Profitability and Productivity of Irrigation in Semi-Arid Tropics of India

Dissertation submitted in partial fulfilment of the requirements for the degree of Master of Philosophy in Applied Economics of the Jawaharlal Nehru University

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MPhil Programme in Applied Economics

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CENTRE FOR DEVELOPMENT STUDIES

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Certificate

I hereby affirm that the work for this dissertation, Profitability and Productivity of Irrigation in Semi-Arid Tropics of India, being submitted as part of the requirements of the MPhil Programme in Applied Economics of the Jawaharlal Nehru University, was carried out entirely by myself. I also affirm that it was not part of any other programme of study and has not been submitted to any other University for the award of any Degree.

June 2022 Tirunagari Likhitha

Certified that this study is the bona fide work of Tirunagari Likhitha, carried out under our supervision at the Centre for Development Studies.

Thiagu Ranganathan

Associate Professor

Director

Centre for Development Studies

Dedicated to my Mom, Dad and Dear sister Pravalika.

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ABSTRACT OF THE DISSERTATION

Profitability and Productivity of Irrigation in Semi-Arid Tropics of India

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Irrigation plays an important role in agricultural development. Reliable and timely water supply enable the farmers to change their cropping pattern and cultivate crops with higher value. It also increases the gross cropped area under cultivation and in effect the cropping intensity. Irrigation also brings stability to production by improving yield in a bad rainfall year. Several studies have discussed economic returns to irrigation. Most of the studies had estimated positive relation between irrigated land, returns and the yield of the crops. This thesis aims to find the profitability and productivity of irrigation in the semi-arid tropics of India. With depleting groundwater resources and increase in failure of wells and tube well-related indebtedness in these regions, it is important to know what has been the profitability and productivity of the crops under irrigation over the years.

ICRISAT's Village Dynamics in South Asia (VDSA) data is used for the study. For this study, data from 1975-79 and 2009-14 is used as it can capture the trends in profitability. Six villages from two states, Telangana and Maharashtra, are covered in this study.

Regarding the changes in cropping pattern, during 1975-79, most villages cultivated less water-intensive crops, like castor, jowar, bajra, cotton & pigeon pea. Paddy, a high-water intensive crop is grown in only Dokur village due to the higher percentage of the irrigated area in the village. During 2009-14, villages with more irrigation cultivated water-intensive crops such as paddy and sugarcane. In moderately irrigated villages, less water-intensive crops and commercial crops are grown, like cotton in Aurapalle and soybean in the Akola district.

For measuring profitability, I use net returns per acre. Net returns are calculated as gross returns minus cost. A1+FL and A2+FL are used as costs. All the values are in constant prices

with the base year as 1975. Results show that the average net returns per acre for irrigated and rainfed areas increased during the study period. However, the returns to irrigation, i.e., the number of times irrigated net returns are higher than rainfed areas net returns have been declining from 1975 to 2014. This phenomenon is observed primarily because of the higher increase in gross returns and costs of rainfed areas. Gross returns and costs in irrigated areas did not increase as much as rainfed areas. The increase in costs for rainfed areas might be due to changes in the contribution of different inputs. During 1975-79, labour, seed and organic material costs accounted for 75%,13% and 7% respectively of total cost in rainfed agriculture. During 2009-14, besides labour costs, there was a significant increase in other inputs costs such as fertilisers, machinery and seed costs in rainfed agriculture. This change might have led to increase in costs and simultaneously the gross returns of rainfed agriculture. Even though returns to irrigation have declined during the study period, two broad trends can be observed between highly and moderately irrigated villages. In highly irrigated villages high water-intensive crops are grown (i.e., paddy and sugarcane), and profits from irrigated agriculture are still high in these villages. In moderately irrigated villages, returns from irrigated agriculture are not very different from rainfed agriculture during 2009-14. Farmers in these villages grow low water-intensive crops. However, they increased their investments in improved varieties and machinery etc. These investments might have led to increased returns from rainfed agriculture in these villages.

For measuring productivity, yield per acre is used. We took those crops which were prominent both during 1975-79 and 2009-14. Although five crops are used for the analysis, only two crops, jowar and cotton, are strictly comparable over the years. Results show that the difference between rainfed and irrigated yield has declined during the study period.

We also analyse the profitability and productivity of irrigation among different land classes. Results are similar to the above results, i.e., returns to irrigation have been declining across all land classes from 1975 to 2014. Gross returns and costs of rainfed areas increased at a higher rate for all the land-holding groups; more importantly, rainfed areas gross returns and costs increased much more for large farmers than small farmers.

We estimate the coefficient of variation for analysing variation in profits in irrigated and unirrigated households. Results show that during 1975-79, variation in irrigated households this is contrary to the understanding and needs further study was higher than in rainfed

households; During 2009-14, there was a considerable increase in variation of rainfed households and variation in irrigated households decreased a lot during the same time.

Key words: Irrigation, Profitability, Rainfed agriculture, Irrigated agriculture

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Chapter -1

Introduction

1.1) Introduction

Irrigation plays a vital role in a country's agricultural development. Reliable and timely water supplies enable the farmers to change the cropping pattern and cultivate crops with higher water requirements and higher value. Irrigation increases the cropping intensity, and bring less fertile lands under cultivation (Abbie et al.,1982; Narayanamoorthy et al.,2015). Irrigation helps bring more area under cultivation, as it helps cultivate during rabi season or when rainfall in kharif (monsoon season) is inadequate. Overall, irrigation is a crucial instrument in decreasing uncertainty and increasing the productivity of the land.

"In the expansion of crop output in India, irrigation has played the role of a kingpin. To a lesser extent, this is also true about its role in imparting stability to wheat and rice production, the two principal food grains that constitute the backbone of the food grains distribution system under public aegis in the country" (Dhawan,1988).

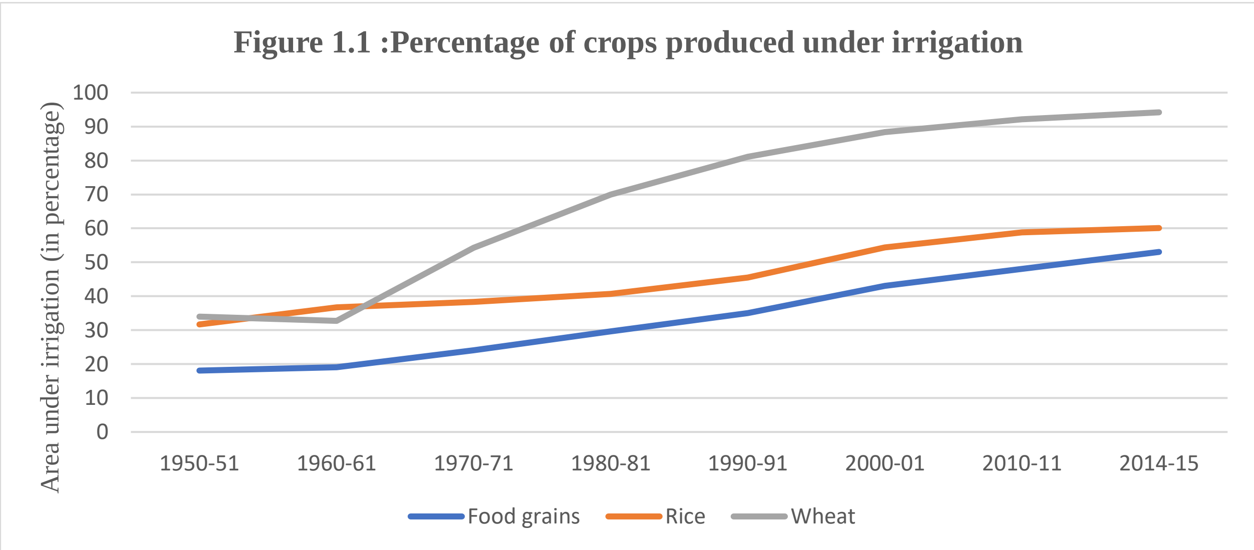
Irrigation is the primary consumer of freshwater and more than 90 per cent of groundwater draft in India (Jain et al., 2019). The country's gross irrigated area increased from 29.71 million hectares in 1963-64 to 100 million hectares in 2017-18. Net irrigated area increased from 25.8 million hectares in 1963-64 to 69.4 million hectares in 2017-18. The percentage of both gross and net irrigated areas to gross and net sown areas increased from 19 per cent in 1963.-64 to 50 per cent in 2017-18. Cropping intensity has also increased from 115 per cent in 1963-64 to 143 per cent in 2017-18 (RBI handbook of statistics on the Indian economy,2020-21)

Regarding the percentage of crops produced under irrigated conditions,18 per cent of food grains were produced under irrigated areas in 1950-51; it increased to 53 per cent in 2014-15. Among the crops, the percentage of rice and wheat produced under irrigation increased from 31 per cent to 60 per cent and from 34 per cent to 94 per cent, respectively, during this period. (Agricultural statistics at a glance,2018) [Figure 1.1]

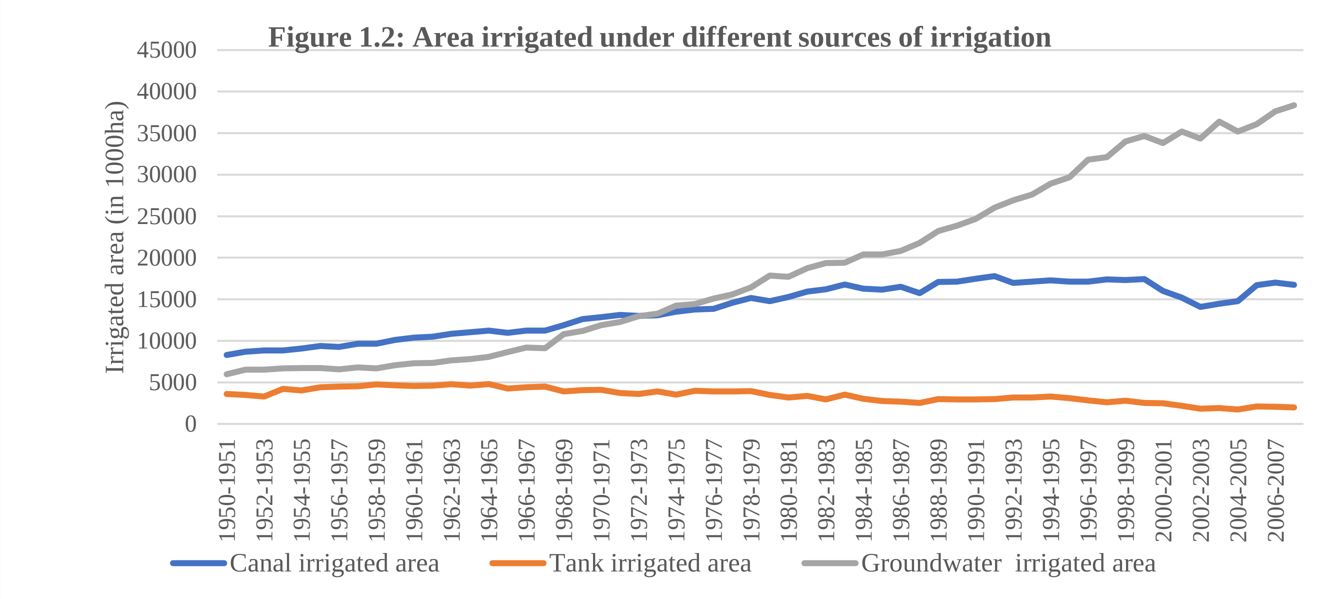
Regarding the sources of irrigation, governments initially focused on building large scale public irrigation systems immediately after independence. Since 1970s, the focus has shifted to increasing groundwater irrigation. Groundwater irrigation accounted for 29 per cent of the total irrigated area in 1950-51, and this has increased to 63 per cent in 2013-14 (Jain et al.,2019). [Figure 1.2]

Due to the farm power policies, there has been widespread depletion of groundwater resources in much of southern, western and north-western India. (Shah et al.,2012). In peninsular India, this has increased the failure of wells and tube well-related indebtedness. (Anantha,2009; Narayanamoorthy,2013) In this context, it is essential to know the profitability and productivity of the crops under irrigation in the semi-arid tropics and analyse the trends over the years.

Semi-arid tropical regions are often characterised by scanty and uncertain rainfall, on which agricultural production largely depends. Agroclimatologically, the semi-arid tropics include those tropical regions where rainfall exceeds potential evaporation for four to six months of the year. Mean annual rainfall in the S A T ranges from about 400 to 1,200 mm. Much of peninsular India is semi-arid tropical, and so are significant parts of the states of Andhra Pradesh, Gujarat, Haryana and Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, and Uttar Pradesh.



Source: Agricultural statistics at a glance,2018



Source: Ministry of agriculture and farmers welfare. (Accessed through Indiastat.com)

1.2) Literature Review

Economic returns to irrigation have been discussed by several authors (Abbie et al.,1985; Dhawan,1988; Vaidyanathan,1987; Bagi, 1981; Vaidyanathan et al., 1994). All the studies had estimated positive relation between irrigated land and the yield of the crops.

Abbie et al. (1985) analyses the economic rates of return to investments in irrigation in India and the factors limiting the efficiency of the investments for both surface and groundwater. They estimate the difference in net value added per hectare between irrigated and rainfed land for 19 states in India. They found that the gross cropped hectare of irrigated land produces (in 1979/80 prices) about Rs.2,950 per year more than a hectare of rainfed land and up to Rs 4480 more per year per hectare if one takes into account of higher cropping intensity of irrigated land.

Vaidyanathan (1987) estimates the average production value per hectare of irrigated and unirrigated areas for 12 states and found that irrigated area produces about 2.8 times per hectare compared to the unirrigated area. He also has presented six other studies that compared agricultural performance in areas commanded by irrigation and those outside (control areas).

These results also show that the gross value of output per unit of gross sown area (GSA) in the command area is between 7 per cent and 340 per cent higher than in the control area, and the difference is more prominent in the case of net sown area.

Bagi (1981) have also analysed the economic contribution of irrigation in Haryana and finds that both outputs per hectare and quintal cost of production are high for the irrigated land. Though costs are high, per hectare profit margins are higher on the irrigated land.

Narayanamoorthy et al. (2015) investigated the role of irrigation in increasing the value of agricultural output at six-time points from 1962-65 to 2005-08. The results show that the difference in the value of agricultural output per hectare has narrowed down over the years between less, medium and high irrigated districts. The univariate regression shows that irrigation impact on agricultural output appears to be an inverted U shape curve over the years. The value of regression coefficient of irrigation increased from 46.43 in 1962-65 to 95.95 in 1990-93 and then declined to around 70 during 2003-06 and 2005-08 Even multivariate regression shows that the irrigation coefficient has declined in recent years. They conclude that the declining role of irrigation in agricultural output can be due to increased output in less irrigated districts or due to poor crop output in irrigated districts, which needs to be studied further.

