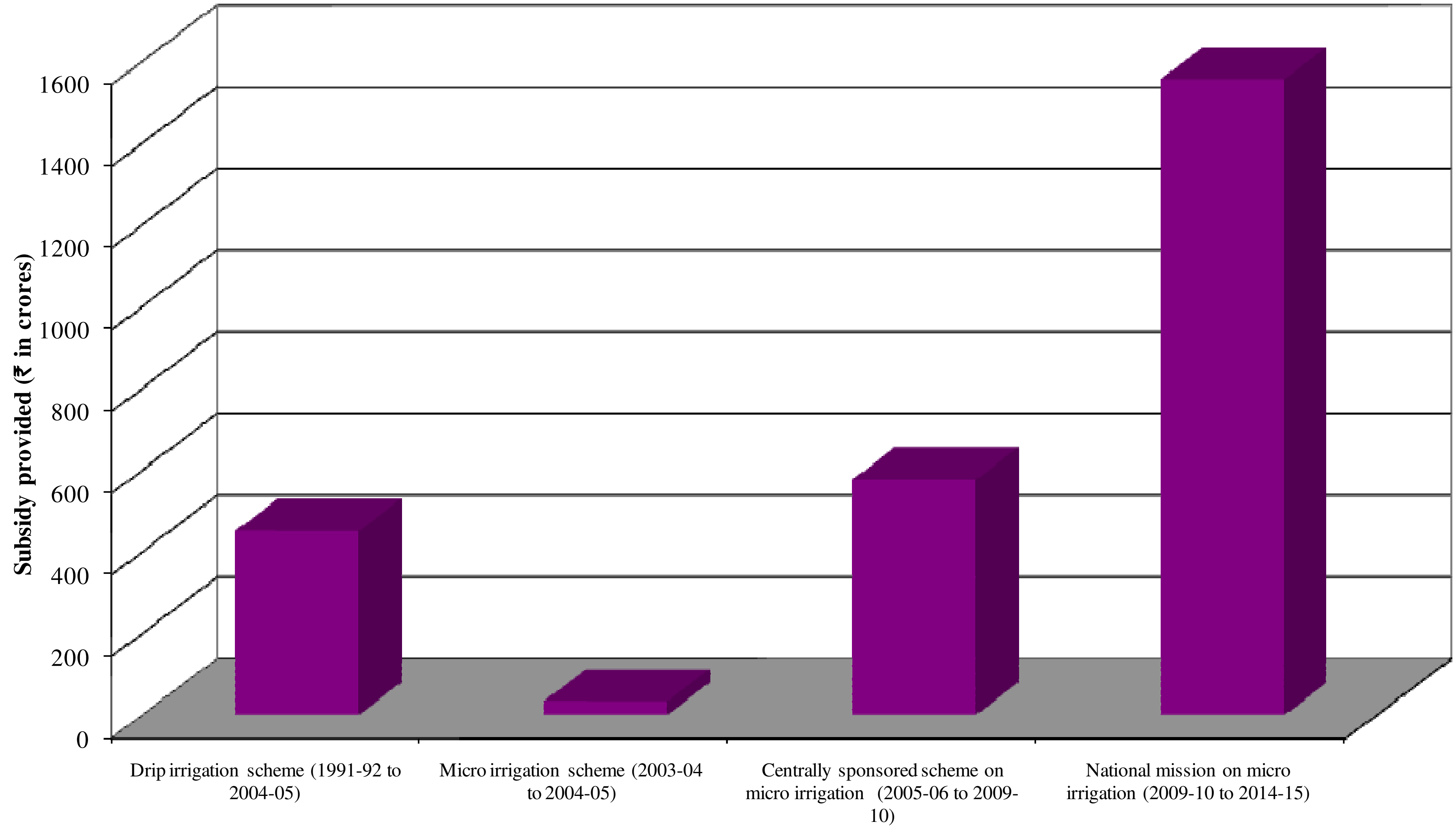

Fig. 5: Subsidy provided under different micro irrigation schemes in the state

The area covered under and subsidy provided for micro irrigation system under different micro irrigation schemes in the state are presented in Table 4.3 and Fig. 4, 5. The drip irrigation scheme was introduced in Karnataka during the year 1991-92 under the Department of Horticulture for horticultural crops. An amount of ` 450 crores was spent as subsidy by the end of the year 2004-05 and covered an area of 2.27 lakh hectares. Later the micro irrigation scheme was introduced in Karnataka in agricultural crops during the year 2003-04 and the area covered and subsidy provided under the scheme by the end of the year 2004-05 was only 0.17 lakh hectares and ` 33.70 crores, respectively. The significant progress has been made after the introduction of the Centrally Sponsored Scheme on Micro Irrigation (CSSMI) during 2005-06. The area covered and subsidy provided under the CSSMI was 2.43 lakh hectares and ` 575.73 crores by the end of the year 2009-10. The scheme was further up scaled into mission mode in 2010 as the National Mission on Micro Irrigation (NMMI) and covered an area of 5.06 lakh hectares and provided subsidy to the extent of ` 1,555.80 crores by the end of 2014-15. The total cumulative area covered and subsidy provided for micro irrigation system by different micro irrigation schemes in the state was 9.93 lakh hectares and ` 2,615.23 crores, respectively.

4.3 General characteristics of sample respondents

4.3.1 Socio-economic characteristics of sample respondents

An understanding of general characters of the sample respondents is expected to provide a bird's eye view of the general features prevailing in the study area. Therefore an attempt has been made in the study to analyse some of the important socio-economic characters of the sample respondents and are presented in Table 4.4

In case of farmers practicing drip irrigation, the average age of the respondents was 40.78 years where as in case of sprinkler irrigation and conventional method of irrigation it was 41.58 and 46.43 years, respectively. The average family size of the farmers practicing drip irrigation was 5.61 where as it was 6.03 and 6.24 in case of sprinkler irrigation farmers and conventional irrigation farmers, respectively. Majority of the farmers following drip irrigation, sprinkler irrigation and conventional method of irrigation were literate and it was 85.00 per cent, 76.67 per cent and 60.83 per cent while illiterate range was 15.00 per cent, 23.33 per cent and 39.17 per cent, respectively. The average land holding of the farmers practicing drip irrigation, sprinkler irrigation and conventional method of irrigation was 3.86 hectares (3.67 ha irrigated & 0.19 ha dryland), 3.56 hectares (3.27 ha irrigated & 0.29 ha dryland) and 2.58 hectares (2.03 ha irrigated & 0.55 ha dryland), respectively.

Table 4.4 indicates that the main occupation of the respondents was agriculture and 19.17 per cent of drip irrigation farmers, 7.50 per cent of sprinkler irrigation farmers and 5.00 per cent of conventional irrigation farmers were going for jobs as their subsidiary occupation. Majority of them were not associated with social organisations. The percentage of not associated with social organisations was 73.33 per cent under drip irrigation farmers, 75.83 per cent under sprinkler irrigation farmers and 87.50 per cent under conventional irrigation farmers. The average annual income of the drip irrigation farmers, sprinkler irrigation farmers and conventional irrigation farmers was ` 3,92,666.67, ` 2,66,583.33 and ` 1,72,700.00, respectively.

Table 4.4: Socio-economic characteristics of sample respondents of the study area

Sl. No.	Particulars	Units	Drip irrigation (n=120)	Sprinkler irrigation (n=120)	Conventional method of irrigation (n=120)
1	Average age of the farmer	Year	40.78	41.58	46.43
2	Average family size	Number	5.61	6.03	6.24
3	**Education level**				
	Illiterate	Number	18 (15.00)	28 (23.33)	47 (39.17)
	Literate	Number	102 (85.00)	92 (76.67)	73 (60.83)
	a. Primary school	Number	20 (16.67)	16 (13.33)	26 (21.67)
	b. High school	Number	36 (30.00)	36 (30.00)	29 (24.17)
	c. Pre university	Number	22 (18.33)	19 (15.83)	13 (10.83)
	d. Degree and above	Number	24 (20.00)	21 (17.50)	5 (4.17)
	Average education	Year	9.20	8.38	5.52
4	**Average land holding**				
	Irrigated	Area (ha)	3.67 (95.16)	3.27 (91.77)	2.03 (78.68)
	Dryland	Area (ha)	0.19 (4.84)	0.29 (8.23)	0.55 (21.32)
	Total	Area (ha)	3.86 (100.00)	3.56 (100.00)	2.58 (100.00)
5	**Occupation**				
	Agriculture	Number	97 (80.33)	111 (92.50)	114 (95.00)
	Agriculture + other jobs	Number	23 (19.17)	9 (7.50)	6 (5.00)
	Total	Number	120 (100.00)	120 (100.00)	120 (100.00)
6	**Association with social organisation**				
	Yes	Number	32 (26.67)	29 (24.17)	15 (12.50)
	No	Number	88 (73.33)	91 (75.83)	105 (87.50)
	Total	Number	120 (100.00)	120 (100.00)	120 (100.00)
7	**Average annual income**				
	Agriculture	`	2,56,250.00 (65.26)	2,41,916.67 (90.75)	1,57,283.33 (91.07)
	Subsidiary	`	1,36,416.67 (34.74)	24,666.67 (9.25)	15,416.67 (8.93)
	Total	`	3,92,666.67 (100.00)	2,66,583.33 (100.00)	1,72,700.00 (100.00)

Note: Figures in the parentheses indicate percentage to total

4.3.2 Cropping pattern of sample respondents

It could be seen from Table 4.5 that, all sample farmers were growing number of crops under different irrigation methods. The major crops grown by the farmers practicing drip irrigation considered during *kharif* were redgram, maize and soyabean. The area under redgram was found to be highest (0.53 ha) followed by maize (0.41 ha) and soyabean (0.33 ha). During *rabi* season, sorghum, wheat and groundnut were the major crops grown. The average area under these crops was 0.47 hectares, 0.37 hectares and 0.33 hectares, respectively. The major commercial crop grown was sugarcane (1.76 ha) and the major horticultural crops grown were banana (0.23 ha), grapes (0.14 ha) and turmeric (0.12 ha).

In case of sprinkler irrigation farmers, the major crops grown during *kharif* season were redgram, maize and sunflower. The area under redgram was found to be highest (0.51 ha) followed by maize (0.44 ha) and sunflower (0.26 ha). During *rabi* season sorghum, groundnut and wheat were the major crops grown. The average area under these crops was 0.55 hectares, 0.46 hectares and 0.37 hectares, respectively. It was also observed from the Table 4.5 that maize (0.16 ha) and groundnut (0.14 ha) were grown during summer season by the sprinkler irrigation farmers. The major commercial crop grown was sugarcane (1.20 ha) whereas the major horticultural crops grown were banana (0.35 ha), grapes (0.09 ha) and turmeric (0.04 ha).

The major crops grown by conventional irrigation farmers during *kharif* were redgram, maize and greengram. The area under redgram under conventional irrigation farmers was found to be highest (0.54 ha) followed by maize (0.46 ha) and greengram (0.15 ha). During *rabi* season, groundnut, sorghum and wheat were the major crops grown. Among these crops the average area under groundnut was found to be highest (0.35 ha) followed by sorghum (0.28 ha) and wheat (0.22 ha). The major horticultural crops grown under conventional method of irrigation were banana (0.09 ha), grape (0.08 ha) and turmeric (0.06 ha) and major commercial crop grown was sugarcane and its area was found to be 0.80 hectares.

It was noticed that the cropping intensity on farms in case of drip irrigation farmers was highest (257.14 %) followed by sprinkler irrigation farms (254.89 %) and conventional irrigation farms (221.31 %).

4.4 Water use efficiency in major crops under different irrigation systems

4.4.1 Water use efficiency of sugarcane under drip irrigation and conventional method of irrigation

It could be observed from the Table 4.6 and Fig. 6 that per hectare yield was highest under drip irrigated farms (164.77 t/ha) compared to conventional irrigated farms (130.27 t/ha). Whereas the water applied was lowest in case of drip irrigated farms (64.52 ha cm) compared to conventional irrigated farms (174.47 ha cm). The water use efficiency was calculated by dividing per hectare yield by the water applied in ha cm. It was noticed from the table that the water use efficiency was highest in case of drip irrigated farms (2.55 t/ha cm) compared to conventional irrigated farms (0.75 t/ha cm). Hence the gain in water use efficiency by drip irrigation over the conventional method of irrigation was 70.59 per cent.

Table 4.5: Cropping pattern of sample respondents in the study area

(Hectares)

Sl. No.	Crops	Drip irrigation (n=120)	Sprinkler irrigation (n=120)	Conventional method of irrigation (n=120)
I	***Kharif***			
	Cereals			
1	Maize	0.41 (10.71)	0.44 (12.43)	0.46 (17.97)
	Pulses			
2	Redgram	0.53 (13.70)	0.51 (14.21)	0.54 (20.94)
3	Greengram	0.17 (4.41)	0.16 (4.58)	0.15 (5.62)
4	Blackgram	0.08 (2.16)	0.10 (2.81)	0.05 (2.07)
	Oilseeds			
5	Sunflower	0.03 (0.78)	0.26 (7.34)	0.10 (3.81)
6	Soyabean	0.33 (8.41)	0.20 (5.56)	0.14 (5.56)
7	Sesamum	0.03 (0.78)	0.04 (1.12)	0.01 (0.39)
	Commercial crops			
8	Cotton	0.02 (0.60)	0.15 (4.11)	0.08 (3.10)
9	Chilli	0.01 (0.17)	0.02 (0.65)	0.02 (0.65)
10	Sugarcane	1.76 (45.61)	1.20 (33.76)	0.80 (31.10)
	Horticultural crops			
11	Banana	0.23 (5.92)	0.35 (9.77)	0.09 (3.36)
12	Turmeric	0.12 (3.02)	0.04 (1.22)	0.06 (2.33)
13	Grape	0.14 (3.71)	0.09 (2.38)	0.08 (3.10)
	Sub-total	3.86 (100.00)	3.56 (100.00)	2.58 (100.00)
II	***Rabi***			
	Cereals			
1	Wheat	0.37 (9.66)	0.37 (10.44)	0.22 (10.48)
2	Sorghum	0.47 (12.29)	0.55 (15.38)	0.28 (13.34)
	Pulses			
3	Chickpea	0.32 (8.39)	0.32 (8.93)	0.11 (5.40)

Contd…..

Sl. No.	Crops	Drip irrigation (n=120)	Sprinkler irrigation (n=120)	Conventional method of irrigation (n=120)
	Oilseeds			
4	Groundnut	0.33 (8.57)	0.46 (13.06)	0.35 (16.53)
5	Safflower	0.04 (1.05)	0.02 (0.66)	0.03 (1.44)
	Commercial crops			
6	Cotton	0.02 (0.52)	0.15 (4.14)	0.08 (3.81)
7	Sugarcane	1.76 (46.15)	1.20 (33.95)	0.80 (38.20)
	Horticultural crops			
8	Watermelon	0.02 (0.52)	-	-
9	Banana	0.23 (6.03)	0.35 (9.83)	0.09 (4.13)
10	Turmeric	0.12 (3.15)	0.04 (1.22)	0.06 (2.86)
11	Grape	0.14 (3.67)	0.09 (2.40)	0.08 (3.81)
	Sub total	3.81 (100.00)	3.54 (100.00)	2.10 (100.00)
III	**Summer**			
	Cereals			
1	Maize	**-**	0.16 (8.09)	-
	Oilseeds			
2	Groundnut	**-**	0.14 (6.91)	-
	Commercial crop			
3	Sugarcane	1.76 (78.22)	1.20 (60.88)	0.80 (77.96)
	Horticultural crops			
4	Banana	0.23 (10.22)	0.35 (17.62)	0.09 (8.43)
5	Turmeric	0.12 (5.33)	0.04 (2.19)	0.06 (5.83)
6	Grape	0.14 (6.22)	0.09 (4.30)	0.08 (7.78)
	Sub total	2.25 (100.00)	1.98 (100.00)	1.03 (100.00)
IV	**Gross cropped area**	9.92	9.09	5.71
V	**Net cropped area**	3.86	3.56	2.58
VI	**Cropping intensity (%)**	**257.15**	**255.34**	**221.31**

4.4.2 Water use efficiency of maize under sprinkler irrigation and conventional method of irrigation

Table 4.7 and Fig. 7 indicates that per hectare yield was highest under sprinkler irrigation (62.67 q/ha) compared to conventional method of irrigation (51.17 q/ha). Whereas the water applied was lowest in case of sprinkler irrigation (13.77 ha cm) compared to conventional method of irrigation (24.25 ha cm). The water use efficiency was highest in case of sprinkler irrigation (4.55 q/ha cm) compared to conventional method of irrigation (2.11 q/ha cm) and the gain in water use efficiency under sprinkler irrigation over the conventional method of irrigation was 53.63 per cent.

4.4.3 Water use efficiency of groundnut under sprinkler irrigation and conventional method of irrigation

The water use efficiency of groundnut under sprinkler irrigation and conventional method of irrigation presented in Table 4.8 and Fig. 8. The yield was highest under sprinkler irrigation system (29.17 q/ha) followed by conventional method of irrigation (19.38 q/ha). The water use efficiency was also highest under sprinkler irrigation system (4.65 q/ha cm) followed by conventional method of irrigation (1.35 q/ha cm) where as water applied was 6.27 ha cm and 14.38 ha cm in sprinkler irrigation and conventional method of irrigation, respectively.

4.4.4 Water use efficiency of redgram under sprinkler irrigation and conventional method of irrigation

It could be noticed from the Table 4.9 and Fig. 9 that the redgram yield was found to be highest under sprinkler irrigation (19.42 q/ha) over the conventional method of irrigation (13.52 q/ha). Whereas the water applied was found to be lowest in case of sprinkler irrigation (7.37 ha cm) compared to conventional method of irrigation (15.24 ha cm). The Table 4.9 also indicates that the water use efficiency was highest in case of sprinkler irrigation (2.64 q/ha cm) compared to conventional method of irrigation (0.89 q/ha cm) and the gain in water use efficiency under sprinkler irrigation over the conventional method of irrigation was found to be 66.29 per cent.

4.4.5 Water use efficiency of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation

The water use efficiency of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation presented in Table 4.10 and Fig. 10. The sorghum yield and water use efficiency was found to be more under sprinkler irrigation (34.67 q/ha and 3.99 q/ha cm) over the conventional method of irrigation (24.63 q/ha and 1.37 q/ha cm). Whereas irrigation water applied under conventional method of irrigation was more (18.03 ha cm) compared to sprinkler irrigation (8.70 ha cm). The water use efficiency was highest in case of sprinkler irrigation (3.99 q/ha cm) compared to conventional method of irrigation (1.37 q/ha cm) and the gain in water use efficiency under sprinkler irrigation over the conventional method of irrigation was found to be 65.66 per cent.

Table 4.6: Water use efficiency of sugarcane under drip irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Drip irrigation n=120	Conventional method of irrigation n=120
1	No. of irrigations	92	47
2	Time required per irrigation (hour)	1.87	16.29
3	Total hours of irrigation	172.04	765.63
4	Water applied per hour (lit)	37,500	22,788
5	Total water applied (lit)	64,51,500	1,74,47,176
6	Water applied in ha cm	64.52	174.47
7	Yield (t/ha)	164.77	130.27
8	Water use efficiency (t/ha cm)	2.55	0.75
9	Gain in WUE under drip irrigation over conventional method of irrigation (%)	70.59	

Note: Water use efficiency = yield/water applied

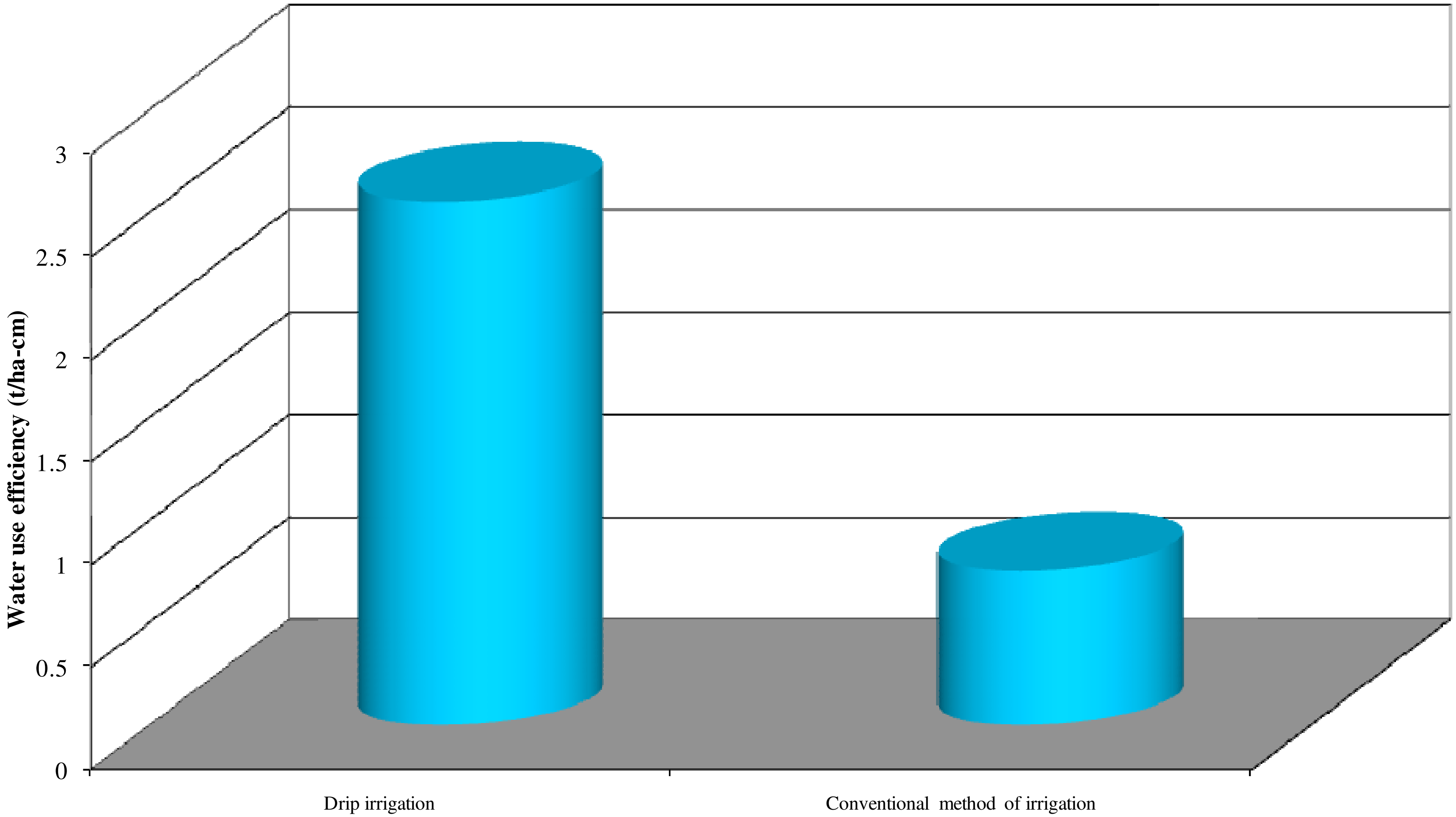

Fig. 6: Water use efficiency of sugarcane under drip irrigation and conventional method of irrigation in the study area

Table 4.7: Water use efficiency of maize under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation n= 60		Conventional method of irrigation n= 60
		Irrigation by sprinkler	Irrigation by furrow	
1	No. of irrigations	5.6	2.58	6.65
2	Time required per irrigation (hour)	10.04	16.25	16.00
3	Total hours of irrigation	56.22	41.93	106.40
4	Water applied per hour (lit)	7,500	22,788	22,788
5	Total water applied (lit)	13,77,150.84		24,24,643.20
6	Water applied in ha cm	13.77		24.25
7	Yield (q/ha)	62.67		51.17
8	Water use efficiency (q/ha cm)	4.55		2.11
9	Gain in WUE under sprinkler irrigation over conventional method of irrigation (%)	53.63		

Note: Water use efficiency = yield/water applied

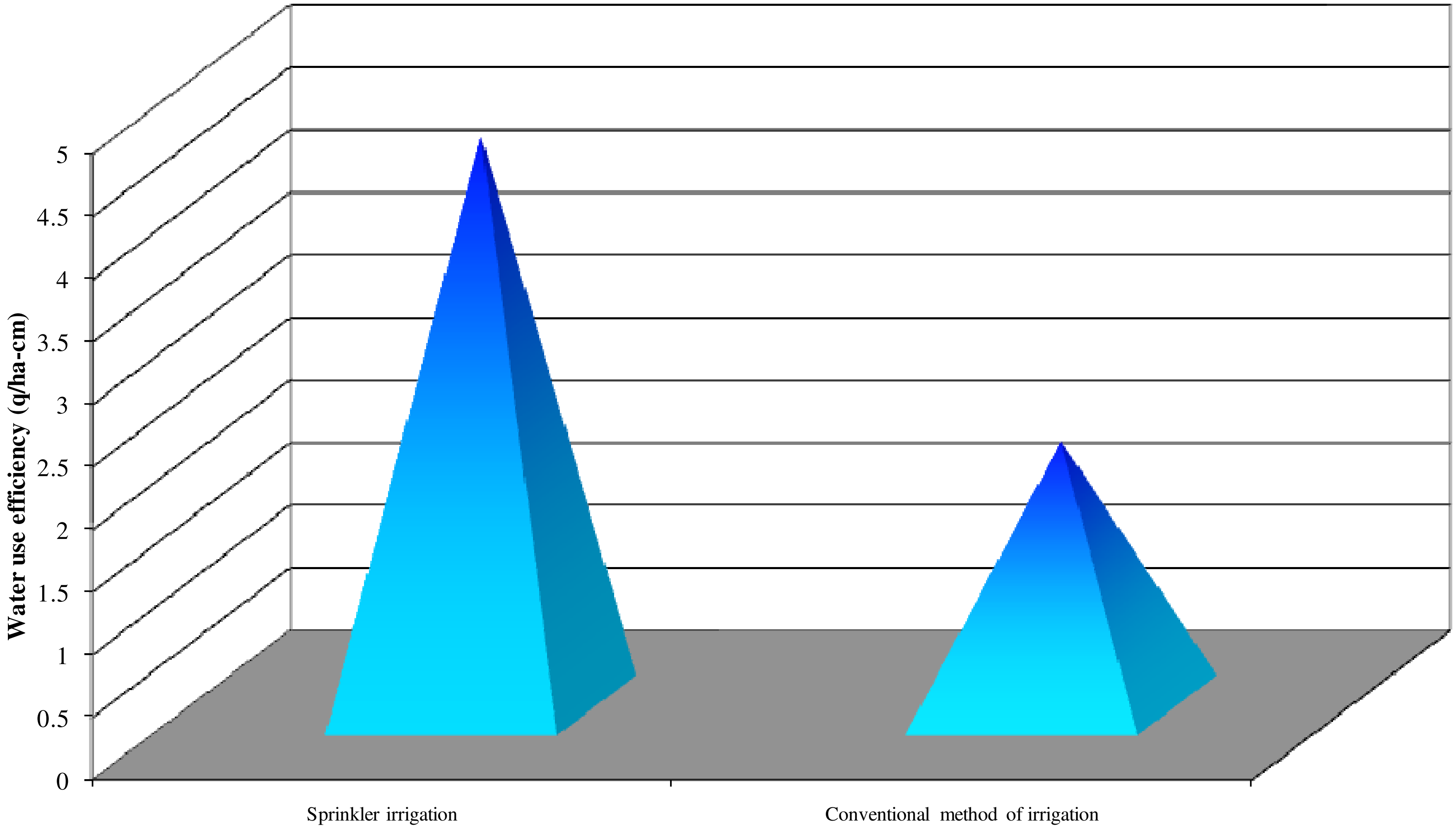

Fig. 7: Water use efficiency of maize under sprinkler irrigation and conventional method of irrigation in the study area

Table 4.8: Water use efficiency of groundnut under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation n= 60	Conventional method of irrigation n=60
1	No. of irrigations	7.68	3.77
2	Time required per irrigation (hour)	10.88	13.25
3	Total hours of irrigation	83.56	49.95
4	Water applied per hour (lit)	7,500	22,788
5	Total water applied (lit)	6,26,700	14,37,960
6	Water applied in ha cm	6.27	14.38
7	Yield (q/ha)	29.17	19.38
8	Water use efficiency (q/ha cm)	4.65	1.35
9	Gain in WUE under sprinkler irrigation over conventional method of irrigation (%)	70.97	

Note: Water use efficiency = yield/water applied

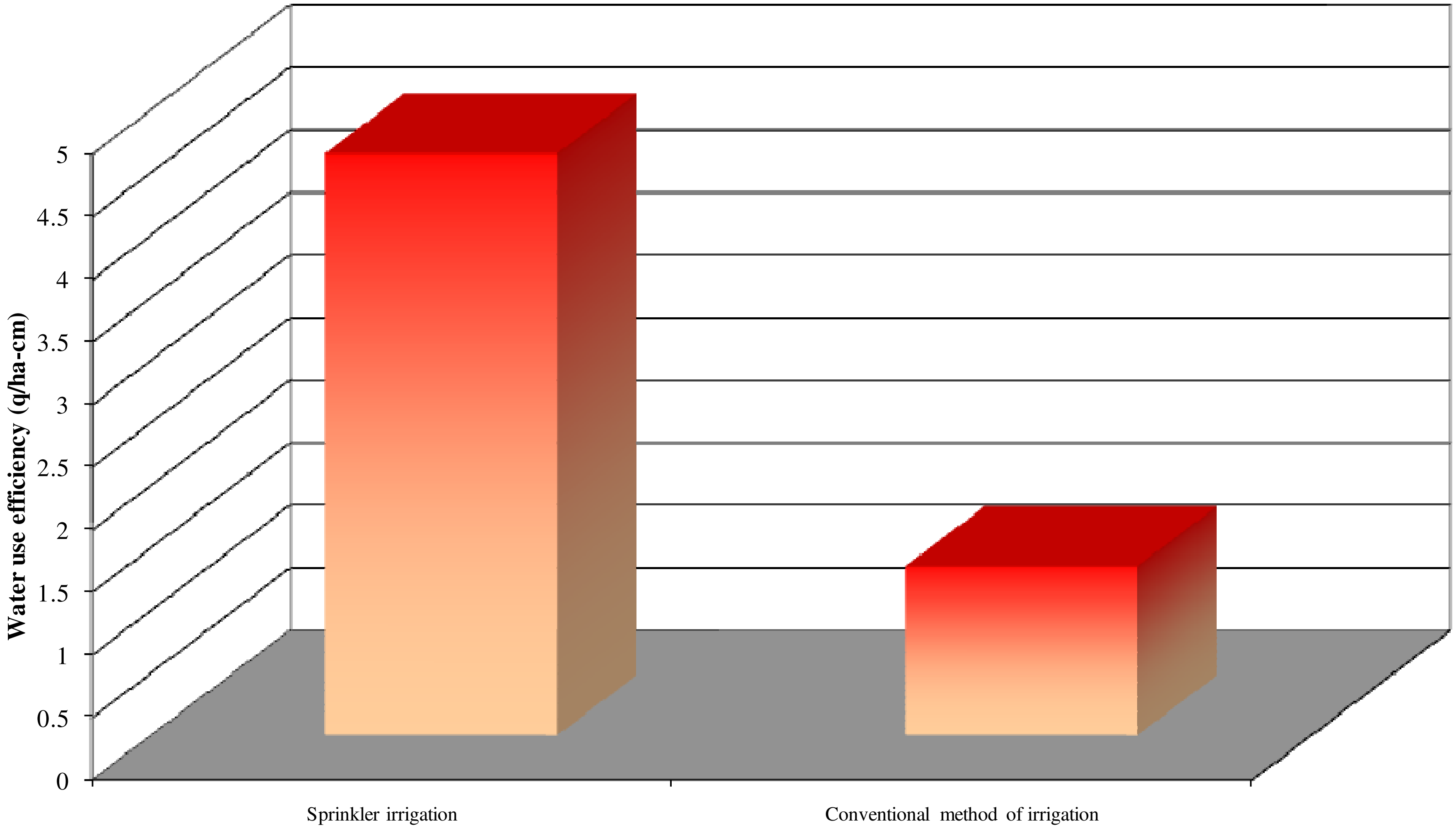

Fig. 8: Water use efficiency of groundnut under sprinkler irrigation and conventional method of irrigation in the study area

Table 4.9: Water use efficiency of redgram under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation n= 60	Conventional method of irrigation n=60
1	No. of irrigations	7.68	4.37
2	Time required per irrigation (hour)	12.79	15.33
3	Total hours of irrigation	98.23	66.99
4	Water applied per hour (lit)	7,500	22,752
5	Total water applied (lit)	7,36,725	15,24,156
6	Water applied in ha cm	7.37	15.24
7	Yield (q/ha)	19.42	13.52
8	Water use efficiency (q/ha cm)	2.64	0.89
9	Gain in WUE under sprinkler irrigation over conventional method of irrigation (%)	66.29	

Note: Water use efficiency = yield/water applied

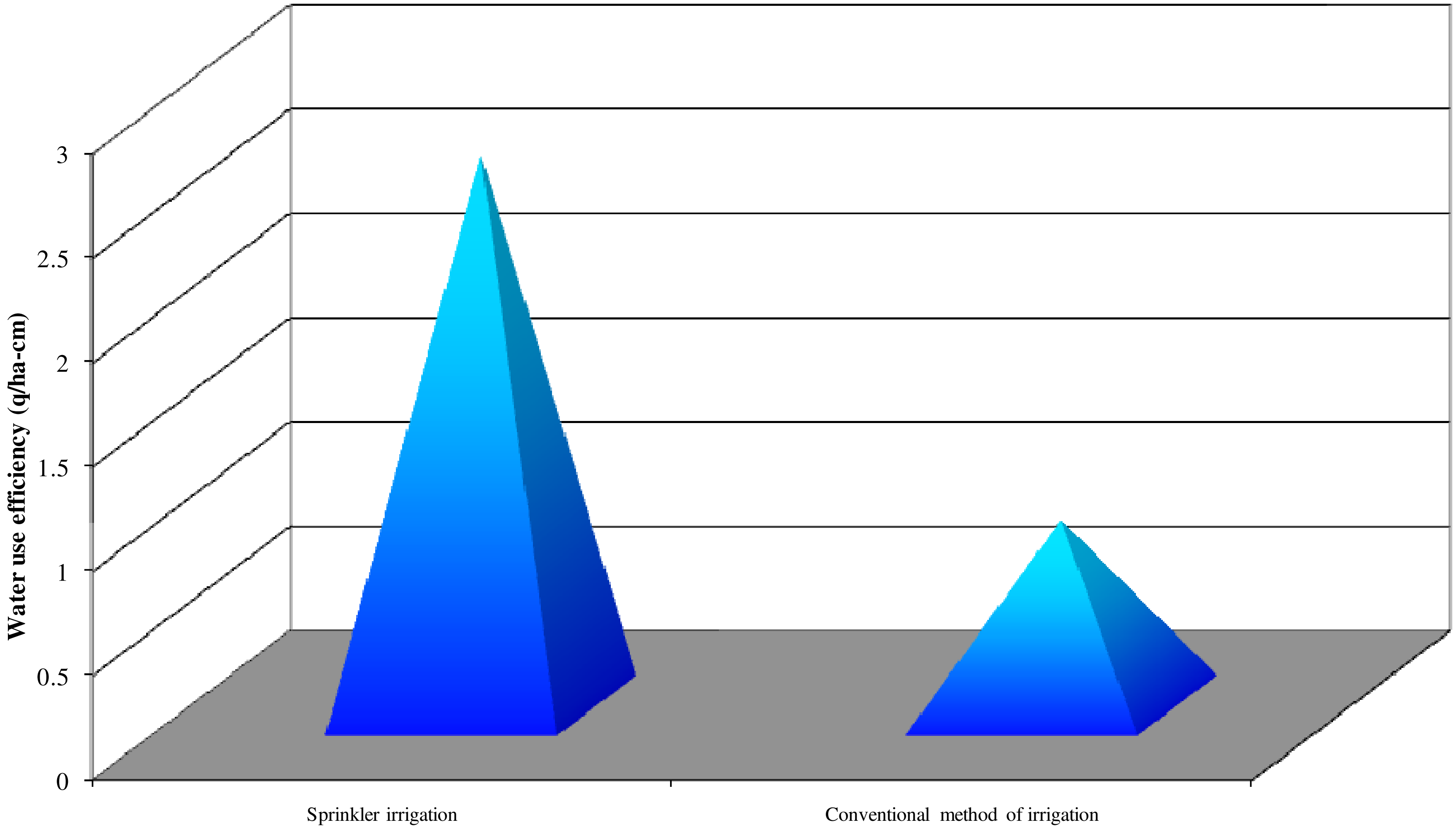

Fig. 9: Water use efficiency of redgram under sprinkler irrigation and conventional method of irrigation in the study area

Table 4.10: Water use efficiency of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation n= 60	Conventional method of irrigation n=60
1	No. of irrigations	10.27	5.17
2	Time required per irrigation (hour)	11.29	15.33
3	Total hours of irrigation	115.95	79.26
4	Water applied per hour (lit)	7,500	22,752
5	Total water applied (lit)	8,69,625	18,03,323
6	Water applied in ha cm	8.70	18.03
7	Yield (q/ha)	34.67	24.63
8	Water use efficiency (q/ha cm)	3.99	1.37
9	Gain in WUE under sprinkler irrigation over conventional method of irrigation (%)	65.66	

Note: Water use efficiency = yield/water applied

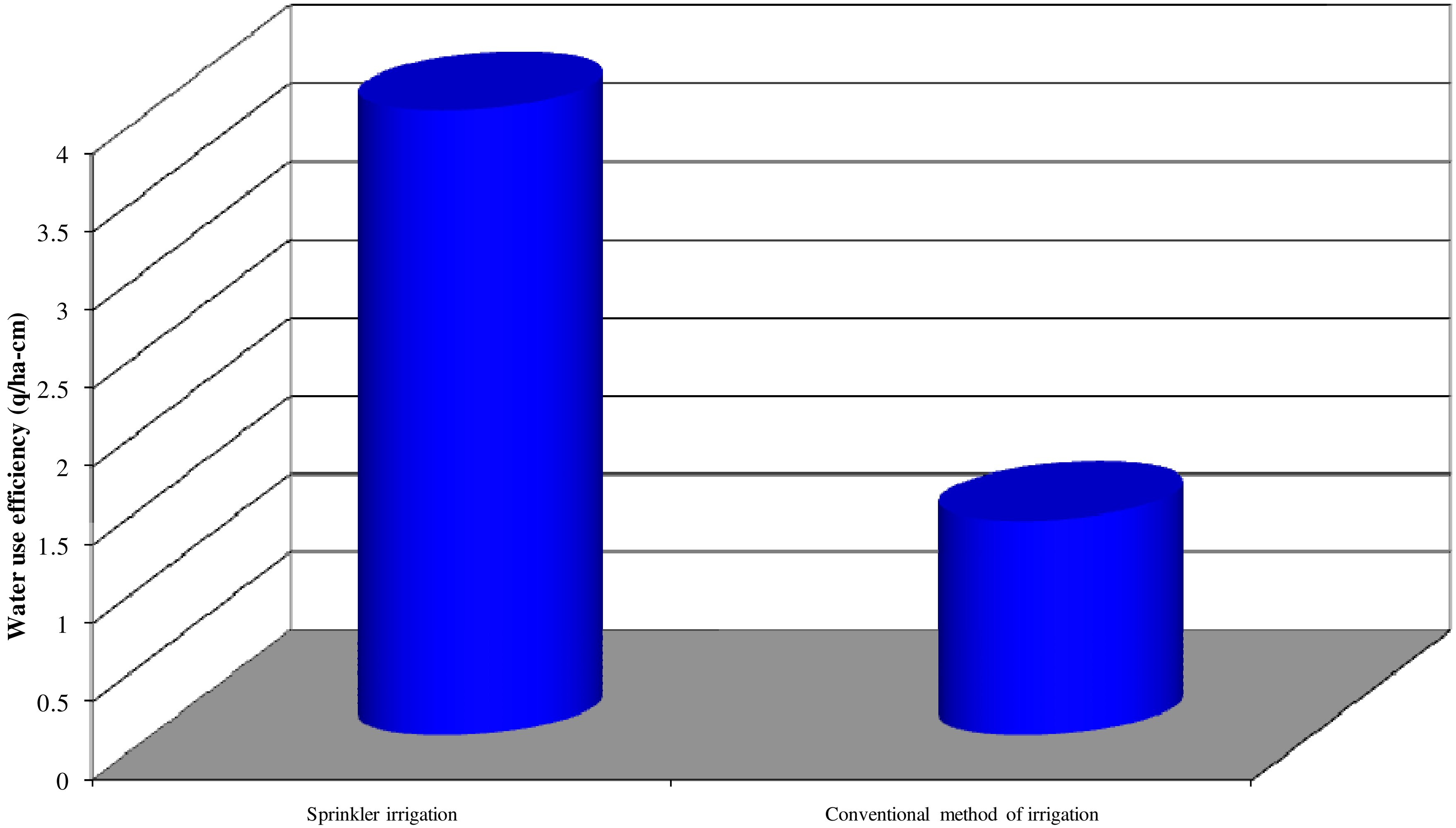

Fig. 10: Water use efficiency of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area

4.5 Profitability of major crops in conventional v/s micro irrigation systems

4.5.1 Sugarcane

4.5.1.1 Labour utilisation pattern in sugarcane cultivation under drip irrigation and conventional method of irrigation

The labour utilisation pattern in cultivation of sugarcane under drip irrigation and conventional method of irrigation is presented in Table 4.11. In case of sugarcane cultivation under drip irrigation, about 3.96, 2.38 and 2.19 hours of machine labour were used for ploughing, transportation of farmyard manure and harrowing, respectively. The highest pair days of bullock labour was used for set bed preparation (2.5 pair days) followed by intercultivation (1.63 pair days), harrowing (0.31 pair days) and transportation of farmyard manure (0.13 pair days). Among the human labour used for different operations, the highest human labour was used for irrigation (74.13 man days) followed by harvesting (54.06 man days), weeding (50.87 man days), planting (26.02 man days), fertiliser application (6.15 man days), set bed preparation (5.31 man days), transportation of farmyard manure (5.29 man days), application of plant protection chemicals (4.91 man days), spreading of farmyard manure (2.77 man days), inter cultivation (1.63 man days) and harrowing (0.31 man days).