Dhawan (1988) and Vaidyanathan (1987) have emphasised the productivity variations across regions. The productivity differences between rainfed and irrigated land are more significant in low rainfall zones and fall as we move to regions with high rainfall. This implies that the impact of irrigation is higher in the arid and semi-arid regions of India as it gave scope to increase the land under cultivation. Vaidyanathan (1994) finds the impact of irrigation at three different points of time and found that irrigation plays a significant role in explaining inter-district variations in low and medium rainfall zones but not in high rainfall tracts.

Narayanamoorthy (2013) and Narayanamoorthy et al. (2014) have discussed the issue of profitability of crop cultivation in India. Narayanamoorthy (2013) estimated the trends in the profitability of six different crops, using the CACP data, during the period 1975-76 to 2006-07. The results show that farmers either suffered huge losses or had a slight gain in cultivating the crops. Especially for crops like cotton, groundnut and sugarcane, farmers suffered huge losses post 1990. One of the main reasons for these huge losses is steep rise in the cost of cultivation.

Narayanamoorthy et al. (2014) have compared the profitability of five prominent rainfed crops grown in India's irrigated and less irrigated regions. Two states (one with better irrigation coverage and the other with less irrigation coverage) were selected for a particular crop to compare the profitability using CACP data. The results show that farmers either had little profit or huge losses. This is because of the high cost of cultivation.

1.3) Motivation

Irrigation gives scope for the farmers to use various complementary inputs like fertilisers, shifting to high yielding varieties. Along with the increase in income, cost may also go up simultaneously using these inputs.

Narayanamoorthy et al. (2015) have investigated the role of irrigation in increasing the value of agricultural output. The results show that the difference in the value of agricultural output per hectare has narrowed down over the years between less and high irrigated districts. This can be due to poor performance in irrigated districts or better performance in non-irrigated districts. In this context, it is essential to analyse the profitability of crops in irrigated and non-irrigated areas and estimate the trends in profitability over the years.

Also, literature on the impact of irrigation on the profitability of the crops has been rare, except few like Narayana Moorthy et al. (2014) which compares the profitability of rainfed crops under irrigated and less irrigated conditions. But this study looks only at the profitability of rainfed crops.

Our study focuses on semi-arid tropics. Semi-arid tropics are those tropical areas of the world where they receive substantial precipitation for at least a few months of the year. Mean annual rainfall in the S A T ranges from about 400 to 1,200mm. The non-coastal regions of Andhra Pradesh, Karnataka, Maharashtra, and Tamil Nadu on the deccan Plateau and much of Gujarat and western and central Madhya Pradesh comprise the heart -land of the rainfed agricultural belt in India's semi-arid tropics (Walker and Ryan,1990). Groundwater irrigation is one of the prominent inputs to agricultural development in these regions (Anantha, 2009). There has been widespread depletion of groundwater resources in the region (Shah et al.,2012). This increased the failure of wells and tube well-related indebtedness in peninsular India. (Anantha,2009; Narayanamoorthy,2013) In this context, it is important to estimate the profitability and productivity of the crops under irrigation in these areas over the years.

Though there has been some literature on irrigation's impact on productivity, most of them have worked on state or district level data. This study is based on the farm level data, and comparing data from the 1970s to 2014 can also help us to understand the differences in productivity over the time.

1.4) Research Objectives

The research aims to understand the benefits of irrigation to the farmer. We also want to understand how the quantum of benefits has changed over time in the context of a semi-arid tropical region. The objectives of the study are:

1) To compare the productivity and profitability of agriculture under the irrigated and unirrigated conditions and changes in profitability over time.
2) To compare the returns to irrigated and unirrigated farms for farmers belonging to different land classes.
3) To analyse the variability of the profits under irrigated and unirrigated conditions

1.5) Data Source:

I use ICRISAT's Village Dynamics in South Asia (VDSA) data for the study. VDSA survey provides longitudinal data at the village level in the semi-arid tropics of India from the 1970s to 2014. This survey contains data on six villages from two states, Telangana and Maharashtra, from 1975-85, 2001-04, 2005-08, and 2009-14.

For this study, data from 1975-79 and 2009-14 is used to capture the trends in profitability. Six villages were Aurapalle and Dokur from Mahbubnagar district in Telangana, Kinkheda and Kanzara from Akola district, Shirapur and Kalman from Sholapur district in Maharashtra. These three districts represent three broad agro-climatic subregions within the semi-arid tropics of India. (VDSA Manual,1985).

The survey contains data such as area owned by the farmer, percentage of irrigated area, source of irrigation, crops sown, detailed schedule on inputs and outputs of the cultivation and income from the sale of output. This data is available at the plot level for each cultivating household.

1.6) Methodology

1. For our first objective to measure profitability, net returns per acre is used. Net returns are calculated as gross returns minus cost. We have used two different types of costs for the analysis- A1+FL and A2+FL.
    - A1 +FL = All actual expenses in cash and kind incurred in production by owner + Imputed value of family labour (This is mostly used for all the analysis)
    - A2+FL = All actual expenses in cash and kind incurred in production by owner + Imputed value of family labour + Rent paid for leased in land.

      (or)
    - A2+FL = (A1+FL) + Rent paid for leased in land

   Rent paid for leased in land (which is used in the calculation of A2+FL) is not available for 1975-79 and is available for 2009-14. So, to get the rent for the period 1975-79, we calculated the share of rent in total cost (A1+FL) for the leased plots during 2009-14 and then took the average share of rent in total cost for the period 2009-14. This share has been applied to the 1975-79 data. This is further explained in chapter 3 with an example.

2. For measuring productivity, yield per acre is used. To measure the productivity over time, we need crops cultivated in both irrigated and rainfed plots and cultivated during 1975-79 and 2009-14.

   In many villages, the cropping pattern has changed over the years from 1975-79 to 2009-14. So instead of analysing at the village level separately, this analysis is done at all village level (six villages combined) as it would give an adequate sample size.

   For this purpose, some prominent crops which were cultivated both during 1975-79 and 2009-14 are considered. They are Jowar, Cotton, Paddy, Pigeon pea and Wheat.

These five crops are considered for analysis on productivity. While analysing different land classes productivity, only two crops (Jowar and Cotton) were considered (as all the crops are not cultivated across all the landholding groups).

3. For most of the thesis, plots are divided into rainfed and irrigated plots. If a plot is even partially irrigated, it is considered an irrigated plot, and if a plot is not irrigated at all, it is treated as a rainfed plot.

4. The analysis is based on constant prices. For this purpose, consumer price index for agricultural labourers (CPI- AL) has been chosen. As the CPI (AL) data is available from the 1960s, this index is chosen (the base of CPI – AL was 1960-61=100, and its base has been replaced to 1986-87=100). All the variables are converted according to 1975 prices.

5. VDSA data has categorised households into labour and cultivator households. Labour households are categorised as those who own less than 0.2 hectares of land or have daily wage work as a primary or secondary source of income. Cultivator households are the ones who operate more than 0.2 hectares of land, and they are further divided into small, medium and large based on the operational holdings. (VDSA Manual, 1985). Landholding data, which can be the basis for categorising small, medium and large farmers, is not uniform across all the villages.

Chapter –2

Understanding the Cropping pattern of the Households during 1975-79 & 2009-14.

2.1) Introduction:

This chapter discusses the basic profile of households and their cropping pattern during 1975-79 & 2009-14. Before understanding the trends in profitability and productivity, it is necessary to understand the changes in the cropping pattern and irrigation in this region.

This study is focused on six villages in the semi-arid tropics of India. This chapter is divided into two sections. Section 2.2 discusses the basic profile of the villages and the households during 1975-79& 2009-14. Section 2.3 discusses the cropping pattern in villages and sources of irrigation during 1975-79 &2009-14.

Section 2.2 - Basic Characteristics of Villages and Households

Section 2.2 describes the basic characteristics of villages and households. Village profiles, such as soil and rainfall pattern of the village, number of sample households, average cropped area of households, average proportion of irrigated area, primary occupation of the households and educational qualifications of the households are discussed.

Most of the variables in section 2.2 are calculated for the years 1975 &2009, representing the periods 1975-79 and 2009-14.

2.2.1) Profiles of Villages:

Table 2.1: Village Profile

State	District	Village	Soil	Rainfall	Prominent cultivated season
Andhra Pradesh	Mahbubnagar	Aurapalle	Red, shallow and medium black soils	Unassured	Kharif
		Dokur			Kharif
Maharashtra	Sholapur	Shirapur	shallow,	Unassured	Rabi, Annual

		Kalman	Medium and deep black soils.		Rabi
	Akola	Kanzara	shallow, Medium and deep black soils		Kharif
Maharashtra		Kinkheda		Assured	Kharif

Source: VDSA data

Table 2.1 shows the profiles of the villages. This study is based on the data from 2 states, Andhra Pradesh (A.P) (present-day Telangana) and Maharashtra (M.H). These three districts represent three broad agro-climatic subregions within the semi-arid tropics of India. (VDSA Manual,1985). With Alfisols and an annual rainfall of 713 mm, Mahbubnagar district represented Telangana and Rayalaseema tracts; Sholapur, with deep and medium-deep vertisols and an annual rainfall of 707 mm (raising mainly postrainy-season Jowar) represented the drought-prone zone of Maharashtra and parts of Karnataka. Akola, with medium-deep vertisols, a relatively higher rainfall of 819 mm represented the relatively stable agricultural region of Vidarbha and neighbouring parts of Madhya Pradesh and Gujarat.

Two villages are selected from each district. They are Aurapalle & Dokur from Mahbubnagar district (A.P), Shirapur & Kalman from Sholapur district (M.H), and Kanzara& Kinkheda from Akola district (M.H).

In Mahbubnagar district (Aurapalle and Dokur), most of the area is covered in red, shallow and medium black soils. Rainfall is unassured in these areas (It has an annual rainfall of 713 mm). Majority of the crops are grown in the kharif season (83% of the gross cropped area (GCA) in Aurapalle and 76% of GCA in Dokur are grown in the kharif season)

In Sholapur (Shirapur and Kalman), most of the area is covered in shallow, medium and deep black soils. Rainfall is unassured in these areas (It has an annual rainfall of 707 mm). Most crops are grown in the rabi season (61% of GCA in Shirapur and Kalman are grown in the rabi season). As per the climatic conditions of Sholapur, cultivating during rabi season is more profitable than kharif. Because, during rainy seasons with erratic rainfall and excessive moisture, it is difficult to cultivate. It is profitable for farmers to store precipitation in their deeper soils during the rainy season and cultivate during the rabi season when soil moisture recedes. (Walker and Ryan,1990).

In Akola (Kanzara and Kinkheda)**,** most of the area is covered in shallow, medium and deep black soils. Rainfall is assured in these areas (It has an annual rainfall of 819 mm). the prominent cultivated season is kharif (94% and 89% of GCA in Kanzara and Kinkheda are grown during the kharif season) .

2.2.2) Sample Households:

Table 2.2 - Number of Sample Households

Village	**1975**	**2009**
Aurepalle	40	70
Dokur	40	50
Shirapur	40	89
Kalman	40	61
Kanzara	40	62
Kinkheda	40	52
Total	240	384

Source: VDSA data

The following table (Table 2.2) shows the number of sample households. In 1975, there were 240 households in total. Each village has 40 sample households. In 2009, along with the households selected in 1975, new households were added to the sample. A total of 384 households were interviewed in these six villages (70 households in Aurepalle, 50 households in Dokur,89 households in Shirapur,61 households in Kalman,62 households in Kanzara, and 52 households in Kinkheda).

Table 2.3 shows the number of households in the sample according to their landholding category in 1975. Each landholding category has ten households, making a total of 40 households in each village. (10 labour households, 10 small farmer households,10 medium farmer households and 10 large farmer households). Similarly, Table 2.4 shows the number of households in each landholding category in 2009.

Table 2.3 Number of Sample Households (1975)					
Village	**Labour**	**Small farmer**	**Medium farmer**	**Large farmer**	**Total**
Aurepalle	10	10	10	10	40
Dokur	10	10	10	10	40
Shirapur	10	10	10	10	40
Kalman	10	10	10	10	40
Kanzara	10	10	10	10	40
Kinkheda	10	10	10	10	40
Total	60	60	60	60	240

Source: VDSA data

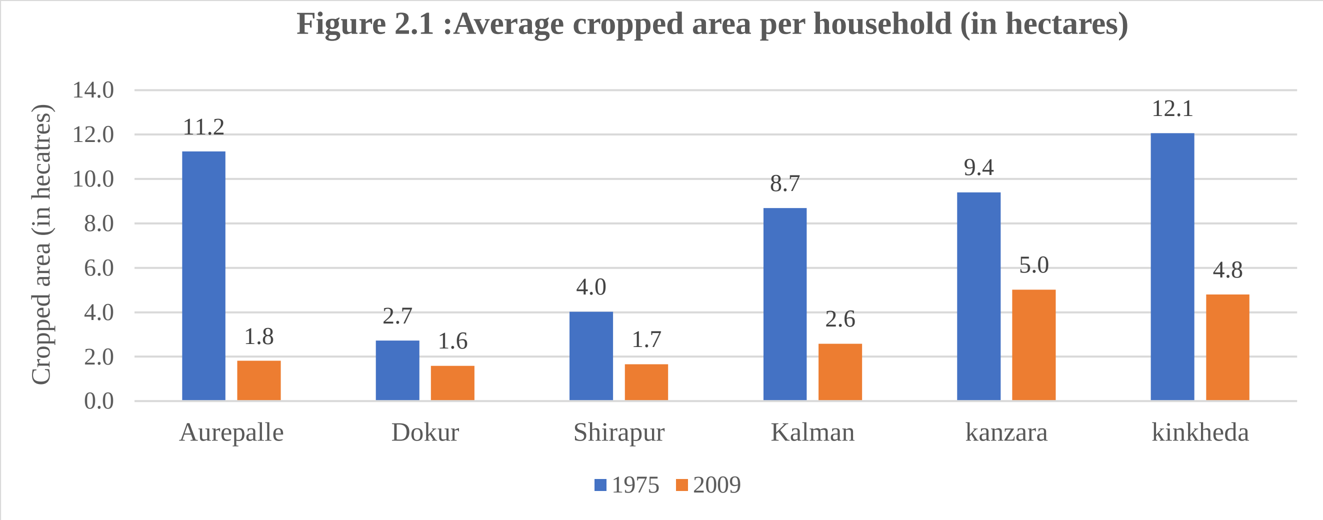
Table 2.4 Number of Sample Households (2009)					
Village	**Labour**	**Small farmer**	**Medium farmer**	**Large farmer**	**Total**
Aurepalle	18	11	21	20	70
Dokur	5	12	8	25	50
Shirapur	17	48	20	4	89
Kalman	8	37	13	3	61
Kanzara	15	21	16	10	62
Kinkheda	6	28	9	9	52
Total	69	157	87	71	384