Similarly in case of sugarcane cultivation under conventional method of irrigation, about 4.96, 2.67 and 3.81 hours of machine labour were used for ploughing, transportation of farmyard manure and harrowing, respectively. The highest bullock labour was used for intercultivation operation (4.40 pair days) followed by set bed preparation (2.50 pair days). Among the human labour used for different operations, the highest human labour was used for irrigation (127.62 man days) followed by weeding (71.57 man days), harvesting (52.71 man days), planting (28.08 man days), transportation of farmyard manure (9.75 man days), fertiliser application (7.40 man days), set bed preparation (6.81 man days), application of plant protection chemicals (5.48 man days), inter cultivation (4.40 man days) and spreading of farmyard manure (3.17 man days).

4.5.1.2 Input use pattern and output obtained in sugarcane cultivation under drip irrigation and conventional method of irrigation

Inputs used and output produced per hectare of sugarcane cultivation in the study area are depicted in Table 4.12 and Fig. 11.

It can be observed from the Table 4.12 that, the average per hectare utilisation of sets among the different irrigation methods was highest in case of conventional method of irrigation (7.59 t/ha) compared to drip irrigation (6.00 t/ha). The average per hectare utilisation of human labour was also highest in case of conventional method of irrigation (317.99 man days) compared to drip irrigation (231.47 man days). Similarly the highest bullock and tractor labour used under conventional method of irrigation was highest (6.90 pair days & 11.44 hours, respectively) compared to drip irrigation (4.57 pair days & 8.52 hours, respectively).

Table 4.11: Labour utilisation pattern in sugarcane cultivation under drip irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Drip irrigation (n=120)			Conventional method of irrigation (n=120)			Difference		
		Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)	Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)	Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)
1	Ploughing	-	-	3.96	-	-	4.96	-	-	-1 (-25.25)
2	Transportation of FYM	5.29	0.13	2.38	9.75	-	2.67	-4.46 (-84.31)	0.13 (100.00)	-0.29 (-12.18)
3	Spreading of FYM	2.77	-	-	3.17	-	-	-0.40 (-14.44)	-	-
4	Harrowing	0.31	0.31	2.19	-	-	3.81	0.31 (100.00)	0.31 (100.00)	-1.62 (-73.97)
5	Set bed preparation	5.31	2.50	-	6.81	2.50	-	-1.50 (-28.25)	-	-
6	Planting	26.02	-	-	28.08	-	-	-2.06 (-7.92)	-	-
7	Fertilizer application	6.15	-	-	7.40	-	-	-1.25 (-20.33)	-	-
8	Weeding	50.87	-	-	71.57	-	-	-20.70 (-40.69)	-	-
9	Inter cultivation	1.63	1.63	-	4.40	4.40	-	-2.77 (-169.94)	-2.77 (-169.94)	-
10	Irrigation	74.13	-	-	127.62	-	-	-53.49 (-72.16)	-	-
11	Application of PPC	4.91	-	-	5.48	-	-	-0.57 (-11.61)	-	-
12	Harvesting	54.06	-	-	52.71	-	-	1.35 (2.50)	-	-

Note: Figures in the parentheses indicate percentage difference

It could also be observed from the Table 4.12 that the use of farmyard manure, chemical fertilisers and plant protection chemicals was also highest under conventional method of irrigation (19.96 t/ha, 12.10 q/ha & 3.86 lit/ha, respectively) compared to drip irrigated farms (13.67 t/ha, 10.81 q/ha & 2.93 lit/ha, respectively).

The highest yield was obtained in case of drip irrigated farms compared to conventional irrigated farms. It was 164.77 t/ha under drip irrigated farms and 130.27 t/ha under conventional irrigated farms. The average quantity of sugarcane by-product was also highest under drip irrigated farms (5.73 t/ha) compared to conventional irrigated farms (4.24 t/ha).

4.5.1.3 Cost involved in cultivation of sugarcane under drip irrigation and conventional method of irrigation

The costs incurred in cultivation of sugarcane under drip and conventional methods of irrigation were analysed and are presented in Table 4.13 and Fig. 12.

It could be noticed from the table that the total variable cost incurred per hectare under conventional method of irrigation was highest (` 1,49,105.21/ha) compared to drip irrigated farms (` 1,05,527.64/ha). The distribution pattern of operational cost under various inputs revealed that the cost of human labour was highest in case of conventional method of irrigation (` 64,418.81/ha) compared to drip irrigation (` 43,727.78/ha). Whereas bullock labour cost was highest in case of conventional method of irrigation (` 6,367.15/ha) followed by drip irrigation (` 4,220.40/ha). The cost of tractor labour and sets was also highest in case of conventional method of irrigation (` 9,340.63/ha & ` 18,971.72/ha, respectively) compared to drip irrigation (` 6,958.68/ha & ` 15,700.00/ha, respectively).

It could also be observed from the table that expenditure on farmyard manure, chemical fertilisers and plant protection chemicals applied per hectare in the study area was more under conventional method of irrigation (` 19,958.33/ha, ` 18,961.04/ha & ` 1,332.98/ha, respectively) and was less in drip irrigated farms (` 13,632.50/ha, ` 13,432.72/ha & ` 951.87/ha, respectively).

The irrigation method wise analysis indicated that the fixed cost incurred per hectare in case of drip irrigated farms was highest (` 40,480.32/ha) compared to conventional irrigated farms (` 31,198.86/ha). Among the different components of fixed cost, rental value of the land was highest in both the methods of irrigation (` 20,000/ha in each method) followed by apportioned cost of irrigation structure (` 13,712.78/ha & ` 5,732.95/ha under drip and conventional method of irrigation, respectively). The other components like land revenue, depreciation charges and interest on fixed cost are of minor importance.

Among the two methods of irrigation, the total cost incurred in case of conventional method of irrigation was highest (` 1,80,304.07/ha) as compared to cost incurred in cultivation of sugarcane under drip irrigation (` 1,46,007.96/ha).

Table 4.12: Input use pattern and output obtained in sugarcane cultivation under drip irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Units	Drip irrigation n=120	Conventional method of irrigation n=120	Difference	Difference (%)
1	Human labour	Man days	231.47	317.99	-86.52	-37.38
2	Bullock labour	Pair days	4.57	6.90	-2.33	-50.98
3	Machine labour	Hours	8.52	11.44	-2.92	-34.27
4	Sets	Tonnes	6.00	7.59	-1.59	-26.50
5	Farm Yard Manure	Tonnes	13.67	19.96	-6.29	-46.01
6	Chemical fertilisers					
	a. Urea	Quintals	4.70	5.38	-0.68	-14.47
	b. DAP	Quintals	3.55	5.31	-1.76	-49.58
	c. MOP	Quintals	2.56	1.42	1.14	44.53
	Total	Quintals	10.81	12.10	-1.29	-11.93
7	Plant protection chemicals					
	a. Pesticide	Litres	1.64	2.02	-0.38	-23.17
	b. Herbicide	Kilograms	1.29	1.84	-0.55	-42.64
	Total	Litres/Kilograms	2.93	3.86	-0.93	-31.74
8	Main product	Tonnes	164.77	130.27	34.50	20.94
9	By-product	Tonnes	5.73	4.24	1.49	26.00

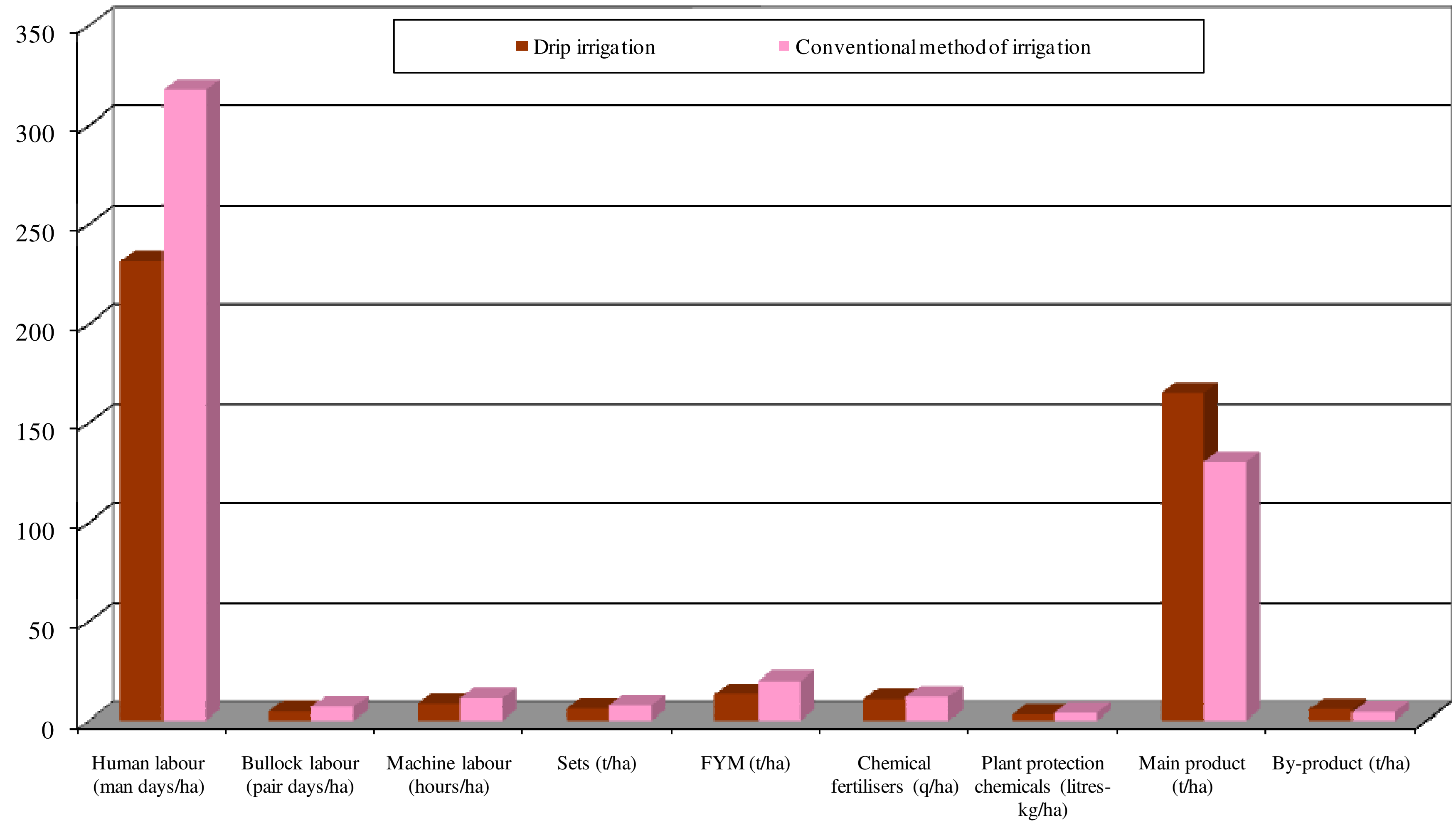

Fig. 11: Input use pattern and output obtained in sugarcane cultivation under drip irrigation and conventional method of irrigation in the study area

Table 4.13: Cost involved in cultivation of sugarcane under drip irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Drip irrigation (n=120)			Conventional method of irrigation (n=120)			Difference	Difference
		Quantity	Value (`)	Per cent to total cost	Value (`)	Value (`)	Per cent to total cost	Value (`)	(%)
A.	**Variable cost**								
1	Human labour (man days)	231.47	43,727.78	29.95	317.99	64,418.81	35.73	-20,691.03	-47.32
2	Bullock labour (pair days)	4.57	4,220.40	2.89	6.90	6,367.15	3.53	-2,146.75	-50.87
3	Machine labour (hours)	8.52	6,958.68	4.77	11.44	9,340.63	5.18	-2,381.95	-34.23
4	Sets (tonnes)	6.00	15,700.00	10.75	7.59	18,971.72	10.52	-3,271.72	-20.84
5	FYM (tonnes)	13.67	13,632.50	9.34	19.96	19,958.33	11.07	-6,325.83	-46.40
6	Chemical fertilisers (quintals)								
	a. Urea	4.70	3,349.61	2.29	5.38	3,870.00	2.15	-520.39	-15.54
	b. DAP	3.55	8,128.94	5.57	5.31	11,705.21	6.49	-3,576.27	-43.99
	c. MOP	2.56	1,954.17	1.34	1.42	3,385.83	1.88	-1,431.66	-73.26
	Total	10.81	13,432.72	9.20	12.10	18,961.04	10.52	-5,528.32	-41.16
7	Plant protection chemicals (litres/kilograms)								
	a. Pesticide (litres)	1.64	616.87	0.42	2.02	741.75	0.41	-124.88	-20.24
	b. Herbicide (kilograms)	1.29	335.00	0.23	1.84	591.23	0.33	-256.23	-76.49
	Total	2.93	951.87	0.65	3.86	1,332.98	0.74	-381.11	-40.04
8	Interest on working capital @ 7 %	-	6,903.68	4.73	-	9,754.55	5.41	-2,850.87	-41.29
	Sub total	-	1,05,527.64	72.28	-	1,49,105.21	82.70	-43,577.57	-41.29

Contd…..

Sl. No.	Particulars	Drip irrigation (n=120)			Conventional method of irrigation (n=120)			Difference	Difference
		Quantity	Value (`)	Per cent to total cost	Quantity	Value (`)	Per cent to total cost	Value (`)	(%)
B.	**Fixed cost**								
1	Land revenue	-	30.00	0.02	-	30.00	0.02	0.00	0.00
2	Rental value of the land	-	20,000.00	13.70	-	20,000.00	11.09	0.00	0.00
3	Depreciation	-	2,400.37	1.64	-	2,093.18	1.16	307.19	12.80
4	Apportioned cost of irrigation structure	-	13,712.78	9.39	-	5,732.95	3.18	7,979.83	58.19
5	Interest on fixed capital @ 12 %	-	4,337.18	2.97	-	3,342.73	1.85	994.45	22.93
	Sub total	-	40,480.32	27.72	-	31,198.86	17.30	9,281.46	22.93
	Total cost of cultivation	-	**1,46,007.96**	**100.00**	**-**	**1,80,304.07**	**100.00**	**-34,296.11**	**-23.49**

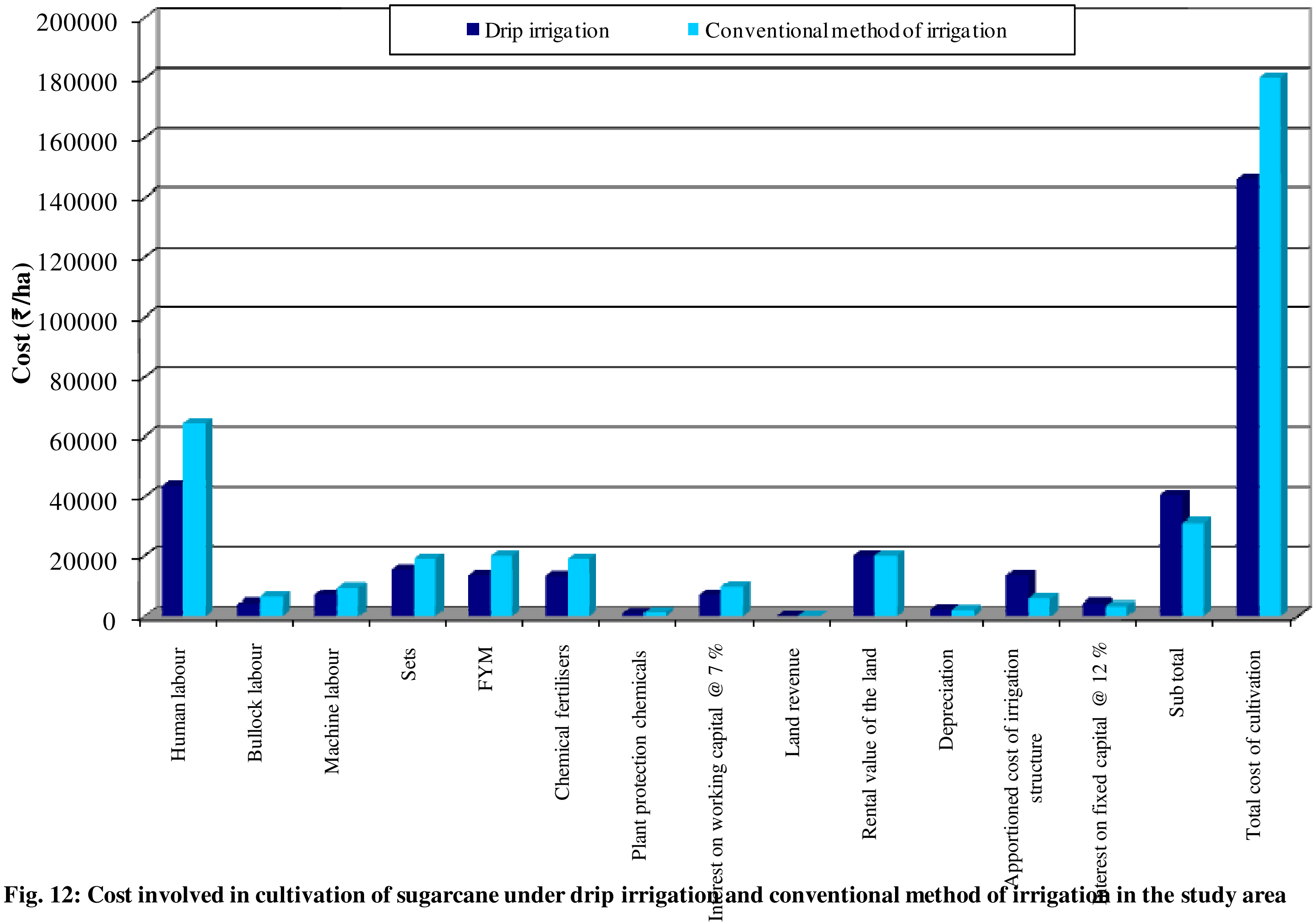

Fig. 12: Cost involved in cultivation of sugarcane under drip irrigation and conventional method of irrigation in the study area

4.5.1.4 Returns from cultivation of sugarcane under drip irrigation and conventional methods of irrigation

The returns obtained from sugarcane cultivation under drip and conventional method of irrigation is presented in Table 4.14 and Fig. 13.

The irrigation method wise analysis of gross returns indicated that the gross returns obtained per hectare in case of drip irrigated farms was high (` 2,97,720.98/ha) compared to conventionally irrigated farms (` 2,30,856.55/ha). With respect to net returns also, the per hectare net returns obtained in drip irrigated farms was high (` 1,51,713.02/ha) as compared to conventionally irrigated farms (` 50,552.49/ha).

Thus the cultivation of sugarcane crop in the study area was found to be highly profitable under drip irrigation as also supported by a high magnitude of returns per rupee investment (2.04) compared to sugarcane cultivation under conventional method of irrigation (1.28).

4.5.2 Maize

4.5.2.1 Labour utilisation pattern in maize cultivation under sprinkler and conventional methods of irrigation

The labour utilisation pattern in cultivation of maize under sprinkler and conventional method of irrigation is presented in Table 4.15. In case of maize cultivation under sprinkler irrigation system, about 2.75, 1.38, 1.50 and 2.50 hours of machine labour were used for ploughing, transportation of farmyard manure, harrowing and threshing, respectively. The bullock labour was used for ploughing (1.13 pair days) and harrowing (1.13 pair days). Among the human labour used for different operations, the highest human labour was used for weeding (23.64 man days) followed by irrigation (16.37 man days), harvesting (9.13 man days), sowing (7.43 man days), threshing (6.58 man days), fertiliser application (5.25 man days), transportation of farmyard manure (4.95 man days), application of plant protection chemicals (3.00 man days), spreading of farmyard manure and, drying and packing (2.63 man days in each operation) and ploughing and harrowing (1.13 man days in each operation).

Similarly in case of maize cultivation under conventional method of irrigation, about 3.19, 2.50, 2.83 and 2.50 hours of machine labour were used for ploughing, transportation of farmyard manure, harrowing and threshing, respectively. No bullock labour was used for any of the operation under conventional method of irrigation. Among the human labour used for different operations, the highest human labour was used for weeding (28.78 man days) followed by irrigation (17.73 man days), sowing (9.81 man days), harvesting (8.30 man days), transportation of farmyard manure (5.08 man days), threshing (4.84 man days), application of plant protection chemicals (4.20 man days), fertiliser application (4.17 man days), spreading of farmyard manure (2.58 man days) and, drying and packing (2.20 man days).

4.5.2.2 Input use pattern and output obtained in maize cultivation under sprinkler irrigation and conventional methods of irrigation

Inputs used and output realised per hectare of maize cultivation in the study area are depicted in Table 4.16 and Fig. 14.

Table 4.14: Returns from cultivation of sugarcane under drip irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Drip irrigation (n=120)	Conventional method of irrigation (n=120)	Difference	Difference (%)
1	Yield				
	a. Main product (tonnes)	164.77	130.27	34.50	20.94
	b. By-product (tonnes)	5.73	4.24	1.49	26.00
2	Market price				
	a. Main product (`)	1,772.08	1,739.58	32.50	1.83
	b. By-product (`)	1,000.00	1,000.00	0.00	0.00
3	Gross returns (`)	2,97,720.98	2,30,856.55	66,864.43	22.46
4	Total cost (`)	1,46,007.96	1,80,304.07	-34,296.11	-23.49
5	Net returns (`)	1,51,713.02	50,552.49	1,01,160.53	66.68
6	Returns per rupee of investment	2.04	1.28	0.76	37.25

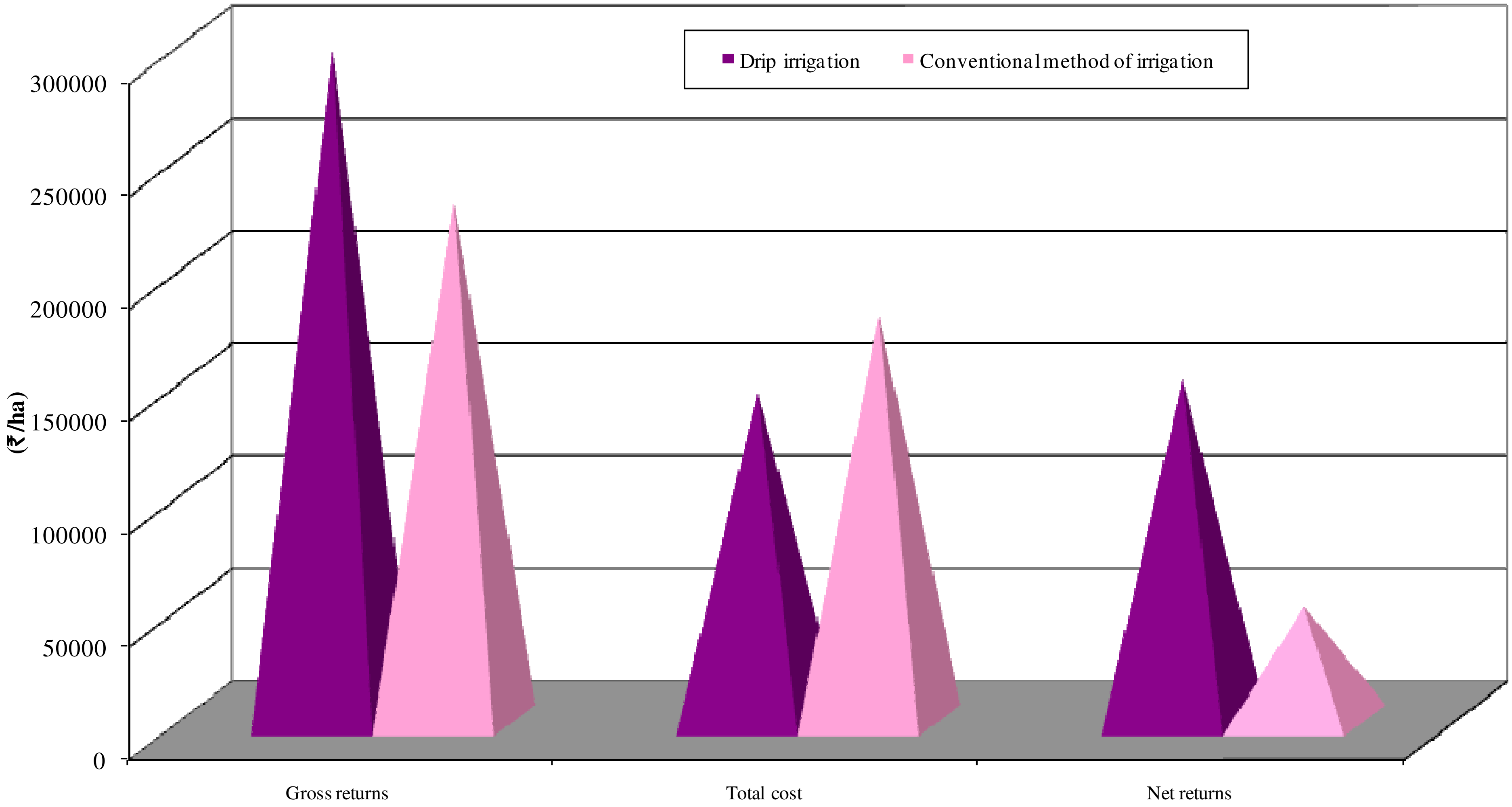

Fig. 13: Returns from cultivation of sugarcane under drip irrigation and conventional method of irrigation in the study area

Table 4.15: Labour utilisation pattern in maize cultivation under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference		
		Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)	Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)	Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)
1	Ploughing	1.13	1.13	2.75	-	-	3.19	1.13 (100.00)	1.13 (100.00)	-0.44 (-16.00)
2	Transportation of FYM	4.95	-	1.38	5.08	-	2.50	-0.13 (-2.63)	-	-1.12 (-81.16)
3	Spreading of FYM	2.63	-	-	2.58	-	-	0.05 (1.90)	-	-
4	Harrowing	1.13	1.13	1.50	-	-	2.83	1.13 (100.00)	1.13 (100.00)	-1.33 (-88.67)
5	Sowing	7.43	-	-	9.81	-	-	-2.38 (-32.03)	-	-
6	Fertilizer application	5.25	-	-	4.17	-	-	1.08 (20.57)	-	-
7	Weeding	23.64	-	-	28.78	-	-	-5.14 (-21.74)	-	-
8	Irrigation	16.37	-	-	17.73	-	-	-1.36 (-8.31)	-	-
9	Application of PPC	3.00	-	-	4.20	-	-	-1.20 (-40.00)	-	-
10	Harvesting	9.13	-	-	8.30	-	-	0.83 (9.09)	-	-
11	Threshing	6.58	-	2.50	4.84	-	2.50	1.74 (26.44)	-	-
12	Drying and packing	2.63	-	-	2.20	-	-	0.43 (16.35)	-	-

Note: Figures in the parentheses indicate percentage difference

It can be observed from the table that, the average per hectare utilisation of seeds among the different irrigation methods was highest in case of conventional method of irrigation (26.42 kg/ha) compared to sprinkler irrigation (21.33 kg/ha). The average per hectare utilisation of human labour was also highest in case of conventional method of irrigation (87.70 man days) compared to sprinkler irrigation (83.83 man days). Similarly the highest tractor labour used under conventional method of irrigation was highest (11.02 hours) followed by sprinkler irrigation (8.13 hours). The bullock labour used under sprinkler irrigation was 2.25 pair days whereas it was not used under conventional method of irrigation.

It could also be observed from the table that the use of farmyard manure, chemical fertilisers and plant protection chemicals was also highest under conventional method of irrigation (5.96 t/ha, 4.40 q/ha & 3.14 lit/ha, respectively) compared to sprinkler irrigation (5.25 t/ha, 3.85 q/ha & 2.66 lit/ha, respectively).

The highest yield was obtained in case of sprinkler irrigated farms compared to conventional irrigated farms. It was 62.67 q/ha under sprinkler irrigated farms and 51.17 q/ha under conventional irrigated farms. The average quantity of maize by-product was also highest under sprinkler irrigated farms (11.33 t/ha) compared to conventional irrigated farms (9.85 t/ha).

4.5.2.3 Cost involved in cultivation of maize under sprinkler irrigation and conventional method of irrigation

The costs incurred in cultivation of maize under sprinkler irrigation and conventional method of irrigation were analysed and are presented in Table 4.17 and Fig. 15.

It could be noticed from the Table 4.17 that the total variable cost incurred per hectare under conventional method of irrigation was highest (` 47,042.70/ha) compared to sprinkler irrigated farms (` 40,423.66/ha). The distribution pattern of operational cost under various inputs revealed that the cost of human labour was highest in case of conventional method of irrigation (` 18,563.17/ha) compared to sprinkler irrigation (` 16,976.33/ha) whereas bullock labour cost in case of sprinkler irrigation was (` 1,620.00/ha). The cost of tractor labour and seeds was also highest in case of conventional method of irrigation (` 8,137.05/ha & ` 4,755.00/ha, respectively) compared to sprinkler irrigation (` 5,389.58/ha & ` 3,584.00/ha, respectively).

It could also be observed from the table that expenditure on farmyard manure, chemical fertilisers and plant protection chemicals applied per hectare in the study area was more under conventional method of irrigation (` 5,958.33/ha, ` 6,961.46/ha & ` 1,076.88/ha, respectively) and is less in sprinkler irrigated farms (` 5,092.50/ha, ` 5,525.10/ha & ` 869.16/ha, respectively).

The irrigation method wise analysis indicated that the fixed cost incurred per hectare in case of sprinkler irrigated farms was highest (` 14,514.69/ha) compared to conventional irrigated farms (` 9,368.15/ha). Among the different components of fixed cost, apportioned cost of irrigation structure was highest under sprinkler irrigated farms (` 7,949.05/ha) and in case of conventional method of irrigation rental value of the land was highest (` 4,687.50/ha). The other components like land revenue, depreciation charges and interest on fixed cost are of minor importance.