Source: VDSA data

2.2.3) cropped area (in 1975 and 2009)

Figure 2.1 shows the average cropped area per household in each village in 1975 and 2009. Both in 1975 and 2009, the average cropped area per household was higher in Kanzara and Kinkheda village (M.H)

In 1975, the average cropped area was highest in Kinkheda (12.1 hectares) and lowest in Dokur (2.7 hectares). From 1975 to 2009, the average cropped area declined in every village. The decline was primarily seen in Aurepalle (From 11 hectares to 1.8 hectares). In 2009, the average cropped area is highest in Kanzara (5 hectares) and lowest in Dokur (1.6 hectares)



Source: Author's estimates based on VDSA data

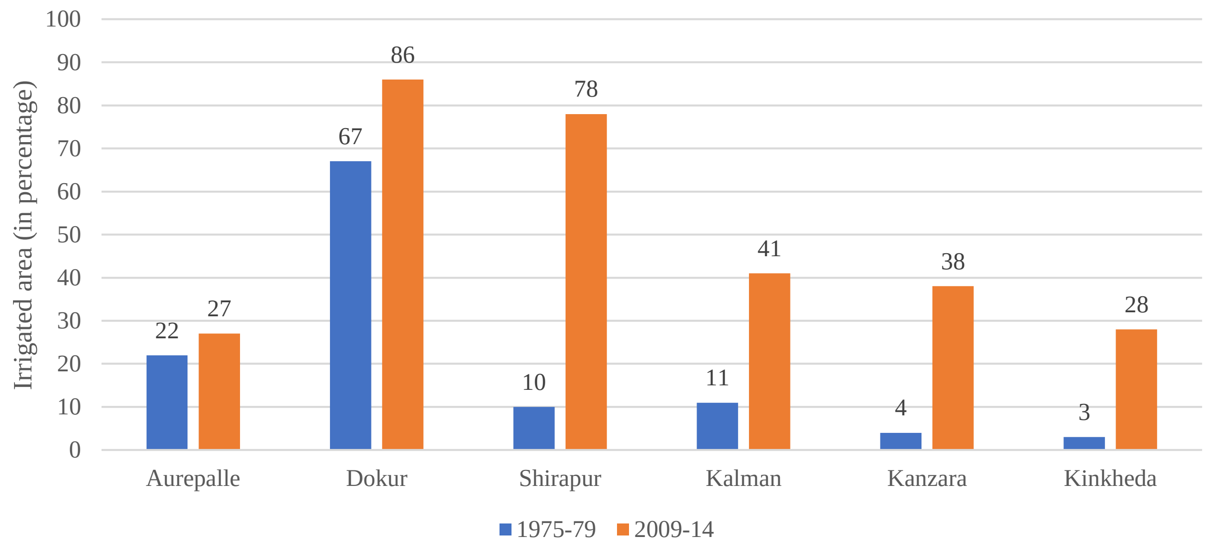
2.2.4) Irrigated area (1975-79 & 2009-14):

The proportion of irrigated area is calculated as the number of acres cultivated under irrigated agriculture divided by the total acres cultivated and multiplied by 100. The analysis excludes the fallow lands. It only took the cultivated land into consideration. This proportion is calculated year-wise, and then the average of all years is taken (i.e., an average of 1975-79 and 2009-14)

In figure 2.4, we can see that during 1975-79, Dokur had the highest percentage of irrigated area (67%) among all the six villages. Of all the three districts, Mahbubnagar in Telangana is mostly irrigated, Sholapur in Maharashtra is partially irrigated, and Akola district is least irrigated (only 3-4% of cultivated land is irrigated in Akola district) Compared to 1975, the percentage of irrigated area increased in every village. Irrigation in Maharashtra villages increased considerably. This is due to increase in canal irrigation in the state.

During 2009-14, villages such as Shirapur and Dokur have the highest percentage of irrigated area. While Dokur had a higher percentage of irrigated area even from 1975, the irrigated area increased to a great extent in Shirapur (From 10 % in 1975-79 to 78% in 2009-14). Aurepalle is the only village where improvement in the irrigation percentage is very meagre. It increased from 22% to 27% from 1975 to 2014.

Figure 2.2:Average of proportion of irrigated area (in percent)

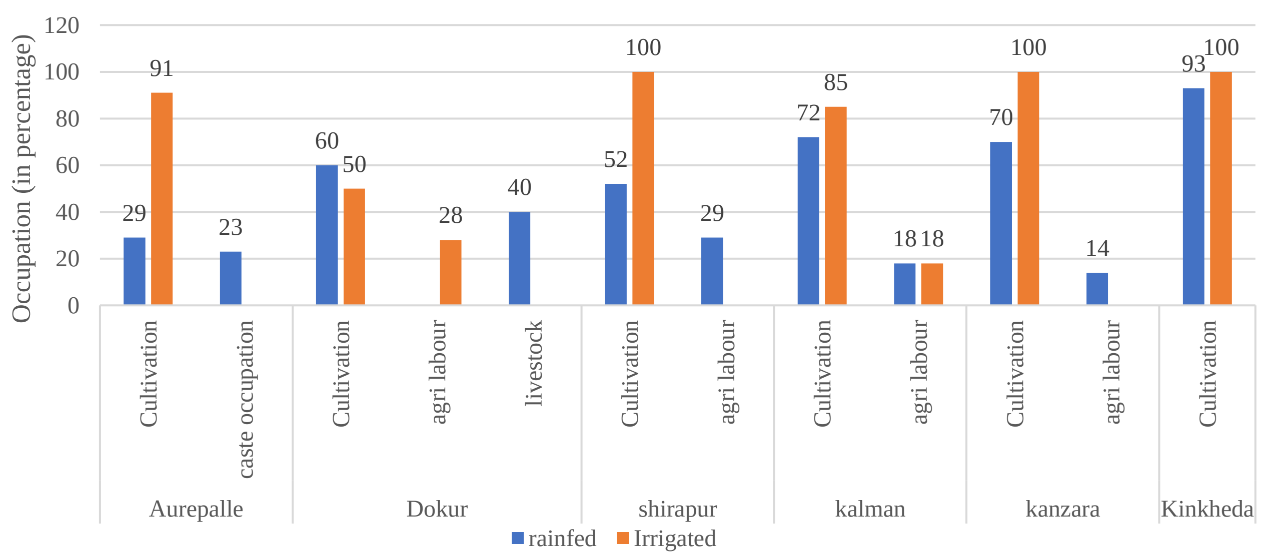


Source: Author’s calculations using VDSA data

2.2.5) Primary occupation of households in 1975 and 2009:

Figure 2.5 shows the main occupation of rainfed and irrigated households in 1975. We can see that the primary occupation of the majority of the households is cultivation (both among rainfed and irrigated households). Apart from cultivation, agricultural labour, traditional caste occupations and livestock rearing are the primary occupations for a few households, especially rainfed households.

Figure 2.3: Primary occupation of rainfed and irrigated households in 1975



Source: Author’s calculations using VDSA data

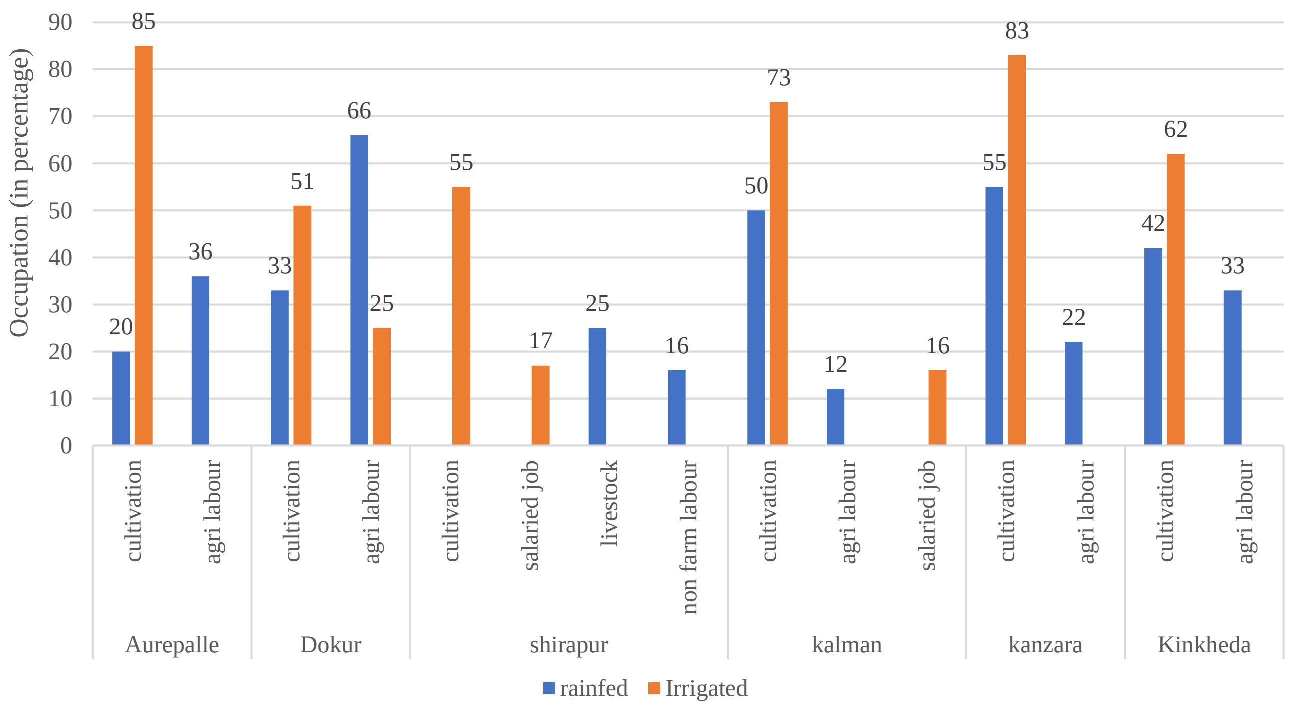


Figure 2.4:Primary occupation of rainfed and irrigated households in 2009

Source: Author's calculations using VDSA data

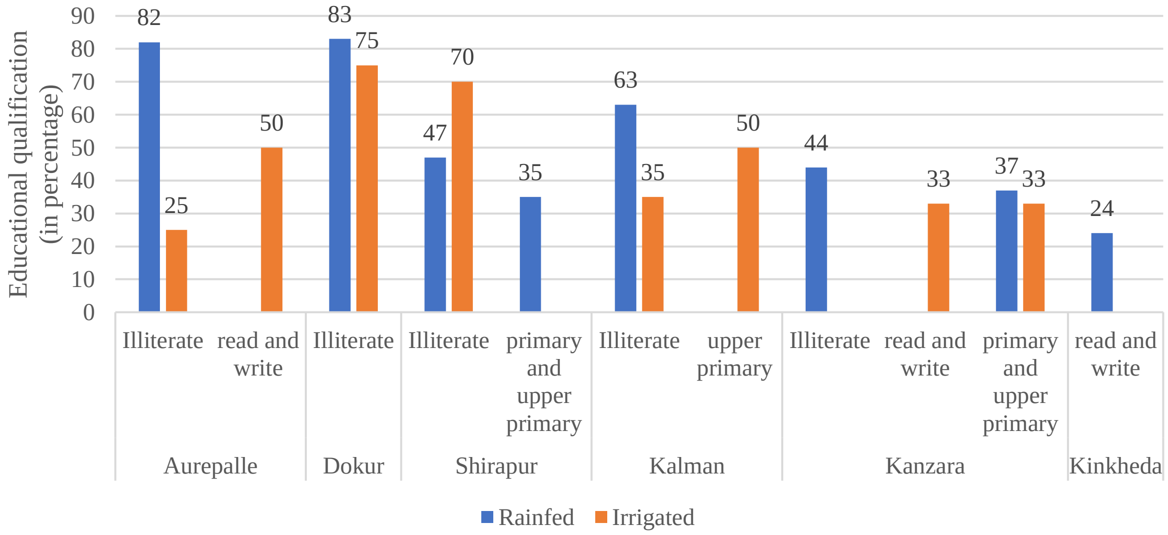
Figure 2.6 shows the primary occupation of rainfed and irrigated households in 2009. cultivation is still the primary occupation for most irrigated households (of all villages) and rainfed households of some villages (such as Kalman, Kanzara and Kinkheda).

However, an interesting change from 1975 is that in villages like Aurepalle, Dokur and Shirapur, the primary occupation of most rainfed households has changed to agricultural labour, livestock non-farm labour. Another change from 1975 is in villages like shirapur and Kalman, we can see the notable presence of salaried jobs among the irrigated households.

2.2.6) Educational qualification of households in 1975 and 2009:

Figure 2.7 shows the educational qualifications of households in 1975. we can see that majority of the households in 1975 were illiterate. We can also see some households who have studied until upper primary education or know how to read and write. Comparatively, the illiterate percentage is less in the Akola district; most of them either studied till primary education or know how to read and write.

Figure 2.5:Educational qualification of rainfed and irrigated households in 1975

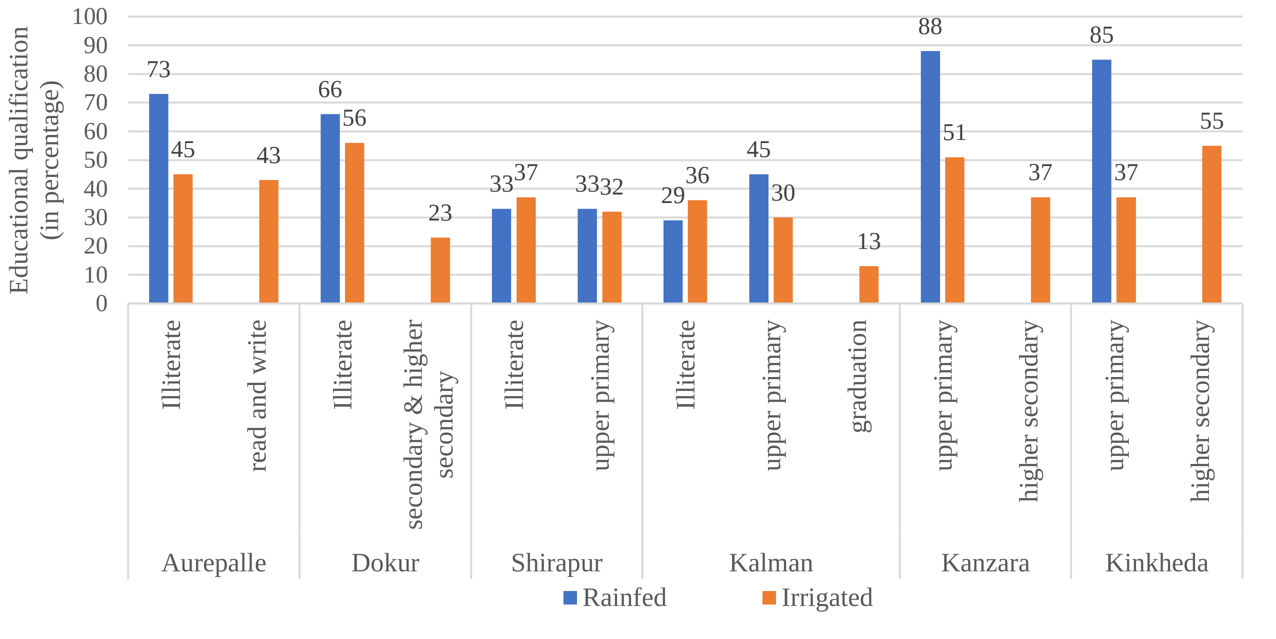


Source: Author's calculations using VDSA data

Figure 2.8 shows the educational qualification of rainfed and irrigated households in 2009. The percentage of illiterate people has decreased when compared to 1975. However, the majority of households are illiterate.

In the Mahbubnagar district, majority of them are illiterate. Illiteracy is more in rainfed households than in irrigated households. In Sholapur district (Shirapur and Kalman). Most households are illiterate or have completed primary education In Akola district (Kanzara and Kinkheda), most of the households have completed their upper primary education. Percentage of people who have completed secondary education are more in irrigated households.

Figure 2.6 : Educational qualification of rainfed and irrigated households in 2009



Source: Author's calculations using VDSA data

<u>Section 2.3: Cropping pattern and Source of Irrigation (1975-79 & 2009-14)</u>

This section describes the cropping pattern and source of irrigation during 1975-79 to 2009-14 in all villages combined and every village separately. Two aspects are presented for each village—primary sources of irrigation and changes to it, cropping pattern and changes to it.

Analysis in this section is based on the period 1975-79 & 2009- 14. To identify the principal crops, we have used the share of a particular crop in the gross cropped area (GCA). GCA is defined as the total area sown once and more than once in a particular year. Instead of one year, we took the total gross cropped area for the period 1975-79 & 2009-14 and have seen the share of the major crops in GCA during that period.For example, the total GCA in Aurepalle during 1975-79 is 1551.7 acres, and the area under castor is 562.4 acres. So, the share of castor in GCA is 36%. During 2009-14, the total GCA is 1530.7 acres, and the area under castor is 42 acres. So, the share of castor in GCA is 3% during 2009-14.

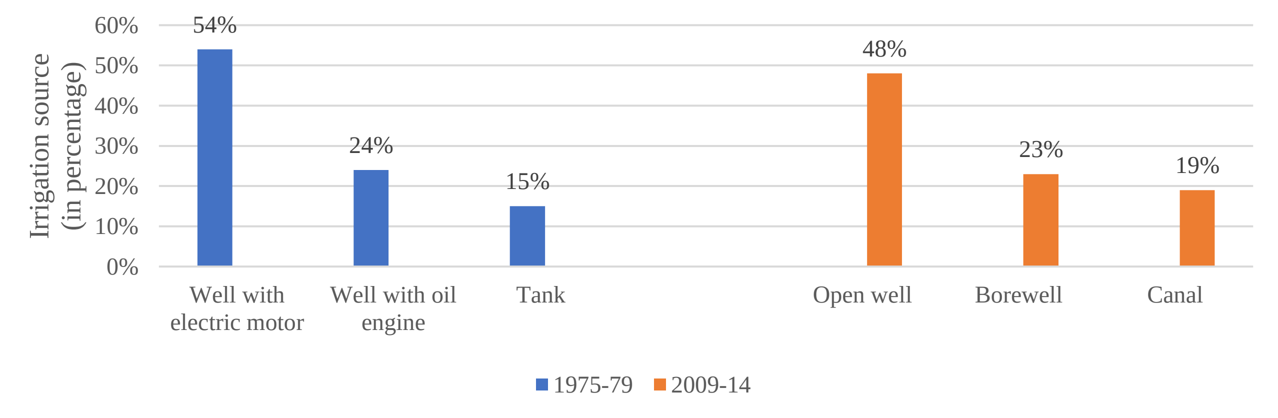
2.3.1) All village analysis:

This analysis is for all villages combined. The villages are located in Maharashtra and Telangana states. The average gross cropped area per household in these villages was 8.02 hectares and 2.79 hectares in 1975 and 2009, respectively. The percentage of irrigated area to cultivated area was 14% during 1975-79, and it has increased to 48% during 2009-14.

Figure 2.9 shows the primary source of irrigation in the villages. During 1975-79, well was the primary source of irrigation; combinedly, well with electric motor and oil engine could source 78% of irrigation and 15% was irrigated through the tank. Tank was important source of irrigation in Telangana, especially in Dokur.

During 2009-14, the primary source of irrigation was open well, followed by borewell and canal. Open well and canal are the main source of irrigation in Maharashtra villages. Canal irrigation has improved in Maharashtra villages during this period. Borewell is the primary source of irrigation in Telangana villages.

Figure 2.7 :Main source of irrigation in 1975-79 &2009-14



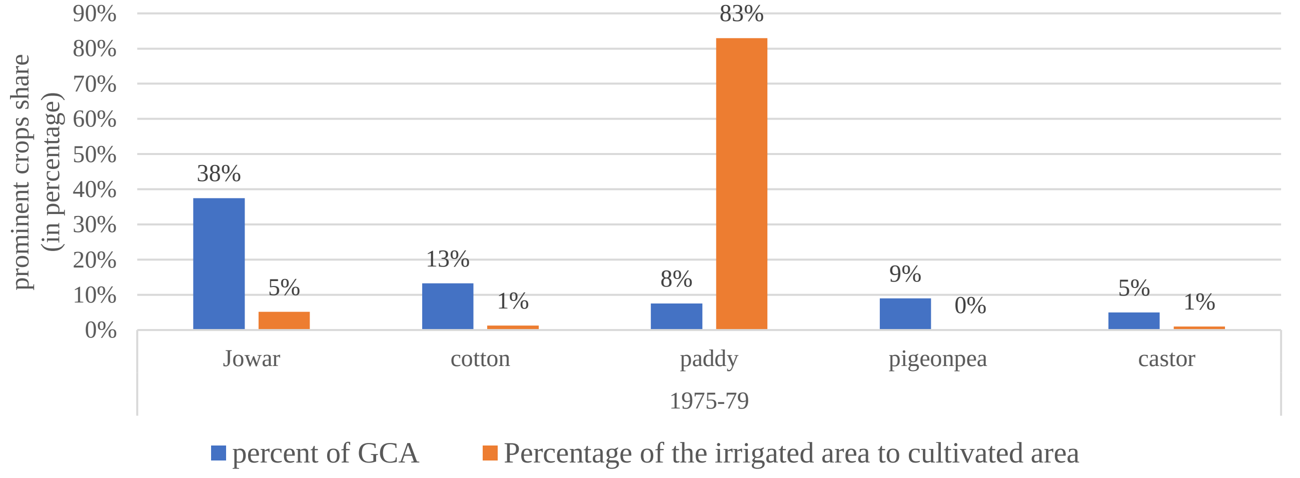
Source: Author’s calculations using VDSA data

Figure 2.10 shows the cropping pattern in the villages during 1975-79. Major crop is jowar which occupied around 38% of GCA. Jowar is grown in all villages but is the prominent crop in the Sholapur district (Shirapur and Kalman). Cotton is the main crop in the Akola district (Kanzara and Kinkheda villages). Paddy is grown in Mahbubnagar district, especially in

Dokur village. Pigeon pea is grown in M.H villages, and castor is grown mainly in Aurepalle village of Telangana.

We observe that except paddy, the rest of the crops are not irrigated. Only paddy is irrigated. Compared to other villages, farmers in Mahbubnagar villages (Aurapalle and Dokur) had access to irrigation; as a result, paddy is grown in these villages.

Figure 2.8:Prominent crops share in GCA &their irrigation percentages during 1975-79

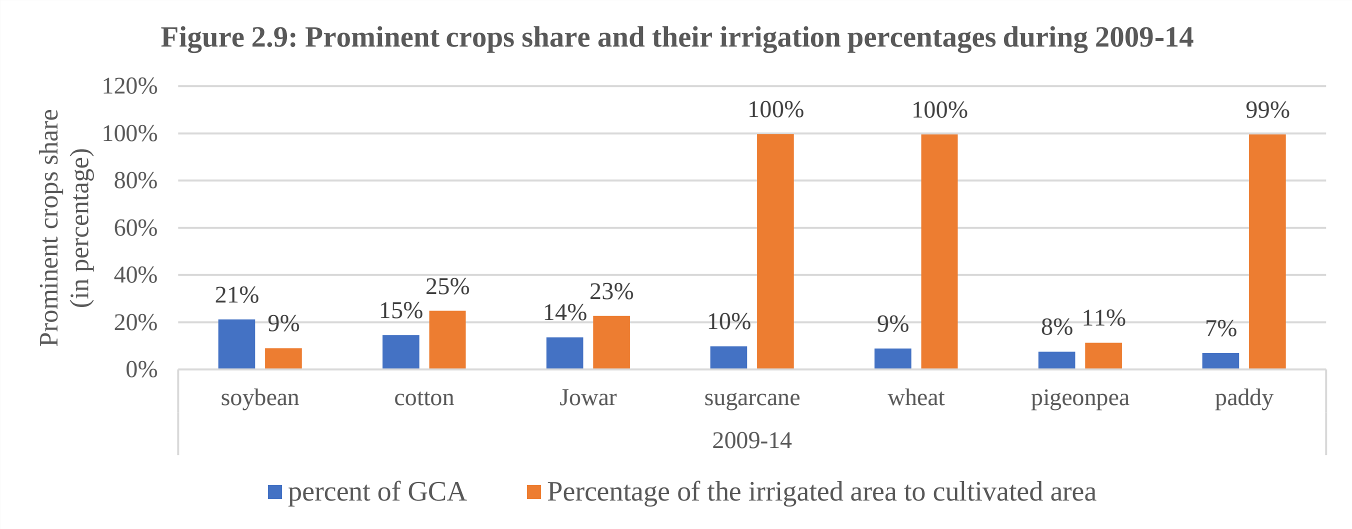


Source: Author's calculations using VDSA data

During 2009-14, the cropping pattern has changed; apart from the traditional crops, some new crops like soybean, sugarcane and wheat are grown. Soybean occupies around 21% of GCA; soybean and wheat are grown in Akola district of M.H. Cotton though traditionally grown in the Akola district; it is replaced with soybean. Cotton is mainly grown in Aurepalle village. The share of jowar has declined in all villages. Sholapur is the only district which cultivates significant share of jowar. Sugarcane is prominently grown in Shirapur village. Pigeon pea is mostly grown in M.H villages, especially in Kalman. Paddy is grown mainly in Dokur village.

[Figure -2.11]

In general, the percentage of irrigated land has increased in all villages. With availability of irrigation, farmers have been able to cultivate high intensive crops like sugarcane, wheat and paddy. In villages such as Shirapur, with the availability of irrigation, farmers have cultivated sugarcane.



Source: Author's calculations using VDSA data

Village level analysis

2.3.2) Aurapalle village:

Aurapalle is situated in Mahbubnagar of Andhra Pradesh. The average cropped area per household in Aurepalle in 1975 was 11.2 hectares. It declined to 1.8 hectares in 2009. The percentage of irrigated area to the cultivated area was 22% during 1975-79; it has increased to 27% during 2009-14.

During 1975-79, the primary source of irrigation was well (well with electric motor is used for 94% of irrigated area). During 2009-14, it has changed to borewell (which irrigates 72% of the area). [Appendix-A.2.1]

Table 2.5: Prominent crops in Aurapalle in 1975-79 &2009-14

Year	Prominent crops	Seasons grown	Per cent of GCA	Percentage of the irrigated area to cultivated area
1975-79	Castor	Kharif	36%	1%
	Jowar + Bajra	Kharif	26% (17% + 6%)	4%
	Paddy	Kharif/Rabi	19%	99%
2009-14	Cotton	Kharif	70%	13%
	paddy	Kharif/Rabi	12%	98%

Source: Author's calculations using VDSA data

Regarding the cropping pattern, during 1975-79, castor and intercrop of jowar and bajra were the two most grown crops; they occupy around 36% of gross cropped area (GCA) and 26% of GCA, respectively. Both the crops are grown in unirrigated conditions. Paddy is the only irrigated crop in the village, accounting for 17% of GCA During 2009-14, cotton became the most prominent crop, replacing castor and intercrop of jowar and bajra. It occupies around 70% of GCA and is primarily grown in unirrigated conditions. Though paddy's share has declined in GCA, it is the second most cultivated crop and is grown in irrigated conditions. [Table -2.5]

Paddy is one crop cultivated both during 1975-79 &2009-14; the rest of the crops cultivated during 1975 were replaced with cotton. Most of the cultivated area is dedicated to less irrigated crops, such as castor and intercrop of jowar and bajra during 1975-79 and cotton during 2009-14. According to Deb et al. (2014) Income of the farmers in this village improved over time with the cultivation of high value and commercial crops like Bt Cotton.

2.3.3) Dokur village:

Dokur is situated in Mahbubnagar of Andhra Pradesh. The average cropped area per household in Dokur in 1975 was 2.7 hectares; it has decreased to 1.6 hectares in 2009. The proportion of irrigated area to the cultivated area was 67 % during 1975-79 (highest among all the villages), it has increased to 86% during 2009-14.