Table 4.16: Input use pattern and output obtained in maize cultivation under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Units	Sprinkler irrigation n=60	Conventional method of irrigation n=60	Difference	Difference (%)
1	Human labour	Man days	83.83	87.70	-3.87	-4.62
2	Bullock labour	Pair days	2.25	0.00	2.25	100.00
3	Machine labour	Hours	8.13	11.02	-2.89	-35.55
4	Seeds	Kilograms	21.33	26.42	-5.09	-23.86
5	Farm Yard Manure	Tonnes	5.25	5.96	-0.71	-13.52
6	Chemical fertilisers					
	a. Urea	Quintals	1.77	1.96	-0.19	-10.73
	b. DAP	Quintals	1.31	1.47	-0.16	-12.21
	c. MOP	Quintals	0.77	0.97	-0.2	-25.97
	Total	Quintals	3.85	4.40	-0.55	-14.29
7	Plant protection chemicals					
	a. Pesticide	Litres	1.44	1.83	-0.39	-27.08
	b. Herbicide	Kilograms	1.22	1.31	-0.09	-7.38
	Total	Litres/Kilograms	2.66	3.14	-0.48	-18.05
8	Main product	Quintals	62.67	51.17	11.5	18.35
9	By-product	Tonnes	11.33	9.85	1.48	13.06

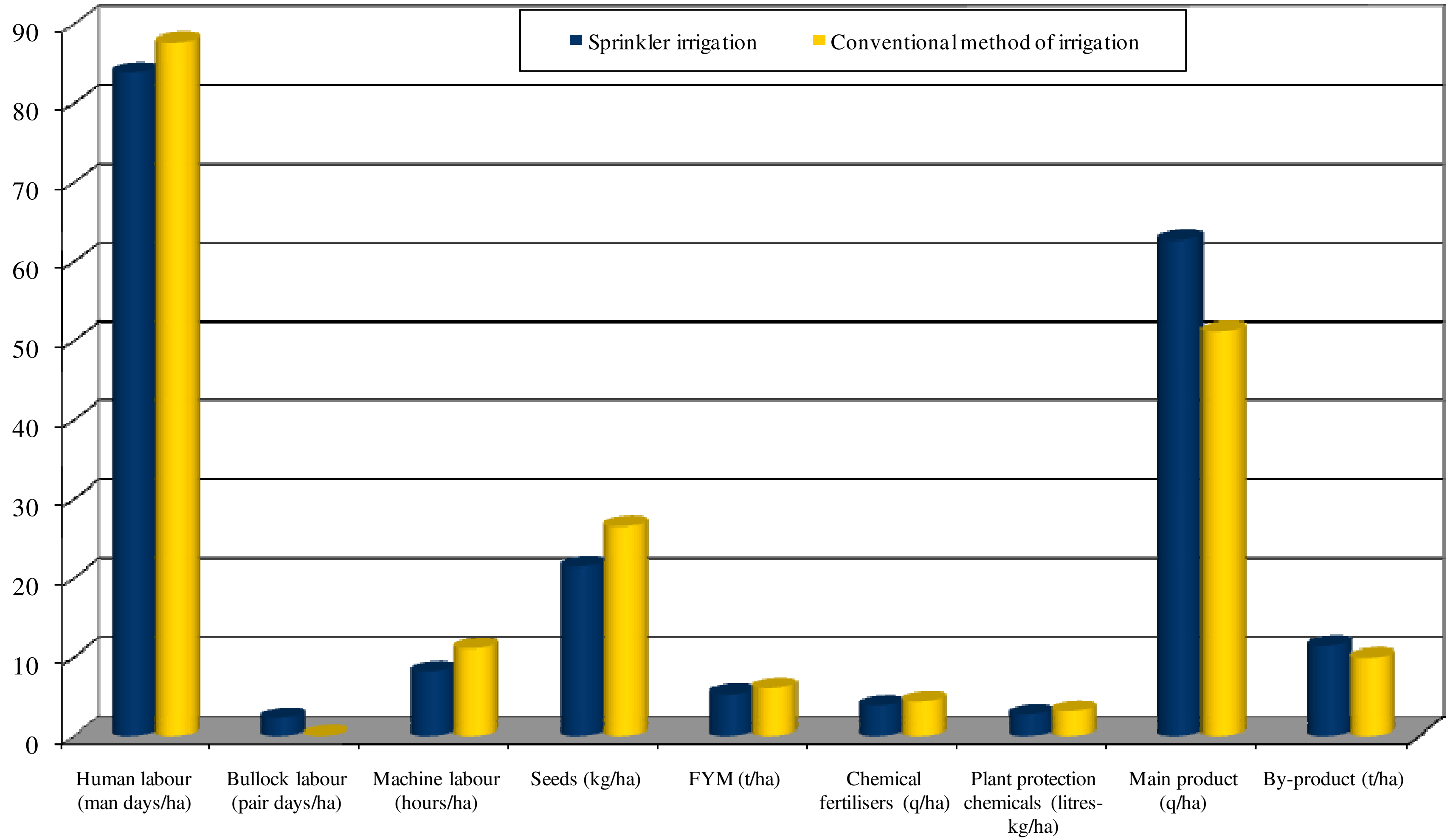

Fig. 14: Input use pattern and output obtained in maize cultivation under sprinkler irrigation and conventional method of irrigation in the study area

Table 4.17: Cost involved in cultivation of maize under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference	Difference
		Quantity	Value (`)	Per cent to total cost	Quantity	Value (`)	Per cent to total cost	Value (`)	(%)
A.	**Variable cost**								
1	Human labour (man days)	83.83	16,976.33	30.90	87.70	18,563.17	32.91	-1,586.84	-9.35
2	Bullock labour (pair days)	2.25	1,620.00	2.95	0.00	0.00	0.00	1,620.00	100.00
3	Machine labour (hours)	8.13	5,389.58	9.81	11.02	8,137.05	14.42	-2,747.47	-50.98
4	Seeds (kilograms)	21.33	3,584.00	6.52	26.42	4,755.00	8.43	-1,171.00	-32.67
5	FYM (tonnes)	5.25	5,092.50	9.27	5.96	5,958.33	10.56	-865.83	-17.00
6	Chemical fertilisers (quintals)								
	a. Urea	1.77	1,248.44	2.27	1.96	1,410.00	2.50	-161.56	-12.94
	b. DAP	1.31	2,966.25	5.40	1.47	3,236.15	5.74	-269.90	-9.10
	c. MOP	0.77	1,310.42	2.39	0.97	2,315.31	4.10	-1,004.89	-76.68
	Total	3.85	5,525.10	10.06	4.40	6,961.46	12.34	-1,436.36	-26.00
7	Plant protection chemicals (litres/kilograms)								
	a. Pesticide	1.44	690.00	1.26	1.83	880.00	1.56	-190.00	-27.54
	b. Herbicide	1.22	179.16	0.33	1.31	196.88	0.35	-17.72	-9.89
	Total	2.66	869.16	1.58	3.15	1,076.88	1.91	-207.72	-23.90
8	Interest on working capital @ 7 %		1,366.98	2.49	-	1,590.82	2.82	-223.84	-16.37
	Sub total		40,423.66	73.58	-	47,042.70	83.39	-6,619.04	-16.37

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Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference	Difference
		Quantity	Value (`)	Per cent to total cost	Quantity	Value (`)	Per cent to total cost	Value (`)	(%)
B.	**Fixed cost**								
1	Land revenue		30.00	0.05	-	30.00	0.05	0.00	0.00
2	Rental value of the land		4,687.50	8.53	-	4,687.50	8.31	0.00	0.00
3	Depreciation		1,026.56	1.87	-	1,046.59	1.86	-20.03	-1.95
4	Apportioned cost of irrigation structure		7,949.05	14.47	-	3,073.79	5.45	4,875.26	61.33
5	Interest on fixed capital @ 12 %		821.59	1.50	-	530.27	0.94	291.32	35.46
	Sub total		14,514.69	26.42	-	9,368.15	16.61	5,146.54	35.46
	Total cost of cultivation		**54,938.35**	**100.00**	**-**	**56,410.85**	**100.00**	**-1,472.50**	**-2.68**

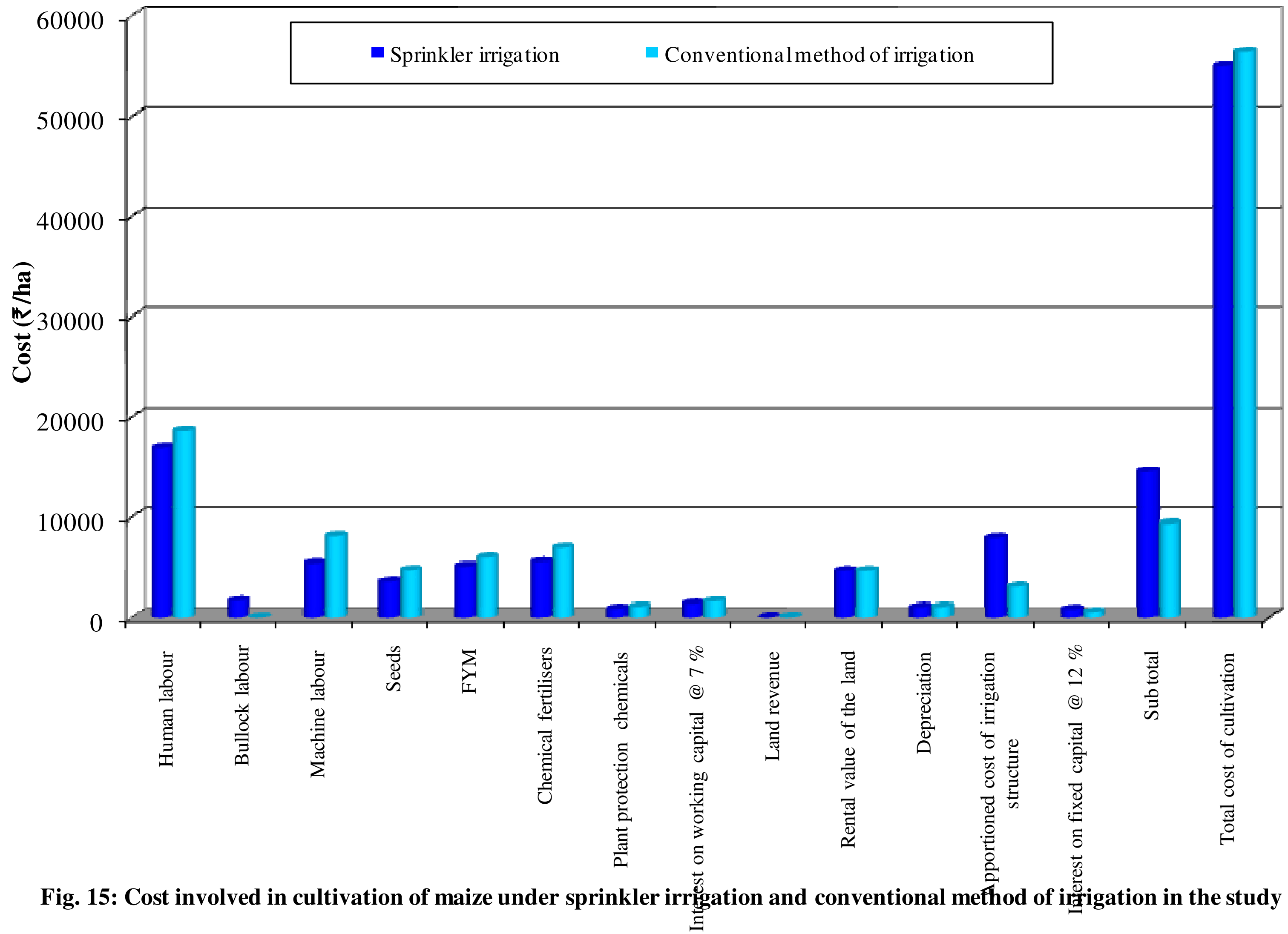

Fig. 15: Cost involved in cultivation of maize under sprinkler irrigation and conventional method of irrigation in the study area

Table 4.18: Returns from cultivation of maize under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)	Conventional method of irrigation (n=60)	Difference	Difference (%)
1	Yield				
	a. Main product (quintals)	62.67	51.17	11.50	18.35
	b. By-product (tonnes)	11.33	9.85	1.48	13.06
2	Market price				
	a. Main product (`)	1,474.17	1,440.83	33.34	2.26
	b. By-product (`)	500.00	500.00	0.00	0.00
3	Gross returns (`)	98,047.78	78,649.72	19,398.06	19.78
4	Total cost (`)	54,938.35	56,410.85	-1,472.50	-2.68
5	Net returns (`)	43,109.42	22,238.87	20,870.55	48.41
6	Returns per rupee of investment	1.78	1.39	0.39	21.91

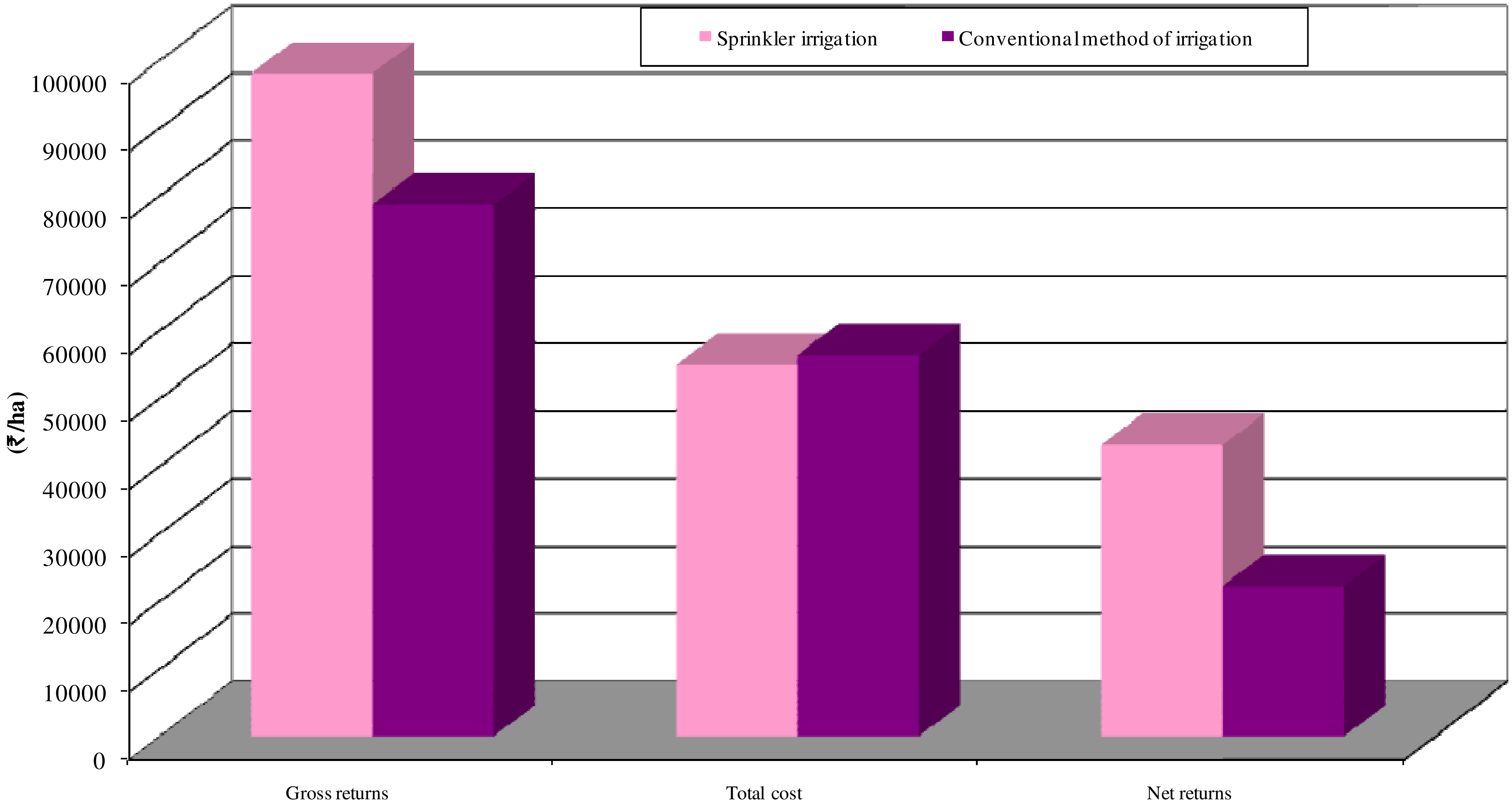

Fig. 16: Returns from cultivation of maize under sprinkler irrigation and conventional method of irrigation in the study area

Among the two methods of irrigation, the total cost incurred in case of conventional method of irrigation was highest (` 56,410.85/ha) as compared to cost incurred in cultivation of maize under sprinkler irrigation (` 54,938.35/ha).

4.5.2.4 Returns from cultivation of maize under sprinkler irrigation and conventional method of irrigation

The returns obtained from maize cultivation under sprinkler irrigation and conventional method of irrigation is presented in Table 4.18 and Fig. 16.

The irrigation method wise analysis of gross returns indicated that the gross returns obtained per hectare in case of sprinkler irrigated farms was high (` 98,047.78/ha) compared to conventional irrigated farms (` 78,649.72/ha). With respect to net returns also the per hectare net returns obtained under sprinkler irrigated farms was high (` 43,109.42/ha) compared to conventional irrigated farms (` 22,238.87/ha).

Thus the cultivation of maize crop in the study area was found to be profitable under sprinkler irrigation as also supported by a high benefit cost ratio of 1.78 compared to maize cultivation under conventional method of irrigation with benefit cost ratio of 1.39.

4.5.3 Groundnut

4.5.3.1 Labour utilisation pattern in groundnut cultivation under sprinkler irrigation and conventional method of irrigation

The labour utilisation pattern in cultivation of groundnut under sprinkler and conventional method of irrigation is presented in Table 4.19

In case of groundnut cultivation under sprinkler irrigation system, about 2.50, 2.50 and 1.38 hours of machine labour were used for ploughing, transportation of farmyard manure and harrowing, respectively. Per hectare bullock labour used for ploughing and harrowing was 1.13 pair days in each case. Among the human labour used for different operations, the highest human labour was used for weeding (23.84 man days) followed by irrigation (13.93 man days), harvesting (13.08 man days), sowing (10.23 man days), fertiliser application (5.00 man days), application of plant protection chemicals (3.75 man days), transportation of farmyard manure (3.29 man days), drying and packing (2.71 man days), spreading of farmyard manure and (2.50 man days) and, ploughing and harrowing (1.13 man days in each operation).

In case of groundnut cultivation under conventional method of irrigation system, about 2.04, 2.50 and 1.88 hours of machine labour were used for ploughing, transportation of farmyard manure and harrowing, respectively. Per hectare bullock labour used for ploughing and harrowing was 0.67 and 0.75 pair days, respectively. Among the human labour used for different operations, the per hectare human labour was used was highest for weeding (26.61 man days) followed by sowing (12.14 man days), harvesting (10.65 man days), irrigation (8.32 man days), fertiliser application (5.58 man days), application of plant protection chemicals (5.04 man days), transportation of farmyard manure

Table 4.19: Labour utilisation pattern in groundnut cultivation under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference		
		Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)	Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)	Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)
1	Ploughing	1.13	1.13	2.50	0.67	0.67	2.04	0.46 (40.71)	0.46 (40.71)	0.46 (18.40)
2	Transportation of FYM	3.29	-	2.50	4.79	-	2.50	-1.50 (-45.59)	-	-
3	Spreading of FYM	2.50	-	-	2.71	-	-	-0.21 (-8.40)	-	-
4	Harrowing	1.13	1.13	1.38	0.75	0.75	1.88	0.38 (33.63)	0.38 (33.63)	-0.50 (-36.23)
5	Sowing	10.23	-	-	12.14	-	-	-1.91 (-18.67)	-	-
6	Fertilizer application	5.00	-	-	5.58	-	-	-0.58 (-11.60)	-	-
7	Weeding	23.84	-	-	26.61	-	-	-2.77 (-11.62)	-	-
8	Irrigation	13.93	-	-	8.32	-	-	5.61 (40.27)	-	-
9	Application of PPC	3.75	-	-	5.04	-	-	-1.29 (-34.40)	-	-
10	Harvesting	13.08	-	-	10.65	-	-	2.43 (18.58)	-	-
11	Drying and packing	2.71	-	-	2.23	-	-	0.48 (17.71)	-	-

Note: Figures in the parentheses indicate percentage difference

Table 4.20: Input use pattern and output obtained in groundnut cultivation under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Units	Sprinkler irrigation n=60	Conventional method of irrigation n=60	Difference	Difference (%)
1	Human labour	Man days	80.57	79.49	1.08	1.34
2	Bullock labour	Pair days	2.25	1.42	0.83	36.89
3	Machine labour	Hours	6.38	6.42	-0.04	-0.63
4	Seeds	Kilograms	96.67	103.42	-6.75	-6.98
5	Farm Yard Manure	Tonnes	5.13	6.33	-1.20	-23.39
6	Chemical fertilisers					
	a. Urea	Quintals	0.69	1.22	-0.53	-76.81
	b. DAP	Quintals	0.78	1.33	-0.55	-70.51
	c. MOP	Quintals	0.64	0.65	-0.01	-1.56
	Total	Quintals	2.11	3.20	-1.09	-51.66
7	Plant protection chemicals					
	a. Pesticide	Litres	1.31	1.44	-0.13	-9.92
8	Main product	Quintals	29.17	19.38	9.79	33.56
9	By-product	Quintals	19.21	15.46	3.75	19.52

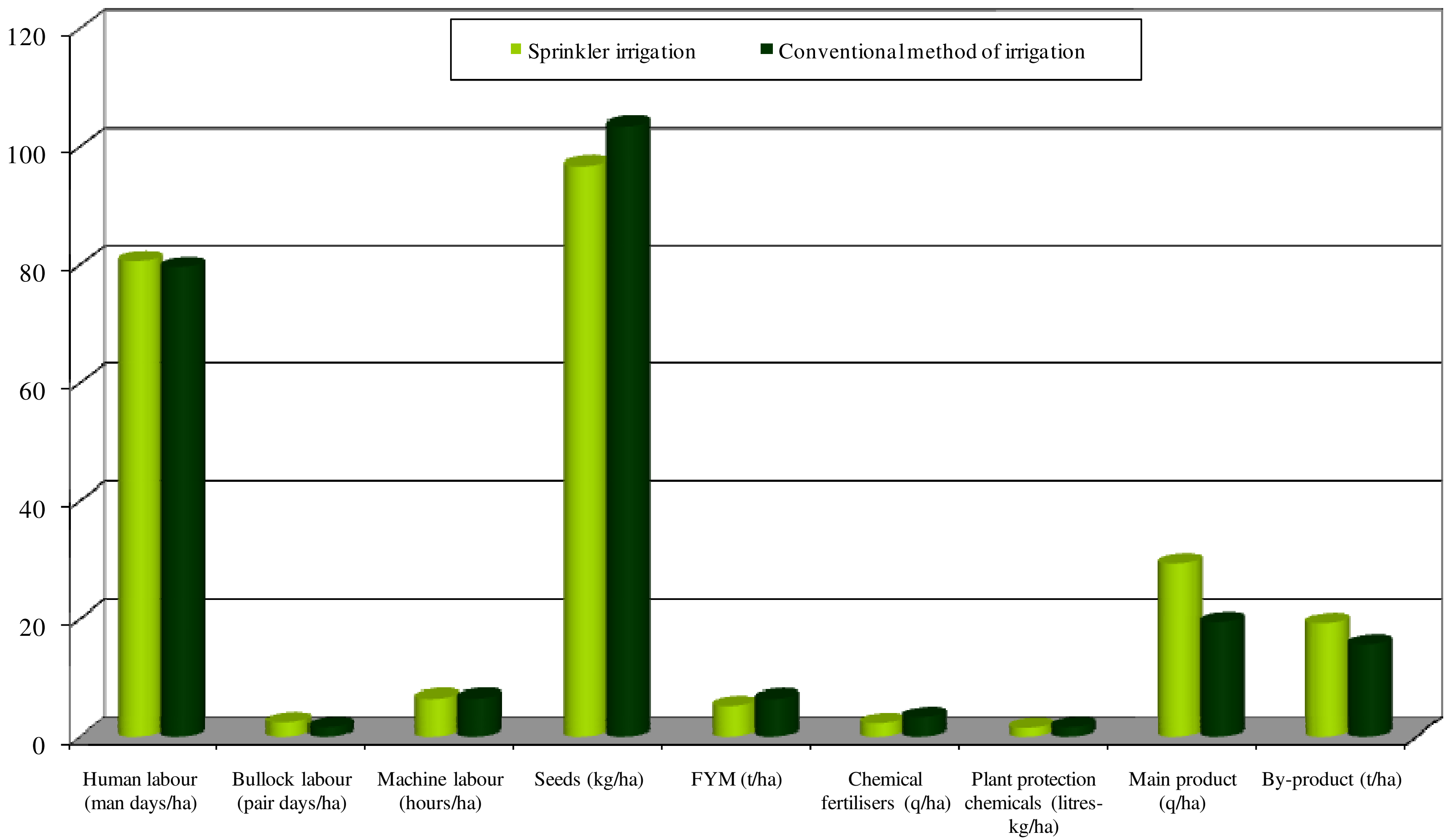

Fig. 17: Input use pattern and output obtained in groundnut cultivation under sprinkler irrigation and conventional method of irrigation in the study area

Table 4.21: Cost involved in cultivation of groundnut under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference	Difference
		Quantity	Value (`)	Per cent to total cost	Quantity	Value (`)	Per cent to total cost	Value (`)	(%)
A.	**Variable cost**								
1	Human labour (man days)	80.57	16,315.30	27.08	79.49	16,825.38	28.24	-510.08	-3.13
2	Bullock labour (pair days)	2.25	1,620.00	2.69	1.42	1,057.78	1.78	562.22	34.70
3	Machine labour (hours)	6.38	4,228.75	7.02	6.42	4,737.64	7.95	-508.89	-12.03
4	Seeds (kilograms)	96.67	13,050.00	21.66	103.42	13,961.25	23.43	-911.25	-6.98
5	FYM (tonnes)	5.13	5,022.50	8.34	6.33	6,333.33	10.63	-1,310.83	-26.10
6	Chemical fertilisers (quintals)								
	d. Urea	0.69	496.03	0.82	1.22	877.50	1.47	-381.47	-76.90
	e. DAP	0.78	1,738.28	2.89	1.33	2,933.33	4.92	-1,195.05	-68.75
	f. MOP	0.64	1,083.75	1.80	0.65	1,097.92	1.84	-14.17	-1.31
	Total	2.11	3,318.06	5.51	3.20	4,908.75	8.24	-1,590.69	-47.94
7	Plant protection chemicals (litres)								
	a. Pesticide	1.31	630.00	1.05	1.44	690.00	1.16	-60.00	-9.52
8	Interest on working capital @ 7 %		1,546.46	2.57		1,697.99	2.85	-151.53	-9.80
	Sub total		45,731.07	75.91		50,212.13	84.28	-4,481.06	-9.80

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Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference	Difference
		Quantity	Value (`)	Per cent to total cost	Quantity	Value (`)	Per cent to total cost	Value (`)	(%)
B.	**Fixed cost**								
1	Land revenue		30.00	0.05		30.00	0.05	0.00	0.00
2	Rental value of the land		4,687.50	7.78		4,687.50	7.87	0.00	0.00
3	Depreciation		1,026.56	1.70		1,046.59	1.76	-20.03	-1.95
4	Apportioned cost of irrigation structure		7,949.05	13.19		3,073.79	5.16	4,875.26	61.33
5	Interest on fixed capital @ 12 %		821.59	1.36		530.27	0.89	291.32	35.46
	Sub total		14,514.69	24.09		9,368.15	15.72	5,146.54	35.46
	Total cost of cultivation		**60,245.77**	**100.00**		**59,580.28**	**100.00**	**665.49**	**1.10**

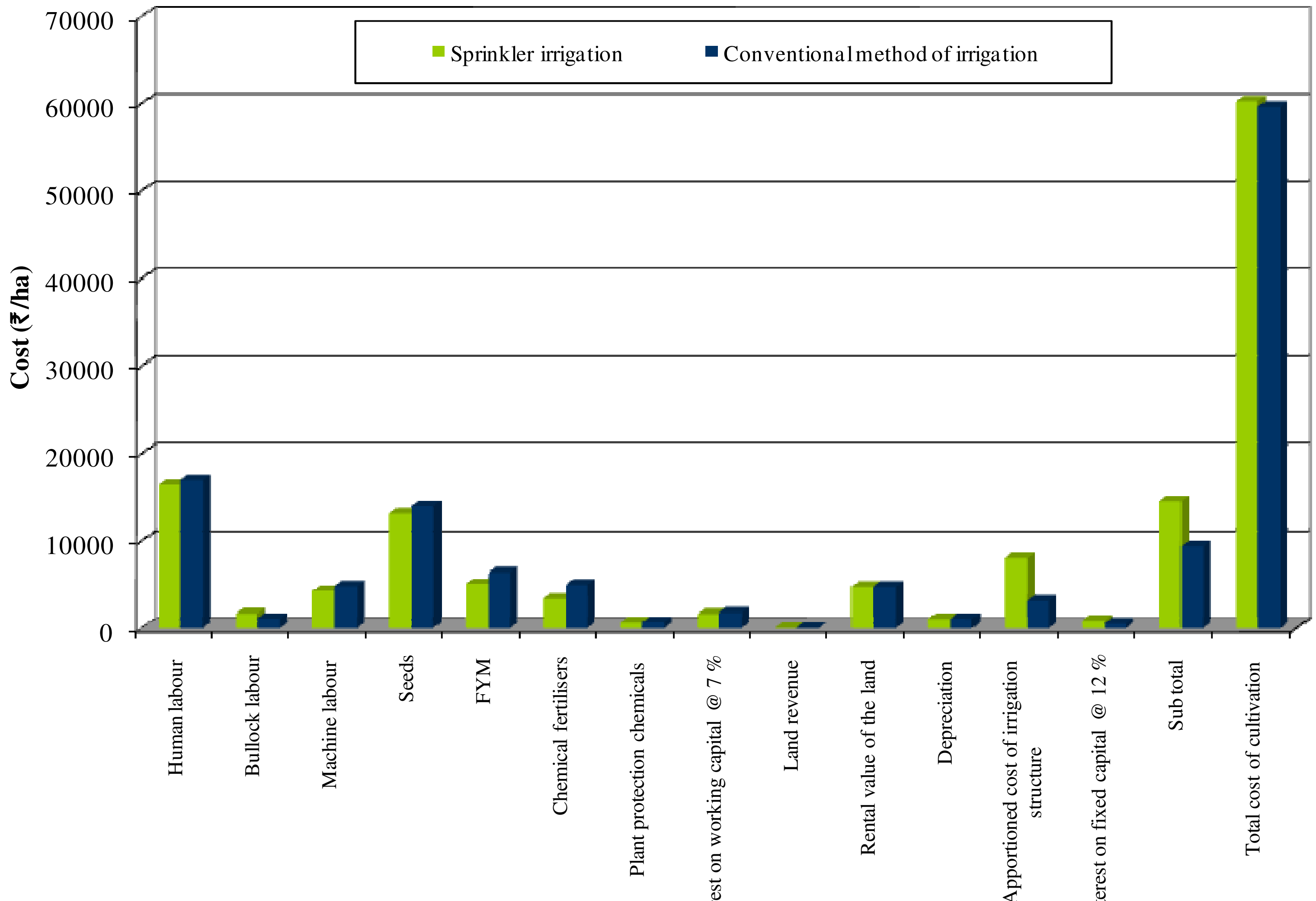

Fig. 18: Cost involved in cultivation of groundnut under sprinkler irrigation and conventional method of irrigation in the study area

(4.79 man days), spreading of farmyard manure (2.71 man days), drying and packing (2.23 man days), harrowing (0.75 man days) and ploughing (0.67 man days).

4.5.3.2 Input use pattern and output obtained in groundnut cultivation under sprinkler irrigation and conventional methods of irrigation

Inputs used and output obtained per hectare of groundnut cultivation in the study area are presented in Table 4.20 and Fig. 17.

It can be observed from the table that, the average per hectare utilisation of seeds among the different irrigation methods was highest in case of conventional method of irrigation (103.42 kg/ha) compared to sprinkler irrigation (96.67 kg/ha). The average per hectare utilisation of human labour was highest in case of sprinkler irrigation (80.57 man days) compared to conventional method of irrigation (79.49 man days). The highest tractor labour used under conventional method of irrigation was highest (6.42 hours) followed by sprinkler irrigation (6.38 hours). The bullock labour used under sprinkler irrigation was 2.25 pair days whereas it was 1.42 pair days under conventional method of irrigation.

It could also be observed from the table 4.20 that the use of farmyard manure, chemical fertilisers and plant protection chemicals was highest under conventional method of irrigation (6.33 t/ha, 3.20 q/ha & 1.44 lit/ha, respectively) compared to sprinkler irrigation (5.13 t/ha, 2.11 q/ha & 1.31 lit/ha, respectively).

The highest groundnut yield was obtained in case of sprinkler irrigated farms compared to conventional irrigated farms. It was 29.17 q/ha under sprinkler irrigated farms and 19.38 q/ha under conventional irrigated farms. The average quantity of groundnut by product was also highest under sprinkler irrigated farms (19.21 t/ha) compared to conventional irrigated farms (15.46 t/ha).

4.5.3.3 Cost involved in cultivation of groundnut under sprinkler irrigation and conventional methods of irrigation

The costs incurred in cultivation of groundnut under sprinkler and conventional methods of irrigation were analysed and are presented in Table 4.21 and Fig. 18.

It could be noticed from the table that the total variable cost incurred per hectare under conventional method of irrigation was highest (` 50,212.13/ha) compared to sprinkler irrigated farms (` 45,731.07/ha). The distribution pattern of operational cost under various inputs revealed that the cost of human labour was highest in case of conventional method of irrigation (` 16,825.38/ha) compared to sprinkler irrigation (` 16,315.30/ha). Whereas bullock labour cost in case of sprinkler irrigation was highest (` 1,620.00/ha) compared to conventional method of irrigation (` 1,057.78/ha). The cost of tractor labour and cost of seeds were also highest in case of conventional method of irrigation (` 4,737.64/ha & ` 13,961.25/ha, respectively) compared to sprinkler irrigation (` 4,228.75/ha & ` 13,050.00/ha, respectively).

It could also be observed from the table that expenditure on farmyard manure, chemical fertilisers and plant protection chemicals applied per hectare in the study area was more under conventional method of irrigation (` 6,333.33/ha, ` 4,908.75/ha & ` 690/ha, respectively) and is compared to less in sprinkler irrigated farms (` 5,022.50/ha, ` 3,318.06/ha & ` 630.00/ha, respectively).

The irrigation method wise analysis indicated that the fixed cost incurred per hectare in case of sprinkler irrigated farms was highest (` 145,14.69/ha) compared to conventional irrigated farms (` 9,368.15/ha). Among the different components of fixed cost, apportioned cost of irrigation structure was highest under sprinkler irrigated farms (` 7,949.05/ha) and in case of conventional method of irrigation rental value of the land was highest (` 4,687.50/ha). The other components like land revenue, depreciation charges and interest on fixed cost are of minor importance.

Among the two methods of irrigation, the total cost incurred in case of sprinkler irrigation was highest (` 6,02,45.77/ha) as compared to cost incurred in cultivation of groundnut under conventional method of irrigation (` 59,580.28/ha).

4.5.3.4 Returns from cultivation of groundnut under sprinkler irrigation and conventional methods of irrigation

The returns obtained from groundnut cultivation under sprinkler irrigation and conventional method of irrigation is presented in Table 4.22 and Fig. 19.

The irrigation method wise analysis of gross returns indicated that the gross returns obtained per hectare in case of sprinkler irrigated farms was high (` 1,36,868.06/ha) compared to conventional irrigated farms (` 90,977.08/ha). With respect to net returns also the per hectare net returns obtained under sprinkler irrigated farms was high (` 76,622.29/ha) compared to conventional irrigated farms (` 31,396.80/ha).

Thus the cultivation of groundnut crop in the study area was found to be highly profitable under sprinkler irrigation as also supported by a high benefit cost ratio of 2.27 compared to groundnut cultivation under conventional method of irrigation with benefit cost ratio of 1.53.

4.5.4 Redgram

4.5.4.1 Labour utilisation pattern in redgram cultivation under sprinkler irrigation and conventional methods of irrigation

The labour utilisation pattern in cultivation of redgram under sprinkler and conventional method of irrigation is depicted in Table 4.23.

In case of redgram cultivation under sprinkler irrigation system, about 4.00, 1.78, 1.75 and 2.50 hours of machine labour were used for ploughing, transportation of farmyard manure, harrowing and threshing, respectively. Per hectare bullock labour used for ploughing and harrowing was 0.83 pair days in each case and it was 0.89 pair days for transportation of farmyard manure. Among the human labour used for different operations, the highest human labour was used for weeding (18.57 man days) followed by irrigation (16.38 man days), harvesting (12.30 man days), sowing (8.14 man days), threshing (5.78 man days), transportation of farmyard manure (5.24 man days), drying and packing (2.63 man days), spreading of farmyard manure and (2.54 man days), fertiliser application (2.13 man days), application of plant protection chemicals (1.20 man days) and, ploughing and harrowing (0.83 man days in each operation).

Table 4.22: Returns from cultivation of groundnut under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)	Conventional method of irrigation (n=60)	Difference	Difference (%)
1	Yield				
	c. Main product (quintals)	29.17	19.38	9.79	33.56
	d. By-product (quintals)	19.21	15.46	3.75	19.52
2	Market price				
	b. Main product (`)	4,363.33	4,296.67	66.66	1.53
	c. By-product (`)	500.00	500.00	0.00	0.00
3	Gross returns (`)	1,36,868.06	90,977.08	45,890.98	33.53
4	Total cost (`)	60,245.77	59,580.28	665.49	1.10
5	Net returns (`)	76,622.29	31,396.80	45,225.49	59.02
6	Returns per rupee of investment	2.27	1.53	0.74	32.60

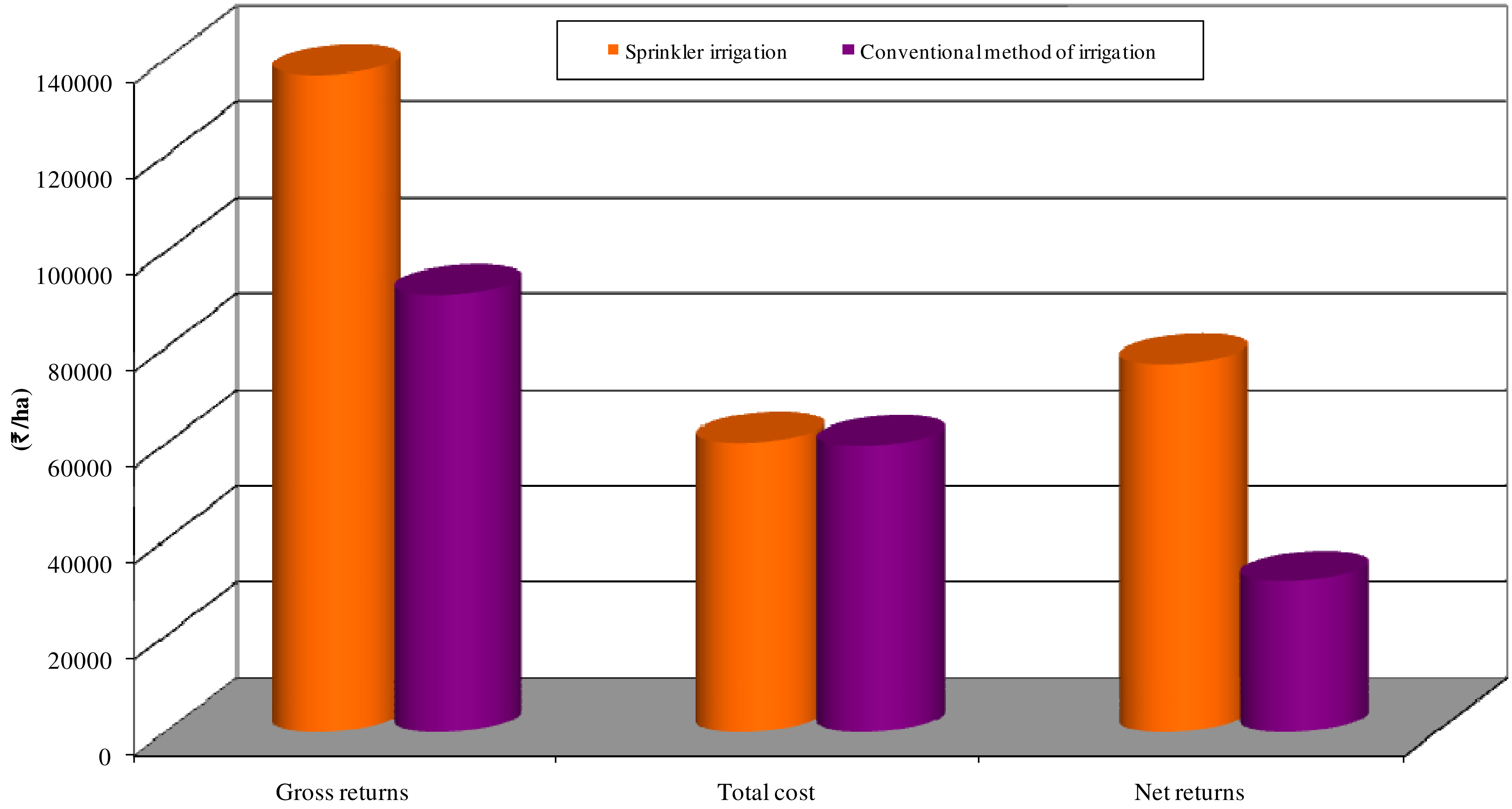

Fig. 19: Returns from cultivation of groundnut under sprinkler irrigation and conventional method of irrigation in the study area

Table 4.23: Labour utilisation pattern in redgram cultivation under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference		
		Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)	Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)	Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)
1	Ploughing	0.83	0.83	4.00	0.38	0.38	3.38	0.45 (54.22)	0.45 (54.22)	0.62 (15.50)
2	Transportation of FYM	5.24	0.89	1.78	5.21	0.83	1.79	0.03 (0.57)	0.06 (6.74)	-0.01 (-0.56)
3	Spreading of FYM	2.54	-	-	2.70	-	-	-0.16 (-6.30)	-	-
4	Harrowing	0.83	0.83	1.75	0.50	0.50	2.04	0.33 (39.76)	0.33 (39.76)	-0.29 (-16.57)
5	Sowing	8.14	-	-	11.33	-	-	-3.19 (-39.19)	-	-
6	Fertilizer application	2.13	-	-	2.30	-	-	-0.17 (-7.98)	-	-
7	Weeding	18.57	-	-	31.45	-	-	-12.88 (-69.36)	-	-
8	Irrigation	16.38	-	-	4.46	-	-	11.92 (72.77)	-	-
9	Application of PPC	1.20	-	-	1.72	-	-	-0.52 (-43.33)	-	-
10	Harvesting	12.30	-	-	10.71	-	-	1.59 (12.93)	-	-
11	Threshing	5.78	-	2.50	5.56	-	2.50	0.22 (3.81)	-	-
12	Drying and packing	2.63	-	-	2.22	-	-	0.41 (15.59)	-	-

Note: Figures in the parentheses indicate percentage difference

In case of redgram cultivation under conventional method of irrigation system, about 3.38, 1.79, 2.04 and 2.50 hours of machine labour were used for ploughing, transportation of farmyard manure, harrowing and threshing, respectively. Per hectare bullock labour used for ploughing, harrowing and transportation of farmyard manure was 0.38, 0.83 and 0.50 pair days, respectively. Among the human labour used for different operations, the highest human labour was used for weeding (31.45 man days) followed by harvesting (10.71 man days), sowing (11.33 man days), threshing (5.56 man days), transportation of farmyard manure (5.21 man days), irrigation (4.46 man days), spreading of farmyard manure (2.70 man days), fertiliser application (2.30 man days), drying and packing (2.22 man days), application of plant protection chemicals (1.72 man days), harrowing (0.50 man days) and ploughing (0.38 man days).

4.5.4.2 Input use pattern and output obtained in redgram cultivation under sprinkler irrigation and conventional method of irrigation

Inputs used and output obtained per hectare of redgram cultivation in the study area are presented in Table 4.24 and Fig. 20.

It can be observed from the table that, the average per hectare utilisation of seeds among the different irrigation methods was highest in case of conventional method of irrigation (10.88 kg/ha) compared to sprinkler irrigation (9.54 kg/ha). The average per hectare utilisation of human labour was highest in case of conventional method of irrigation (78.52 man days) compared to sprinkler irrigation (76.58 man days). The highest tractor labour used under conventional method of irrigation was low (9.71 hours) compared to sprinkler irrigation (10.03 hours). The bullock labour used under sprinkler irrigation was 2.56 pair days whereas it was 1.71 pair days under conventional method of irrigation.

It could also be observed from the table that the use of farmyard manure, chemical fertilisers and plant protection chemicals was highest under conventional method of irrigation (6.13 t/ha, 3.28 q/ha & 2.17 lit/ha, respectively) compared to sprinkler irrigation (5.33 t/ha, 2.61 q/ha & 1.75 lit/ha, respectively).

The highest redgram yield was obtained in case of sprinkler irrigated farms (19.42 q/ha) compared to conventional irrigated farms (13.92 q/ha).

4.5.4.3 Cost involved in cultivation of redgram under sprinkler irrigation and conventional method of irrigation

The costs incurred in cultivation of redgram under sprinkler and conventional methods of irrigation were analysed and are presented in Table 4.25 and Fig. 21.

It could be noticed from the table that the total variable cost incurred per hectare under conventional method of irrigation was highest (` 39,759.62/ha) compared to sprinkler irrigated farms (` 38,439.64/ha). The distribution pattern of operational cost under various inputs revealed that the cost of human labour was highest in case of conventional method of irrigation (` 16,293.93/ha) compared to sprinkler irrigation (` 16,273.58/ha). Whereas bullock labour cost in case of sprinkler irrigation was highest (` 2,040.19/ha) compared to conventional method of irrigation (` 1,478.75/ha). The cost of tractor labour was highest under sprinkler irrigation (` 8,089.07/ha) compared to conventional method of irrigation (` 7,930.17/ha) and cost of seeds was also highest in case of conventional method of irrigation (` 712.31/ha) compared to sprinkler irrigation (` 618.62/ha).

Table 4.24: Input use pattern and output obtained in redgram cultivation under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Units	Sprinkler irrigation n=60	Conventional method of irrigation n=60	Difference	Difference (%)
1	Human labour	Man days	76.58	78.52	-1.94	-2.53
2	Bullock labour	Pair days	2.56	1.71	0.85	33.20
3	Machine labour	Hours	10.03	9.71	0.32	3.19
4	Seeds	Kilograms	9.54	10.88	-1.34	-14.05
5	Farm Yard Manure	Tonnes	5.33	6.13	-0.8	-15.01
6	Chemical fertilisers					
	a. Urea	Quintals	1.16	1.52	-0.36	-31.03
	b. DAP	Quintals	0.81	0.93	-0.12	-14.81
	c. MOP	Quintals	0.65	0.83	-0.18	-27.69
	Total	Quintals	2.61	3.28	-0.67	-25.67
7	Plant protection chemicals					
	a. Pesticide	Litres	1.75	2.17	-0.42	-24.00
8	Main product	Quintals	19.42	13.92	5.5	28.32

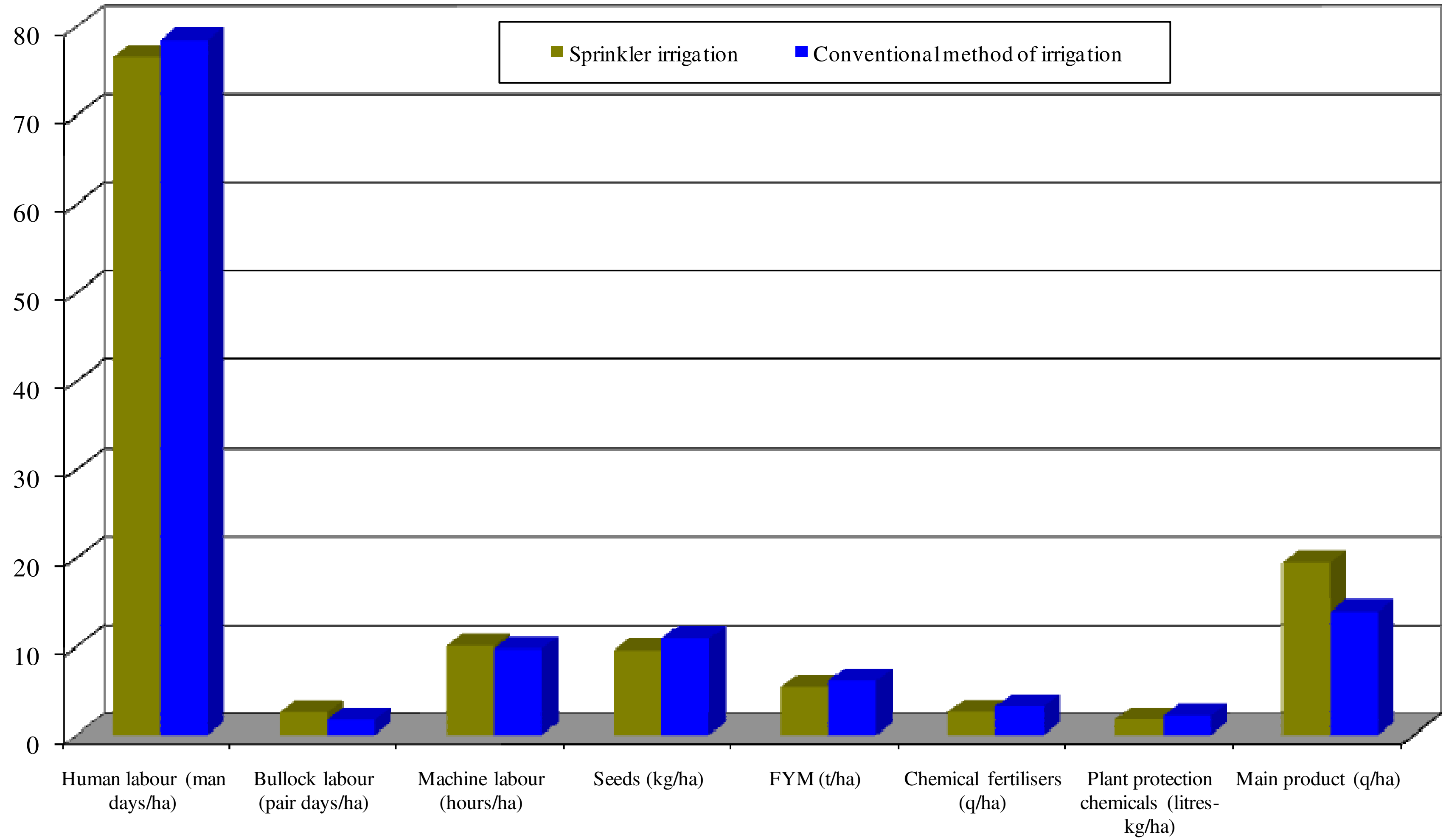

Fig. 20: Input use pattern and output obtained in redgram cultivation under sprinkler irrigation and conventional method of irrigation in the study area

It could also be observed from the table that expenditure on farmyard manure, chemical fertilisers and plant protection chemicals applied per hectare in the study area was more under conventional method of irrigation (` 6,125.00/ha, ` 5,073.26/ha & ` 801.67/ha, respectively) and is less in sprinkler irrigated farms (` 5,333.33/ha, ` 4,137.46/ha & ` 647.50/ha, respectively).

The irrigation method wise analysis indicated that the fixed cost incurred per hectare in case of sprinkler irrigated farms was highest (` 15,793.35/ha) compared to conventional irrigated farms (` 9,594.51/ha). Among the different components of fixed cost, apportioned cost of irrigation structure was highest under sprinkler irrigated farms (` 8,938.13/ha) and in case of conventional method of irrigation rental value of the land was highest (` 4,375.00/ha). The other components like land revenue, depreciation charges and interest on fixed cost are of minor importance.

Among the two methods of irrigation, the total cost incurred in case of sprinkler irrigation was highest (` 54,232.99/ha) as compared to cost incurred in cultivation of redgram under conventional method of irrigation (` 49,354.13/ha).

4.5.4.4 Returns from cultivation of redgram under sprinkler irrigation and conventional method of irrigation

The returns obtained from redgram cultivation under sprinkler irrigation and conventional method of irrigation is presented in Table 4.26 and Fig. 22.

The irrigation method wise analysis of gross returns indicated that the gross returns obtained per hectare in case of sprinkler irrigated farms was high (` 1,40,317.78/ha) compared to conventional irrigated farms (` 99,504.17/ha). With respect to net returns also the per hectare net returns obtained under sprinkler irrigated farms was high (` 86,084.79/ha) compared to conventional irrigated farms (` 50,150.03/ha).

Thus the cultivation of redgram crop in the study area was found to be highly profitable under sprinkler irrigation and is supported by a high benefit cost ratio of 2.59 compared to redgram cultivation under conventional method of irrigation with benefit cost ratio of 2.02.

4.5.5 Sorghum

4.5.5.1 Labour utilisation pattern in *rabi* sorghum cultivation under sprinkler irrigation and conventional method of irrigation

The labour utilisation pattern in cultivation of sorghum under sprinkler and conventional method of irrigation is depicted in Table 4.27

In case of sorghum cultivation under sprinkler irrigation system, about 2.38, 1.38, 1.38 and 2.50 hours of machine labour were used for ploughing, transportation of farmyard manure, harrowing and threshing, respectively. Per hectare bullock labour used for ploughing, harrowing and transportation of farmyard manure was 1.13 pair days in each operation. Among the human labour used for different operations, the highest human labour was used for irrigation (19.32 man days) followed by weeding (12.81 man days), harvesting (11.38 man days), sowing (8.90 man days), threshing (6.38 man days), transportation of farmyard manure (4.63 man days), fertiliser application

Table 4.25: Cost involved in cultivation of redgram under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference	Difference
		Quantity	Value (`)	Per cent to total cost	Quantity	Value (`)	Per cent to total cost	Value (`)	(%)
A.	**Variable cost**								
1	Human labour (man days)	76.58	16,273.58	30.01	78.52	16,293.93	33.01	-20.35	-0.13
2	Bullock labour (pair days)	2.56	2,040.19	3.76	1.71	1,478.75	3.00	561.44	27.52
3	Machine labour (hours)	10.03	8,089.07	14.92	9.71	7,930.17	16.07	158.9	1.96
4	Seeds (kilograms)	9.54	618.62	1.14	10.88	712.31	1.44	-93.69	-15.15
5	FYM (tonnes)	5.33	5,333.33	9.83	6.13	6,125.00	12.41	-791.67	-14.84
6	Chemical fertilisers (quintals)								
	a. Urea	1.16	820.94	1.51	1.52	1,079.79	2.19	-258.85	-31.53
	b. DAP	0.81	1,915.06	3.53	0.93	2,185.14	4.43	-270.08	-14.10
	c. MOP	0.65	1,401.46	2.58	0.83	1,808.33	3.66	-406.87	-29.03
	Total	2.61	4,137.46	7.63	3.28	5,073.26	10.28	-935.8	-22.62
7	Plant protection chemicals (litres)								
	a. Pesticide	1.75	647.50	1.19	2.17	801.67	1.62	-154.17	-23.81
8	Interest on working capital @ 7 %		1,299.89	2.40		1,344.53	2.72	-44.64	-3.43
	Sub total		38,439.64	70.88		39,759.62	80.56	-1,319.98	-3.43

Contd…..

Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference	Difference
		Quantity	Value (`)	Per cent to total cost	Quantity	Value (`)	Per cent to total cost	Value (`)	(%)
B.	**Fixed cost**								
1	Land revenue		30.00	0.06		30.00	0.06	0	0.00
2	Rental value of the land		4,375.00	8.07		4,375.00	8.86	0	0.00
3	Depreciation		1,556.26	2.87		1,651.60	3.35	-95.34	-6.13
4	Apportioned cost of irrigation structure		8,938.13	16.48		2,994.82	6.07	5,943.31	66.49
5	Interest on fixed capital @ 12 %		893.96	1.65		543.09	1.10	350.87	39.25
	Sub total		15,793.35	29.12		9,594.51	19.44	6,198.84	39.25
	Total cost of cultivation		**54,232.99**	**100.00**		**49,354.13**	**100.00**	**4,878.86**	**9.00**

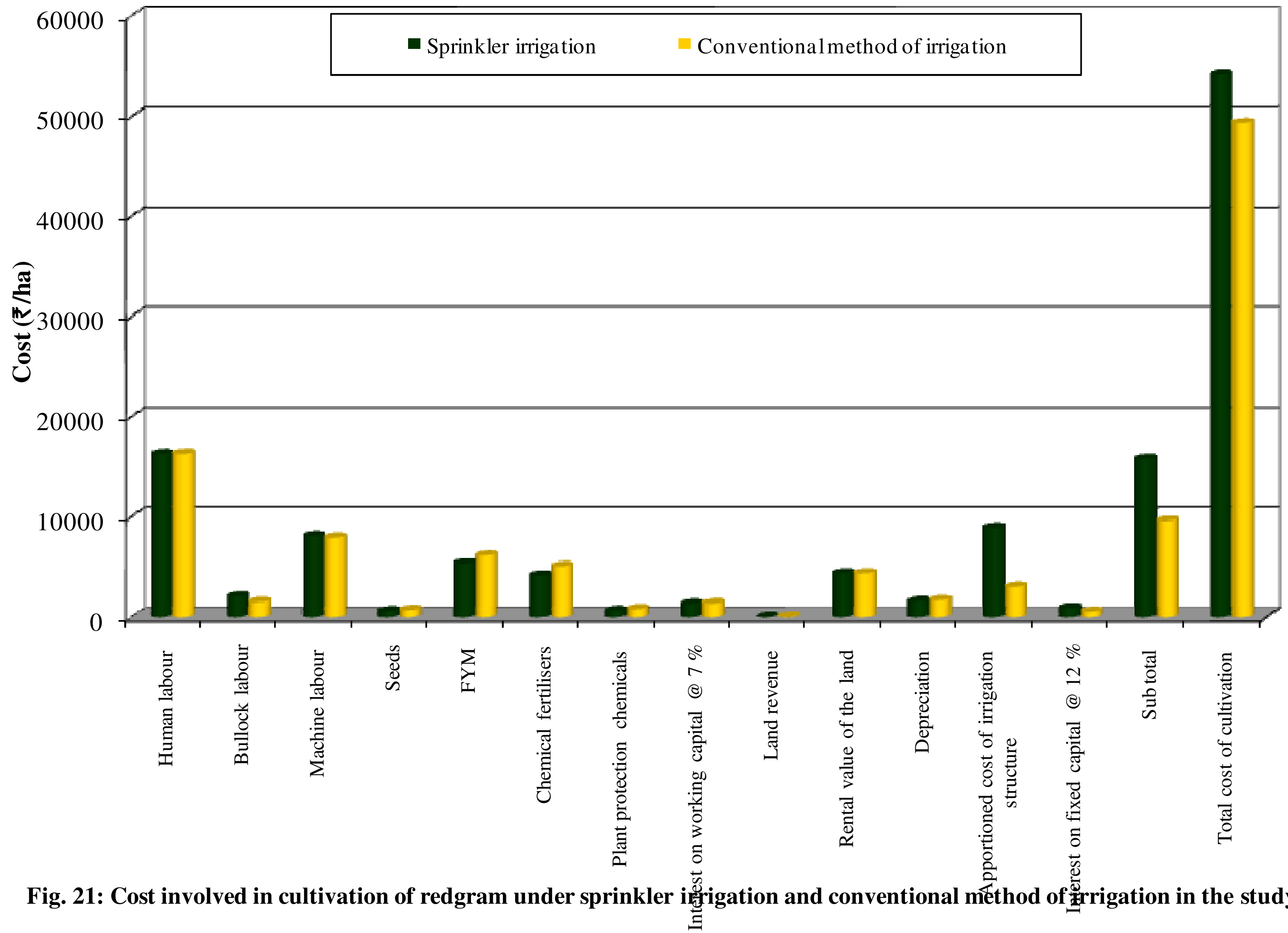

Fig. 21: Cost involved in cultivation of redgram under sprinkler irrigation and conventional method of irrigation in the study area

Table 4.26: Returns from cultivation of redgram under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)	Conventional method of irrigation (n=60)	Difference	Difference (%)
1	Yield (quintals)	19.42	13.92	5.50	28.32
2	Market price	7,226.67	7,150.00	76.67	1.06
3	Gross returns (`)	1,40,317.78	99,504.17	40,813.61	29.09
4	Total cost (`)	54,232.99	49,354.13	4,878.86	9.00
5	Net returns (`)	86,084.79	50,150.03	35,934.76	41.74
6	Returns per rupee of investment	2.59	2.02	0.57	22.01

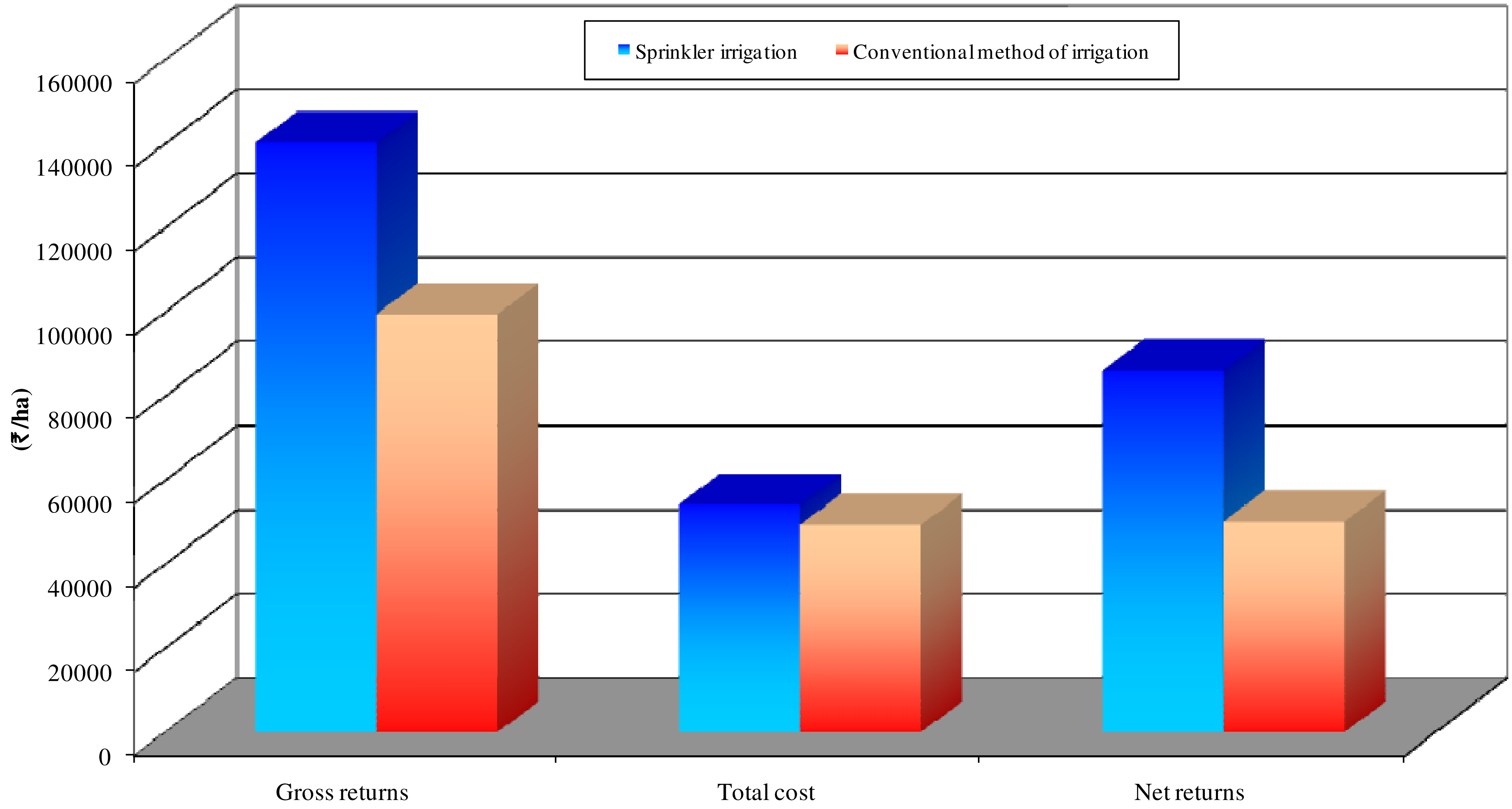

Fig. 22: Returns from cultivation of redgram under sprinkler irrigation and conventional method of irrigation in the study area

Table 4.27: Labour utilisation pattern in *rabi* sorghum cultivation under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference		
		Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)	Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)	Human labour (man days)	Bullock pair (pair days)	Machine labour (hours)
1	Ploughing	1.13	1.13	2.38	0.75	0.75	3.21	0.38 (33.63)	0.38 (33.63)	-0.83 (-34.87)
2	Transportation of FYM	4.63	1.13	1.38	5.08	1.29	1.21	-0.45 (-9.72)	-0.16 (-14.16)	0.17 (12.32)
3	Spreading of FYM	1.28	-	-	1.08	-	-	0.20 (15.63)	-	-
4	Harrowing	1.13	1.13	1.38	0.79	0.79	2.08	0.34 (30.09)	0.34 (30.09)	-0.70 (-50.72)
5	Sowing	8.90	-	-	10.92	-	-	-2.02 (-22.70)	-	-
6	Fertilizer application	1.85	-	-	2.13	-	-	-0.28 (-15.14)	-	-
7	Weeding	12.81	-	-	21.51	-	-	-8.70 (-67.92)	-	-
8	Irrigation	19.32	-	-	5.28	-	-	14.04 (72.67)	-	-
9	Application of PPC	1.50	-	-	1.65	-	-	-0.15 (-10.00)	-	-
10	Harvesting	11.38	-	-	9.76	-		1.62 (14.24)	-	-
11	Threshing	6.38	-	2.50	4.67	-	2.50	1.71 (26.80)	-	-
12	Drying and packing	1.53	-	-	1.32	-	-	0.21 (13.73)	-	-

Note: Figures in the parentheses indicate percentage difference

(1.85 man days), drying and packing (1.53 man days), application of plant protection chemicals (1.50 man days), spreading of farmyard manure and (1.28 man days) and, ploughing and harrowing (1.13 man days in each operation).

Similarly in case of sorghum cultivation under conventional method of irrigation, about 3.21, 1.21, 2.08 and 2.50 hours of machine labour were used for ploughing, transportation of farmyard manure, harrowing and threshing, respectively. Per hectare bullock labour used for ploughing, harrowing and transportation of farmyard manure was 0.75, 0.79 and 1.29 pair days, respectively. Among the human labour used for different operations, the highest human labour was used for weeding (21.51 man days) followed by sowing (10.92 man days), harvesting (9.76 man days), irrigation (5.28 man days), transportation of farmyard manure (5.08 man days), threshing (4.67 man days), fertiliser application (2.13 man days), application of plant protection chemicals (1.65 man days), drying and packing (1.32 man days), spreading of farmyard manure and (1.08 man days), harrowing (0.79 man days) and ploughing (0.75 man days).

4.5.5.2 Input use pattern and output obtained in *rabi* sorghum cultivation under sprinkler irrigation and conventional method of irrigation

Inputs used and output obtained per hectare of sorghum cultivation in the study area are presented in Table 4.28 and Fig. 23.

It can be observed from the table that, the average per hectare utilisation of seeds among the different irrigation methods was highest in case of conventional method of irrigation (9.88 kg/ha) compared to sprinkler irrigation (7.29 kg/ha). The average per hectare utilisation of human labour was highest in case of sprinkler irrigation (71.83 man days) compared to conventional method of irrigation (64.94 man days). The highest tractor labour used under conventional method of irrigation was high (9.00 hours) compared to sprinkler irrigation (7.63 hours). The bullock labour used under sprinkler irrigation was 3.38 pair days whereas it was 2.83 pair days under conventional method of irrigation.

It could also be observed from the table that the use of farmyard manure, chemical fertilisers and plant protection chemicals was highest under conventional method of irrigation (4.38 t/ha, 3.80 q/ha & 3.94 lit/ha, respectively) compared to sprinkler irrigation (3.92 t/ha, 3.28 q/ha & 2.98 lit/ha, respectively).

The highest sorghum yield was obtained in case of sprinkler irrigated farms compared to conventional irrigated farms. It was 34.67 q/ha under sprinkler irrigated farms and 24.63 q/ha under conventional irrigated farms. The average quantity of sorghum by product was also highest under sprinkler irrigated farms (9.71 t/ha) compared to conventional irrigated farms (8.04 t/ha).

4.5.5.3 Cost involved in cultivation of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation

The costs incurred in cultivation of sorghum under sprinkler and conventional methods of irrigation were analysed and are presented in Table 4.29 and Fig. 24.

Table 4.28: Input use pattern and output obtained in *rabi* sorghum cultivation under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Units	Sprinkler irrigation n=60	Conventional method of irrigation n=60	Difference	Difference (%)
1	Human labour	Man days	71.83	64.94	6.89	9.59
2	Bullock labour	Pair days	3.38	2.83	0.55	16.27
3	Machine labour	Hours	7.63	9.00	-1.37	-17.96
4	Seeds	Kilograms	7.29	9.88	-2.59	-35.53
5	Farm Yard Manure	Tonnes	3.92	4.38	-0.46	-11.73
6	Chemical fertilisers					
	a. Urea	Quintals	1.60	1.85	-0.25	-15.63
	b. DAP	Quintals	0.93	1.12	-0.19	-20.43
	c. MOP	Quintals	0.75	0.82	-0.07	-9.33
	Total	Quintals	3.28	3.80	-0.52	-15.85
7	Plant protection chemicals					
	a. Pesticide	Litres	1.46	1.90	-0.44	-30.14
	b. Herbicide	Kilograms	1.52	2.04	-0.52	-34.21
	Total	Litres/Kilograms	2.98	3.94	-0.96	-32.21
8	Main product	Quintals	34.67	24.63	10.04	28.96
9	By-product	Tonnes	9.71	8.04	1.67	17.20

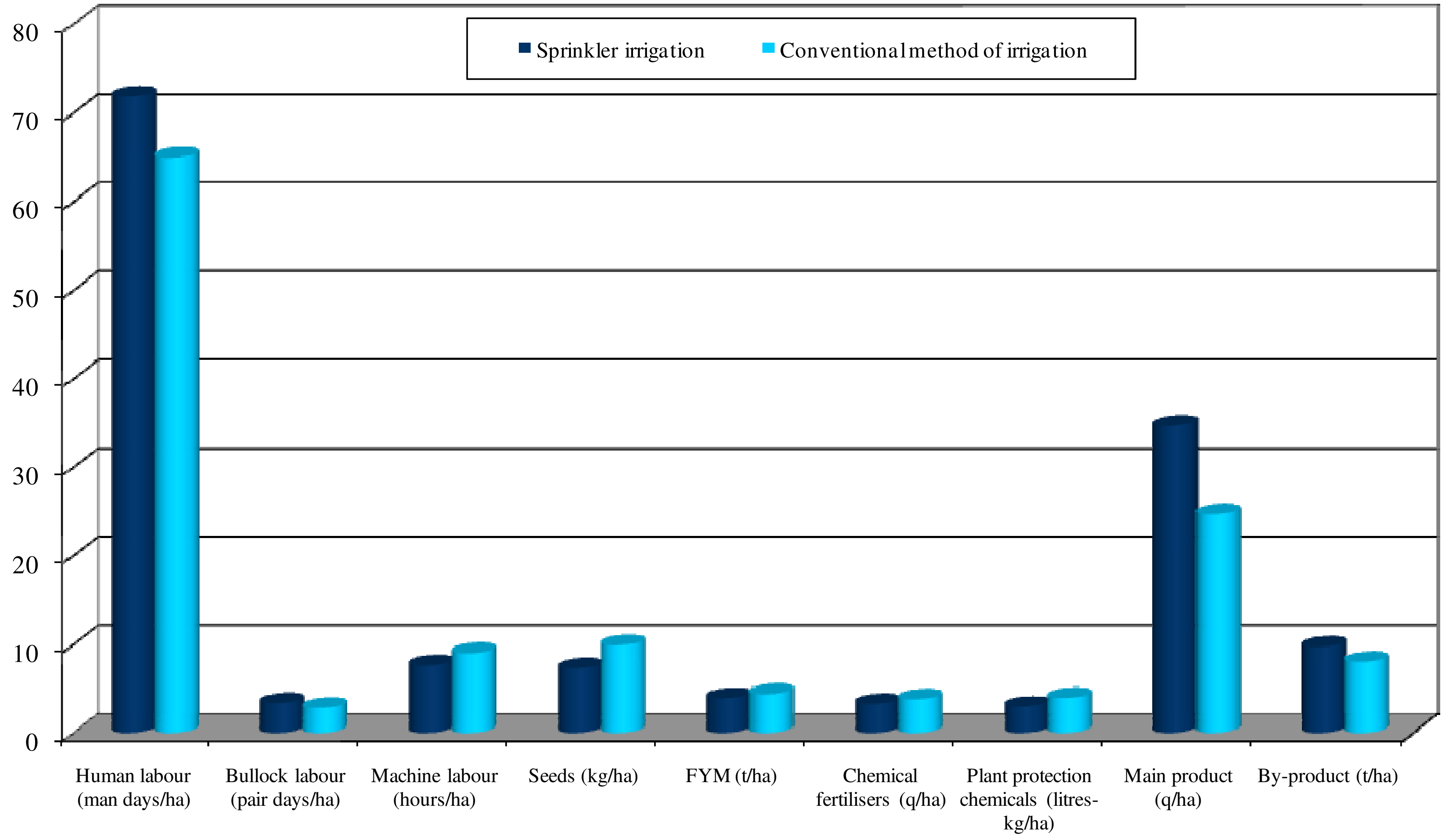

Fig. 23: Input use pattern and output obtained in *rabi* sorghum cultivation under sprinkler irrigation and conventional method of irrigation in the study area

It could be noticed from the table that the total variable cost incurred per hectare under conventional method of irrigation was highest (` 36,746.32/ha) compared to sprinkler irrigated farms (` 35,685.81/ha). The distribution pattern of operational cost under various inputs revealed that the cost of human labour was highest in case of sprinkler irrigation (` 15,264.15/ha) compared to conventional method of irrigation (` 13,476.05/ha). The bullock labour cost in case of sprinkler irrigation was highest (` 2,694.38/ha) compared to conventional method of irrigation (` 2,455.56/ha). The cost of tractor labour was highest under conventional method of irrigation (` 7,350.00/ha) compared to conventional method of irrigation (` 6,150.83/ha) and cost of seeds was also highest in case of conventional method of irrigation (` 432.85/ha) compared to sprinkler irrigation (` 314.76/ha).

It could also be observed from the table that expenditure on farmyard manure, chemical fertilisers and plant protection chemicals applied per hectare in the study area was highest under conventional method of irrigation (` 4,375.00/ha, ` 5,748.82/ha & ` 1,665.42/ha, respectively) compared to sprinkler irrigated farms (` 3,916.67/ha, ` 4,951.59/ha & ` 1,186.67/ha, respectively).

The irrigation method wise analysis indicated that the fixed cost incurred per hectare in case of sprinkler irrigated farms was highest (` 15,793.35/ha) compared to conventional irrigated farms (` 9,594.51/ha). Among the different components of fixed cost, apportioned cost of irrigation structure was highest under sprinkler irrigated farms (` 8,938.13/ha) and in case of conventional method of irrigation rental value of the land was highest (` 4,375.00/ha). The other components like land revenue, depreciation charges and interest on fixed cost are of minor importance.

Among the two methods of irrigation, the total cost incurred in case of sprinkler irrigation was highest (` 51,479.16/ha) as compared to cost incurred in cultivation of sorghum under conventional method of irrigation (` 46,340.84/ha).

4.5.5.4 Returns from cultivation of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation

The returns obtained from sorghum cultivation under sprinkler irrigation and conventional method of irrigation is presented in Table 4.30 and Fig. 25.

The irrigation method wise analysis of gross returns indicated that the gross returns obtained per hectare in case of sprinkler irrigated farms was high (` 11,0471.94/ha) compared to conventional irrigated farms (` 75,022.92/ha). With respect to net returns also the per hectare net returns obtained under sprinkler irrigated farms was high (` 58,992.79/ha) compared to conventional irrigated farms (` 28,682.08/ha).

Thus the cultivation of sorghum crop in the study area was found to be highly profitable under sprinkler irrigation and is supported by a high benefit cost ratio of 2.15 compared to sorghum cultivation under conventional method of irrigation with benefit cost ratio of 1.62.

Table 4.29: Cost involved in cultivation of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference	Difference
		Quantity	Value (`)	Per cent to total cost	Quantity	Value (`)	Per cent to total cost	Value	(%)
A.	**Variable cost**								
1	Human labour (man days)	71.83	15,264.15	29.65	64.94	13,476.05	29.08	1,788.10	11.71
2	Bullock labour (pair days)	3.38	2,694.38	5.23	2.83	2,455.56	5.30	238.82	8.86
3	Machine labour (hours)	7.63	6,150.83	11.95	9.00	7,350.00	15.86	-1,199.17	-19.50
4	Seeds (kilograms)	7.29	314.76	0.61	9.88	432.85	0.93	-118.09	-37.52
5	FYM (tonnes)	3.92	3,916.67	7.61	4.38	4,375.00	9.44	-458.33	-11.70
6	Chemical fertilisers (quintals)								
	a. Urea	1.60	1,138.96	2.21	1.85	1,316.46	2.84	-177.50	-15.58
	b. DAP	0.93	2,185.14	4.24	1.12	2,646.63	5.71	-461.49	-21.12
	c. MOP	0.75	1,627.50	3.16	0.82	1,785.73	3.85	-158.23	-9.72
	Total	3.28	4,951.59	9.62	3.80	5,748.82	12.41	-797.23	-16.10
7	Plant protection chemicals (litres/kilograms)								
	a. Pesticide	1.46	700.00	1.36	1.90	910.00	1.96	-210.00	-30.00
	b. Herbicide	1.52	486.67	0.95	2.04	755.42	1.63	-268.75	-55.22
	Total	2.98	1,186.67	2.31	3.94	1,665.42	3.59	-478.75	-40.34
8	Interest on working capital @ 7 %		1,206.77	2.34		1,242.63	2.68	-35.86	-2.97
	Sub total		35,685.81	69.32		36,746.32	79.30	-1,060.51	-2.97

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Sl. No.	Particulars	Sprinkler irrigation (n=60)			Conventional method of irrigation (n=60)			Difference	Difference
		Quantity	Value (`)	Per cent to total cost	Quantity	Value (`)	Per cent to total cost	Value	(%)
B.	**Fixed cost**								
1	Land revenue		30.00	0.06		30.00	0.06	0.00	0.00
2	Rental value of the land		4,375.00	8.50		4,375.00	9.44	0.00	0.00
3	Depreciation		1,556.26	3.02		1,651.60	3.56	-95.34	-6.13
4	Apportioned cost of irrigation structure		8,938.13	17.36		2,994.82	6.46	5,943.31	66.49
5	Interest on fixed capital @ 12 %		893.96	1.74		543.09	1.17	350.87	39.25
	Sub total		15,793.35	30.68		9,594.51	20.70	6,198.84	39.25
	Total cost of cultivation		**51,479.16**	**100.00**		**46,340.84**	**100.00**	**5,138.32**	**9.98**

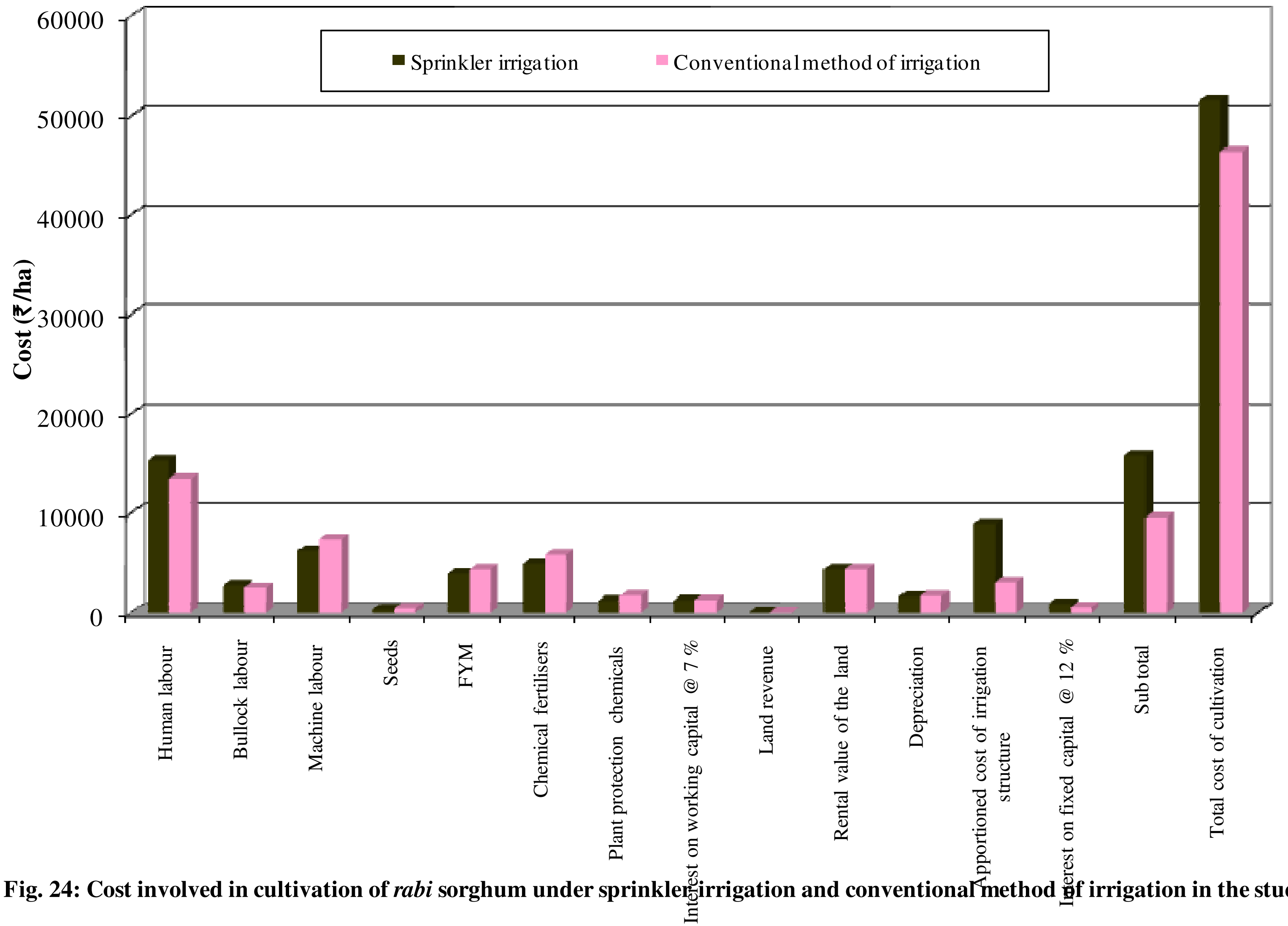

Fig. 24: Cost involved in cultivation of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area

4.5.6 Returns from cultivation of different crops under micro irrigation systems and conventional method of irrigation

The returns obtained from different methods of irrigation in selected crops presented in table 4.31.