Literature suggests that the high irrigated percentage is due to due to the presence of a large tank in dokur. Its command area approaches to 200 ha (Walker and Ryan,1990). As red soils have low water retention capacity, the presence of tanks is prominent in Mahbubnagar villages (Engelhardt,1984)

During 1975-79, the primary source of irrigation is through wells (61%) and tank (38%). As the literature suggests, tank irrigation is prominent in Dokur. During 2009-14, the main source of irrigation is borewell (67%). The share of tank irrigation has decreased from 38% in 1975-79 to 20% during 2009-14. [Appendix -A.2.2]

Table 2.6: Prominent crops in Dokur in 1975-79 &2009-14				
Year	Prominent crops	Season	Per cent of GCA	Percentage of the irrigated area to cultivated area
1975-79	Paddy	Kharif/Rabi	48%	98%
	Groundnut+ (pigeon pea)	Kharif/Rabi	29% (23% +6%)	72%
	Jowar	Kharif	11%	12%
2009-14	Paddy	Kharif/Rabi	63%	100%
	Groundnut	Rabi	14%	99%
	Castor	Kharif	9%	25%

Source: Author’s calculations using VDSA data

During 1975-79, paddy and groundnut were the most cultivated crops, occupying around 48% and 29% of GCA, respectively. Both the crops are mostly irrigated. Jowar accounts for 11% of GCA and is grown in unirrigated conditions. During 2009-14, The percentage of paddy in GCA increased to 63% from 48%. Groundnut is the second most cultivated crop; its share has decreased from 23% to 14% of GCA. Castor has replaced Jowar. Most of the crops cultivated during 1975-79 &2009-14 are the ones which require high amounts of water, such as paddy and groundnut. [Table-2.6]

According to Deb et al. (2014), there has been a persistent drought in this village for more than a decade. Farmers diversified their income with temporary migration and non-farm activities and preferred growing paddy whenever they could grow.

2.3.4) Shirapur village:

Shirapur is located in the Sholapur district in the state of Maharashtra. The average cropped area per household in 1975 was 4 hectares. It has decreased to 1.7 hectares in 2009. The proportion of irrigated area to the cultivated area was 10% during 1975-79; it has increased to 78% during 2009-14.

During 1975-79, the primary and only source of irrigation is through well. During 2009-14, the primary source of irrigation was open well & borewell (sourcing for 64% &18% of irrigated area, respectively). Another important feature of Shirapur is that during 2009-14, most of them, who use open wells or borewell as the primary source of their irrigation, supplement their irrigation through canals as their second source of irrigation. [Appendix - A.2.3]

Irrigation facilities have remarkably improved in Maharashtra due to the improvement in canal irrigation. Except for Kalman, the other villages in Maharashtra benefitted from these resources. (Rao et al.,2007)

Table -2.7: Prominent crops in shirapur in 1975-79 &2009-14

Year	Prominent crops	season	Per cent of GCA	Percentage of the irrigated area to cultivated area
1975-79	Jowar	Rabi	60.9%	3.6
	Pigeonpea and other pulses	Kharif	9%	0%
2009-14	sugarcane	Annual	48.7%	99.7
	Jowar	Rabi	21%	10.2
	onion	Kharif	8.1%	98.5

Source: Author's calculations using VDSA data

During 1975-79, jowar is one of the main crops grown in Shirapur, occupying around 61% of GCA; it is primarily unirrigated. The yield for rabi jowar is relatively high and is popular among traditional cropping systems (Walker and Ryan, 1980). The share of jowar in GCA has decreased during 2009-14, but it is still the second most cultivated crop in Shirapur. [Table 2.7]

During 2009-14, we can see an increase in sugarcane percentage to GCA. Sugarcane became the dominant crop surpassing jowar. It occupied 48.7% of GCA. Improvement in irrigation facilities and the establishment of the sugar factory in the 1990s have made farmers shift to high intensive crops like sugarcane. (Deb et al.,2014)

2.3.5) Kalman village:

Kalman is located in the Sholapur district in Maharashtra. The average cropped area per household in 1975 was 8.7 hectares; it decreased to 2.6 hectares in 2009. unlike in Shirapur, the proportion of irrigated area to the cultivated area did not increase remarkably in Kalman.

It increased from 11% during 1975-79 to 41% during 2009-14. This is because of no improvement in canal irrigation in the village.

Kalman's irrigation sources are very similar to shirapur. During 1975-79, well was the primary source of irrigation. During 2009-14, the primary source of irrigation was open well (sourcing for 97% of irrigated area). [Appendix-A.2.4]

Table -2.8: Prominent crops in Kalman in 1975-79 &2009-14

Year	Prominent crops	season	Per cent of GCA	Percentage of the irrigated area to cultivated area
1975-79	Jowar	Rabi	56.6%	9.2%
	Pigeonpea and other pulses	Kharif	13.7 %	0%
2009-14	Jowar	Rabi	49.4 %	31.8%
	Pigeon pea	Kharif	20.8%	13.2%
	Onion	Kharif	9%	99.5%

Source: Author’s calculations using VDSA data

Kalman's cropping pattern was very similar to Shirapur during 1975-79. Jowar crop in both the villages (shirapur and Kalman) was popular. During 1975-79, jowar was the main crop in the village; it occupied 57% of GCA.Pigeon pea and other pulses accounted for 13% of GCA. During 2009-14, the crop composition of Kalman has not changed, but the irrigation percentages of the crops have increased. The share of onion in GCA has increased during 2009-14, and it is completely irrigated.

2.3.6) Kanzara village:

Kanzara is located in the Akola district in the state of Maharashtra. The average cropped area per household in 1975 was 9.44 hectares. It has decreased to 5 hectares in 2009. The proportion of irrigated area to the cultivated area was 4% during 1975-79; it has increased to 38% during 2009-14.

During 1975-79, the primary and only source of irrigation is through well. During 2009-14, the primary source of irrigation was open well & canals (sourcing for 56% &32% of irrigated area, respectively). Like Shirapur, most of them, who use open well as the primary source of their irrigation, supplement their irrigation through canals as their second source of irrigation. This is due to the improvement of canal irrigation in the region [Appendix -A.2.5]

Table -2.9: Prominent crops in Kanzara in 1975-79 &2009-14				
Year	Prominent crops	season	Per cent of GCA	Percentage of the irrigated area to cultivated area
1975-79	Cotton and pigeon pea	kharif	52% (38% + 14%)	1.5%
	Jowar	kharif	23.0%	1.1%
2009-14	Soybean (soybean and pigeon pea)	kharif	56.3% (48% +7%)	10.8%
	Cotton	kharif	11.8%	58.8%
	wheat	Rabi	17.4%	99.4%

Source: Author's calculations using VDSA data

Major crops during 1975-79 are intercrop of cotton& pigeon pea, covering 52% of GCA and jowar (covering 23% of GCA). These crops are primarily unirrigated. During 2009-14, the dominant crop was soybean, replacing cotton; it accounted for 56.3% of GCA and is slightly irrigated. wheat is the second most cultivated crop; it is grown in rabi. It occupied 17% of GCA and is completely irrigated. Cotton's share in GCA decreased a lot compared to 1975-79 (it decreased from 52% to 12%). [Table 2.9].

According to Deb et al. (2014), due to fluctuations in cotton crop, farmers have shifted to the cropping pattern of soybean and wheat (soybean is cultivated during kharif and wheat during rabi). The adoption of new technologies is one of the reasons for the flourishment of agriculture in these villages.

2.3.7) Kinkheda village:

Kinkheda is located in the Akola district in the state of Maharashtra. The average cropped area per household in 1975 was 12.1 hectares. It has decreased to 4.8 hectares in 2009. The proportion of irrigated area to the cultivated area was 3% during 1975-79; it has increased to 28% during 2009-14.

Irrigation sources are similar to kanzara village. During 1975-79, the primary source of irrigation is through well. During 2009-14, the primary source of irrigation were canals and open well (sourcing for 78% & 21% of irrigated area, respectively). Most of them, who use open well as the primary source of their irrigation, supplement their irrigation through canals as a second source of irrigation. Though the irrigation improved in this village, it did not improve at the same pace as Kanzara. [Appendix -A.2.6]

Table -2.10: Prominent crops in kinkheda in 1975-79 &2009-14				
Year	Prominent crops	season	Per cent of GCA	Percentage of the irrigated area to cultivated area
1975-79	Cotton (Cotton and Pigeon pea)	Kharif	47% (37 % +10%)	1%
	Jowar	Kharif	26.4%	0.2%
2009-14	Soybean (Soybean and pigeon pea)	Kharif	57% (50% + 7%)	6%
	Cotton	Kharif	11.8 %	12.7 %
	Wheat	Rabi	20.6 %	99.7 %

Source: Author's calculations using VDSA data

The cropping pattern in kinkheda is very similar to kanzara. Major crops during 1975-79 are Intercrop of Cotton& pigeon pea (covering 47% of GCA) and Jowar (covering 26% of GCA). These crops are mostly unirrigated. During 2009-14, the dominant crop was soybean, covering 57 % of GCA. wheat is the second most cultivated crop; it is completely irrigated. Cotton's share in GCA decreased a lot compared to 1975-79; it decreased from 47 % to 12%. [Table -2.10]

2.4) Conclusion:

The major takeaways from this chapter are that the proportion of irrigated area increased in all the villages from 1975-79 to 2009-14. During 1975-79, Dokur had the highest share of the irrigated area to cultivated area because of the presence of a large tank in dokur. During 2009-14, irrigation facilities remarkably improved in Maharashtra; this is due to improvement in canal irrigation. As a result, irrigation percentages increased very much in Maharashtra villages. During 2009-14, shirapur had the highest proportion of the irrigated area of all the villages.

During 1975-79, most villages cultivated less water-intensive crops, like castor, jowar& bajra in Aurepalle village, jowar in Sholapur district (shirapur and Kalman villages) and cotton & pigeon pea in Akola district (kanzara and kinkheda villages). Dokur is only one village where high water-intensive crop like paddy is grown due to the higher percentage of irrigated area.

During 2009-14, higher irrigated villages like Dokur and Shirapur cultivated water-intensive crops such as paddy and sugarcane. In Shirapur, sugarcane has become the dominant crop due to the availability of water and the presence of sugar factories in the region.

In villages such as Aurepalle, Kanzara and Kinkheda, where irrigation percentages increased only moderately, less water-intensive crops and commercial crops are grown. These crops are different from what was grown during 1975-79. In aurapalle, crops like jowar and bajra are replaced with cotton. In kanzara and kinkheda villages, because of the high price fluctuations in cotton, it is replaced with soybean and wheat (soybean grown during kharif and wheat in rabi). In Kalman, there has been no shift in the cropping pattern.

Chapter-3

Profitability and Productivity of Irrigation in Semi-Arid Tropics of India

3.1) Introduction

Irrigation plays an important role in agricultural development. It helps to shift the cropping pattern to higher water-intensive and commercial crops; it helps in bringing less fertile land under cultivation and increases the cropping intensity by the increasing area under cultivation during rabi season or during kharif when there is inadequate rainfall.

Several studies have studied the impact of irrigation in agriculture, such as authors like Abbie, 1985; Vaidyanathan, 1987; Narayanamoorthy et al.,2015 etc. Results show that there is a positive relation between irrigation, returns from irrigation and the yield.

This paper aims to find the profitability and productivity of irrigated and rainfed agriculture in semi-arid tropics. Semi-arid tropics are characterised by low to moderate rainfall. Groundwater is one of the prominent sources of irrigation; with declining groundwater tables and an increase in agriculture costs, the trends in the profitability of irrigated and rainfed agriculture in this region is important to understand.

Results show that the returns to irrigation have been declining from 1975 to 2014. This is primarily because of the higher increase in gross returns and costs of rainfed agriculture. The increase in gross returns and costs for rainfed areas might be due to changes in the contribution of different inputs, like increase in fertiliser and machinery share in the total cost of rainfed agriculture. Although a general trend of decline in returns to irrigation is observed in all villages, there are differences between highly and moderately irrigated villages.

This chapter is organised into six sections. Section 3.2 discusses the methodology, section 3.3,3.4 and 3.5 discusses the profitability analysis (all villages combined and at village level), and section 3.6 discusses the productivity.

3.2) Methodology

1) The analysis is based on the plot level data and sub-plot-level data. Each household may have one or more plots. In each plot, either one crop or an intercrop of 2- 3 crops are cultivated.

   If 2-3 crops are cultivated in one plot, the output (Yield and gross returns) details are given according to the number of crops cultivated, but input (Cost) details are given at the plot level. To arrive at cost details for the subplot level, the cost of the plot is divided according to the percentage of land cultivated by different crops in that plot.

2) Regarding irrigation status, plots are divided into rainfed and irrigated plots. If a plot is even partially irrigated, it is considered an irrigated plot; if it is not irrigated, it is treated as a rainfed plot. In section 3.5, plots are divided as rainfed, partially irrigated and completely irrigated and returns to irrigation are calculated. It is considered a completely irrigated plot if it is 100% irrigated. If a plot is irrigated, but not entirely, it is treated as partially irrigated, and if it is not irrigated, it is treated as a rainfed plot.

3) Profitability analysis is done at all villages (six villages) combined and also at the village level separately.

   For measuring profitability, net returns per acre is used. Net returns are calculated as gross returns minus cost. We have used two different types of costs for the analysis. A1+FL and A2+FL

   - A1 +FL = All actual expenses in cash and kind incurred in production by owner + Imputed value of family labour (This is mainly used for all the analysis)
   - A2+FL = All actual expenses in cash and kind incurred in production by owner + Imputed value of family labour + rent paid for leased in land.

     (or)

     A2+FL = (A1+FL) + Rent paid for leased in land .

   Rent paid for leased in land (which is used in the calculation of A2+FL) is not available for 1975-79 and is available for 2009-14. So to get the rent for 1975-79, we calculated the share of rent in total cost (A1+FL) for the leased in plots during 2009-14 and then took the average share of rent in total cost for the period 2009-14. This share has been applied to the 1975-79 data.

Example: Below table shows the sample on how we have approached at A2+FL

Table 1: Example showing the data during 1975			
Year -1975	leased in Households		
Household	A1+FL (1)	Rent for leased in land (2)	A2+FL (3)
1	150	-	-
2	100	-	-
3	200	-	-

Source: Hypothetical data

Table 1 shows the data during 1975; rent for the leased land is not given, so A2+FL is not calculated.