The per hectare net returns and B-C ratio in case of sugarcane crop under micro irrigation (drip irrigation) was found to be highest (` 1,51,713 & 2.04, respectively) compared to conventional method of irrigation (` 50,552 & 1.28., respectively). Whereas in case of maize the net returns obtained and B-C ratio under micro irrigation (sprinkler irrigation) were found to be highest (` 43,109/ha & 1.78, respectively) compared to conventional method of irrigation (` 22,238 /ha & 1.39, respectively). Similarly the returns per rupee investment on sprinkler irrigation in case of groundnut, redgram and rabi sorghum were higher (2.27, 2.59 & 2.15, respectively) compared to conventional method of irrigation (1.53, 2.02 & 1.62, respectively).

4.6 Financial feasibility of investment on micro irrigation system and conventional method of irrigation

To evaluate the financial feasibility of investment on micro irrigation systems as well as on conventional method of irrigation the financial feasibilities tests namely, Net Present Value (NPV), Internal Rate of Returns (IRR), Benefit-Cost Ratio (BCR) and Pay Back Period (PBP) were computed by assuming the cash outflows and cash inflows are constant throughout the life period of the micro irrigation system and the average life span of the micro irrigation system is considered as ten years. To compare the financial feasibility of investment on micro irrigation system with that of conventional method of irrigation the cash flows for conventional method of irrigation were also worked out for ten years.

The annual net cash flows were discounted at a discount rate of 12 per cent to obtain the present value of net benefits from different methods of irrigation. The initial investment made on different irrigation methods then deducted from the present value of their net benefits.

4.6.1 Financial feasibility of investment on drip irrigation and conventional method of irrigation in cultivation of sugarcane

The results of the financial feasibility analysis of investment made on different irrigation methods in cultivation of different crops presented in Table 4.32 and Fig. 26.

In case of sugarcane the discounted Benefit Cost Ratios for investment on drip irrigation system with subsidy and without subsidy were 2.16 and 2.04, respectively. It can be concluded that investment on drip irrigation system in cultivation of sugarcane in the study area was economically feasible since Benefit Cost Ratio was more than one. The Net Present Value of the investment on drip irrigation system was ` 6,85,163.83 without subsidy and with subsidy it was ` 7,80,045. The positive Net Present Value indicates that the investment made on drip irrigation in cultivation of sugarcane was financial feasible. The Internal Rate of Return measures the rate of return that can be earned by investing on drip irrigation system. It also indicates the re-investment opportunities which are absent

Table 4.30: Returns from cultivation of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Sprinkler irrigation (n=60)	Conventional method of irrigation (n=60)	Difference	Difference (%)
1	Yield				
	a. Main product (quintals)	34.67	24.63	10.04	28.96
	b. By-product (tonnes)	9.71	8.04	1.67	17.20
2	Market price				
	a. Main product (`)	3,046.67	2,883.33	163.34	5.36
	b. By-product (`)	500.00	500.00	0.00	0.00
3	Gross returns (`)	1,10,471.94	75,022.92	35,449	32.09
4	Total cost (`)	51,479.16	46,340.84	5,138.32	9.98
5	Net returns (`)	58,992.79	28,682.08	30,310.70	51.38
6	Returns per rupee of investment	2.15	1.62	0.53	24.65

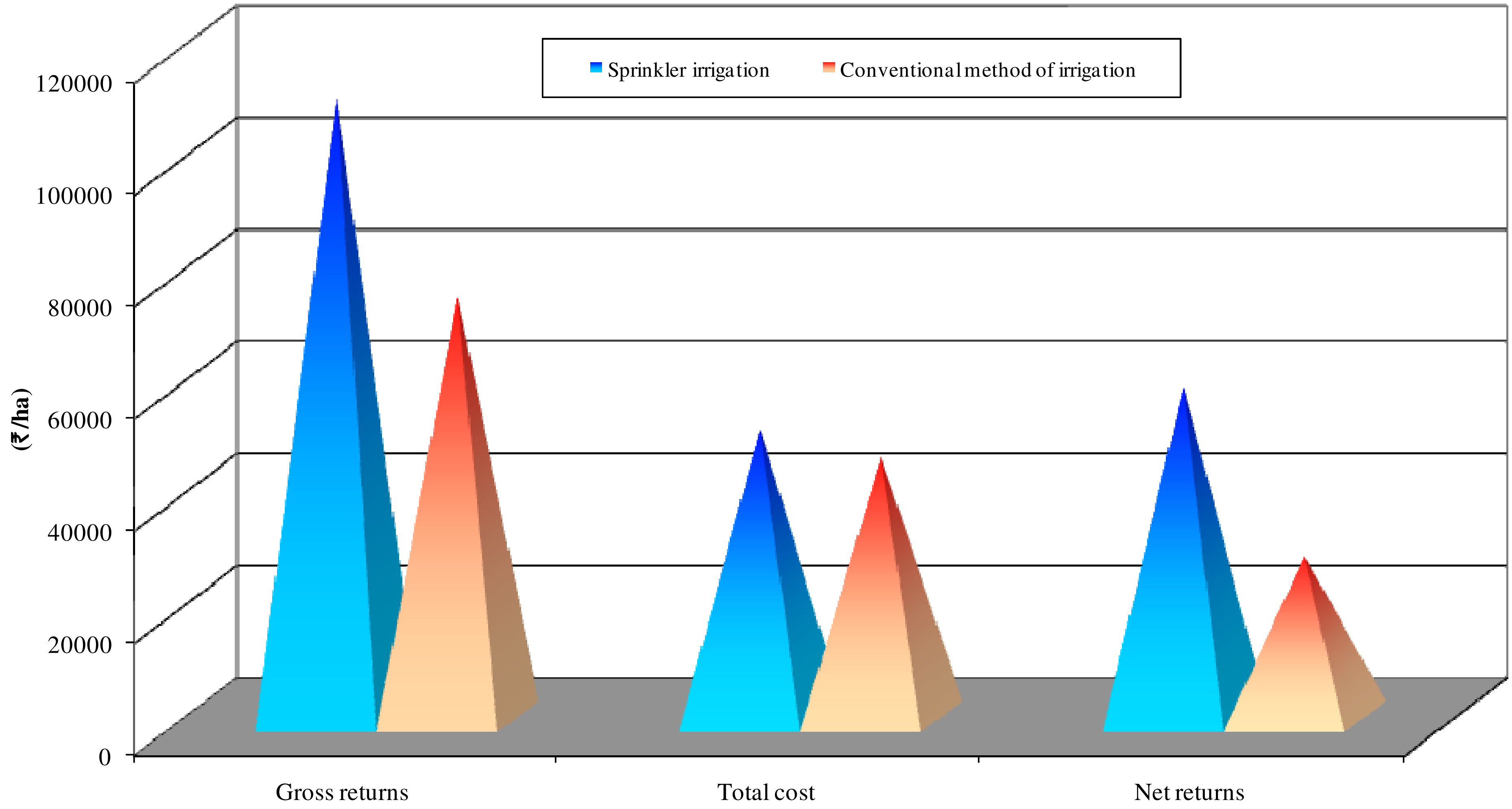

Fig. 25: Returns from cultivation of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area

Table 4.31: Economics and financial feasibility of investment on different methods of irrigation in cultivation of different crops

(Per ha)

Sl. No.	Particulars	Micro irrigation	Conventional method of irrigation	Difference
Sugarcane				
1	Total costs (`)	1,46,007	1,80,304	-34,297 (-19.02)
2	Total returns (`)	2,97,720	2,30,856	66,864 (28.96)
3	Net returns (`)	1,51,713	50,552	1,01,161 (200.11)
4	Returns per rupee of investment	2.04	1.28	0.76 (59.38)
Maize				
1	Total costs (`)	54,938	56,410	-1,472 (-2.61)
2	Total returns (`)	98,047	78,649	19,398 (24.66)
3	Net returns (`)	43,109	22,238	20,871 (93.85)
4	Returns per rupee of investment	1.78	1.39	0.39 (28.06)
Groundnut				
1	Total costs (`)	60,245	59,580	665 (1.12)
2	Total returns (`)	1,36,868	90,977	45,891 (50.44)
3	Net returns (`)	76,622	31,396	45,226 (144.05)
4	Returns per rupee of investment	2.27	1.53	0.74 (48.37)
Redgram				
1	Total costs (`)	54,232	49,354	4,878 (09.88)
2	Total returns (`)	1,40,317	99,504	40,813 (41.02)
3	Net returns (`)	86,084	50,150	35,934 (71.65)
4	Returns per rupee of investment	2.59	2.02	0.57 (28.22)
***Rabi* sorghum**				
1	Total costs (`)	51,479	46,340	5,139 (11.09)
2	Total returns (`)	1,10,471	75,022	35,449 (47.25)
3	Net returns (`)	58,992	28,682	30,310 (105.68)
4	Returns per rupee of investment	2.15	1.62	0.53 (32.72)

Note: Figures in the parentheses indicate percentage difference

Table 4.32: Financial feasibility of investment on micro irrigation and conventional method of irrigation in cultivation of different crops in the study area

(Per ha)

Sl. No.	Particulars	With subsidy	Without subsidy	Conventional method of irrigation
Sugarcane				
1	NPV (`)	780045	685163	153065
2	IRR (%)	51.51	30.51	11.52
3	B-C Ratio	2.16	2.04	1.28
4	PBP (Year)	0.96	1.51	2.93
Maize				
1	NPV (`)	2,12,963	2,04,159	60,542
2	IRR (%)	31.51	27.51	8.52
3	B-C Ratio	1.83	1.78	1.39
4	PBP (Year)	1.49	1.65	3.26
Groundnut				
1	NPV (`)	4,02,318	3,93,515	1,12,286
2	IRR (%)	55.51	49.51	16.52
3	B-C Ratio	2.33	2.27	1.53
4	PBP (Year)	0.90	1.00	2.39
Redgram				
1	NPV (`)	4,33,624	4,25,060	1,89,656
2	IRR (%)	44.51	41.51	20.52
3	B-C Ratio	2.62	2.59	2.02
4	PBP (Year)	1.09	1.18	2.08
***Rabi* sorghum**				
1	NPV (`)	2,80,548	2,71,985	68,357
2	IRR (%)	30.51	27.51	7.52
3	B-C Ratio	2.18	2.15	1.62
4	PBP (Year)	1.52	1.65	3.49

Note: NPV, IRR and B-C Ratio were calculated at 12 % discount rate

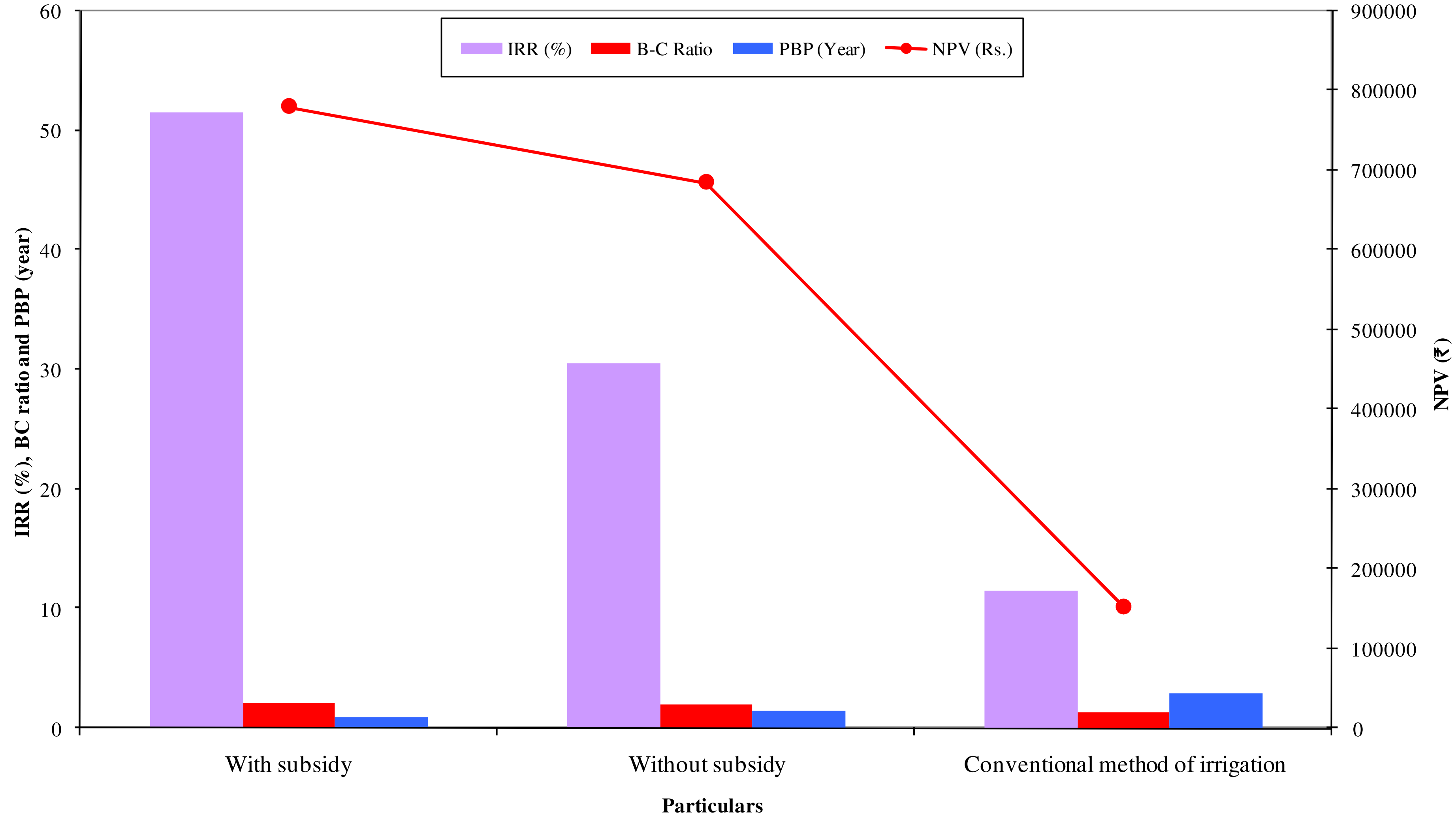

Fig. 26: Financial feasibility of investment on drip irrigation and conventional method of irrigation in cultivation of sugarcane in the study area

in other techniques. It can be seen from the Table 4.32 that Internal Rate of Returns with and without subsidy were 51.51 per cent and 30.51 per cent, respectively. The investment on drip irrigation in cultivation of sugarcane in the study area was found to be financially feasible since Internal Rate of Return was higher than the opportunity cost of capital which was 12 per cent as considered in the evaluation. The time required to recover the initial investment on drip irrigation system is indicated by Pay Back Period. The Pay Back Periods for drip irrigation system with and without subsidy were 0.96 years and 1.51 years, respectively. Hence investment on drip irrigation in cultivation of sugarcane in the study area was found to be financially feasible since the investment made could be recovered in a relatively short span of time.

Similarly the discounted Benefit Cost Ratio of investment on conventional method of irrigation was 1.28. It can be concluded that investment on conventional method of irrigation in cultivation of sugarcane in the study area was economically feasible since Benefit Cost Ratio was more than one. It can also be seen in the Table 4.32 that the Net Present Value of the investment on conventional method of irrigation was ` 1,53,065.38. The positive Net Present Value indicates that the investment made on conventional method of irrigation in cultivation of sugarcane was financial feasible. Table 4.32 revealed that Internal Rate of Return for conventional method of irrigation was 11.52 per cent. The investment on conventional method of irrigation in cultivation of sugarcane in the study area was found to be financially infeasible since Internal Rate of Return was lower than the opportunity cost of capital which was 12 per cent as considered in the evaluation. The Pay Back Period for conventional method of irrigation was 2.93 years. Hence investment on conventional method of irrigation in cultivation of sugarcane in the study area was found to be financially infeasible since the investment made could be recovered in a relatively longer span of time compared to drip irrigation.

It can be concluded that the financial feasibility of investment on drip irrigation system in cultivation of sugarcane was financially feasible and economically viable compared to that of conventional method of irrigation since discounted Benefit Cost Ratio, Net Present Value, Internal Rate of Returns were higher and Pay Back Period was lower for drip irrigation system in case of both with and without subsidy compared to conventional method of irrigation.

4.6.2 Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of maize

The results of the financial feasibility analysis of investment made on sprinkler irrigation and conventional method of irrigation in cultivation of maize are presented in Table 4.32 and Fig. 27.

Table 4.32 indicates that the discounted benefit cost ratio of investment on sprinkler irrigation system with subsidy and without subsidy were 1.83 and 1.78, respectively. Hence investment on sprinkler irrigation system in cultivation of maize in the study area was economically feasible since Benefit Cost Ratio was more than one. The Net Present Value of the investment on sprinkler irrigation system was ` 2,04,159.96 without subsidy and in case of with subsidy it was ` 2,12,963 . The positive Net Present Value indicates that the investment made on sprinkler irrigation in cultivation of maize was financial feasible. The Internal Rate of Return in case of with subsidy and without subsidy was

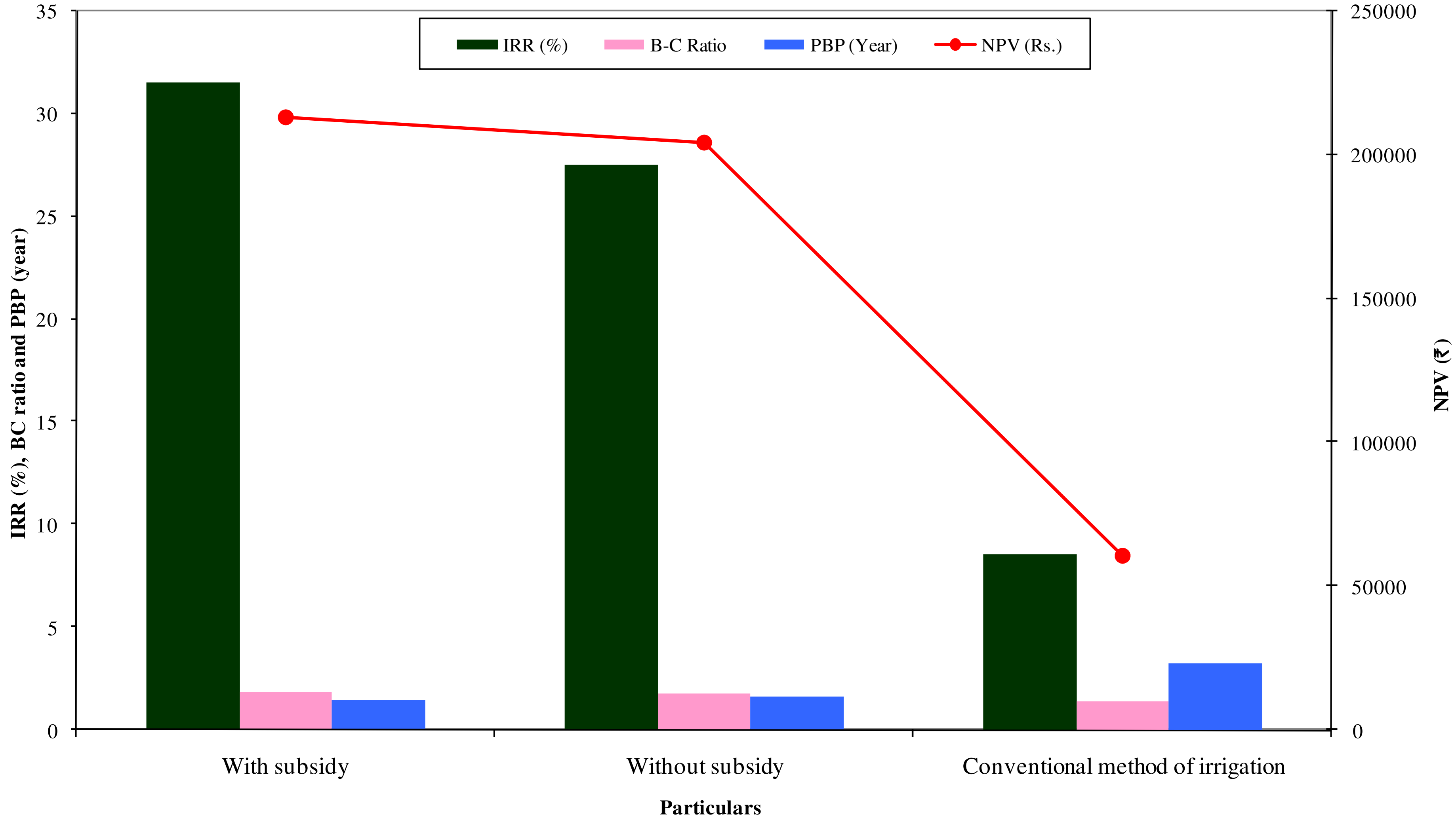

Fig. 27: Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of maize in the study area

31.51 per cent and 27.51 per cent, respectively. Thus it can be interpreted that the investment on sprinkler irrigation in cultivation of maize in the study area was found to be financially feasible since Internal Rate of Return was higher than the opportunity cost of capital (12 %). The Pay Back Period for sprinkler irrigation system in case of with subsidy and without subsidy was 1.49 years and 1.65 years, respectively. Hence investment on sprinkler irrigation in cultivation of maize in the study area was found to be financially feasible since the investment made could be recovered in a relatively short span of time.

Similarly the discounted benefit cost ratio of investment on conventional method of irrigation was 1.39. It can be concluded that investment on conventional method of irrigation in cultivation of maize in the study area was economically feasible since Benefit Cost Ratio was more than one. It can also be seen from the Table 4.32 that the Net Present Value of the investment on conventional method of irrigation was ` 60,542.26. The positive Net Present Value indicates that the investment made on conventional method of irrigation in cultivation of maize was financial feasible. Table 4.32 revealed that Internal Rate of Return for conventional method of irrigation was 08.52 per cent. The investment on conventional method of irrigation in cultivation of maize in the study area was found to be financially infeasible since Internal Rate of Return was lower than the opportunity cost of capital (12 %). Table 4.32 also revealed that the payback period for conventional method of irrigation was 3.26 years. Hence investment on conventional method of irrigation in cultivation of maize in the study area was found to be financially infeasible since the investment made could be recovered in a relatively longer span of time compared to sprinkler irrigation.

Thus it can be concluded that the financial feasibility of investment on sprinkler irrigation system in cultivation of maize was financially feasible and economically viable compared to that of conventional method of irrigation since discounted benefit cost ratio, net present value, internal rate of returns were higher and payback period was lower for sprinkler irrigation in case of both with and without subsidy compared to conventional method of irrigation.

4.6.3 Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of groundnut

The results of the financial feasibility analysis of investment made on sprinkler irrigation and conventional method of irrigation in cultivation of groundnut depicted in Table 4.32 and Fig. 28.

Table 4.32 indicates that the discounted benefit cost ratio of investment on sprinkler irrigation system in case of with subsidy and without subsidy was 2.33 and 2.27, respectively. Hence investment on sprinkler irrigation system in cultivation of groundnut in the study area was economically feasible since benefit cost ratio was more than one. Net present value of the investment on sprinkler irrigation system in case of without subsidy was ` 3,93,515.13 and in case of with subsidy it was ` 4,02,318. The positive Net Present Value indicates that the investment made on sprinkler irrigation in cultivation of groundnut was financial feasible. Internal rate of return was 49.51 per cent in case of without subsidy and in case of with subsidy it was 55.51 per cent. Thus it can be interpreted that the investment on sprinkler irrigation in cultivation of groundnut in the study area was found to be

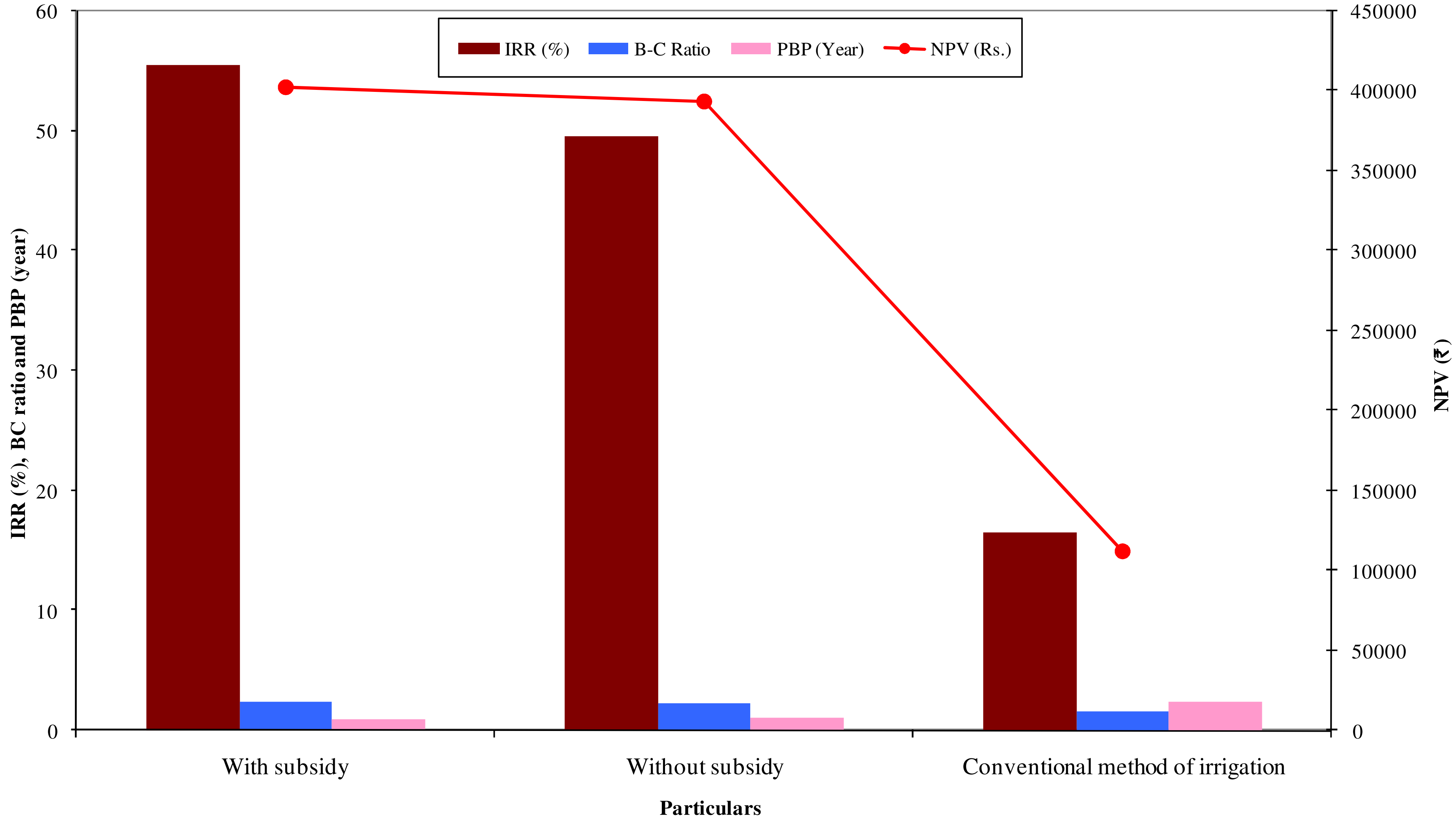

Fig. 28: Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of groundnut in the study area

financially feasible since internal rate of return was much higher than the opportunity cost of capital (12 %). The Payback period for sprinkler irrigation system was one year (1 crop season) in case of without subsidy and it was less than one year (0.90 year) in case of with subsidy. Hence investment on sprinkler irrigation in cultivation of groundnut in the study area was found to be financially feasible since the investment made could be recovered in the first crop season itself.

Similarly the discounted benefit cost ratio of investment on conventional method of irrigation was 1.53. Thus investment on conventional method of irrigation in cultivation of groundnut in the study area was economically feasible. It can also be seen from the Table 4.32 that the net present value of the investment on conventional method of irrigation was ` 1,12,286.61. The positive net present value indicates that the investment made on conventional method of irrigation in cultivation of groundnut was financial feasible. Internal rate of return for conventional method of irrigation was 16.52 per cent. Hence investment on conventional method of irrigation in cultivation of groundnut was found to be financially feasible since internal rate of return was higher than the opportunity cost of capital (12 %). Payback period for conventional method of irrigation was 2.39 years (2.39 crop seasons). Hence investment on conventional method of irrigation in cultivation of groundnut in the study area was found to be financially infeasible since the investment made could be recovered in a relatively longer span of time compared to sprinkler irrigation.

Thus it can be interpreted that the financial feasibility of investment on sprinkler irrigation system in cultivation of groundnut was financially feasible and economically viable compared to that of conventional method of irrigation since discounted benefit cost ratio, net present value, internal rate of returns were higher and payback period was lower for sprinkler irrigation system in case of both with and without subsidy compared to conventional method of irrigation.

4.6.4 Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of redgram

The results of the financial feasibility analysis of investment made on sprinkler irrigation and conventional method of irrigation in cultivation of redgram are depicted in Table 4.32 and Fig. 29.

Table 4.32 indicates that the discounted benefit cost ratio of investment on sprinkler irrigation system with subsidy and without subsidy was 2.62 and 2.59, respectively. Hence investment on sprinkler irrigation system in cultivation of redgram in the study area was economically feasible since benefit cost ratio was more than one. It can be seen from the Table 4.32 that the net present value of the investment on sprinkler irrigation system was ` 4,25,060.90 in case of without subsidy and in case of with subsidy it was found to be ` 4,33,624. The positive net present value indicates that the investment made on sprinkler irrigation in cultivation of redgram was financial feasible. Internal rate of return in case of with subsidy was 44.51 per cent and it was 41.51 per cent under without subsidy. Thus it can be interpreted that the investment on sprinkler irrigation in cultivation of redgram in the study area was found to be financially feasible since internal rate of return was much higher than the opportunity cost of capital (12 %). The payback period for sprinkler irrigation system was 1.18 years (1.18 crop seasons) in case of without subsidy and 1.09 years (1.09 crop seasons) with subsidy.

Hence investment on sprinkler irrigation in cultivation of redgram in the study area was found to be financially feasible since the investment made could be recovered in very short span of time.

Similarly the discounted benefit cost ratio of investment on conventional method of irrigation was 2.02. Thus investment on conventional method of irrigation in cultivation of redgram in the study area was economically feasible. It can also be seen from the Table 4.32 that the net present value of the investment on conventional method of irrigation was ` 1,89,656.15. The positive net present value indicates that the investment made on conventional method of irrigation in cultivation of redgram was financial feasible. Internal rate of return for conventional method of irrigation was 20.52 per cent. Hence investment on conventional method of irrigation in cultivation of redgram was found to be financially feasible since internal rate of return was higher than the opportunity cost of capital (12 %). Payback period for conventional method of irrigation was 2.08 years (2.08 crop seasons). Hence investment on conventional method of irrigation in cultivation of redgram in the study area was found to be financially infeasible since the investment made could be recovered in a relatively longer span of time compared to sprinkler irrigation.

Thus it can be interpreted that the financial feasibility of investment on sprinkler irrigation system in cultivation of redgram was financially feasible and economically viable compared to that of conventional method of irrigation since discounted benefit cost ratio, net present value, internal rate of returns were higher and payback period was lower for sprinkler irrigation system in case of both with and without subsidy compared to conventional method of irrigation.

4.6.5 Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of *rabi* sorghum

The results of the financial feasibility analysis of investment made on sprinkler irrigation and conventional method of irrigation in cultivation of *rabi* sorghum presented in Table 4.32 and Fig. 30.

Table 4.32 indicates that the discounted benefit cost ratio for investment on sprinkler irrigation system in cultivation of sorghum was 2.15 without subsidy and in case of with subsidy it was 2.18. Hence investment on sprinkler irrigation system was economically feasible since benefit cost ratio was more than one. Net present value of the investment on sprinkler irrigation system in case of with subsidy and without subsidy were ` 2,80,548 and ` 2,71,985.04, respectively. The positive net present value indicates that the investment made on sprinkler irrigation in cultivation of sorghum was financial feasible. Internal rate of return was 30.51 per cent and 27.51 per cent in case of with subsidy and without subsidy, respectively. Thus it can be interpreted that the investment on sprinkler irrigation in cultivation of sorghum in the study area was found to be financially feasible since internal rate of return was much higher than the opportunity cost of capital (12 %). The payback periods for sprinkler irrigation system in case of with subsidy and without subsidy were 1.52 years (1.52 crop seasons) and 1.65 years (1.65 crop seasons), respectively. Hence investment on sprinkler irrigation in cultivation of sorghum in the study area was found to be financially feasible since the investment made could be recovered in very short span of time.