Table 2: Example showing the data during 2009				
Year -2009	leased in Households			
Household	A1+FL (1)	Rent for leased in land (2)	A2+FL (3)	Share of Rent in A1+FL (2/1)*100
1	100	25	125	25
2	250	45	295	18
3	450	65	515	14.4
Average share of rent in A1+FL Cost				**19.1**

Source: Hypothetical data

In 2009, rent for leased in land was given. Share of Rent in A1+FL cost is calculated so that it can be used to approximate 1975 leased in land rent. The average share of rent in A1+FL is 19.1%

Table 3: Example Showing the data during 1975			
Year -1975	leased in Households		
Household	A1+FL (1)	Rent for leased in land (A1 +FL * (19.1/100) (2)	A2+FL (1+2)
1	150	28.65	178.7
2	100	19.1	119.1
3	200	38.2	238.2

Source: Hypothetical data

Table 3 shows data from 1975. Rent for leased in land is calculated based on the data from 2009. The average share of rent in A1+FL costs during 2009 is 19.1%. Multiplying this per cent with A1+FL cost gives rent. Adding the A1+FL cost to rent for leased land gives us A2+FL cost.

4)For measuring productivity, yield per acre is used.

To measure the productivity over time, we need crops which are cultivated in both irrigated and rainfed plots and also which are cultivated during 1975-79 and 2009-14.

In many villages, the cropping pattern has changed over the years from 1975-79 to 2009-14. So instead of analysing at the village level separately, this analysis is done at all village levels (six villages combined) as it would give an adequate sample size.

For this purpose, some major crops cultivated during 1975-79 and 2009-14 are considered. They are jowar, cotton, paddy, pigeon pea and wheat. These five crops are considered for analysis on productivity

Profitability Analysis:

Sections 3.3,3.4 &3.5 Profitability of the crops is discussed in a detailed way. Section 3.3 discusses the profitability at all village level, Section 3.4 discusses at the village level (six villages separately), and section 3.5 discusses the profitability when irrigation status is divided into three parts (rainfed, partially irrigated and completely irrigated)

The primary analysis is done at the group level, i.e., 1975-79 as one group and 2009-14 as the other. Variables like net returns per acre, gross returns and costs are discussed.

3.3) Profitability Analysis (All villages combined):

Section 3.3 discusses the profitability at all village level (six villages combined). Plots are divided into rainfed and irrigated, and analysis is done for 1975-79 and 2009-14. Average net returns per acre, gross returns and costs, and changes in the composition of costs are discussed.

3.3.1) Net returns per acre.

In this section, net returns per acre have been discussed. Net returns are defined as gross returns minus costs. This section discusses net returns with two types of costs, A1+FL and A2+FL.

Net returns (A1+FL) = Gross returns – cost (A1+FL)

Net returns (A2+FL) = Gross returns - cost (A2+FL)

Table 3.1: Average net returns per acre (A1 +FL)			
			[In parenthesis - cultivated area]
year	**Rainfed (1)**	**Irrigated (2)**	**Returns to irrigation (2/1)**
1975-79	131.2 (10580)	691.7 (1696)	5.27
2009-14	564.8 (6205)	1541 (5915)	2.73

Source: Author's calculations using VDSA data

Table 3.1 shows the average net returns (A1+FL) per acre of all villages combined. Net returns per acre are calculated year-wise, and then the average of net returns for the years 1975-79 and 2009-14 is taken. These are in constant prices where the base year is 1975.

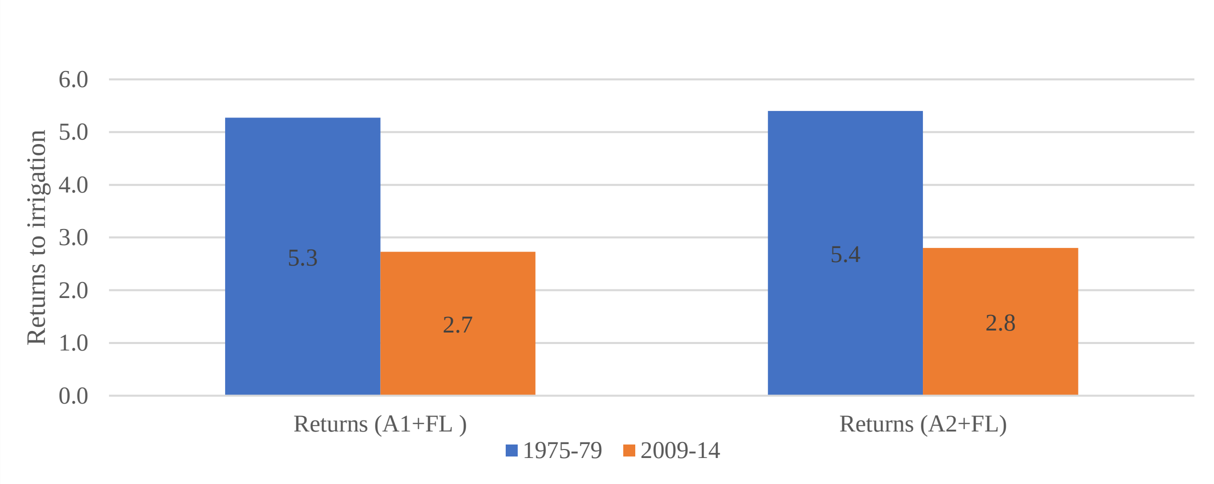
During 1975-79 rainfed area had net returns of Rs 131/acre, and the irrigated area had net returns of Rs.692/acre**.** Returns to irrigation are calculated as net returns of irrigated area/ net returns of rainfed area. The returns to irrigation during 1975-79 is 5.27, which means irrigated area net returns are five times more than the rainfed area's net returns.

During 2009-14, net returns were Rs 564.8/acre and Rs 1541/acre for the rainfed and irrigated area. The returns to irrigation is 2.7. The irrigated net returns are 2.7 times more than the rainfed net returns. Returns to irrigation have decreased from 5.2 times to 2.7 times during 1975-79 to 2009-14.

Regarding average net returns per acre (A2+FL). The returns are almost similar to net returns (A1+FL). During 1975-79, irrigated areas net returns were 5.4 times more than rainfed returns. During 2009-14 the irrigated net returns were 2.8 times more than the rainfed net returns. [Appendix -A.3.1]

Clearly, we can see that returns to irrigation have decreased from 1975-79 to 2009-14. Figure 3.1 shows the returns to irrigation for 1975-79 & 2009-14 (for both A1+FL & A2+FL). In both cases, returns have decreased over the years. During 1975-19, irrigated area's net returns used to be around five times more than the rainfed area's net returns; this has decreased to approximately 2.5 times during 2009-14.

Figure 3.1: Returns to irrigation (A1+FL & A2+FL)



Source: Author's calculations using VDSA data

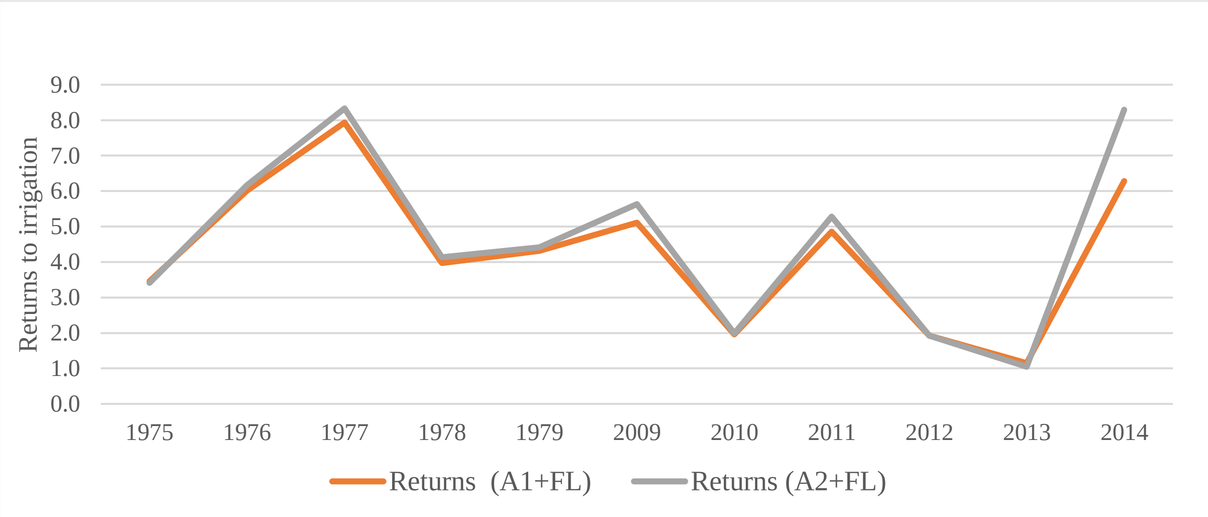
Table 3.2 shows the year-wise net returns per acre (A1+FL). We could see that during 1975-79, the irrigated area's net returns were much higher than the rainfed area's net return (returns to irrigation ranged from 3.5 times to 7.9 times). During 2009-14, although the irrigated area's net returns were higher than the rainfed area's returns, there were huge fluctuations between rainfed and irrigated net returns (returns to irrigation ranged from 1.1 times to 6.3 times)

Figure 3.2 shows the returns to irrigation for 1975-79 & 2009-14 (for both A1+FL & A2+FL). We could see a declining trend in returns to irrigation over the years. There have been many fluctuations in returns to irrigation during the period 2009-14. Though irrigated agriculture reaps more profit than rainfed agriculture, the rate of profitability is decreasing over the years**.**

Table 3.2: Year wise net returns per acre (A1 +FL)			
			[in parenthesis - cultivated area]
year	Rainfed (1)	Irrigated (2)	Returns to irrigation (2/1)
1975	86.8 (2013)	300.2 (327)	3.5
1976	121.1 (2235)	728.1 (330)	6.0
1977	149.5 (2407)	1186.6 (323)	7.9
1978	130.4 (2009)	518 (370)	4.0
1979	168.2 (1916)	725.4 (345)	4.3
2009	434 (1137)	2216.4 (698)	5.1
2010	840.6 (1078)	1647.2 (848)	2.0
2011	283.7 (836)	1378.9 (1096)	4.9
2012	909 (1109)	1753.1 (984)	1.9
2013	689.1 (1148)	792.4 (1281)	1.1
2014	232 (898)	1458.2 (1008)	6.3

Source: Author's calculations using VDSA data

Figure 3.2: Year-wise returns to irrigation of net returns (A1+FL & A2+FL)



Source: Author's calculations using VDSA data

3.3.2) Gross returns and costs (All villages)

This section discusses the gross returns and costs (A1+FL & A2+FL). From the previous section, we have seen that returns to irrigation are decreasing over the years, or the gap between irrigated and rainfed area's net returns is decreasing. By analysing gross returns and costs, we will know which part plays a major role in this phenomenon.

Table 3.3: Average gross returns and costs (A1 +FL) per acre							
Year	**Gross returns per acre**				**Cost (A1+FL)**		
	Rainfed (1)	Irrigated (2)	Returns to irrigation (2/1)		Rainfed (1)	Irrigated (2)	No of times than rainfed cost (2/1)
1975-79	271.7	1521.8	5.6		140.5	830.1	5.9
2009-14	1342.1	2974.0	2.2		777.4	1433.5	1.8

Source: Author's calculations using VDSA data

Table 3.3 shows gross returns and costs per acre at constant prices. Gross return per acre and cost per acre are calculated year-wise, and the average is taken for the years 1975-79 and 2009-14.

During 1975-79, irrigated area's gross returns were 5.6 times more than the rainfed area's gross returns. During 2009-14, irrigated gross returns were 2.2 times more than rainfed ones. From 1975-79 to 2009-14, gross returns per acre for rainfed area increased 394% (an increase from Rs 271 to 1342 per acre), whereas gross returns for irrigated area increased around 95% (an increase from 1521 to 2974 per acre) during the same period.

Regarding costs, during 1975-79 irrigated area costs were 5.9 times more than rainfed area's costs, this has declined to 1.8 times during 2009-14. From 1975-79 to 2009-14, the costs (A1+FL) of the rainfed area increased 453% (an increase from Rs 140 to 777 per acre), whereas the cost for irrigated area increased around 73% (an increase from 830 to 1433 per acre) during the same period.

A2+FL costs have been similar to A1+FL costs. From 1975-79 to 2009-14, A2+FL costs for rainfed areas increased 472% (an increase from 145 to 834 per acre), and costs for irrigated areas increased 83% (an increase from 838 to 1535 per acre). [Appendix -A.3.2]

We could see both gross returns and costs of the rainfed area have increased from 1975 to 2014; irrigated area's gross returns and costs did not increase as much as the rainfed area. The gap between net returns of irrigated and rainfed areas has decreased due to increase in gross returns and costs of rainfed agriculture.

3.3.3) Cost composition (All villages)

In the previous section, we have seen the decline in returns to irrigation is due to an increase in gross returns and costs of rainfed agriculture. This section discusses how the cost profile has changed during the study period (1975 -79 to 2009-14) for irrigated and rainfed agriculture.

A1+FL cost is used for this analysis. This section presents the cost per acre and the share of different inputs to the total cost.

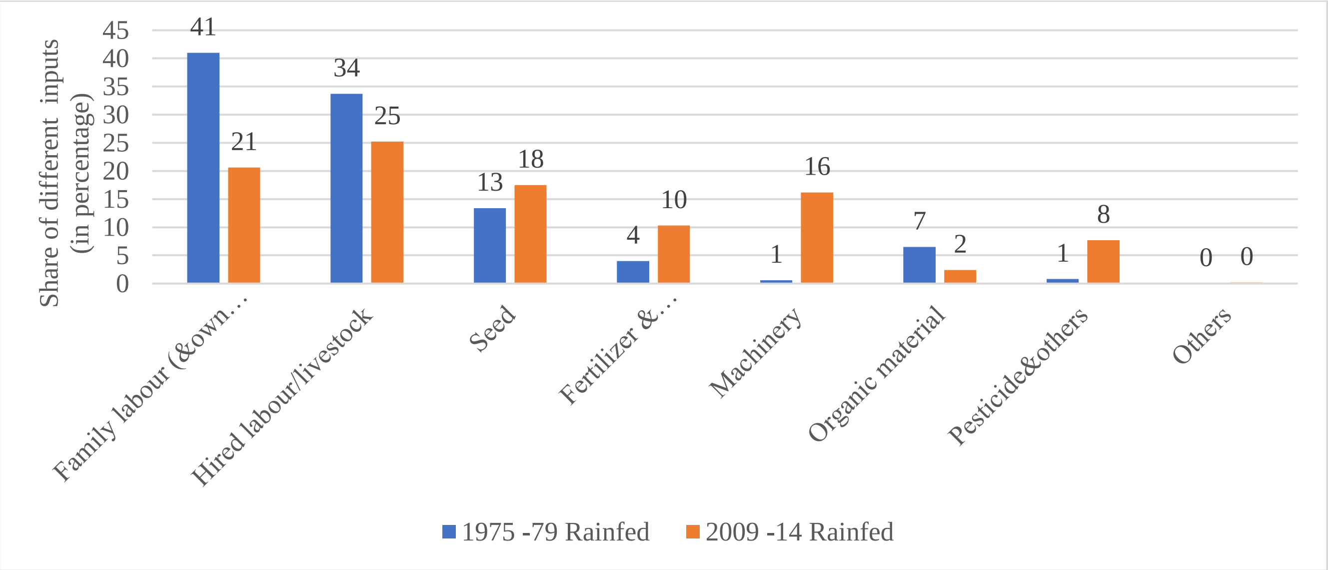
Table 3.4 shows the cost composition per acre (A1+FL) during 1975-79 & 2009-14. The analysis is done at all village level (six villages combined).