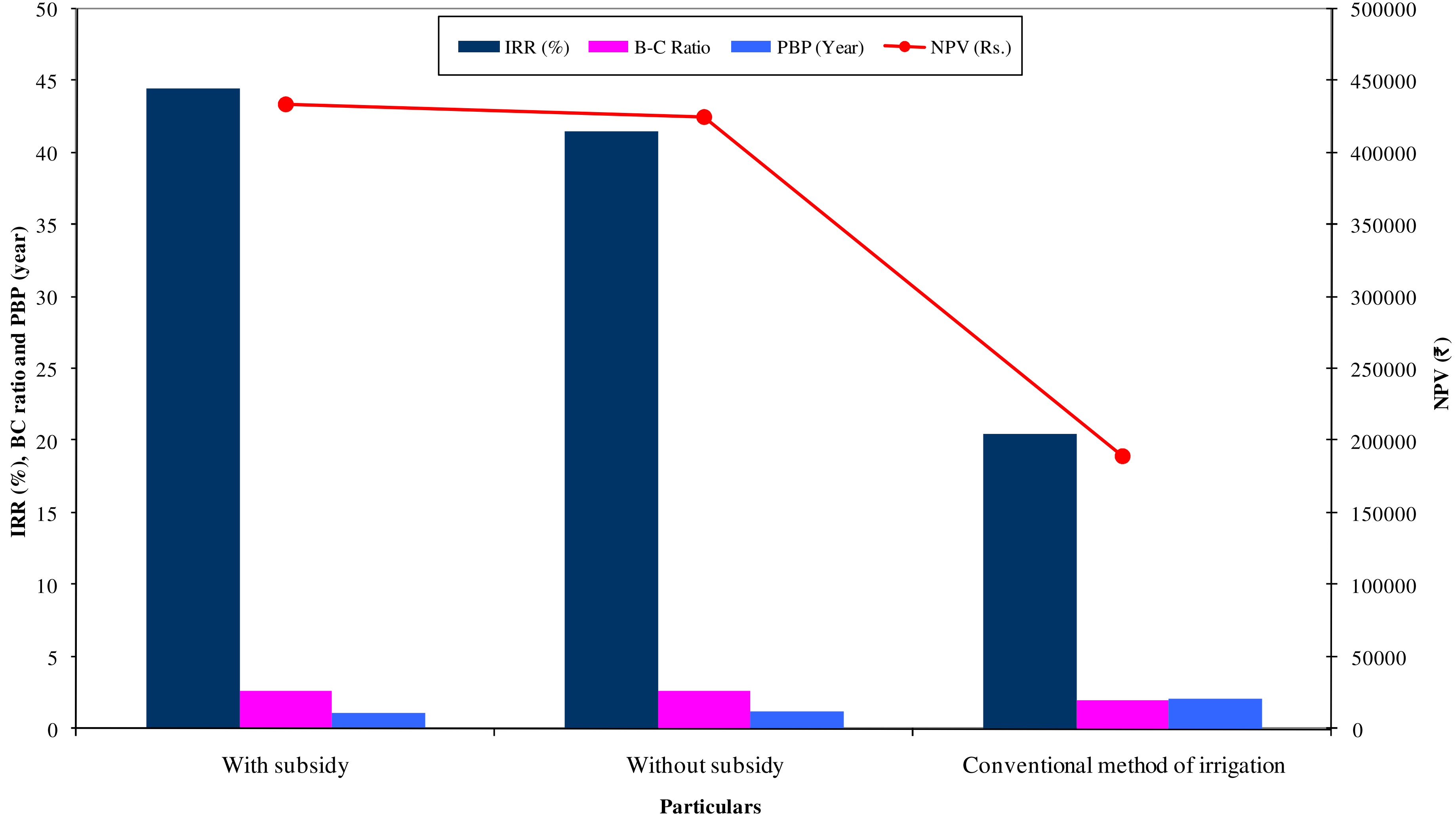

Fig. 29: Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of redgram in the study area

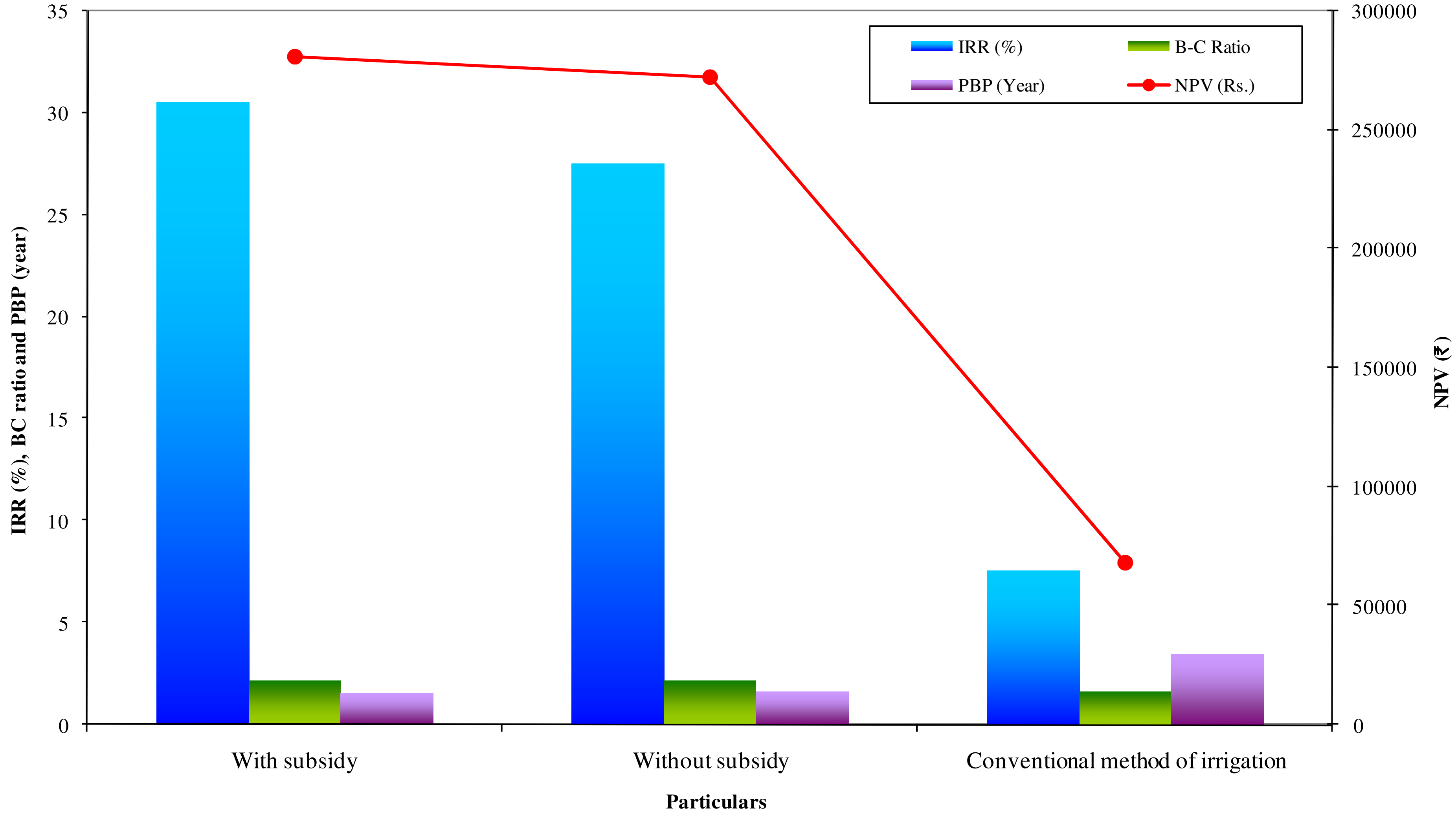

Fig. 30: Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of *rabi* sorghum in the study area

Similarly the discounted benefit cost ratio of investment on conventional method of irrigation was 1.62. Thus investment on conventional method of irrigation in cultivation of sorghum in the study area was economically feasible. It can also be seen from the Table 4.32 that the net present value of the investment on conventional method of irrigation was ` 68,357.42. The positive net present value indicates that the investment made on conventional method of irrigation in cultivation of sorghum was financially feasible. Internal rate of return for conventional method of irrigation was 07.52 per cent. Hence investment on conventional method of irrigation in cultivation of sorghum was found to be financially infeasible since internal rate of return was lower than the opportunity cost of capital (12 %). Payback period for conventional method of irrigation was 3.49 years (3.49 crop seasons). Hence investment on conventional method of irrigation in cultivation of sorghum in the study area was found to be financially infeasible since the investment made could be recovered in a relatively longer span of time compared to sprinkler irrigation.

Thus it can be interpreted that the financial feasibility of investment on sprinkler irrigation system in cultivation of sorghum was financially feasible and economically viable compared to that of conventional method of irrigation since discounted benefit cost ratio, net present value, internal rate of returns were higher and payback Period was lower for sprinkler irrigation system under both with and without subsidy situation compared to conventional method of irrigation.

4.7 Decomposition analysis of total change in per hectare income between micro irrigation systems and conventional method of irrigation in cultivation of different crops

4.7.1 Sugarcane

4.7.1.1 Structural break in the production relation of sugarcane under drip irrigation and conventional method of irrigation

To identify the structural break in sugarcane production relation with the introduction of drip irrigation as new technology, direct estimates of Cobb-Douglas type of production function presented in Table 4.33 indicates that in case of new technology (drip irrigation), the calculated ‘F’ value 374.45 was greater than the ‘F’ critical value (11.91) at one per cent for 7 and 112 degrees of freedom, the R^2 value 0.959 was statistically significant. The intercept value was 3.566. The regression coefficients for seed (0.120), fertiliser (0.243) and human labour (0.450) were statistically significant at 1 per cent level of significance. The regression coefficients for remaining variables namely farmyard manure (0.047), bullock and machine labour (-0.036), plant protection chemicals (0.054) and irrigation water applied (0.085) were found to be non significant.

In case of conventional method of irrigation, the calculated ‘F’ value 197.02 was greater than the ‘F’ critical value (11.91) at one per cent for 7 and 112 degrees of freedom, the R^2 value 0.925 was statistically significant. The intercept value was 5.740. The regression coefficients for farmyard manure (0.547), fertiliser (-0.274), bullock and machine labour (0.179) and irrigation water applied (0.261) were significant at one per cent level of significance where as the regression coefficient for plant protection chemicals (0.055) was significant at ten per cent level of significance. The regression coefficients for remaining variables namely seed (0.059) and human labour (-0.013) were found to be non significant.

Table 4.33: Production function estimates in sugarcane production under drip irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Parameter	Conventional method of irrigation	Drip irrigation	Pooled
1	No. of observations	n	120	120	240
2	Intercept	a	5.740 (1.174)	3.566 (0.888)	7.087 (0.500)
3	Seed (`)	X_1	0.059 (0.090)	0.120*** (0.037)	0.135*** (0.035)
4	FYM (`)	X_2	0.547*** (0.126)	0.047 (0.038)	0.113*** (0.027)
5	Fertiliser (`)	X_3	-0.274*** (0.073)	0.243*** (0.058)	0.069 (0.044)
6	Human labour (`)	X_4	-0.013 (0.099)	0.450*** (0.108)	-0.013 (0.067)
7	Bullock and Machine labour (`)	X_5	0.179*** (0.041)	0.028 (0.049)	0.053** (0.028)
8	Plant protection chemicals (`)	X_6	0.055* (0.031)	0.054 (0.043)	0.021 (0.027)
9	Irrigation water applied (ha cm)	X_7	0.261*** (0.075)	0.085 (0.090)	0.312*** (0.051)
10	Dummy for drip irrigation		-	-	0.647*** (0.030)
11	Coefficient of multiple determination	R^2	0.925	0.959	0.961
12	Adjusted R^2	R^2	0.920	0.956	0.959
13	F Value	F	197.02	374.45	702.15

Note: *** Significant at 1 % level
** Significant at 5 % level
* Significant at 10 % level
Figures in parentheses indicate standard errors of coefficients

In case of pooled sugarcane production function with drip irrigation as dummy variable was used for identifying structural break if any in production relation with the introduction of drip irrigation as a new technology. The regression coefficient for dummy variable (0.647) was significant at one per cent level of significance and calculated 'F' value (702.15) was greater than 'F' critical value (9.36) and is significant at one per cent for 8 and 231 degrees of freedom, so R^2 value 0.961 was statistically significant. The regression coefficients for seed (0.135), farmyard manure (0.113), irrigation water applied (0.312) and dummy variable (0.647) were significant at one per cent level of significance. The regression coefficient for bullock and machine labour (0.053) was significant at five per cent level of significance where as the regression coefficients of remaining variables such as fertiliser (0.069), human labour (-0.013) and plant protection chemicals (0.021) were found to be non significant.

4.7.1.2 Geometric mean levels of returns and cost involved in sugarcane production under drip irrigation and conventional method of irrigation

The per hectare geometric mean levels of gross returns and input costs in sugarcane production are presented in Table 4.34.

It is clear from the table that the gross returns under drip irrigation (` 2,93,785.14) were 28.80 per cent more compared to conventional method of irrigation (` 2,28,102.85). With respect to inputs, the drip irrigation involves about 18.11 per cent less seed cost, 34.84 per cent less farmyard manure cost, 15.02 per cent less fertiliser cost, 31.39 per cent less human labour cost, 26.18 per cent less bullock and machine labour cost, 22.23 per cent less plant protection chemicals cost and 60.63 per cent less irrigation water.

4.7.1.3 Decomposition analysis of total change in per hectare income between drip irrigation and conventional method of irrigation in cultivation of sugarcane

The total change in income received from sugarcane production due to adoption of drip irrigation technology was decomposed using decomposition equation (4) provided in chapter III, using the production function parameters (estimates) from Table 4.33 and geometric mean levels of returns and cost of inputs from Table 4.34. The results of output decomposition analysis are presented in Table 4.35.

A perusal of Table 4.35 indicates that the adopters of drip irrigation technology produced 25.31 per cent higher income from sugarcane production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change such as adoption of drip irrigation technology and all other inputs. The drip irrigation technology alone could contribute 44.83 per cent increase in income, while the contribution of change in input levels was found to be negative (-19.53 %). Amongst the various inputs, seed (-2.40 %), farmyard manure (-2.00 %), fertiliser (-3.95 %), human labour (-16.95 %), bullock and machine labour (-0.84 %) and plant protection chemicals (-1.35 %) contributed negatively to the income.

Table 4.34: Geometric mean levels of returns and cost involved in the production of sugarcane under drip irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Conventional method of irrigation	Drip irrigation	Difference (%)
1	No of observations	120	120	
2	Seed (`)	18,934.41	15,504.47	-18.11
3	FYM (`)	19,952.11	12,999.99	-34.84
4	Fertiliser (`)	18,795.17	15,972.86	-15.02
5	Human labour (`)	63,036.67	43,248.96	-31.39
6	Bullock and machine labour (`)	14,817.82	10,937.85	-26.18
7	Plant protection chemicals (`)	1,313.16	1,021.30	-22.23
8	Irrigation water applied (ha cm)	167.19	65.82	-60.63
9	Gross returns (`)	2,28,102.85	2,93,785.14	28.80

4.7.2 Maize

4.7.2.1 Structural break in the production relation of maize under sprinkler and conventional method of irrigation

To identify the structural break in maize production relation with the introduction of sprinkler irrigation as new technology, direct estimates of Cobb-Douglas type of production function presented in Table 4.36 indicates that in case of new technology (sprinkler irrigation), the calculated 'F' value 219.33 was greater than the 'F' critical value (12.20) at one per cent for 7 and 52 degrees of freedom, the R^2 value 0.967 was statistically significant. The intercept value was 11.242. The regression coefficient for irrigation water applied (0.472) was statistically significant at 1 per cent level of significance where as the regression coefficient for fertiliser (-0.040) was found to be significant at ten per cent level of significance. The regression coefficients for remaining variables namely seed (0.087), farmyard manure (-0.069), human labour (-0.156), bullock and machine labour (0.048) and plant protection chemicals (0.046) were found to be non-significant.

In case of conventional method of irrigation, the calculated 'F' value 326.33 was greater than the 'F' critical value (12.20) at one per cent for 7 and 52 degrees of freedom, the R^2 value 0.978 was statistically significant. The intercept value was 6.837. The regression coefficients for fertiliser (0.109), human labour (0.368), bullock and machine labour (-0.109) and irrigation water applied (0.113) were significant at one per cent level of significance where as the regression coefficient for plant protection chemicals (-0.042) was significant at ten per cent level of significance. The regression coefficients for remaining variables namely seed (0.074) and farmyard manure (0.015) were found to be non-significant.

In case of pooled maize production function with sprinkler irrigation as dummy variable was used for identifying structural break if any in production relation with the introduction of sprinkler irrigation as a new technology. The regression coefficient for dummy variable (0.392) was significant at one per cent level of significance and calculated 'F' value (290.44) was greater than 'F' critical value (9.53) and is significant at one per cent for 8 and 111 degrees of freedom, so R^2 value 0.954 was statistically significant. The regression coefficients for bullock and machine labour (0.179), plant protection chemicals (-0.125) and irrigation water applied (0.326) and dummy variable (0.392) were significant at one per cent level of significance where as regression coefficient for farmyard manure (-0.046) was significant at ten per cent level of significance. The regression coefficients of remaining variables such as seed (-0.049), fertiliser (0.008) and human labour (-0.004) were found to be non-significant.

4.7.2.2 Geometric mean levels of returns and cost involved in maize production under sprinkler irrigation and conventional method of irrigation

The per hectare geometric mean levels of gross returns and inputs in maize production are presented in Table 4.37.

It is clear from the table that the gross returns under sprinkler irrigation (` 97,169.65) were 24.34 per cent more compared to conventional method of irrigation (` 78,148.30). With respect to

Table 4.35: Decomposition analysis of total change in per hectare income between drip irrigation and conventional method of irrigation in cultivation of sugarcane in the study area

(Per ha)

Sl. No.	Particulars	Per cent contribution
	Total change in measured income	**25.31**
1	**Drip irrigation**	**44.83**
	a. Neutral component	**-217.39**
	b. Non neutral component	**262.22**
	Seed (`)	59.83
	FYM (`)	-494.81
	Fertiliser (`)	509.23
	Human labour (`)	511.17
	Bullock and machine labour (`)	-145.11
	Plant protection chemicals (`)	-0.91
	Irrigation water applied (ha cm)	-177.18
2	**Input contribution**	**-19.53**
	Seed (`)	-2.40
	FYM (`)	-2.00
	Fertiliser (`)	-3.95
	Human labour (`)	-16.95
	Bullock and machine labour (`)	-0.84
	Plant protection chemicals (`)	-1.35
	Irrigation water applied (ha cm)	7.96
	Total estimated difference in the income	**25.31**

Table 4.36: Production function estimates in maize production under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Parameter	Conventional method of irrigation	Sprinkler irrigation	Pooled
1	No. of observations	n	60	60	120
2	Intercept	a	6.837 (0.608)	11.242 (1.807)	10.291 (0.826)
3	Seed (`)	X_1	0.074 (0.046)	0.087 (0.102)	-0.049 (0.061)
4	FYM (`)	X_2	0.015 (0.028)	-0.069 (0.047)	-0.046* (0.026)
5	Fertiliser (`)	X_3	0.109*** (0.025)	-0.040* (0.023)	0.008 (0.018)
6	Human labour (`)	X_4	0.368*** (0.060)	-0.156 (0.256)	-0.004 (0.084)
7	Bullock and machine labour (`)	X_5	-0.109*** (0.037)	0.048 (0.058)	0.179*** (0.039)
8	Plant protection chemicals (`)	X_6	-0.042* (0.021)	0.046 (0.062)	-0.125*** (0.031)
9	Irrigation water applied (ha cm)	X_7	0.113*** (0.034)	0.472*** (0.078)	0.326*** (0.050)
10	Dummy for sprinkler irrigation		-	-	0.392*** (0.039)
11	Coefficient of multiple determination	R^2	0.978	0.967	0.954
12	Adjusted R^2	R^2	0.975	0.963	0.951
13	F Value	F	326.33	219.33	290.44

Note: *** Significant at 1 % level
** Significant at 5 % level
* Significant at 10 % level
Figures in parentheses indicate standard errors of coefficients

inputs, the sprinkler irrigation involves about 24.39 per cent less seed cost, 15.35 per cent less farmyard manure cost, 81.85 per cent less fertiliser cost, 3.81 per cent less human labour cost, 10.27 per cent less bullock and machine labour cost, 16.48 per cent less plant protection chemicals cost and 43.39 per cent less irrigation water.

4.7.2.3 Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of maize

The total change in income received from maize production due to adoption of sprinkler irrigation technology was decomposed using decomposition equation (4) provided in chapter III, using the production function parameters (estimates) from Table 4.36 and geometric mean levels of returns and cost of inputs from Table 4.37. The results of output decomposition analysis are presented in Table 4.38.

A perusal of Table 4.38 indicates that the adopters of sprinkler irrigation technology produced 21.79 per cent higher income from maize production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology alone could contribute 43.77 per cent increase in income, while the contribution of change in input levels was found to be negative (-21.99 %). Amongst the various inputs, seed (-2.42 %), bullock and machine labour (-0.52 %), plant protection chemicals (-0.82 %) and irrigation water applied (-26.84 %) contributed negatively to the income.

4.7.3 Groundnut

4.7.3.1 Structural break in the production relation of groundnut under sprinkler and conventional method of irrigation

To identify the structural break in groundnut production relation with the introduction of sprinkler irrigation as new technology, direct estimates of Cobb-Douglas type of production function presented in Table 4.39 indicates that in case of new technology (sprinkler irrigation), the calculated 'F' value 66.94 was greater than the 'F' critical value (12.20) at one per cent for 7 and 52 degrees of freedom, the R^2 value 0.900 was statistically significant. The intercept value was 1.062. The regression coefficients for fertiliser (0.219) and human labour (0.779) were statistically significant at 1 per cent level of significance where as the regression coefficients for farmyard manure (0.215) and plant protection chemicals (0.227) were found to be significant at five per cent level of significance. The regression coefficients for bullock and machine labour (0.268) was statistically significant at five per cent level of significance and the regression coefficients for remaining variables namely seed (0.206) and irrigation water applied (0.108) were found to be non-significant.

In case of conventional method of irrigation, the calculated 'F' value 278.13 was greater than the 'F' critical value (12.20) at one per cent for 7 and 52 degrees of freedom, the R^2 value 0.974 was statistically significant. The intercept value was -3.114. The regression coefficients for seed (0.618), fertiliser (0.201) plant protection chemicals (-0.184) were significant at one per cent level of significance where as the regression coefficient for human labour (0.755) was significant at five per cent level of significance. The regression coefficients for remaining variables namely farmyard manure (-0.065), bullock and machine labour (0.059) and irrigation water applied (0.068) were found to be non-significant.

Table 4.37: Geometric mean levels of returns and cost involved in the production of maize under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Conventional method of irrigation	Sprinkler irrigation	Difference (%)
1	No of observations	60	60	
2	Seed (`)	4,700.04	3,553.92	-24.39
3	FYM (`)	5,840.79	4,944.14	-15.35
4	Fertiliser (`)	6,647.28	1,206.47	-81.85
5	Human labour (`)	18,992.01	18,268.53	-3.81
6	Bullock and machine labour (`)	7,698.15	6,907.55	-10.27
7	Plant protection chemicals (`)	1,011.39	844.71	-16.48
8	Irrigation water applied (ha cm)	22.90	12.96	-43.39
9	Gross returns (`)	78,148.30	97,169.65	24.34

Table 4.38: Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of maize in the study area

(Per ha)

Sl. No.	Particulars	Per cent contribution
	Total change in measured income	**21.79**
1	**Sprinkler irrigation**	**43.77**
	a. Neutral component	**440.53**
	b. Non neutral component	**-396.76**
	Seed (`)	10.20
	FYM (`)	-73.18
	Fertiliser (`)	-131.31
	Human labour (`)	-516.03
	Bullock and machine labour (`)	140.59
	Plant protection chemicals (`)	60.63
	Irrigation water applied (ha cm)	112.34
2	**Input contribution**	**-21.99**
	Seed (`)	-2.42
	FYM (`)	1.16
	Fertiliser (`)	6.86
	Human labour (`)	0.61
	Bullock and machine labour (`)	-0.52
	Plant protection chemicals (`)	-0.82
	Irrigation water applied (ha cm)	-26.84
	Total estimated difference in the income	**21.79**

In case of pooled groundnut production function with sprinkler irrigation as dummy variable was used for identifying structural break if any in production relation with the introduction of sprinkler irrigation as a new technology. The regression coefficient for dummy variable (0.268) was significant at one per cent level of significance and calculated 'F' value (391.55) was greater than 'F' critical value (9.53) and is significant at one per cent for 8 and 111 degrees of freedom so R^2 value 0.966 was statistically significant. The regression coefficients for seed (0.486), human labour (0.527) and dummy variable (0.268) were significant at one per cent level of significance where as regression coefficient for bullock and machine labour (0.152) and plant protection chemicals (-0.083) were significant at five per cent level of significance and the regression coefficient for irrigation water applied (0.104) was found to be significant at ten per cent level of significance. The regression coefficients of remaining variables such as farmyard manure (-0.007) and fertiliser (-0.066) were found to non-significant.

4.7.3.2 Geometric mean levels of returns and cost involved in groundnut production under sprinkler irrigation and conventional method of irrigation

The per hectare geometric mean levels of gross returns and inputs in groundnut production are presented in Table 4.40.

It is clear from the table that the gross returns under sprinkler irrigation (` 1,34,392.66) were more compared to conventional method of irrigation (` 88,309.25). With respect to inputs, the sprinkler irrigation involves about 5.92 per cent less seed cost, 17.80 per cent less farmyard manure cost, 34.64 per cent less fertiliser cost, 6.70 per cent less plant protection chemicals cost and 42.78 per cent less irrigation water.

4.7.3.3 Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of groundnut

The total change in income received from groundnut production due to adoption of sprinkler irrigation technology was decomposed using decomposition equation (4) provided in chapter III, using the production function parameters (estimates) from Table 4.39 and geometric mean levels of returns and cost of inputs from Table 4.40. The results of output decomposition analysis are presented in Table 4.41.

A perusal of Table 4.41 indicates that the adopters of sprinkler irrigation technology produced 37.06 per cent higher income from groundnut production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology contributed positively to the income (67.88 %) and the contribution of change in input levels was found to be negative (-30.81 %). Amongst the various inputs, fertiliser (-9.30 %), human labour (-23.59 %), bullock and machine labour (-7.87 %) and plant protection chemicals (-1.57 %) contributed negatively to the income.

Table 4.39: Production function estimates in groundnut production under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Parameter	Conventional method of irrigation	Sprinkler irrigation	Pooled
1	No of observations	n	60	60	120
2	Intercept	a	-3.114 (2.707)	1.062 (2.086)	1.245 (1.449)
3	Seed (`)	X_1	0.618*** (0.106)	0.206 (0.141)	0.486*** (0.089)
4	FYM (`)	X_2	-0.065 (0.043)	0.215* (0.110)	-0.007 (0.039)
5	Fertiliser (`)	X_3	0.201*** (0.056)	0.219*** (0.062)	-0.066 (0.044)
6	Human labour (`)	X_4	0.755** (0.311)	0.779*** (0.278)	0.527*** (0.184)
7	Bullock and machine labour (`)	X_5	0.059 (0.087)	0.268** (0.123)	0.152** (0.076)
8	Plant protection chemicals (`)	X_6	-0.184*** (0.036)	-0.227* (0.134)	-0.083** (0.037)
9	Irrigation water applied (ha cm)	X_7	0.068 (0.098)	0.108 (0.101)	0.104* (0.059)
10	Dummy for sprinkler irrigation	-	-	-	0.268*** (0.078)
11	Coefficient of multiple determination	R^2	0.974	0.900	0.966
12	Adjusted R^2	R^2	0.970	0.887	0.963
13	F Value	F	278.13	66.94	391.55

Note: *** Significant at 1 % level
** Significant at 5 % level
* Significant at 10 % level
Figures in parentheses indicate standard errors of coefficients

Table 4.40: Geometric mean levels of returns and cost involved in the production of groundnut under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Conventional method of irrigation	Sprinkler irrigation	Difference (%)
1	No of observations	60	60	
2	Seed (`)	13,809.48	12,991.98	-5.92
3	FYM (`)	5,948.72	4,889.66	-17.80
4	Fertiliser (`)	4,845.11	3,166.63	-34.64
5	Human labour (`)	16,635.68	22,522.96	35.39
6	Bullock and machine labour (`)	5,522.10	7,409.24	34.17
7	Plant protection chemicals (`)	665.74	621.16	-6.70
8	Irrigation water applied (ha cm)	10.60	6.06	-42.78
9	Gross returns (`)	88,309.25	1,34,392.66	52.18

Table 4.41: Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of groundnut in the study area

(Per ha)

Sl. No.	Particulars	Per cent contribution
	Total change in measured income	**37.06**
1	**Sprinkler irrigation**	**67.88**
	a. Neutral component	**417.68**
	b. Non neutral component	**-349.81**
	Seed (`)	-390.98
	FYM (`)	237.81
	Fertiliser (`)	-337.88
	Human labour (`)	24.08
	Bullock and machine labour (`)	186.26
	Plant protection chemicals (`)	-27.42
	Irrigation water applied (ha cm)	-41.69
2	**Input contribution**	**-30.81**
	Seed (`)	1.26
	FYM (`)	4.22
	Fertiliser (`)	-9.30
	Human labour (`)	-23.59
	Bullock and machine labour (`)	-7.87
	Plant protection chemicals (`)	-1.57
	Irrigation water applied (ha cm)	6.05
	Total estimated difference in the income	**37.06**

4.7.4 Redgram

4.7.4.1 Structural break in the production relation of redgram under sprinkler irrigation and conventional method of irrigation

To identify the structural break in redgram production relation with the introduction of sprinkler irrigation as new technology, direct estimates of Cobb-Douglas type of production function presented in Table 4.42 indicates that in case of new technology (sprinkler irrigation), the calculated ‘F’ value 96.47 was greater than the ‘F’ critical value (12.20) at one per cent for 7 and 52 degrees of freedom, the R^2 value 0.929 was statistically significant. The intercept value was 0.809. The regression coefficient for human labour (1.258) was statistically significant at 1 per cent level of significance where as the regression coefficients for seed (0.260) and farmyard manure (0.083) were significant at ten per cent level of significance. Regression coefficient for irrigation water applied was found to be significant at five per cent level of significance. The regression coefficients for remaining variables namely fertiliser (-0.105), bullock and machine labour (0.012) and plant protection chemicals (0.017) were found to be non-significant.

In case of conventional method of irrigation, the calculated ‘F’ value 145.54 was greater than the ‘F’ critical value (12.20) at one per cent for 7 and 52 degrees of freedom, the R^2 value 0.951 was statistically significant. The intercept value was 5.890. The regression coefficients for seed (0.908), farmyard manure (0.229), human labour (-0.797), bullock and machine labour (0.493) and irrigation water applied (0.744) were significant at one per cent level of significance where as the regression coefficient for plant protection chemicals (0.190) was significant at five per cent level of significance and regression coefficient for fertiliser (-0.267) was significant at ten per cent level of significance.

In case of pooled redgram production function with sprinkler irrigation as dummy variable was used for identifying structural break if any in production relation with the introduction of sprinkler irrigation as a new technology. The regression coefficient for dummy variable (0.675) was significant at one per cent level of significance and calculated ‘F’ value (121.29) was greater than ‘F’ critical value (9.53) and is significant at one per cent for 8 and 111 degrees of freedom, so R^2 value 0.897 was statistically significant. The regression coefficients for human labour (0.960), irrigation water applied (0.397) and dummy variable (0.675) were significant at one per cent level of significance where as regression coefficients for farmyard manure (0.129), bullock and machine labour (-0.151) and plant protection chemicals (0.165) were significant at five per cent level of significance. The regression coefficients of remaining variables such as seed (0.138) and fertiliser (-0.047) were found to be non-significant.

4.7.4.2 Geometric mean levels of returns and cost involved in redgram production under sprinkler irrigation and conventional method of irrigation

The per hectare geometric mean levels of gross returns and inputs in redgram production are presented in Table 4.43.

Table 4.42: Production function estimates in redgram production under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Parameter	Conventional method of irrigation	Sprinkler irrigation	Pooled
1	No. of observations	n	60	60	120
2	Intercept	a	5.890 (1.645)	0.809 (2.957)	-0.429 (1.469)
3	Seed (`)	X_1	0.908*** (0.229)	0.260* (0.153)	0.138 (0.195)
4	FYM (`)	X_2	0.229*** (0.066)	0.083* (0.050)	0.129** (0.061)
5	Fertiliser (`)	X_3	-0.267* (0.141)	-0.105 (0.094)	-0.047 (0.117)
6	Human labour (`)	X_4	-0.797*** (0.274)	1.258*** (0.368)	0.960*** (0.224)
7	Bullock and machine labour (`)	X_5	0.493*** (0.146)	0.012 (0.044)	-0.151** (0.059)
8	Plant protection chemicals (`)	X_6	0.190** (0.081)	0.017 (0.060)	0.165** (0.063)
9	Irrigation water applied (ha cm)	X_7	0.744*** (0.194)	0.293** (0.149)	0.397*** (0.144)
10	Dummy for sprinkler irrigation	-	-	-	0.675*** (0.075)
11	Coefficient of multiple determination	R^2	0.951	0.929	0.897
12	Adjusted R^2	R^2	0.945	0.919	0.890
13	F Value	F	145.54	96.47	121.29

Note: *** Significant at 1 % level
** Significant at 5 % level
* Significant at 10 % level
Figures in parentheses indicate standard errors of coefficients

Table 4.43: Geometric mean levels of returns and cost involved in the production of redgram under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Conventional method of irrigation	Sprinkler irrigation	Difference (%)
1	No of observations	60	60	
2	Seed (`)	702.18	606.60	-13.61
3	FYM (`)	5,858.68	5,079.14	-13.31
4	Fertiliser (`)	4,790.10	3,933.79	-17.88
5	Human labour (`)	19,217.48	17,124.86	-10.89
6	Bullock and machine labour (`)	8,981.41	2,952.64	-67.12
7	Plant protection chemicals (`)	760.06	607.35	-20.09
8	Irrigation water applied (ha cm)	14.83	7.00	-52.83
9	Gross returns (`)	95,017.67	1,37,180.43	44.37

Table 4.44: Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of redgram in the study area

(Per ha)

Sl. No.	Particulars	Per cent contribution
	Total change in measured income	**36.72**
1	**Sprinkler irrigation**	**67.65**
	a. Neutral component	**-508.14**
	b. Non neutral component	**575.79**
	Seed (`)	-765.68
	FYM (`)	-126.48
	Fertiliser (`)	136.99
	Human labour (`)	2026.91
	Bullock and machine labour (`)	-459.34
	Plant protection chemicals (`)	-115.12
	Irrigation water applied (ha cm)	-121.49
2	**Input contribution**	**-30.93**
	Seed (`)	3.81
	FYM (`)	-1.18
	Fertiliser (`)	2.07
	Human labour (`)	-14.50
	Bullock and machine labour (`)	1.30
	Plant protection chemicals (`)	-0.38
	Irrigation water applied (ha cm)	-22.04
	Total estimated difference in the income	**36.72**

It is clear from the table that the gross returns under sprinkler irrigation (` 1,37,180.43) were more compared to conventional method of irrigation (` 95,017.67). With respect to inputs, the sprinkler irrigation involves about 13.61 per cent less seed cost, 13.31 per cent less farmyard manure cost, 17.88 per cent less fertiliser cost, 10.89 per cent less human labour cost, 67.12 per cent less bullock and machine labour cost, 20.09 per cent less plant protection chemicals cost and 52.83 per cent less irrigation water.

4.7.4.3 Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of redgram

The total change in income received from redgram production due to adoption of sprinkler irrigation technology was decomposed using decomposition equation (4) provided in chapter III, using the production function parameters (estimates) from Table 4.42 and geometric mean levels of returns and cost of inputs from Table 4.43. The results of output decomposition analysis are presented in Table 4.44.

A perusal of Table 4.44 indicates that the adopters of sprinkler irrigation technology produced 36.72 per cent higher income from redgram production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology alone could contribute 67.65 per cent increase in income, while the contribution of change in input levels was found to be negative (-30.93 %). Amongst the various inputs, farmyard manure (-1.18 %), human labour (-14.50 %), plant protection chemicals (-0.38 %) and irrigation water applied (-22.04 %) contributed negatively to the income.

4.7.5 *Rabi* sorghum

4.7.5.1 Structural break in the production relation of sorghum under sprinkler irrigation and conventional method of irrigation

To identify the structural break in sorghum production relation with the introduction of sprinkler irrigation as new technology, direct estimates of Cobb-Douglas type of production function presented in Table 4.45 indicates that in case of new technology (sprinkler irrigation), the calculated ‘F’ value 240.46 was greater than the ‘F’ critical value (12.20) at one per cent for 7 and 52 degrees of freedom, the R^2 value 0.970 was statistically significant. The intercept value was 0.911. The regression coefficients for seed (0.729), farmyard manure (0.165) and fertiliser (0.446) were statistically significant at 1 per cent level of significance where as the regression coefficient for human labour (0.545) was significant at ten per cent level of significance. The regression coefficients for remaining variables namely bullock and machine labour (-0.047), plant protection chemicals (0.090) and irrigation water applied (0.093) were found to be non-significant.

In case of conventional method of irrigation, the calculated ‘F’ value 152.57 was greater than the ‘F’ critical value (12.20) at one per cent for 7 and 52 degrees of freedom, the R^2 value 0.954 was statistically significant. The intercept value was 3.591. The regression coefficients for seed (-0.437), fertiliser (-0.220), human labour (1.125) and irrigation water applied (0.278) were significant at one per cent level of significance where as the regression coefficient for farmyard manure (0.105) was significant at five per cent level of significance and regression coefficients for bullock and machine labour (-0.007) and plant protection chemicals (-0.053) were found to be non-significant.

Table 4.45: Production function estimates in *rabi* sorghum production under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Parameter	Conventional method of irrigation	Sprinkler irrigation	Pooled
1	No. of observations	n	60	60	120
2	Intercept	a	3.591 (0.824)	0.911 (2.581)	8.859 (0.893)
3	Seed (`)	X_1	-0.437*** (0.130)	0.729*** (0.133)	0.706*** (0.085)
4	FYM (`)	X_2	0.105** (0.048)	0.165*** (0.040)	-0.015 (0.043)
5	Fertiliser (`)	X_3	-0.220*** (0.067)	0.446*** (0.122)	-0.299*** (0.086)
6	Human labour (`)	X_4	1.125*** (0.157)	0.545* (0.328)	-0.197 (0.151)
7	Bullock and machine labour (`)	X_5	-0.007 (0.085)	-0.047 (0.116)	0.145 (0.107)
8	Plant protection chemicals (`)	X_6	-0.053 (0.060)	0.090 (0.089)	0.049 (0.056)
9	Irrigation water applied (ha cm)	X_7	0.278*** (0.080)	0.093 (0.122)	0.353*** (0.098)
10	Dummy for sprinkler irrigation	-	-	-	0.845*** (0.064)
11	Coefficient of multiple determination	R^2	0.954	0.970	0.936
12	Adjusted R^2	R^2	0.947	0.966	0.931
13	F Value	F	152.57	240.46	202.40

Note: *** Significant at 1 % level
** Significant at 5 % level
* Significant at 10 % level
Figures in parentheses indicate standard errors of coefficients

In case of pooled sorghum production function with sprinkler irrigation as dummy variable was used for identifying structural break if any in production relation with the introduction of sprinkler irrigation as a new technology. The regression coefficient for dummy variable (0.845) was significant at one per cent level of significance and calculated 'F' value (202.40) was greater than 'F' critical value (9.53) and is significant at one per cent for 8 and 111 degrees of freedom, so R^2 value 0.936 was statistically significant. The regression coefficients for seed (0.706), fertiliser (-0.299), irrigation water applied (0.353) and dummy variable (0.845) were significant at one per cent level of significance. The regression coefficients of remaining variables such as farmyard manure (-0.015), human labour (-0.197), bullock and machine labour (0.145) and plant protection chemicals (0.049) were found to be non-significant.

4.7.5.2 Geometric mean levels of returns and cost involved in *rabi* sorghum production under sprinkler irrigation and conventional method of irrigation

The per hectare geometric mean levels of gross returns and inputs in sorghum production are presented in Table 4.46.

It is clear from the table that the gross returns under sprinkler irrigation (` 1,05,202.34) were more compared to conventional method of irrigation (` 74,073.63). With respect to inputs, the sprinkler irrigation involves about 27.29 per cent less seed cost, 11.93 per cent less farmyard manure cost, 11.82 per cent less fertiliser cost, 16.67 per cent less bullock and machine labour cost, 25.39 per cent less plant protection chemicals cost and 52.60 per cent less irrigation water.

4.7.5.3 Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of *rabi* sorghum

The total change in income received from sorghum production due to adoption of sprinkler irrigation technology was decomposed using decomposition equation (4) provided in chapter III, using the production function parameters (estimates) from Table 4.45 and geometric mean levels of returns and cost of inputs from Table 4.46. The results of output decomposition analysis are presented in Table 4.47.

A perusal of Table 4.47 indicates that the adopters of sprinkler irrigation technology produced 35.08 per cent higher income from sorghum production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology alone could contribute 50.24 per cent increase in income, while the contribution of change in input levels was found to be negative (-15.15 %). Amongst the various inputs, seed (-23.25 %) and fertiliser (-5.61 %) contributed negatively to the income.

Table 4.46: Geometric mean levels of returns and cost involved in the production of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation in the study area

(Per ha)

Sl. No.	Particulars	Conventional method of irrigation	Sprinkler irrigation	Difference (%)
1	No of observation	60	60	
2	Seed (`)	413.46	300.62	-27.29
3	FYM (`)	4,204.48	3,702.74	-11.93
4	Fertiliser (`)	5,481.29	4,833.64	-11.82
5	Human labour (`)	16,549.72	16,919.37	2.23
6	Bullock and machine labour (`)	9,982.94	8,318.63	-16.67
7	Plant protection chemicals (`)	1,556.11	1,161.08	-25.39
8	Irrigation water applied (ha cm)	17.43	8.26	-52.60
9	Gross returns (`)	74,073.63	1,05,202.34	42.02

4.8 Constraints faced by sample respondents in the study area

4.8.1 Constraints faced by farmer beneficiaries in adoption and maintenance of micro irrigation systems

Constraints faced by farmer beneficiaries in adoption and maintenance of micro irrigation systems are presented in Table 4.48.