Table 3.4: Cost composition per acre (A1+FL)

Detailed Cost	**1975 -79**	**2009 -14**		**1975-79**	**2009 -14**
	Rainfed	Rainfed		Irrigated	Irrigated
Family labour/own livestock	57.5	148.0		193.9	357.8
Hired labour/livestock	47.3	181.4		190.8	410.7
Seed	18.8	125.8		109.3	227.2
Fertilizer/Growth reg/Micronutrient	5.6	74.4		163.9	192.4
Machinery	0.9	116.5		47.1	25.7
Organic material	9.1	17.2		8.4	36.2
Pesticide/Fungicide/weedicide	1.1	55.7		117.8	167.2
Others		1.2			9.1
Total Cost (A1+FL)	140.3	720.1		831.3	1426.3

Source: Author's calculations using VDSA data

Figure 3.3: Share of different inputs to total cost of rainfed agriculture (in per cent)



Source: Author's calculations using VDSA data

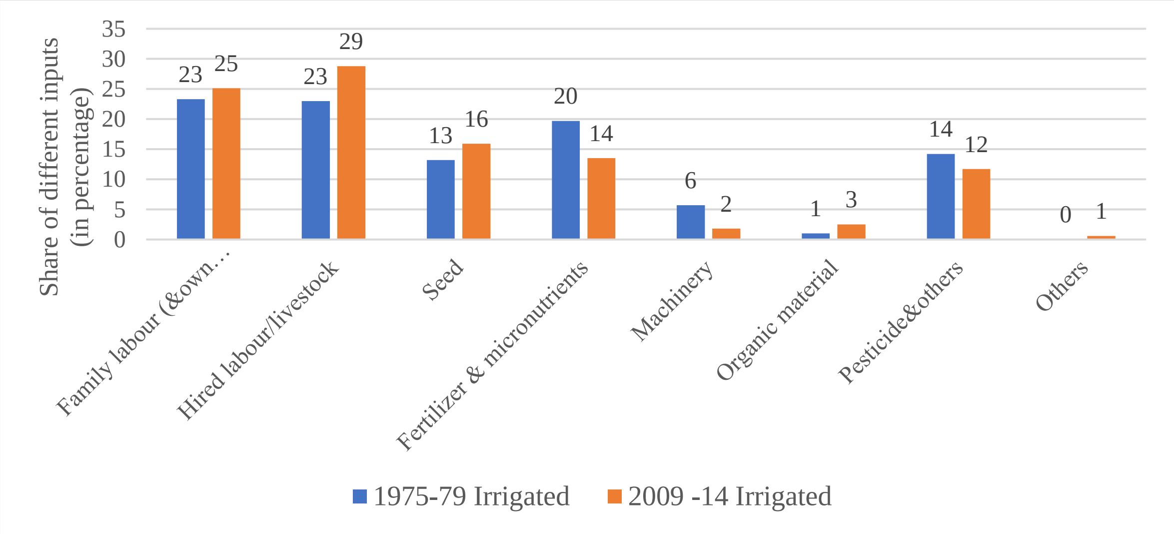
Figure 3.3 shows the percentage of different inputs to total costs in rainfed agriculture during 1975-79 to 2009-14. We could see that during 1975-79 labour costs (both family and hired labour) contributed around 74% to the total cost. Seed and organic material contributed around 13% & 6% of the cost, respectively. Together, these three costs (labour, seed, and organic material) would make up to 93% of rainfed agriculture costs. During 2009-14, (in rainfed agriculture) labour costs (hired and family labour) reduced from 74% to 46%, and seed costs increased from 13% to 17%. Machinery share has increased from 0.6% to 16%, and fertiliser share increased from 4% to 10%.

In irrigated agriculture, during 1975-79, labour costs (hired and family labour) contributed around 46% of the total cost; fertilisers, pesticides and seeds contributed around 19%, 14% and 13%, respectively, to the total cost. During 2009-to 14, the labour cost (hired and family) increased slightly from 46% to 54%, fertiliser cost decreased from 19.7 to 13.5 %, pesticide cost-share decreased slightly from 14% to 11%, and seed cost increased slightly from 13% to 16%. Machinery costs declined from 5.7% to 1.8%. [Figure3.4]

In rainfed agriculture, the contribution of different inputs has changed so much from 1975 to 2014. Labour share has decreased by 20%, and other inputs share such as fertilisers, machinery and pesticides (whose share was negligible during 1975-79) has increased so much. These costs must have increased the cost of rainfed agriculture and simultaneously its gross returns.

Unlike in rainfed agriculture, different inputs contribution like fertilisers, pesticides and seeds are there from 1975-79 for irrigated agriculture. Even during 2009-14, there have been only slight changes like a rise in labour share and a decrease in the share of fertilisers and pesticides. However, overall, there have been no significant changes in the cost component of irrigated agriculture.

Figure 3.4: Share of different inputs to total Cost of irrigated Agriculture (in per cent)



Source: Author's calculations using VDSA data

3.4) Village level profitability Analysis:

This section discusses the average net return per acre, gross return, and cost per acre at the village level (6 villages separately). The analysis is presented for 1975-79 & 2009-14. All the variables are in constant prices (according to 1975 prices).

3.4.1) Net returns per acre (Village level)

Table 3.5 and appendix-A.3.3 shows average net returns per acre (A1+FL) & (A2 +FL) of 6 villages. Returns to irrigation are defined as net returns (irrigated)/ net returns (rainfed). The returns to irrigation have declined from 1975-79 to 2009-14 in all the villages except for Dokur.

During 1975-79, In Kanzara and Kinkheda villages, irrigated net returns (A1+FL) were 2.6 & 1.6 times higher than rainfed net returns, respectively. The returns to irrigation have declined so much in these villages that irrigated net returns are only partially higher (1.3 & 1.5 times) than rainfed net returns during 2009-14.

In aurapalle, returns to irrigation (A1+FL) declined from 4.4 times to 1.6 times. The irrigated net returns did not increase as much as rainfed net returns in the village.

According to Deb et al. (2014), in villages such as Kanzara and Kinkheda, even though they could hold to dryland agriculture, there has been flourishment of agriculture. This is because of assured rainfall in the region, adoption of improved technologies like improved soybean and due to increase in farm mechanisation. Similarly, in Aurapalle, farmer's income improved over time with the adoption of improved crop technologies and highly valued crops like BT cotton.

In Shirapur, although returns to irrigation have declined during the study period (From 12.4 times to 9.9 times), its returns to irrigation are higher compared to other villages. This might be due to the cultivation of the sugarcane crop in Shirapur village.Except for Dokur village, the results presented in the above section are consistent at all village-level analyses. The returns to irrigation have been declining over the years in most villages.

Table 3.5: Average net returns per acre (A1+FL) [village level]

[In parenthesis -No of acres cultivated]

Village	**Year**	**Rainfed (1)**	**Irrigated (2)**	**Returns to Irrigation (2/1)**
Aurepalle	1975-79	115.8 (1214)	512.4 (338)	4.4
	2009-14	435 (1077)	698.8 (453)	1.6
Dokur	1975-79	35.1 (330)	593.7 (649)	16.9
	2009-14	-8 (142)	1173 (887)	147.6
Shirapur	1975-79	118.8 (2196)	1478.2 (229)	12.4
	2009-14	284.4 (500)	2810 (1901)	9.9
Kalman	1975-79	94.4 (2644)	520.7 (333)	5.5
	2009-14	156.6 (1174)	792.8 (842)	5.1
Kanzara	1975-79	184.5 (2119)	485.7 (91)	2.6
	2009-14	1095.2 (1839)	1437.5 (1209)	1.3
Kinkheda	1975-79	178 (2076)	291 (56)	1.6
	2009-14	467.3 (1474)	683.4 (623)	1.5

Source: Author’s calculations using VDSA data

3.4.2) Gross returns and costs (Village level):

Table 3.6 shows gross return and costs (A1+FL) per acre at the village level (six villages separately).

We could see that from 1975 to 2014, gross returns per acre for rainfed areas increased at a higher rate than irrigated areas (except for Kalman) [for example, from 1975 to 2014 in aurapalle gross returns for rainfed areas increased over 7 times, whereas gross returns for irrigated area increased 0.9 times.]

Similarly, the cost for rainfed areas increased at a higher rate than irrigated areas (except for Kalman) [In aurapalle cost for rainfed areas increased 11 times from 1975 to 2014 , whereas the cost for irrigated areas increased 1.2 times during the same period.

In villages such as Aurepalle, Kanzara and Kinkheda, gross returns and costs of the rainfed area have increased so much during 1975-79 to 2009-14. During 2009-14, there was not much difference between irrigated and rainfed gross returns and cost in these villages. (For example, in Kanzara, gross returns and costs of irrigated agriculture are just 0.3 times higher than rainfed agriculture). This phenomenon might be causing the decline in returns to irrigation of net returns.

Similarly, in villages such as Shirapur and Kalman, Although returns to the irrigation of net returns have declined from 1975 to 2014, There is still much difference between irrigated and rainfed gross returns and costs. (For example, During 2009-14 in Shirapur, gross returns and costs for irrigated agriculture were 7.2 & 4.9 times higher than rainfed agriculture.) We could see a considerable difference between irrigated and rainfed agriculture in the villages. Although returns to irrigation of net returns have declined from 1975 to 2014. Still, returns from irrigated agriculture in these villages are relatively high.

Table 3.6 : Gross returns and cost (A1+ FL) per acre [village level]

		Gross returns per acre				Cost (A1+FL) per acre		
Village	Year	Rainfed (1)	Irrigated (2)	Returns to Irrigation (2/1)		Rainfed (1)	Irrigated (2)	Times more than rainfed (2/1)
Aurepalle	**1975-79 (a)**	226.7	1322.4	5.8		110.8	809.9	7.3
	2009-14 (b)	1809.0	2485.3	1.4		1373.9	1786.4	1.3
Increase from 1975 to 2014 (b-a)/a		7.0	0.9			11.4	1.2	
Dokur	1975-79	283.0	1625.9	5.7		247.9	1032.2	4.2
	2009-14	728.8	2733.2	3.8		736.8	1560.2	2.1

		1.6	0.7			2.0	0.5	
Shirapur	1975-79	203.1	2264.7	11.2		84.2	786.4	9.3
	2009-14	606.9	4387.3	7.2		322.4	1575.1	4.9
		2.0	0.9			2.8	1.0	
Kalman	1975-79	188.0	968.1	5.2		93.6	447.4	4.8
	2009-14	454.7	2573.0	5.7		298.1	1780.1	6.0
		1.4	1.7			2.2	3.0	
Kanzara	1975-79	391.7	1366.5	3.5		207.1	880.72566	4.3
	2009-14	1947.8	2523.1	1.3		852.5	1085.6	1.3
		4.0	0.8			3.1	0.2	
Kinkheda	1975-79	371.6	1209.7	3.3		193.6	918.7	4.7
	2009-14	1247.4	1501.1	1.2		780.1	817.7	1.0
		2.4	0.2			3.0	-0.1	

Source: Author’s calculations using VDSA data

3.5) Three-part irrigation status

Our analysis is mostly based on whether the plot is irrigated or rainfed. In previous sections, partially irrigated plots are also counted as irrigated. This section divides the irrigation status into three rainfed, partially irrigated and completely irrigated. The analysis is carried out at all village level and during the period 1975-79 and 2009-14**.**

3.5.1) Net returns per acre:

Table 3.7: Average net returns per acre (A1 +FL) [Three-part irrigation status]

[parenthesis -No of acres cultivated]				Returns to irrigation		
Year	**Rainfed (1)**	**partially irrigated (2)**	**Completely irrigated (3)**	**(2/1)**	**(3/1)**	**(3/2)**
1975-79	131.4 (10580)	234.2 (25)	693.3 (1670)	1.8	5.3	3.0
2009-14	587.2 (6205)	509.6 (126)	1485.8 (5789)	0.9	2.5	2.9

Source: Author’s calculations using VDSA data.

Table 3.7 shows average net returns per acre. Numbers in the parenthesis show that very few plots are partially irrigated during 1975-79 and 2009-14. This is because most of the plots are either completely irrigated or rainfed. Only a few plots are partially irrigated (for example, a household (HH) may have 2-3 plots, some of the plots are entirely irrigated, and some are rainfed).

During 1975-79, the partially irrigated area's net returns were 1.8 times more than the rainfed area's. Completely irrigated area's net returns were 5 times more than rainfed area's net returns, and completely irrigated area's net returns were 3 times higher than partially irrigated area's net returns.

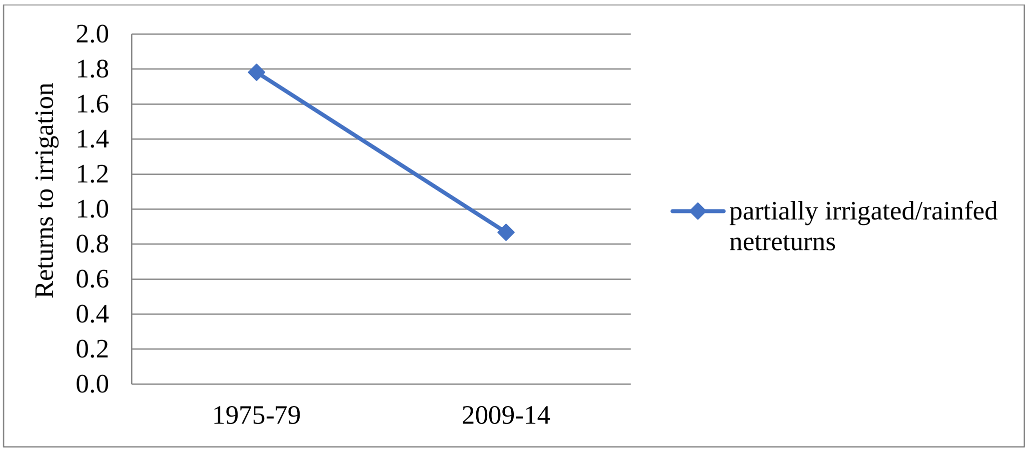
During 1975-79, completely irrigated area's net returns were much higher than rainfed area's net returns. The difference between partially irrigated net returns and rainfed net returns is small.