The major constraints faced by the farmer beneficiaries in adoption and maintenance of micro irrigation systems were lack of quality MIS units, lack of information on design, layout and MIS operating system, high cost of initial investment, insufficient subsidy from the government, clogging of emitters/problem of shifting delay in sanction and supply of MIS unit, delay in sanction of subsidy, inadequate irrigation water supply, inadequate power supply, lack of awareness about fertigation, damage of MIS during field operations and problem of theft.

It can be seen from the table that drip irrigated farmers expressed that inadequate power supply was the serious problem and was ranked first with a score of 81.68 followed by clogging of emitters (65.53), delay in sanction of subsidy (59.89), inadequate irrigation water supply (57.39), high cost of initial investment (56.71), delay in sanction and supply of MIS unit (53.23), insufficient subsidy from the government (47.05), lack of information on design, layout and MIS operating system (46.19), low quality MIS units (38.40), damage of MIS during field operations (35.08), problem of theft (32.24) and lack of awareness about fertigation (26.27).

Similarly sprinkler irrigated farmers also opined that inadequate power supply was the serious problem and was ranked first with a score of 77.39 followed by delay in sanction of subsidy (59.12), problem of shifting sprinkler irrigation system from place to place in the field (57.13), high cost of initial investment (54.79), lack of information on design, layout and MIS operating system (54.42), delay in sanction and supply of MIS unit (53.98), inadequate irrigation water supply (49.49), insufficient subsidy from government (48.13), low quality MIS units (46.22), problem of theft (37.73), damage of MIS during field operations (31.88) and lack of awareness about fertigation (29.79).

4.8.2 Constraints faced by the farmers in cultivation of different crops under conventional method of irrigation

Constraints faced by the farmers in cultivation of different crops under conventional method of irrigation are depicted in Table 4.49.

The major problems faced by the farmers in cultivation of different crops under conventional method of irrigation were inadequate irrigation water supply, wastage of water, water logging, inadequate power supply, high electricity usage, problem of soil erosion, reduced crop yield, low quality produce, labour intensive, increased incidence of pest and diseases, problem of theft and lack of awareness about fertigation.

Table 4.47: Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of *rabi* sorghum in the study area

(Per ha)

Sl. No.	Particulars	Per cent contribution
	Total change in measured income	**35.08**
1	**Sprinkler irrigation**	**50.24**
	a. Neutral component	**-267.91**
	b. Non neutral component	**318.15**
	Seed (`)	702.55
	FYM (`)	-225.34
	Fertiliser (`)	573.56
	Human labour (`)	-562.71
	Bullock and machine labour (`)	-36.97
	Plant protection chemicals (`)	-26.90
	Irrigation water applied (ha cm)	-106.05
2	**Input contribution**	**-15.15**
	Seed (`)	-23.25
	FYM (`)	2.09
	Fertiliser (`)	-5.61
	Human labour (`)	1.20
	Bullock and machine labour (`)	0.86
	Plant protection chemicals (`)	2.62
	Irrigation water applied (ha cm)	6.93
	Total estimated difference in the income	**35.08**

Table 4.48: Constraints in adoption and maintenance of micro irrigation systems by the farmer beneficiaries in the study area

Sl. No.	Particulars	Drip irrigation (n=120)		Sprinkler irrigation (n=120)	
		Garret score	Rank	Garret score	Rank
1	Low quality MIS units	38.40	IX	46.22	IX
2	Lack of information on design , layout and MIS operating system	46.19	VIII	54.42	V
3	High cost of initial investment	56.71	V	54.79	IV
4	Insufficient subsidy from government	47.05	VII	48.13	VIII
5	Clogging of emitters/ problem of shifting	65.53	II	57.13	III
6	Delay in sanction & supply of MIS unit	53.23	VI	53.98	VI
7	Delay in sanction of subsidy	59.89	III	59.12	II
8	Inadequate irrigation water supply	57.39	IV	49.49	VII
9	Inadequate power supply	81.68	I	77.39	I
10	Lack of awareness about fertigation	26.77	XII	29.79	XII
11	Damage of MIS during field operations	35.08	X	31.88	XI
12	Problem of theft	32.24	XI	37.73	X

Table 4.49: Constraints faced by the farmers in cultivation of different crops under conventional method of irrigation in the study area

(n=120)

Sl. No.	Particulars	Garret score	Rank
1	Wastage of water	79.53	I
2	Inadequate power supply	74.75	II
3	Problem of soil erosion	58.33	III
4	Inadequate irrigation water supply	58.09	IV
5	Water logging	54.48	V
6	Reduced crop yield	50.61	VI
7	Labour intensive	48.35	VII
8	High electricity usage	47.82	VIII
9	Increased incidence of pest and diseases	44.39	IX
10	Low quality produce	38.18	X
11	Problem of theft	23.31	XI
12	Lack of awareness about fertigation	22.16	XII

The wastage of water was the most serious problem faced by the farmers and was ranked first with a garret score of 79.53 followed by inadequate power supply (74.75), problem of soil erosion (58.33), inadequate irrigation water supply (58.09), water logging (54.48), reduced crop yield (50.61), labour intensive (48.35), high electricity usage (47.82), increased incidence of pest and diseases (44.39), low quality produce (38.18), problem of theft (23.31) and lack of awareness about fertigation (22.16).

5. DISCUSSION

The results of the investigation presented in the preceding chapter are discussed in detail in this chapter. The discussion would throw light on the possible causes for the results obtained and are presented under the following sub headings.

5.1 Area covered under micro irrigation systems in the state

5.2 Subsidy provided for and private investment on micro irrigation systems in the state and government schemes on micro irrigation

5.3 General characteristics of sample respondents

5.4 Water use efficiency in major crops under different irrigation systems

5.5 Profitability of major crops in conventional v/s micro irrigation systems

5.6 Financial feasibility of investment on micro irrigation systems and conventional method of irrigation

5.7 Decomposition analysis of total change in per hectare income between micro irrigation systems and conventional method of irrigation in cultivation of different crops

5.8 Constraints faced by sample respondents in the study area

5.1 Area covered under micro irrigation system in the state

The area under micro irrigation systems in the state depicted in Table 4.1 reveals that the area coverage under micro irrigation system showed positive growth rate of 20.33 per cent per annum and is mainly due to the fact that more and more farmers are covered by the micro irrigation scheme over the years and farmers are also motivated towards the adoption of micro irrigation because of scarcity of water and many other advantages of micro irrigation system over the conventional method of irrigation as we discussed in preceding chapter. The hypothesis made in the beginning of the study that the area under micro irrigation is increasing over time is proved. The study is supported by the findings of the Yogi (2008), Palanisami (2011), Anonymous (2013) and Bheemanagouda (2014).

5.2 Subsidy provided for and private investment on micro irrigation system in the state and government schemes on micro irrigation

The extent of subsidy provided for micro irrigation was growing positively at the rate of 25.92 per cent annually (Table 4.2). This might be due to the fact that the scheme is bringing more area under micro irrigation by covering more number of farmers and providing subsidy thereof. The subsidy for micro irrigation in the state by the state government was growing at the higher rate (28.06 %) followed by subsidy given by central government (23.71 %) and the farmer's share (13.19 %) annually. This is due to the fact that the state government increased its share from 35 per cent to 50 per cent from 2013-14 and thus the farmers share decreased from 25 per cent to 10 per cent. Thus the hypothesis made in the beginning of the study that the subsidy provided for micro irrigation systems is increasing over time is proved. The results of the study are in line with the findings of the Anonymous (2000) and Anonymous (2013).

The area covered under and subsidy provided for micro irrigation system under drip irrigation scheme (2.27 lakh ha & ` 450 crores, respectively) and micro irrigation scheme (0.17 lakh ha & ` 33.70 crores, respectively) was less compared to area covered and subsidy provided for micro irrigation under centrally sponsored scheme on micro irrigation (` 2.43 lakh ha & ` 575.73 crores, respectively) and national mission on micro irrigation (` 5.06 lakh ha & ` 1,555.80 crores, respectively). This is because of the fact that the subsidy percentage increased from 50 per cent to 75 per cent under centrally sponsored scheme on micro irrigation and then to 90 per cent under national mission on micro irrigation from last two years. And thus the total cumulative area covered and subsidy provided for micro irrigation system by all micro irrigation schemes in the state was 9.93 lakh hectares and ` 2,615.23 crores, respectively by the end of 2014-15 (Table 4.3).

5.3 General characteristics of sample respondents

5.3.1 Socio-economic characteristics of sample respondents

The important socio-economic characters of the sample respondents presented in Table 4.4 indicates that the farmers cultivating crops under micro irrigation system were younger than the farmers cultivating crops under conventional method of irrigation. This is because the younger farmers have more progressive nature in adopting new water management practices to achieve more crop productivity with less irrigation water and to gain more profit. Although in both the cases the main occupation of them was agriculture, the average size of the family was slightly more for farmers of traditional method of irrigation compared to farmers practicing micro irrigation. This might be due to the fact that as the average size of the family increases, some amount of expenditure on agriculture may get diverted towards the family consumption like education and health *etc.* Hence the investment on improved technologies decreases as the size of the family increases. The findings of the study are in conformity with the results of Vinod (2010) and Rudrapur (2015).

Table 4.4 also indicates that most of the farmers following conventional method of irrigation (39.17 %) were illiterate as compared to sprinkler irrigation (23.33 %) and drip irrigation (15.00 %) in the study area. This reveals that much of the farmers following drip irrigation and sprinkler irrigation were more literate (85.00 % and 76.67 %, respectively) compared to farmers following conventional method of irrigation (60.83 %). The farmers having more number of years of schooling have more aggressive in adopting scientific water management practices like micro irrigation for more profit. The average size of land holding was more under drip irrigation (3.86 ha) and sprinkler irrigation (3.56 ha) compared to conventional method of irrigation (2.58 ha). This indicates that the adoption behaviour of farmers for micro irrigation in the study area increases with increase in their land holding and increase in land holding increases their income which ultimately leads to investment on micro irrigation. The findings of the study are in conformity with the results of Vinod (2010) and Rudrapur (2015).

The main occupation of all the farmers was agriculture and very few farmers were working as agricultural labourers because of seasonality of agriculture and were involved in other jobs and works outside field because of their small land holding. The percentage of association with social organisation was more under drip irrigated and sprinkler irrigated farmers compared to conventional irrigated farmers which indicates that association with social organisation motivates the farmers to adopt new improved technologies (micro irrigation) in cultivation of different crops in the study area. The average annual income of the drip irrigation farmers and sprinkler irrigation farmers was more (` 3,92,666.67 & ` 2,66,583.33, respectively) compared to conventional irrigation farmers (` 1,72,700.00). This indicates that as the income of the farmers increases the affordability of the farmers to invest on micro irrigation increases and vice versa. The findings of the study are in conformity with the results of Vinod (2010) and Rudrapur (2015).

5.3.2 Cropping pattern of sample respondents

Table 4.5 reveals that the major crops grown by sample farmers during *kharif* were redgram, maize, soyabean and grengram and during *rabi* season were sorghum, wheat and groundnut. There was an increase in the cropping intensity in case of farmers practicing drip and sprinkler irrigation compared to farmers practicing conventional method of irrigation. This was mainly due to the fact that farmers practicing drip and sprinkler irrigation, by using saved water through these improved methods of irrigation, they brought more area under cultivation in *rabi* and shifted from seasonal crops to commercial crops like sugarcane in the study area. Major crops grown by all the sample farmers include almost all types of crop group like cereals, pulses, oil seeds, commercial crops and horticultural crops. This is because to face various risks and uncertainties which are common in agriculture production. The study is supported by the findings of Rudrapur (2015).

5.4 Water use efficiency in major crops under different irrigation methods

5.4.1 Water use efficiency of sugarcane under drip irrigation and conventional method of irrigation

Table 4.6 indicates that the water use efficiency in sugarcane cultivation was highest in case of drip irrigated farms (2.55 t/ha cm) compared to conventional irrigated farms (0.75 t/ha cm) and hence there was gain in water use efficiency to the extent of 70.59 per cent by adopting drip irrigation over conventional method of irrigation the study area. This is because of the fact that the yield was high (164.77 t/ha) and water application was less (64.54 ha cm) under drip irrigation compared to conventional method of irrigation (130.27 t/ha & 174.47 ha cm, respectively). The water application under drip irrigation was less because of the fact that even though it requires more number of irrigations than the conventional method of irrigation the time required per irrigation (1.87 hours) was very less compared to conventional method of irrigation (16.29 hours).

5.4.2 Water use efficiency of maize under sprinkler irrigation and conventional method of irrigation

Table 4.7 indicates that the water use efficiency was highest in case of sprinkler irrigation (4.55 q/ha cm) compared to conventional method of irrigation (2.11 q/ha cm) and the gain in water use efficiency under sprinkler irrigation over the conventional method of irrigation was 53.63 per cent. This is because of the fact that the yield was high (62.67 q/ha) and water application was less (13.77 ha cm) under sprinkler irrigation compared to conventional method of irrigation (51.17 q/ha & 24.25 ha cm, respectively). The water application by the sprinkler irrigation farmers was less because of the fact that even though there was no much difference between the number of hours of irrigation in both the methods of irrigation, the water applied per hour was less (7,500 litres) compared to conventional method of irrigation (22,788 litres). In case of cultivation of maize under sprinkler irrigation, the farmers usually applied water through both sprinkler irrigation (5.60 No.) and furrow irrigation (2.58 No.).

5.4.3 Water use efficiency of groundnut under sprinkler irrigation and conventional method of irrigation

The water use efficiency of groundnut under sprinkler irrigation and conventional method of irrigation presented in Table 4.8 shows that the water use efficiency was highest under sprinkler irrigation system (4.65 q/ha cm) compared to conventional method of irrigation (1.35 q/ha cm) and the gain in water use efficiency under sprinkler irrigation over the conventional method of irrigation was 70.97 per cent.. This is due to the fact that the yield was high (29.17 q/ha) and water application was less (6.27 ha cm) under sprinkler irrigation compared to conventional method of irrigation (19.38 q/ha & 14.38 ha cm, respectively). The water application by the sprinkler irrigation farmers was less because of the fact that even though the number of irrigations was almost double than the conventional method of irrigation, the time required per irrigation (10.88 hours) and water applied per hour (7,500 litres) were less compared to conventional method of irrigation (13.25 hours & 22,788 litres/hour, respectively).

5.4.4 Water use efficiency of redgram under sprinkler irrigation and conventional method of irrigation

The water use efficiency (Table 4.9) was highest in case of sprinkler irrigation (2.64 q/ha cm) compared to conventional method of irrigation (0.89 q/ha cm) and the gain in water use efficiency under sprinkler irrigation over the conventional method of irrigation was found to be 66.29 per cent. This is due to the fact that the yield was more (19.42 q/ha) and water application was less (7.37 ha cm) under sprinkler irrigation compared to conventional method of irrigation (13.52 q/ha & 15.24 ha cm, respectively). The water application by the sprinkler irrigation farmers was less because of the fact that even though the number of hours of irrigation (98.23 hours) was more than the conventional method of irrigation (66.99 hours), the water applied per hour (7,500 litres) was less compared to conventional method of irrigation (22,752 litres).

5.4.5 Water use efficiency of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation

The water use efficiency of *rabi* sorghum (Table 4.10) was highest in case of sprinkler irrigation (3.99 q/ha cm) compared to conventional method of irrigation (1.37 q/ha cm) and the gain in water use efficiency under sprinkler irrigation over the conventional method of irrigation was found to be 65.66 per cent. This is due to the fact that the yield was more (34.67 q/ha) and water application was less (8.70 ha cm) under sprinkler irrigation compared to conventional method of irrigation (24.63 q/ha & 18.03 ha cm, respectively). The water application by the sprinkler irrigation farmers was less because of the fact that even though the number of hours of irrigation (115.95 hours) was more than the conventional method of irrigation (79.26 hours), the water applied per hour (7,500 litres) was less compared to conventional method of irrigation (22,752 litres). Thus the hypothesis made in the beginning of the study that the water use efficiency in case of micro irrigation systems higher than that of conventional method of irrigation is proved.

The results of the water use efficiency in different crops is also supported by the findings of the Prabhakar (2000), Rahman (2001), Shirahatti (2001), Dinesh (2004), Antony (2004), Aujla (2005), Singh (2005), Webber (2006), Isoda (2007), Singh (2007), Harbi (2008), Dunage (2009), Tyson (2009), Ali (2010), Kumar (2010), Chandrakanth (2012), Kaushal *et al.* (2012), Mamta (2012), Chandrakanth (2013), Saxena (2013), Sharma (2013), Ayyanna (2014), Vimalendran (2014), Danso (2015), Malunjkar (2015) and Sharma (2015).

5.5 Profitability of major crops in conventional v/s micro irrigation systems

5.5.1 Sugarcane

5.5.1.1 Labour utilisation pattern in sugarcane cultivation under drip irrigation and conventional method of irrigation

The labour utilisation pattern in cultivation of sugarcane under drip irrigation and conventional method of irrigation (Table 4.11) reveals that use of drip irrigation over conventional method of irrigation saved labour usage for various operations. In case of ploughing, transportation of farmyard manure and harrowing there was a saving of 1.00 hour, 0.29 hour and 1.62 hours of machine labour, respectively. With respect to bullock labour there was saving of 2.77 pair days for inter cultivation but meanwhile there was increased usage of bullock pair for transportation of farmyard manure and harrowing in drip irrigated farms. Similarly there was a saving in usage of human labour for various operations like transportation of farmyard manure (4.46 man days), spreading of farmyard manure (0.40 man days), set bed preparation (1.50 man days), planting (2.06 man days), fertiliser application (1.25 man days), weeding (20.70 man days), inter cultivation (2.77 man days), irrigation (53.49 man days) and application of plant protection chemicals (0.57 man days).

5.5.1.2 Input use pattern and output obtained in sugarcane cultivation under drip irrigation and conventional method of irrigation

It could be observed from the Table 4.12 that there was a saving in average per hectare utilisation of human labour, bullock labour, machine labour, sets, farmyard manure, chemical fertilisers and plant protection chemicals in cultivation of sugarcane under drip irrigation to the extent of 86.52 man days, 2.33 pair days, 2.92 hours, 1.59 tonnes, 6.29 tonnes, 1.29 quintals and 0.93 litres, respectively. There was an increase in the per hectare yield of sugarcane under drip irrigation over the conventional method of irrigation to the extent of 34.50 tonnes.

5.5.1.3 Cost involved in cultivation of sugarcane under drip irrigation and conventional method of irrigation

Among the two methods of irrigation, there was a saving in per hectare total cost incurred in sugarcane production under drip irrigation over the conventional method of irrigation to the extent of ` 34,296.

5.5.1.4 Returns from cultivation of sugarcane under drip irrigation and conventional methods of irrigation

The irrigation method wise analysis of returns from cultivation of sugarcane indicates that there was increase in per hectare gross returns, net returns and BC ratio in case of drip irrigated farms to the extent of ` 66,864.43, ` 1,01,160 and 0.76, respectively.

5.5.2 Maize

5.5.2.1 Labour utilisation pattern in maize cultivation under sprinkler irrigation and conventional method of irrigation

The labour utilisation pattern in cultivation of maize under sprinkler irrigation and conventional method of irrigation presented in Table 4.15 reveals that the use of sprinkler irrigation over conventional method of irrigation saved labour usage for various operations. In case of ploughing, transportation of farmyard manure and harrowing there was a saving of 0.44 hour, 1.12 hour and 1.33 hours of machine labour, respectively. Similarly there was a saving in usage of human labour for various operations like transportation of farmyard manure (0.13 man days), sowing (2.38 man days), weeding (5.14 man days), irrigation (1.36 man days) and application of plant protection chemicals (1.2 man days). We can observe from the Table 4.14 that there was saving of human labour to the extent of 2.38 man days for sowing, 5.14 man days for weeding and 1.36 man days for irrigation under sprinkler irrigation over the conventional method of irrigation in the study area.

5.5.2.2 Input use pattern and output obtained in maize cultivation under sprinkler irrigation and conventional method of irrigation

There was saving in average per hectare utilisation of human labour, machine labour, seeds, farmyard manure, chemical fertilisers and plant protection chemicals in cultivation of maize under sprinkler irrigation to the extent of 3.87 man days, 2.89 hours, 5.09 kilograms, 0.71 tonnes, 0.55 quintals and 0.48 litres, respectively (Table 4.15). There was an increase in the per hectare yield of maize under sprinkler irrigation over the conventional method of irrigation to the extent of 11.50 quintals.

5.5.2.3 Cost involved in cultivation of maize under sprinkler irrigation and conventional method of irrigation

Among the two methods of irrigation, there was a saving in per hectare total variable cost incurred in maize production under sprinkler irrigation over the conventional method of irrigation to the extent of only ` 6,619.

5.5.2.4 Returns from cultivation of maize under sprinkler irrigation and conventional methods of irrigation

The irrigation method wise analysis of returns from cultivation of maize indicated that there was increase in per hectare gross returns, net returns and BC ratio in case of sprinkler irrigated farms to the extent of ` 19,398, ` 20,870 and 0.39, respectively.

5.5.3 Groundnut

5.5.3.1 Labour utilisation pattern in groundnut cultivation under sprinkler irrigation and conventional method of irrigation

The labour utilisation pattern in cultivation of groundnut under sprinkler irrigation and conventional method of irrigation presented in Table 4.19 reveals that in case of harrowing there was a saving of 0.50 hour of machine labour. Similarly there was a saving in usage of human labour for various operations like transportation of farmyard manure (1.50 man days), spreading of farmyard manure (0.21 man days), sowing (1.91 man days), fertiliser application (0.58 man days), weeding (2.77 man days) and application of plant protection chemicals (1.29 man days).

5.5.3.2 Input use pattern and output obtained in groundnut cultivation under sprinkler irrigation and conventional method of irrigation

Table 4.20 indicates that there was no much difference in average per hectare utilisation of human labour, bullock labour and machine labour in case of both the methods of irrigation but there was a saving in per hectare utilisation of seeds, farmyard manure, chemical fertilisers and plant protection chemicals in cultivation of groundnut under sprinkler irrigation to the extent of 6.75 kilograms, 1.20 tonnes, 1.09 quintals and 0.13 litres, respectively. There was an increase in the per hectare yield of groundnut under sprinkler irrigation over the conventional method of irrigation to the extent of 9.79 quintals.

5.5.3.3 Cost involved in cultivation of groundnut under sprinkler irrigation and conventional method of irrigation

Among the two methods of irrigation, there was a saving in per hectare total variable cost incurred in groundnut production under sprinkler irrigation over the conventional method of irrigation to the extent of only ` 4,481.

5.5.3.4 Returns from cultivation of groundnut under sprinkler irrigation and conventional methods of irrigation

The irrigation method wise analysis of returns from cultivation of groundnut indicated that there was increase in per hectare gross returns, net returns and BC ratio in case of sprinkler irrigated farms to the extent of ` 45,890, ` 45,225 and 0.74, respectively.

5.5.4 Redgram

5.5.4.1 Labour utilisation pattern in redgram cultivation under sprinkler irrigation and conventional method of irrigation

The labour utilisation pattern in cultivation of redgram under sprinkler irrigation and conventional method of irrigation presented in Table 4.23 reveals that there was a saving in usage of human labour for sowing (3.19 man days) and weeding (12.88 man days).

5.5.4.2 Input use pattern and output obtained in redgram cultivation under sprinkler irrigation and conventional method of irrigation

It could be observed from the Table 4.24 that, there was a saving in average per hectare utilisation of human labour, seeds, farmyard manure, chemical fertilisers and plant protection chemicals in cultivation of redgram under sprinkler irrigation to the extent of 1.94 man days, 1.34 kilograms, 0.80 tonnes, 0.67 quintals and 0.42 litres, respectively. There was an increase in the per hectare yield of redgram under sprinkler irrigation over the conventional method of irrigation to the extent of 5.5 quintals.

5.5.4.3 Cost involved in cultivation of redgram under sprinkler irrigation and conventional method of irrigation

Among the two methods of irrigation, there was a saving in per hectare total variable cost incurred in redgram production under sprinkler irrigation over the conventional method of irrigation to the extent of only ` 1,319.

5.5.4.4 Returns from cultivation of redgram under sprinkler irrigation and conventional methods of irrigation

The irrigation method wise analysis of returns from cultivation of redgram indicated that there was increase in per hectare gross returns, net returns and BC ratio in case of sprinkler irrigated farms to the extent of ` 40,813, ` 35,934 and 0.57, respectively.

5.5.5 *Rabi* sorghum

5.5.5.1 Labour utilisation pattern in sorghum cultivation under sprinkler irrigation and conventional method of irrigation

The labour utilisation pattern in cultivation of sorghum under sprinkler irrigation and conventional method of irrigation presented in Table 4.27 reveals that the use of sprinkler irrigation over conventional method of irrigation saved labour usage for various operations. There was a saving in usage of human labour for sowing (2.02 man days) and weeding (8.70 man days).

5.5.5.2 Input use pattern and output obtained in *rabi* sorghum cultivation under sprinkler irrigation and conventional method of irrigation

It could be observed from the Table 4.28 that, there was a saving in average per hectare utilisation of machine labour, seeds, farmyard manure, chemical fertilisers and plant protection chemicals in cultivation of sorghum under sprinkler irrigation to the extent of 1.37 hours, 2.59 kilograms, 0.46 tonnes, 0.52 quintals and 0.96 litres, respectively. There was an increase in the per hectare yield of sorghum under sprinkler irrigation over the conventional method of irrigation to the extent of 10.04 quintals.

5.5.5.3 Cost involved in cultivation of sorghum under sprinkler irrigation and conventional method of irrigation

Among the two methods of irrigation, there was a saving in per hectare total variable cost incurred in sorghum production under sprinkler irrigation over the conventional method of irrigation to the extent of only ` 1,060.

5.5.5.4 Returns from cultivation of sorghum under sprinkler irrigation and conventional methods of irrigation

The irrigation method wise analysis of returns from cultivation of sorghum indicated that there was increase in per hectare gross returns, net returns and BC ratio in case of sprinkler irrigated farms to the extent of ` 35,449. ` 30,310 and 0.53, respectively.

In case of sugarcane cultivation under drip irrigated farms there was saving of human labour for weeding and irrigation over the conventional irrigated farms in the study area. This was due to the fact that the farmers cultivating sugarcane crop under conventional method of irrigation faced more weeds problem and applied more hours of irrigation water compared to farmers cultivating sugarcane under drip irrigation. But in case of other crops like maize, groundnut, redgram and *rabi* sorghum there was saving of human labour for weeding under sprinkler irrigation because of less weed problem and there was a more usage of human labour for irrigation because of the fact that the farmers practicing sprinkler irrigation applied more number of irrigations regularly compared to farmers practicing conventional method of irrigation. But the hidden advantage of irrigating the crop under micro irrigation (sprinkler & drip) is that the farmer who is irrigating the crop under sprinkler irrigation can go for other activities at the same time on the farm which was not possible under conventional method of irrigation which requires the physical presence of the farmers until the irrigation of the entire field gets over.

The farmers practicing conventional method of irrigation were utilising more sets/seeds compared to farmers practicing drip irrigation and sprinkler irrigation due to the fact that the conventional irrigation farmers were not aware about the optimum usage of sets/seeds and there might be a high rate of mortality in production of crops under conventional method of irrigation than under drip irrigation and sprinkler irrigation and thus required more sets/seeds and even more human labour for gap filling operation. The reason behind the more usage of bullock labour in cultivation of sugarcane under conventional method of irrigation was that the conventional method of irrigation required more number of inter-cultivation operations compared to sugarcane production under drip irrigation. The reason behind the utilisation of more human labour under conventional method of irrigation was due to the fact that the conventional method of irrigation required more number of weeding operations and more labour for irrigation compared to drip irrigation in cultivation of sugarcane and more usage of human labour for weeding compared to sprinkler irrigation in cultivation of different field crops like maize, groundnut, redgram and *rabi* sorghum. The other hidden advantage of irrigating the crops under drip irrigation and sprinkler irrigation is that the farmer who is irrigating the crops under drip irrigation and sprinkler irrigation can go for other activities at the same time on the farm which was not possible under conventional method of irrigation which requires the physical presence of the farmers until the irrigation of the entire field gets over. The findings of the study are also in conformity with the findings of the Gaurang (2013).

The conventional irrigated farmers might be believed that the more application of farmyard manure and chemical fertilisers would enhance the productivity of the crop. This was the reason why the conventional irrigation farmers were using more farmyard manure and chemical fertilisers than the drip and sprinkler irrigated farms where the drip and sprinkler irrigation farmers might know that only increased quantity of farmyard manure and fertilisers couldn't increase the yield, the other factors like optimum application of irrigation is also important factor which enhances the yield. Cultivation of crops under conventional method of irrigation resulted more disease and pest problems; hence the plant protection chemicals used under conventional method of irrigation was more compared to cultivation of crops under drip and sprinkler irrigation. The findings of the present study are also supported by the results of the Cassel (2001), Isoda (2007) and Ndeketeya (2014).

There was increase in the per hectare yield of sugarcane under drip irrigation over the conventional method of irrigation. This might be due to the fact that application of water through drip irrigation was uniform and regular, application of water directly to crop root zone hence avoid water contact with the leaves and hence less susceptible for weeds, pests and diseases and there was no problem of soil erosion and loss of soil fertility and also due to the other advantages of drip irrigation over the conventional method of irrigation and increase in the yield of maize, groundnut, redgram and *rabi* sorghum under sprinkler irrigation is due to the fact that there was uniform and regular application of water and no problem of soil erosion and loss of soil fertility. The findings of the study are also in conformity with the findings of the Antony (2004), Narendra (2005), Uday (2007), Patil (2009), Gholap (2011), Kaushal (2012), Birbal (2013), Thirumalaikumar (2014) and Omotayo (2015).

Among different methods of irrigation, there was a saving in per hectare total variable cost incurred in production of different crops under drip irrigation and sprinkler irrigation in the study area over the conventional method of irrigation. This might be due to the fact that as we already discussed the cultivation of crops under the conventional method of irrigation required more inputs and hence high input cost. When intervention (micro irrigation) was taken up the total variable cost was found to be less. The findings of the study are also supported by the results of the Shivakumar (2000), Narayanmoorthy (2001), Shirahatti (2001), Singadhupe (2002), Thamban (2006), Namara (2007), Shashidhara (2007), Chandrakanth (2012), Chandrakanth (2013) and Sharma (2013).

The irrigation method wise analysis of returns from cultivation of different crops in the study area indicates that there was increase in per hectare gross returns, net returns and BC ratio in case of drip irrigated farms and sprinkler irrigated farms compared to conventional irrigated farms. This is due to the fact that the crop productivity as well as the price of the output was highest under drip irrigation and sprinkler irrigation compared to the conventional method of irrigation in cultivation of crops. Thus the hypothesis made in the beginning of the study that the crop productivity and net returns realised in case of micro irrigation systems were higher than that of conventional method of irrigation is proved. The results of the study are also supported by the findings of the Narayanamoorthy (2005), Muraliraj (2008), Narayanamoorthy (2008), Jalajakshi (2009), Jayapiratha (2010), Narayanamoorthy (2010) and Jisnu (2014).

5.6 Financial feasibility of investment on micro irrigation system and conventional method of irrigation

It can be concluded that the financial feasibility of investment on micro irrigation system in cultivation of different crops was found to be financially feasible and economically viable even without subsidy compared to that of conventional method of irrigation since discounted Benefit Cost Ratio, Net Present Value, Internal Rate of Returns were higher and Pay Back Period was lower for micro irrigation system both in case of with and without subsidy compared to conventional method of irrigation. This was due to the fact that the net cash flows were higher in case of micro irrigation system than that of conventional method of irrigation. Thus the hypothesis made in the beginning of the study that investment on micro irrigation systems was financially feasible is proved. The results of the study are also in line with the results of the Shivakumar (2000), Narayanamoorthy (2001), Cetin (2004), Narayanmoorthy (2008), Okunade (2009), Kaur (2010), Gholap (2011), Maddileti (2012), and Ndeketeya (2014).

5.7 Decomposition analysis of total change in per hectare income between micro irrigation systems and conventional method of irrigation in cultivation of different crops

5.7.1 Sugarcane

5.7.1.1 Structural break in the production relation of Sugarcane under drip irrigation and conventional method of irrigation

The production function estimates for sugarcane under drip irrigation and conventional method of irrigation presented in Table 4.33 revealed that the value of co-efficient of determination (R^2) was found to be 0.959 and 0.925 in case of drip irrigation and conventional method of irrigation, respectively. This revealed that the independent variables included in the model have explained 95.90 and 92.50 per cent of variation in the dependent variable of drip irrigation and conventional method of irrigation, respectively. The elasticities of seeds, fertiliser and human labour were positive and significant suggesting that, an increase in the use of these factors over and above their present level resulted in substantial increase in gross returns of farmers practicing drip irrigation where as in case of farmers practicing conventional method of irrigation, the elasticities of variables such as farmyard manure, fertiliser and bullock and machine labour were found to be positive and significant.

5.7.1.2 Geometric mean levels of returns and cost involved in sugarcane production under drip irrigation and conventional method of irrigation

The per hectare geometric mean levels of gross returns and input costs in the sugarcane production presented in the Table 4.34 revealed that the gross returns under drip irrigation (` 2,93,785.14) was more than conventional method of irrigation (` 2,28,102.85).

5.7.1.3 Decomposition analysis of total change in per hectare income between drip irrigation and conventional method of irrigation in cultivation of sugarcane

The results of output decomposition analysis presented in Table 4.35 revealed that the adopters drip irrigation technology produced 25.31 per cent higher income from sugarcane production than conventional method of irrigation. The increase in the income was further decomposed into different sources of change such as adoption of drip irrigation technology and all other inputs. The drip irrigation technology alone could contribute 44.83 per cent increase in income, while the contribution of change in input levels was found to be negative (-19.53 %). Amongst the various inputs, seed (-2.40 %), farmyard manure (-2.00 %), fertiliser (-3.95 %), human labour (-16.95 %), bullock and machine labour (-0.84 %) and plant protection chemicals (-1.35 %) contributed negatively to the income.

5.7.2 Maize

5.7.2.1 Structural break in the production relation of Maize under sprinkler and conventional method of irrigation

The production function estimates for maize under sprinkler irrigation and conventional method of irrigation presented in Table 4.36 revealed that the value of co-efficient of determination (R^2) was found to be 0.967 and 0.978 in case of sprinkler irrigation and conventional method of irrigation, respectively. This revealed that the independent variables included in the model have explained 96.70 and 97.80 per cent of variation in the dependent variable of sprinkler irrigation and conventional method of irrigation, respectively. The elasticity of irrigation water applied was positive and significant suggesting that, an increase in the use of this factor over and above their present level resulted in substantial increase in gross returns of farmers practicing sprinkler irrigation where as in case of farmers practicing conventional method of irrigation, the elasticities of variables such as fertiliser, human labour and irrigation water applied were found to be positive and significant.

5.7.2.2 Geometric mean levels of returns and cost involved in maize production under sprinkler irrigation and conventional method of irrigation

The per hectare geometric mean levels of gross returns and input costs in the maize production presented in the Table 4.37 revealed that the gross returns under sprinkler irrigation (` 97,169.65) was more than conventional method of irrigation (` 78,148.30).

5.7.2.3 Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of maize

The results of output decomposition analysis presented in Table 4.38 revealed that the adopters sprinkler irrigation technology produced 21.79 per cent higher income from maize production than conventional method of irrigation. The increase in the income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology alone could contribute 43.77 per cent increase in income, while the contribution of change in input levels was found to be negative (-21.99 %). Amongst the various inputs, seed (-2.42 %), bullock and machine labour (-0.52 %), plant protection chemicals (-0.82 %) and irrigation water applied (-26.84 %) contributed negatively to the income.

5.7.3 Groundnut

5.7.3.1 Structural break in the production relation of groundnut under sprinkler and conventional method of irrigation

The production function estimates for groundnut under sprinkler irrigation and conventional method of irrigation presented in Table 4.39 revealed that the value of co-efficient of determination (R^2) was found to be 0.900 and 0.974 in case of sprinkler irrigation and conventional method of irrigation, respectively. This revealed that the independent variables included in the model have explained 90.00 and 97.40 per cent of variation in the dependent variable of sprinkler irrigation and conventional method of irrigation, respectively. The elasticities of farmyard manure, fertiliser, human labour, and bullock and machine labour were positive and significant suggesting that, an increase in the use of this factor over and above their present level resulted in substantial increase in gross returns of farmers practicing sprinkler irrigation where as in case of farmers practicing conventional method of irrigation, the elasticities of variables such as seed, fertiliser and human labour were found to be positive and significant.

5.7.3.2 Geometric mean levels of returns and cost involved in groundnut production under sprinkler irrigation and conventional method of irrigation

The per hectare geometric mean levels of gross returns and input costs in the groundnut production presented in the Table 4.40 revealed that the gross returns under sprinkler irrigation (` 1,34,392.66) was more than conventional method of irrigation (` 88,309.25).

5.7.3.3 Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of groundnut

The results of output decomposition analysis presented in Table 4.41 revealed that the adopters of sprinkler irrigation technology produced 37.06 per cent higher income from groundnut production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology contributed positively to the income (67.88 %) and the contribution of change in input levels was found to be negative (-30.81 %). Amongst the various inputs, fertiliser (-9.30 %), human labour (-23.59 %), bullock and machine labour (-7.87 %) and plant protection chemicals (-1.57 %) contributed negatively to the income.

5.7.4 Redgram

5.7.4.1 Structural break in the production relation of redgram under sprinkler irrigation and conventional method of irrigation

The production function estimates for redgram under sprinkler irrigation and conventional method of irrigation presented in Table 4.42 revealed that the value of co-efficient of determination (R^2) was found to be 0.929 and 0.951 in case of sprinkler irrigation and conventional method of irrigation, respectively. This revealed that the independent variables included in the model have explained 92.29 and 95.10 per cent of variation in the dependent variable of sprinkler irrigation and conventional method of irrigation, respectively. The elasticities of seed, farmyard manure, human labour, and irrigation water applied were positive and significant suggesting that, an increase in the use of this factor over and above their present level resulted in substantial increase in gross returns of farmers practicing sprinkler irrigation where as in case of farmers practicing conventional method of irrigation, the elasticities of variables such as seed, farmyard manure, bullock and machine labour, plant protection chemicals and irrigation water applied were found to be positive and significant.

5.7.4.2 Geometric mean levels of returns and cost involved in redgram production under sprinkler irrigation and conventional method of irrigation

The per hectare geometric mean levels of gross returns and input costs in the redgram production presented in the Table 4.43 revealed that the gross returns under sprinkler irrigation (` 1,37,180.43) was more than conventional method of irrigation (` 95,017.67).

5.7.4.3 Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of redgram

The results of output decomposition analysis presented in Table 4.44 revealed that the adopters of sprinkler irrigation technology produced 36.72 per cent higher income from redgram production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology alone could contribute 67.65 per cent increase in income, while the contribution of change in input levels was found to be negative (-30.93 %). Amongst the various inputs, farmyard manure (-1.18 %), human labour (-14.50 %), plant protection chemicals (-0.38 %) and irrigation water applied (-22.04 %) contributed negatively to the income.

5.7.5 *Rabi* sorghum

5.7.5.1 Structural break in the production relation of *rabi* sorghum under sprinkler irrigation and conventional method of irrigation

The production function estimates for sorghum under sprinkler irrigation and conventional method of irrigation presented in Table 4.45 revealed that the value of co-efficient of determination (R^2) was found to be 0.970 and 0.954 in case of sprinkler irrigation and conventional method of irrigation, respectively. This revealed that the independent variables included in the model have explained 97.00 and 95.40 per cent of variation in the dependent variable of sprinkler irrigation and conventional method of irrigation, respectively. The elasticities of seed, farmyard manure, fertiliser and human labour were positive and significant suggesting that, an increase in the use of this factor over and above their present level resulted in substantial increase in gross returns of farmers practicing sprinkler irrigation where as in case of farmers practicing conventional method of irrigation, the elasticities of variables such as farmyard manure, human labour and irrigation water applied were found to be positive and significant.

5.7.5.2 Geometric mean levels of returns and cost involved in sorghum production under sprinkler irrigation and conventional method of irrigation

The per hectare geometric mean levels of gross returns and input costs in the sorghum production presented in the Table 4.46 revealed that the gross returns under sprinkler irrigation (` 1,05,202.34) was more than conventional method of irrigation (` 74,073.63).

5.7.5.3 Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in cultivation of sorghum

The results of output decomposition analysis presented in Table 4.47 revealed that the adopters of sprinkler irrigation technology produced 35.08 per cent higher income from sorghum production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology alone could contribute 50.24 per cent increase in income, while the contribution of change in input levels was found to be negative (-15.15 %). Amongst the various inputs, seed (-23.25 %) and fertiliser (-5.61 %) contributed negatively to the income.

The regression co-efficients for dummy variable were significant at one per cent level of significance. This implied that the parameter governing the input-output relations in case of micro irrigation was different from that of conventional method of irrigation. Thus, the results provided the necessary proof for decomposing the total change in per hectare income with the adoption of micro irrigation. This result is in conformity with those of Bisaliah (1977), Indusekharan (1982), Sisodiya (1999), Lalwani (2000), Gaddi *et al.* (2002), Kunnal (2004), Radha (2005), Ravichandran (2006), Mohan (2009) and Vinod (2010).

The per hectare geometric mean levels of gross returns and input costs in production of different crops revealed that the gross returns under micro irrigation was more than conventional method of irrigation. This was mainly due to the fact that the crops grown under micro irrigation yielded more than the conventional method of irrigation and crops grown under micro irrigation could fetch the high premium price in the market. With regard to input costs the micro irrigation practice involves less cost than conventional method of irrigation this is because in case of conventional method of irrigation the farmers were spending more money for sets/seeds, farmyard manure, fertilisers, human labour, bullock and machine labour and plant protection chemicals and more irrigation water for irrigating the crop.

The input costs contributed negatively to the income which implied that the adoption of micro irrigation has to be encouraged by extension activities. The result highlights the judicious utilization of resources to increase the income from cultivation of different crops.

5.8 Constraints faced by sample respondents in the study area

5.8.1 Constraints faced by farmer beneficiaries in adoption and maintenance of micro irrigation systems

Constraints faced by farmer beneficiaries in adoption and maintenance of micro irrigation systems presented in Table 4.48 reveals that inadequate power supply, clogging of emitters and delay in sanction of subsidy were the major top three problems faced by the farmers practicing drip irrigation where as the farmers practicing sprinkler irrigation opined that inadequate power supply, delay in sanction of subsidy and shifting of sprinkler irrigation system were the top three problems. There was irregular and insufficient supply of power to irrigate the crop in the study area. The drip irrigated farmers ranked clogging of emitters as the second major problem where as practicing sprinkler irrigation opined that shifting of sprinkler irrigation system in the field was the top second problem because the scheme providing only 30 lateral pipes and five nozzles per hectare. And both sprinkler irrigation farmers and drip irrigation farmers opined that delay in sanction of subsidy was the third major problem which might be due to government procedural delay. Thus the hypothesis made in the beginning of the study is proved.

5.8.2 Constraints faced by the farmers in cultivation of different crops under conventional method of irrigation

Constraints faced by the farmers in cultivation of different crops under conventional method of irrigation depicted in Table 4.49 indicates that the wastage of water was the most serious problem faced by the farmers and was ranked first followed by inadequate power supply and problem of soil erosion, inadequate irrigation water supply, water logging, reduced crop yield, labour intensive, high electricity usage, increased incidence of pest and diseases, low quality produce, problem of theft and lack of awareness about fertigation. The wastage of water was ranked first and was mainly due to the fact that water under conventional method of irrigation gets lost to evaporation, run off, infiltration in uncultivated areas, transpiration through the leaves of weeds, anaerobic conditions in the soil and around crop root zone and deep percolation below the crop root zone that is unavailable to the plants and infiltrates for longer period of time at the top end of the field compared to other end.

The results of the constraints faced by the farmers in the study area are also supported by the studies of Batta (2000), Zenebe (2000), Kulecho (2005), Uday (2007), Navaneeth (2008), Balasubramanaiam (2009), Muruganantham (2009), Nogues (2009), Kumar (2012) and Mostafa (2013).

6. SUMMARY AND POLICY IMPLICATIONS

Water is gradually becoming a scarce resource worldwide especially in developing countries like India. With the increasing need of providing food and water security for an ever increasing population, the availability, usability and affordability of water is becoming a major challenge. Efficient use of this resource is essential. However, this requires innovation and more precision in its utilisation, especially where it is used in abundance like agriculture. In spite of technological advancements in pressurised irrigation techniques, a substantial amount of land worldwide, especially in countries like India is still irrigated by surface irrigation. With agriculture being the most dominant water user, it is essential to develop and improve existing technologies for more efficient use of this precious resource.

There are different conventional methods of irrigation being practiced by farmers, such as flood and furrow irrigation. Among these two, flood irrigation is an ancient method of irrigation and is one of the most commonly used methods of irrigation. While the flood irrigation generally assumed that only half of the water applied actually used up by the crop; the other half is lost in the form of evaporation, run off, transpiration through the leaves of weeds, anaerobic conditions in the soil and around crop root zone and deep percolation below the crop root zone that is unavailable to the plants. In furrow irrigation, the water is applied to the top end of each furrow and flows down the field through gravity. Furrows may range anywhere from less than 100 meters to 300 meters long depending on the soil type, location, topography and crop type. In this method, water can take a considerable period of time to reach the other end, meaning water has been infiltrating for longer period of time at the top end of the field. This results in poor uniformity with high application at the top end and lower application at the bottom end. These conventional methods of irrigation not only reduce crop production and affect the soil fertility but also cause ecological hazards like water logging and soil salinity. The application of irrigation water by conventional methods causes upto 30 per cent loss of water through deep percolation depending on the soil type (Anon, 2014a).

Thus to overcome these problems of conventional irrigation methods and to achieve the projected food grain production of 245 million tonnes by the end of the year 2010, Government of India constituted a national task force on micro irrigation in 2004 with an objective to emphasize on all aspects of water conservation and to improve water use efficiency to achieve more crop per drop of water. Later, the government launched a centrally sponsored scheme on micro irrigation (CSSMI) in January 2006 with an objective to increase the area under improved methods of irrigation for better water use efficiency to provide stimulus to agricultural growth. The scheme was further up scaled into mission mode in 2010 as the national mission on micro irrigation covering an area of 1.5 million hectares under drip irrigation and 0.5 million hectares under sprinkler irrigation. The estimated potential of micro irrigation systems in the country is 69.50 Million hectares; of which drip and sprinkler irrigation technology in the country is 27.0 & 42.5 million hectares, respectively. The main objectives of the national mission on micro irrigation are: to increase the area under micro irrigation through improved technologies, to enhance the water use efficiency in the country, to increase the productivity of crops and farmers' income, to establish convergence & synergy among on-going

Government programmes, to promote, develop and disseminate micro irrigation technology for agriculture/ horticulture development with modern scientific knowledge and to create employment opportunities for skilled and unskilled person especially unemployed youth.

Karnataka state has achieved more than 100 per cent of physical targets (105.03 %) and 98.23 per cent of financial targets. The physical target was 5,10,960 hectares and target achieved by the end of 2012-13 is 5,36,680 hectares. The financial target fixed was ` 60,889.32 lakh and target achieved by the end of 2012-13 is ` 59,812.26 lakh (Anon, 2014b). The potential area for micro irrigation in Karnataka is 41.37 lakh hectares and the cumulative area under micro irrigation till 2014-15 is only about 9.93 lakh hectares. Thus there is scope to increase the area under micro irrigation to the extent of 33.87 lakh hectares (76.00 %).

Water is the elixir of life. Every drop of water needs to be used optimally. So much water is being wasted through conventional methods of irrigation even water availability in plenty at the bossom of the earth cannot be extracted at cheap. With every passing day, water is going to become the most critical factor in agriculture and pattern of its use assumes greater importance in the context of its scarcity and huge investment in its creation. Hence, the study is timely and appropriate. The study aims at assessing the impact of micro irrigation in terms of increase in area under micro irrigation, cropping intensity, changes in cropping pattern, crop yield, income and amount of water saved *etc.* In the light of the above and considering the relevance of micro irrigation system in the current agricultural scenario, the study was undertaken with the following specific objectives;

6.1 Specific objectives

1. To study the extent of area coverage under micro irrigation in the state over the years
2. To document the extent of private investment and subsidy provided for micro irrigation systems in the state and to study the government schemes on micro irrigation and provisions thereof
3. To analyse the water use efficiency in major crops under different irrigation systems
4. To estimate profitability of major crops in conventional v/s micro irrigation systems in the study area
5. To evaluate the financial feasibility of investment in micro irrigation systems in the study area
6. To identify constraints in adoption of micro irrigation systems by the farmers in the study area

6.2 Methodology

The purposive multistage random sampling was followed for the selection of districts, taluks, villages and micro irrigation beneficiary farmers. The farmers practicing conventional methods of irrigation were selected from the selected villages randomly.

For detailed study, four major districts in terms of no. of beneficiaries covered (both drip & sprinkler) under the project entitled “Evaluation of micro irrigation scheme implemented in Karnataka” were selected. Hence, Belagavi, Viyayapur, Bidar and Kalaburgi districts were selected purposively.

From each selected district one major taluk in terms of no. of beneficiaries covered (both drip & sprinkler) under the project were selected purposively. Three villages from each taluk based on the availability of beneficiaries practicing both drip and sprinkler irrigation systems for raising the field crops were selected purposively for the study. From each selected village ten farmers practicing sprinkler irrigation, ten farmers practicing drip irrigation and ten farmers practicing conventional methods of irrigation (flood/furrow) were selected purposively. Thus village wise sample size was 30, district wise sample size was 90 and irrigation method wise sample size was 120 and thus making the total sample size of 360.

The data on socio economic characteristics of the farmers, cropping pattern, cost of cultivation and water applied in cultivation of major crops under different methods of irrigation, and constraints faced by the respondents in adoption and maintenance of different irrigation methods *etc.*, were collected.

Secondary data on area covered under and subsidy provided for micro irrigation in the state and list of farmer beneficiaries etc were collected from the Department of Agriculture and Department of Horticulture, Bangalore. General features of the study area and land revenue *etc* were collected from the district statistical offices of each selected district. Efforts were also made to gain the secondary data required for the study from the Joint Director offices of respective districts and important websites like www.planninigcommission.nic.in, www.indiastat.com, www.karnataka state at a glance.com *etc.*

6.3 Analytical tools and techniques

For the purpose of achieving the objectives and to draw meaningful interpretations and inferences of the study, the data were analysed using the growth rate analysis, instability analysis, budgeting technique, financial feasibility analysis, decomposition analysis and garret ranking technique.

6.4 Major findings of the study

The area coverage under micro irrigation system in the state showed positive growth rate of 20.33 per cent per annum. The extent of subsidy provided for micro irrigation was growing positively at the rate of 25.92 per cent annually. The subsidy for micro irrigation in the state by the state government was growing at the higher rate (28.06 %) followed by subsidy given by central government (23.71 %) and the farmer's share (13.19 %) annually.

The major occupation of the farmers was agriculture and the crops selected for the study were sugarcane, maize, groundnut, redgram and *rabi* sorghum. In the study area the farmers were following conventional method of irrigation *i.e.* flood and furrow method of irrigation for the crops before implementation of the scheme. Most of the farmers were illiterate in conventional method of irrigation compared to farmers following scientific irrigation methods (sprinkler irrigation & drip irrigation).

The gain in water use efficiency was to the extent of 70.59 per cent, 53.63 per cent, 70.97 per cent, 66.29 per cent and 65.66 per cent by adopting micro irrigation over the conventional method of irrigation in cultivation of sugarcane, maize, groundnut, redgram and *rabi* sorghum, respectively in the study area.

The per hectare increase in yield and income by drip irrigation over conventional method of irrigation in cultivation of sugarcane was 34.50 tonnes and ` 1,01,160.53, respectively. The per hectare increase in yield and income by sprinkler irrigation over conventional method of irrigation in cultivation of maize was 11.50 quintals and ` 20,870.55, respectively. The per hectare increase in yield and income by sprinkler irrigation over conventional method of irrigation in cultivation of groundnut was 9.79 quintals and ` 45,225.49, respectively. The per hectare increase in yield and income by sprinkler irrigation over conventional method of irrigation in cultivation of redgram was 5.50 quintals and ` 35,934.76, respectively. Similarly, per hectare increase in yield and income by sprinkler irrigation over conventional method of irrigation in cultivation of *rabi* sorghum was 10.04 quintals and ` 30,310.70, respectively.

The financial feasibility of investment on micro irrigation system in cultivation of sugarcane, maize, groundnut, redgram and *rabi* sorghum was found to be financially feasible and economically viable compared to that of conventional method of irrigation since discounted Benefit Cost Ratio (BCR), Net Present Value (NPV), Internal Rate of Returns (IRR) were higher and Pay Back Period (PBP) was lower for micro irrigation system compared to conventional method of irrigation. The Benefit Cost Ratio, Net Present Value, Internal Rate of Returns and Pay Back Period for sugarcane crop under drip irrigation in case of without subsidy were 2.04, ` 6,85,163.83, 30.51 per cent and 1.51 years, respectively and in case of with subsidy these values were found to be 2.16, ` 7,80,045, 51.51 per cent and 0.96 years, respectively. For maize crop under sprinkler irrigation without subsidy BCR, NPV, IRR and PBP were 1.78, ` 2,04,159.96, 27.51 per cent and 1.65 years, respectively where as with subsidy these values were found to be 1.83, ` 2,12,963, 31.51 per cent and 1.49 years, respectively. In case of groundnut without subsidy these values were 2.27, ` 3,93,515.13, 49.51 per cent and 1.00 year, respectively and with subsidy these values were 2.33, ` 4,02,318, 55.51 per cent and 0.90 year, respectively. Similarly, for redgram under sprinkler irrigation without subsidy BCR, NPV, IRR and PBP were 2.59, ` 4,25,060.90, 41.51 per cent and 1.18 years, respectively and in case of with subsidy these values were 2.62, ` 4,33,624, 44.51 per cent and 1.09 years, respectively. In case of *rabi* sorghum, sprinkler irrigation without subsidy these values were 2.15, ` 2,71,985.04, 27.51 per cent and 1.65 years, respectively and in case of with subsidy these values were found to be 2.18, ` 2,80,548, 30.51 per cent and 1.52 years, respectively.

In case of sugarcane production the adopters of drip irrigation technology produced 25.31 per cent higher income from sugarcane production than conventional method of irrigation. The increase in the income was further decomposed into different sources of change such as adoption of drip irrigation technology and all other inputs. The drip irrigation technology alone could contribute 44.83 per cent increase in income, while the contribution of change in input levels was found to be negative (-19.53 %). Amongst the various inputs, seed (-2.40 %), farmyard manure (-2.00 %), fertiliser (-3.95

%), human labour (-16.95 %), bullock and machine labour (-0.84 %) and plant protection chemicals (-1.35 %) contributed negatively to the income.

In case of maize production in the study area the adopters of sprinkler irrigation technology produced 21.79 per cent higher income from maize production than conventional method of irrigation. The increase in the income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology alone could contribute 43.77 per cent increase in income, while the contribution of change in input levels was found to be negative (-21.99 %). Amongst the various inputs, seed (-2.42 %), bullock and machine labour (-0.52 %), plant protection chemicals (-0.82 %) and irrigation water applied (-26.84 %) contributed negatively to the income.

In case of groundnut production the adopters of sprinkler irrigation technology produced 37.06 per cent higher income from groundnut production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology contributed positively to the income (67.88 %) and the contribution of change in input levels was found to be negative (-30.81 %). Amongst the various inputs, fertiliser (-9.30 %), human labour (-23.59 %), bullock and machine labour (-7.87 %) and plant protection chemicals (-1.57 %) contributed negatively to the income.

In case of redgram production in the study area the adopters of sprinkler irrigation technology produced 36.72 per cent higher income from redgram production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology alone could contribute 67.65 per cent increase in income, while the contribution of change in input levels was found to be negative (-30.93 %). Amongst the various inputs, farmyard manure (-1.18 %), human labour (-14.50 %), plant protection chemicals (-0.38 %) and irrigation water applied (-22.04 %) contributed negatively to the income.

In case of *rabi* sorghum production the adopters of sprinkler irrigation technology produced 35.08 per cent higher income from sorghum production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change such as adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology alone could contribute 50.24 per cent increase in income, while the contribution of change in input levels was found to be negative (-15.15 %). Amongst the various inputs, seed (-23.25 %) and fertiliser (-5.61 %) contributed negatively to the income.

Inadequate power supply, clogging of emitters and delay in sanction of subsidy were the major top three problems faced by the farmers practicing drip irrigation with a garret score of 81.68, 65.53 and 59.89, respectively. In case of farmers practicing sprinkler irrigation opined that inadequate power supply, delay in sanction of subsidy and problem of shifting were the top three problems with a garret score of 77.39, 59.12 and 57.13, respectively. Wastage of water in the form of excess irrigation was the most serious problem faced by the farmers practicing conventional method of irrigation and was ranked first with a garret score of 79.53 followed by inadequate power supply (74.75) and problem of soil erosion (58.33).

Policy implications

1. The potential area for micro irrigation in Karnataka state is 41.37 lakh hectares and the area covered under micro irrigation is only 9.93 lakh hectares by the end of the year 2014-15. Thus, there is a vast scope to increase the area under micro irrigation to the extent of 31.44 lakh hectares (76.00 %). Hence, efforts need to be made by the government to extend the ongoing scheme to cover the remaining interested farmers to adopt micro irrigation systems and also supply of spare parts of the micro irrigation system under subsidy to bring more under micro irrigation in the state.
2. Even though the state government has increased the subsidy of micro irrigation systems from 75 per cent to 90 per cent to all categories of the farmers, most of the farmers are not aware. Hence, there is a need to strengthen the extension services to make the farmers aware of the benefits of the scheme and motivate them for adoption of micro irrigation system.
3. In cultivation of sugarcane, maize, groundnut, redgram and *rabi* sorghum in the study area, the gain in water use efficiency by adopting micro irrigation system over conventional method of irrigation was found to be 70.59 per cent, 53.63 per cent, 70.97 per cent, 66.29 per cent and 65.66 per cent, respectively. Hence to save water and enhance water use efficiency, the farmers are to be advised for adoption of micro irrigation systems in cultivation of above mentioned crops in the study area.
4. The cultivation of sugarcane under drip irrigation system showed a saving in usage of human labour to the extent of 86.52 man days per hectare over conventional method of irrigation in the study area. Hence the farmers need to be encouraged to adopt drip irrigation system in cultivation of sugarcane to overcome the problem of scarcity of labour.
5. The per hectare increase in yield by adopting micro irrigation system over conventional method of irrigation in cultivation of sugarcane, maize, groundnut, redgram and *rabi* sorghum in the study area was 34.50 tonnes, 11.50 quintals, 9.79 quintals, 5.50 quintals and 10.04 quintals, respectively, whereas the per hectare increase in income was ` 1,01,160.53, ` 20,870.55, ` 45,225.49, ` 35,934.76 and ` 30,310.70, respectively. Hence farmers are to be advised the benefits of micro irrigation systems in enhancing the crop productivity and farm income in the study area.
6. The financial feasibility of investment on micro irrigation system in cultivation of sugarcane, maize, groundnut, redgram and *rabi* sorghum was found to be financially feasible and economically viable (even without subsidy) as compared to conventional method of irrigation as indicated by higher net present value (NPV), internal rate of returns (IRR), benefit cost ratio (BCR) and lower payback period (PBP). Therefore awareness among the farmers needs to be created about the

benefits of investment on micro irrigation systems over conventional method of irrigation in the study area.

7. Among various problems faced by the farmers, inadequate power supply, clogging of emitters and delay in sanction of subsidy were the major ones under drip irrigation with a garret score of 81.68, 65.53 and 59.89, respectively where as the inadequate power supply, delay in sanction of subsidy and shifting of sprinkler irrigation system in the field were the major problems faced by the farmers adopted sprinkler irrigation with a garret score of 77.39, 59.12 and 57.13, respectively. Hence, to encourage farmers for the adoption of both systems of micro irrigation and to enhance area under micro irrigation system, efforts need to be made by the concerned departments/institutions/agencies for the timely supply of electricity and release of funds on a regular basis.

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Appendix I: Compound growth rate and instability of area covered under micro irrigation system in Karnataka (2005-06 to 2014-15)

Sl. No.	Year	Area in hectares
1	2005-06	10,562.38
2	2006-07	43,600.16
3	2007-08	66,574.00
4	2008-09	94,785.06
5	2009-10	27,612.00
6	2010-11	84,744.63
7	2011-12	81,879.18
8	2012-13	1,22,031.73
9	2013-14	1,27,546.33
10	2014-15	90,297.17
	Total	7,49,632.65
	CGR (%)	**20.33****
	Instability Index (%)	**35.23**

Source: Centre for budget and policy studies, 2013
www.indiastat.com
www.karnatakastat.com
Note: ** Significance at 5 % level

Appendix II: Compound growth rate and instability of subsidy provided for and private investment on micro irrigation system in Karnataka (2005-06 to 2014-15)

Sl. No.	Year	(Rs. in lakhs)				
		State Subsidy	**Central subsidy**	**Total subsidy**	**Farmers share**	**Total investment**
1	2005-06	1,672.53	1,911.47	3,584.00	1,194.67	4,778.67
2	2006-07	5,048.07	5,769.22	10,817.29	3,605.76	14,423.05
3	2007-08	5,766.41	6,590.18	12,356.59	4,118.86	16,475.45
4	2008-09	7,139.54	8,159.48	15,299.02	5,099.67	20,398.69
5	2009-10	7,241.00	8,275.42	15,516.42	5,172.14	20,688.56
6	2010-11	7,564.42	8,645.05	16,209.47	5,403.16	21,612.63
7	2011-12	7,681.21	8,778.52	16,459.73	5,486.58	21,946.31
8	2012-13	14,995.93	17,138.21	32,134.14	10,711.38	42,845.52
9	2013-14	23,601.55	18,881.24	42,482.80	4,720.31	47,203.11
10	2014-15	26,829.95	21,463.96	48,293.91	5,365.99	53,659.90
	Total	1,07,540.61	1,05,612.75	2,13,153.36	50,878.52	2,64,031.89
	CGR (%)	**28.06*** **	**23.71*** **	**25.92*** **	**13.19** **	**23.71*** **
	Instability Index (%)	**28.24**	**23.73**	**25.50**	**33.93**	**23.73**

Source: Centre for budget and policy studies, 2013
www.indiastat.com
www.karnatakastat.com
Note: *** Significance at 1 % level
** Significance at 5 % level

Appendix III: Financial feasibility of investment on drip irrigation and conventional method of irrigation in cultivation of sugarcane in the study area

(Per ha)

Year	Drip irrigation with subsidy				Drip irrigation without subsidy				Conventional method of irrigation			
	Cash outflows	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**	**Cash outflows**	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**	**Cash outflows**	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**
0	1,59,529	-	-1,59,529		2,49,528	-	-2,49,528	-	1,64,959	-	-1,64,959	-
1	1,31,431	2,97,721	1,66,290	1,48,473	1,32,295	2,97,720	1,65,425	1,47,701	1,74,571	2,30,856	56,285	50,254
2	1,31,431	2,97,721	1,66,290	1,32,565	1,32,295	2,97,720	1,65,425	1,31,876	1,74,571	2,30,856	56,285	44,870
3	1,31,431	2,97,721	1,66,290	1,18,362	1,32,295	2,97,720	1,65,425	1,17,746	1,74,571	2,30,856	56,285	40,062
4	1,31,431	2,97,721	1,66,290	1,05,680	1,32,295	2,97,720	1,65,425	1,05,131	1,74,571	2,30,856	56,285	35,770
5	1,31,431	2,97,721	1,66,290	94,357	1,32,295	2,97,720	1,65,425	93,867	1,74,571	2,30,856	56,285	31,937
6	1,31,431	2,97,721	1,66,290	84,248	1,32,295	2,97,720	1,65,425	83,809	1,74,571	2,30,856	56,285	28,515
7	1,31,431	2,97,721	1,66,290	75,221	1,32,295	2,97,720	1,65,425	74,830	1,74,571	2,30,856	56,285	25,460
8	1,31,431	2,97,721	1,66,290	67,162	1,32,295	2,97,720	1,65,425	66,812	1,74,571	2,30,856	56,285	22,732
9	1,31,431	2,97,721	1,66,290	59,966	1,32,295	2,97,720	1,65,425	59,654	1,74,571	2,30,856	56,285	20,297
10	1,31,431	2,97,721	1,66,290	53,541	1,32,295	2,97,720	1,65,425	53,262	1,74,571	2,30,856	56,285	18,122
Total	14,73,841	29,77,210	15,03,369	4,32,183	15,72,480	29,77,209	14,04,729	9,34,692	19,10,671	23,08,565	3,97,894	3,18,025
	NPV (`)	7,80,045			NPV (`)	6,85,163			NPV (`)	1,53,065		
	IRR (%)	51.51			IRR (%)	30.51			IRR (%)	11.52		
	B-C Ratio	2.16			B-C Ratio	2.04			B-C Ratio	1.28		
	PBP (Year)	0.96			PBP (Year)	1.51			PBP (Year)	2.93		

Note: NPV, IRR and B-C Ratio were calculated at 12 % discount rate

Appendix IV: Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of maize in the study area

(Per ha)

Year	Sprinkler irrigation with subsidy				Sprinkler irrigation without subsidy				Conventional method of irrigation			
	Cash outflows	Cash inflows	Net cash flows	Discounted net cash flows	Cash outflows	Cash inflows	Net cash flows	Discounted net cash flows	Cash outflows	Cash inflows	Net cash flows	Discounted net cash flows
0	75,995	-	-75,995	-	84,331	-	-84,331	-	82,479	-	-82,479	-
1	46,907	98,048	51,141	39,039	46,989	98,047	51,058	45,587	53,337	78,649	25,312	22,600
2	46,907	98,048	51,141	29,801	46,989	98,047	51,058	40,703	53,337	78,649	25,312	20,179
3	46,907	98,048	51,141	22,749	46,989	98,047	51,058	36,342	53,337	78,649	25,312	18,017
4	46,907	98,048	51,141	17,365	46,989	98,047	51,058	32,448	53,337	78,649	25,312	16,086
5	46,907	98,048	51,141	13,256	46,989	98,047	51,058	28,971	53,337	78,649	25,312	14,363
6	46,907	98,048	51,141	10,119	46,989	98,047	51,058	25,867	53,337	78,649	25,312	12,824
7	46,907	98,048	51,141	7,725	46,989	98,047	51,058	23,096	53,337	78,649	25,312	11,450
8	46,907	98,048	51,141	5,897	46,989	98,047	51,058	20,621	53,337	78,649	25,312	10,223
9	46,907	98,048	51,141	4,501	46,989	98,047	51,058	18,412	53,337	78,649	25,312	9,128
10	46,907	98,048	51,141	3,436	46,989	98,047	51,058	16,439	53,337	78,649	25,312	8,150
Total	5,45,062	9,80,478	4,35,416	22,503	5,54,224	9,80,477	4,26,252	2,88,491	6,15,850	7,86,497	1,70,646	1,43,022
	NPV (`)	2,12,963			NPV (`)	2,04,159			NPV (`)	60,542		
	IRR (%)	31.51			IRR (%)	27.51			IRR (%)	8.52		
	B-C Ratio	1.83			B-C Ratio	1.78			B-C Ratio	1.39		
	PBP (Year)	1.49			PBP (Year)	1.65			PBP (Year)	3.26		

Note: NPV, IRR and B-C Ratio were calculated at 12 % discount rate

Appendix V: Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of groundnut in the study area

(Per ha)

Year	Sprinkler irrigation with subsidy				Sprinkler irrigation without subsidy				Conventional method of irrigation			
	Cash outflows	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**	**Cash outflows**	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**	**Cash outflows**	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**
0	75,995	-	-75,995		84,331	-	-84,331	-	82,479	-	-82,479	-
1	52,214	1,36,868	84,654	54,265	52,296	1,36,868	84,571	75,510	56,506	90,977	34,470	30,777
2	52,214	1,36,868	84,654	34,785	52,296	1,36,868	84,571	67,419	56,506	90,977	34,470	27,479
3	52,214	1,36,868	84,654	22,298	52,296	1,36,868	84,571	60,196	56,506	90,977	34,470	24,535
4	52,214	1,36,868	84,654	14,294	52,296	1,36,868	84,571	53,746	56,506	90,977	34,470	21,906
5	52,214	1,36,868	84,654	9,163	52,296	1,36,868	84,571	47,988	56,506	90,977	34,470	19,559
6	52,214	1,36,868	84,654	5,874	52,296	1,36,868	84,571	42,846	56,506	90,977	34,470	17,463
7	52,214	1,36,868	84,654	3,765	52,296	1,36,868	84,571	38,255	56,506	90,977	34,470	15,592
8	52,214	1,36,868	84,654	2,414	52,296	1,36,868	84,571	34,156	56,506	90,977	34,470	13,922
9	52,214	1,36,868	84,654	1,547	52,296	1,36,868	84,571	30,497	56,506	90,977	34,470	12,430
10	52,214	1,36,868	84,654	992	52,296	1,36,868	84,571	27,229	56,506	90,977	34,470	11,098
Total	5,98,136	13,68,681	7,70,545	6,018	6,07,298	13,68,680	7,61,381	4,77,846	6,47,544	9,09,770	2,62,226	1,94,766
	NPV (`)	4,02,318			NPV (`)	3,93,515			NPV (`)	1,12,286		
	IRR (%)	55.51			IRR (%)	49.51			IRR (%)	16.52		
	B-C Ratio	2.33			B-C Ratio	2.27			B-C Ratio	1.53		
	PBP (Year)	0.90			PBP (Year)	1.00			PBP (Year)	2.39		

Note: NPV, IRR and B-C Ratio were calculated at 12 % discount rate

Appendix VI: Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of redgram in the study area

(Per ha)

Year	Sprinkler irrigation with subsidy				Sprinkler irrigation without subsidy				Conventional method of irrigation			
	Cash outflows	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**	**Cash outflows**	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**	**Cash outflows**	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**
0	1,03,503	-	-1,03,503	-	1,11,839	-	-1,11,839	-	1,10,624	-	-1,10,624	-
1	45,255	1,40,318	95,063	66,016	45,294	1,40,317	95,022	84,841	46,359	99,504.17	53,144	47,450
2	45,255	1,40,318	95,063	45,844	45,294	1,40,317	95,022	75,751	46,359	99,504.17	53,144	42,366
3	45,255	1,40,318	95,063	31,836	45,294	1,40,317	95,022	67,635	46,359	99,504.17	53,144	37,827
4	45,255	1,40,318	95,063	22,109	45,294	1,40,317	95,022	60,388	46,359	99,504.17	53,144	33,774
5	45,255	1,40,318	95,063	15,353	45,294	1,40,317	95,022	53,918	46,359	99,504.17	53,144	30,155
6	45,255	1,40,318	95,063	10,662	45,294	1,40,317	95,022	48,141	46,359	99,504.17	53,144	26,924
7	45,255	1,40,318	95,063	7,404	45,294	1,40,317	95,022	42,983	46,359	99,504.17	53,144	24,040
8	45,255	1,40,318	95,063	5,142	45,294	1,40,317	95,022	38,378	46,359	99,504.17	53,144	21,464
9	45,255	1,40,318	95,063	3,571	45,294	1,40,317	95,022	34,266	46,359	99,504.17	53,144	19,164
10	45,255	1,40,318	95,063	2,480	45,294	1,40,317	95,022	30,594	46,359	99,504.17	53,144	17,111
Total	5,56,051	14,03,178	8,47,127	15,561	5,64,788	14,03,177	8,38,389	5,36,900	5,74,217	9,95,041.67	4,20,824	3,00,280
	NPV (`)	4,33,624			NPV (`)	4,25,060			NPV (`)	1,89,656		
	IRR (%)	44.51			IRR (%)	41.51			IRR (%)	20.52		
	B-C Ratio	2.62			B-C Ratio	2.59			B-C Ratio	2.02		
	PBP (Year)	1.09			PBP (Year)	1.18			PBP (Year)	2.08		

Note: NPV, IRR and B-C Ratio were calculated at 12 % discount rate

Appendix VII: Financial feasibility of investment on sprinkler irrigation and conventional method of irrigation in cultivation of rabi sorghum in the study area

(Per ha)

Year	Sprinkler irrigation with subsidy				Sprinkler irrigation without subsidy				Conventional method of irrigation			
	Cash outflows	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**	**Cash outflows**	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**	**Cash outflows**	**Cash inflows**	**Net cash flows**	**Discounted net cash flows**
0	1,03,503	-	-1,03,503	-	1,11,839	-	-1,11,839	-	1,10,624	-	-1,10,624	-
1	42,501	1,10,472	67,971	51,886	42,541	1,10,471	67,930	60,652	43,346	75,022	31,676	28,282
2	42,501	1,10,472	67,971	39,608	42,541	1,10,471	67,930	54,154	43,346	75,022	31,676	25,252
3	42,501	1,10,472	67,971	30,235	42,541	1,10,471	67,930	48,351	43,346	75,022	31,676	22,546
4	42,501	1,10,472	67,971	23,080	42,541	1,10,471	67,930	43,171	43,346	75,022	31,676	20,131
5	42,501	1,10,472	67,971	17,618	42,541	1,10,471	67,930	38,545	43,346	75,022	31,676	17,974
6	42,501	1,10,472	67,971	13,449	42,541	1,10,471	67,930	34,415	43,346	75,022	31,676	16,048
7	42,501	1,10,472	67,971	10,267	42,541	1,10,471	67,930	30,728	43,346	75,022	31,676	14,329
8	42,501	1,10,472	67,971	7,837	42,541	1,10,471	67,930	27,436	43,346	75,022	31,676	12,793
9	42,501	1,10,472	67,971	5,982	42,541	1,10,471	67,930	24,496	43,346	75,022	31,676	11,423
10	42,501	1,10,472	67,971	4,567	42,541	1,10,471	67,930	21,871	43,346	75,022	31,676	10,199
Total	5,28,513	11,04,719	5,76,207	30,483	5,37,250	11,04,719	5,67,469	3,83,824	5,44,084	7,50,229	2,06,144	1,78,981
	NPV (`)	2,80,548			NPV (`)	2,71,985			NPV (`)	68,357		
	IRR (%)	30.51			IRR (%)	27.51			IRR (%)	7.52		
	B-C Ratio	2.18			B-C Ratio	2.15			B-C Ratio	1.62		
	PBP (Year)	1.52			PBP (Year)	1.65			PBP (Year)	3.49		

Note: NPV, IRR and B-C Ratio were calculated at 12 % discount rate

IMPACT OF MICRO IRRIGATION SYSTEMS ON CROP PRODUCTIVITY AND WATER USE EFFICIENCY IN NORTHERN KARNATAKA - AN ECONOMIC ANALYSIS

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ABSTRACT

The study analysed the impact of micro irrigation systems (MIS) on crop productivity and water use efficiency (WUE) in major crops of northern Karnataka. Purposive multistage random sampling procedure was used for the selection of sample respondents. A total of 360 respondents were surveyed in Belagavi, Vijayapur, Bidar and Kalaburgi districts. The analytical tools used were compound annual growth rate, tabular and financial feasibility analyses, budgeting technique and garret ranking technique.

The area covered and subsidy provided for adoption of MIS during the period 1991-92 to 2014-15 showed a positive growth rate of 20.33 per cent and 25.92 per cent per annum, respectively. The gain in WUE under MIS over conventional method of irrigation (CMI) was to the extent of 70.59 per cent, 53.63 per cent, 70.97 per cent, 66.29 per cent and 65.66 per cent in cultivation of sugarcane, maize, groundnut, redgram and *rabi* sorghum, respectively and increased the yield of these crops in that order to the extent of 34.50 tonnes, 11.50 quintals, 9.79 quintals, 5.50 quintals and 10.04 quintals. The increase in farm income under MIS over CMI in cultivation of sugarcane, maize, groundnut, redgram and *rabi* sorghum was ` 1,10,160.53, ` 20,870.55, ` 45,225.49, ` 35,934.76 and ` 30,310.70, respectively. The investment on MIS was found to be financially feasible and economically viable.

Inadequate power supply, clogging of emitters, delay in sanction of subsidy and shifting of sprinkler irrigation system were the major constraints faced by the farmers in adoption and maintenance of MIS in the study area. Awareness among the farmers needs to be created about the benefits of investment on micro irrigation systems over conventional method of irrigation and efforts need to be made by the concerned departments /institutions/agencies for the timely supply of electricity and release of funds on a regular basis.