During 2009-14, partially irrigated area's net returns were lower than rainfed area's net returns, completely irrigated net returns were 2.5 times higher than rainfed net returns (a decrease from 5.3 times to 2.5 times), completely irrigated area's net returns are 2.9 times higher than partially irrigated area's net returns (as a slight decline from 3 times to 2.9 times)

During 2009-14, completely irrigated area's net returns were higher than rainfed area's net returns but returns to irrigation have decreased over time (During 1975-79, completely irrigated area's net returns were 5 times more than rainfed returns, it has decreased to 2.5 times). During 2009-14, partially irrigated net returns were lower than rainfed net returns, a phenomenon which was not observed during 1975-79. Returns to irrigation of completely irrigated net returns and partially irrigated net returns remained almost the same during the study period.

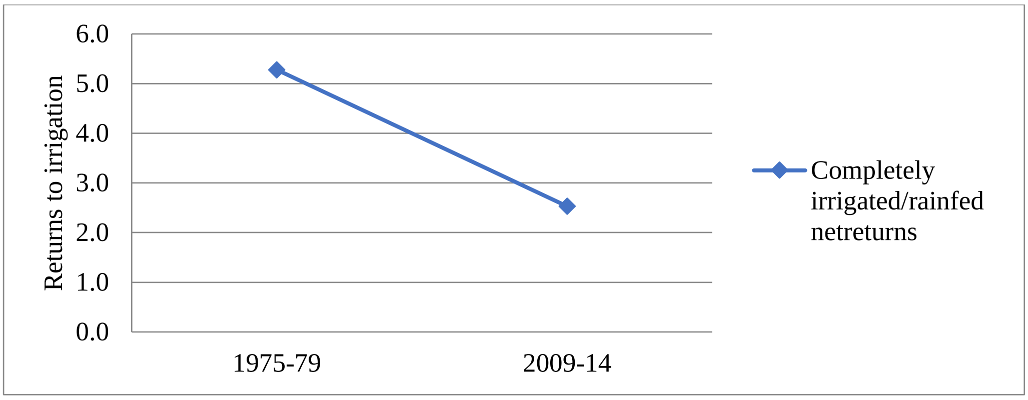
These results are consistent with 2-part (irrigated and rainfed) results. Returns to irrigation have declined over the study period. The following figures clearly explain this

Figure 3.5: Returns to irrigation of partially irrigated and rainfed plots.



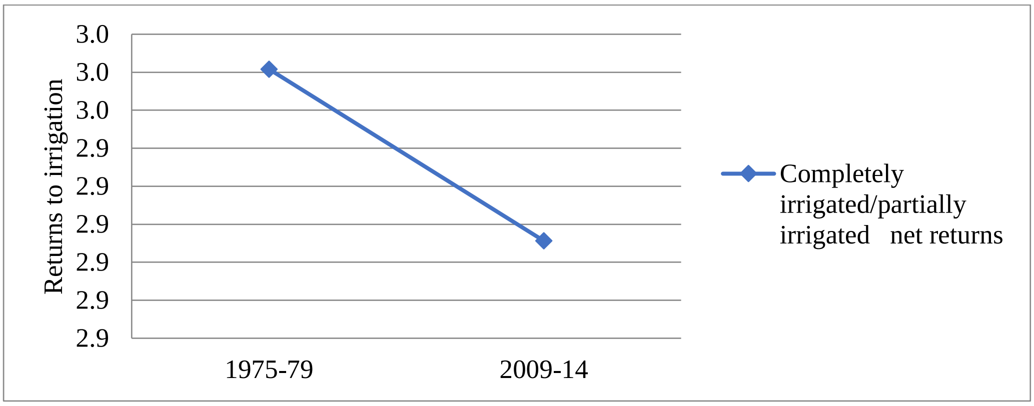
Source: Author's calculations using VDSA data

Figure 3.6: Returns to irrigation of completely irrigated and rainfed plots.



Source: Author's calculations using VDSA data

Figure 3.7: Returns to irrigation of completely irrigated and partially irrigated plots



Source: Author's calculations using VDSA data

3.5.2) Gross returns and costs:

Table 3.8: Gross returns per acre (A1 +FL) [Three-part irrigation status]						
				Returns to irrigation		
Year	Rainfed (1)	Partially Irrigated (2)	Completely Irrigated (3)	(2/1)	(3/1)	(3/2)
1975-79 (a)	271.8	562.1	1532.3	2.1	5.6	2.7
2009-14 (b)	1365.2	1612.2	2921.2	1.2	2.1	1.8
(b-a)/a	**5.0**	**2.9**	**1.9**			

Source: Author's calculations using VDSA data

Table 3.8 shows gross returns and cost per acre at all village level in constant prices. Gross return per acre and cost per acre are calculated year-wise, and the average is taken for the years 1975-79 and 2009-14.

From 1975-79 to 2009-14, gross returns per acre for rainfed, partially irrigated, and completely irrigated areas increased 5 times,2.9 times and 1.9 times, respectively.

Similar to two-part irrigation, gross returns of the rainfed area have increased at a higher rate, followed by GR of partially irrigated and then GR of completely irrigated areas.

Table 3.9: Cost per acre (A1 +FL) [Three-part irrigation status]						
				Returns to irrigation		
Year	Rainfed (1)	Partially Irrigated (2)	Completely Irrigated (3)	(2/1)	(3/1)	(3/2)
1975-79 (a)	140.4	327.9	839.0	2.3	6.0	2.6
2009-14 (b)	778.0	1102.6	1436.0	1.4	1.8	1.3
(b-a)/a	5.5	3.4	1.7			

Source: Author's calculations using VDSA data

From 1975-79 to 2009-14, the cost (A1+FL) per acre for rainfed, partially irrigated, and completely irrigated areas increased 5.5 times,3.4 times and 1.7 times.[Table:3.9]

We could see both gross returns and costs of the rainfed area have increased so much from 1975 to 2014. Partial and completely irrigated area's gross returns and costs did not increase as much as rainfed areas. The gap between net returns of irrigated and rainfed areas has decreased due to increase in gross returns and costs of rainfed agriculture.

3.6) Productivity analysis

This section has discussed the productivity of the irrigated and rainfed plots during 1975-79 and 2009-14. Productivity is measured as yield per acre. For measuring productivity, we took those crops which were prominent both during 1975-79 and 2009-14. This analysis is carried out at all village level. Five crops are considered for the analysis: jowar, cotton, paddy, pigeon pea, and wheat.

Table 3.10: Quantity per acre of some of the prominent crops

[in parenthesis- no of plots]

crops	year	Rainfed (1)	Irrigated (2)	Returns to irrigation (2/1)
Cotton	1975-79	105.2 (556)	411.5 (13)	3.9
	2009-14	503.5 (572)	642.3 (161)	1.3
Paddy	1975-79	116.2 (206)	1189.5 (580)	10.2
	2009-14	2136.9 (6)	1921.3 (573)	0.9
pigeon pea	1975-79	66.4 (1177)	230.8 (4)	3.5
	2009-14	302.3 (1054)	314.8 (130)	1.0
Jowar	1975-79	133.5 (2319)	354.8 (167)	2.7
	2009-14	172.7 (648)	318.4 (233)	1.8
Wheat	1975-79	151 (138)	541.3 (182)	3.6
	2009-14	908.7 (5)	993.6 (544)	1.1

Source: Author’s calculations using VDSA data

Table 3.10 shows the quantity per acre during 1975-79 and 2009-14. Similar to profitability analysis, all crops' return to irrigation has decreased during the study period.

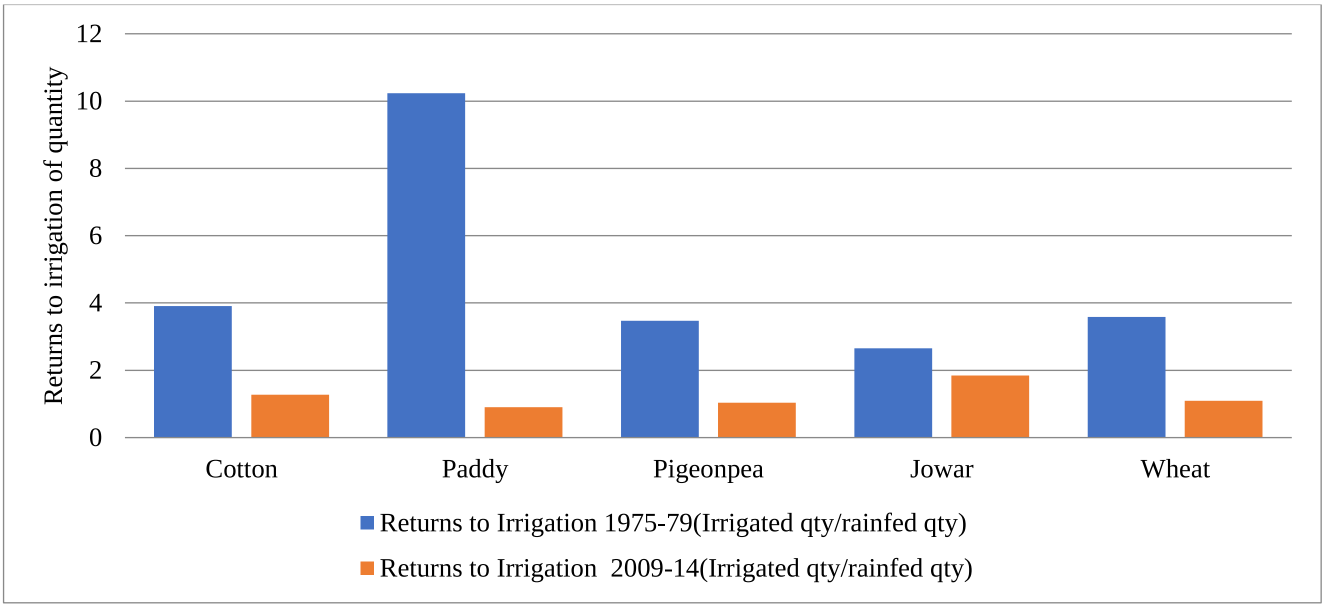
During 1975-79, cotton's yield in a rainfed area was 105 kg per acre, and irrigated area yield was 411 kgs per acre (irrigated area yield was 3.9 times more than rainfed). During 2009-14, rainfed area yield increased to 503 kgs per acre while irrigated area yield increased to 642 per acre (irrigated area's yield was 1.3 times more than rainfed area).

This is same for every crop. During 1975-79, irrigated pigeon pea yielded 3.5 times more than the rainfed yield; it decreased to 1.0 times during 2009-14. Irrigated jowar and wheat yielded 2.7 & 3.6 times more than the rainfed area during 1975-79; this has decreased to 1.8 &1.6 times respectively during 2009-14.

During 1975-79, irrigated paddy yield was so high that it was 10 times more than the rainfed area's yield, but during 2009-14, the rainfed yield was slightly higher than the irrigated Yield (Rainfed yield was 2136 Kgs per acre and irrigated yield was 1921 kgs per acre). However, this result should be interpreted with caution because there were only six plots which were cultivating paddy in a rainfed area during 2009-14. Even wheat and pigeon pea have the same issue (during 2009-14 rainfed wheat was cultivated in 5 plots only and during 1975-79 irrigated pigeon pea was cultivated in 4 plots only).

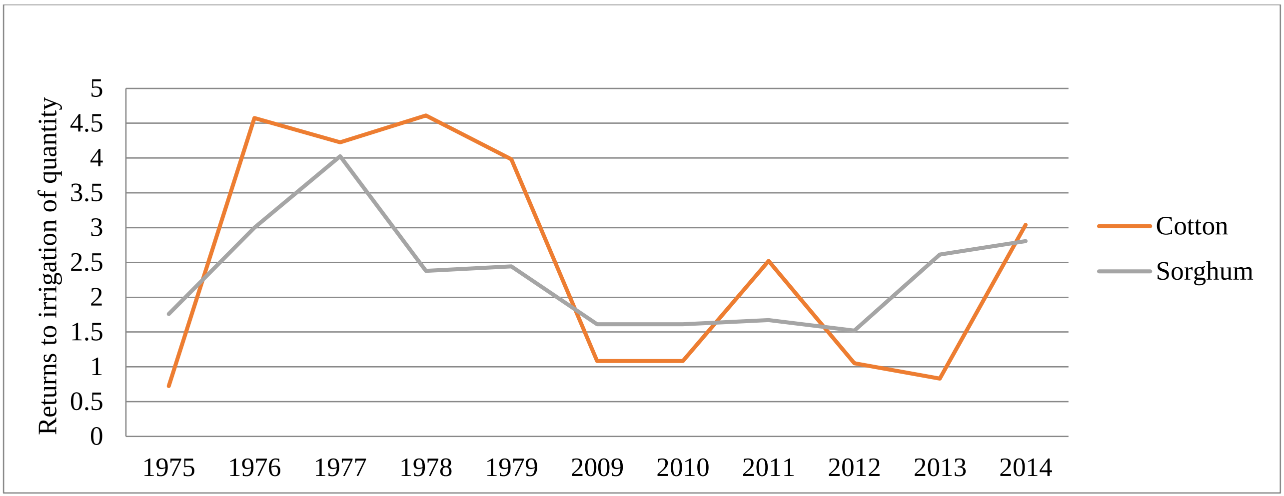
Cotton and Jowar can be compared over the period; even these results show that the difference between rainfed and irrigated yield has declined during the study period. This is clearly shown in figure 3.9.

Figure 3.8 : Returns to irrigation of quantity per acre



Source: Author’s calculations using VDSA data

Figure 3.9: Year wise returns to irrigation of quantity per acre



Source: Author's calculations using VDSA data

Figure 3.9 shows year-wise returns to irrigation of quantity per acre of cotton and jowar. Only cotton and jowar are used for comparison because these are the only two crops cultivated consistently over the years. Though returns to irrigation are fluctuating over the years, a broadly declining trend is seen. [Tables for year-wise quantity data are shown in the appendix -Table A.3.4 and A.3.5]

3.7) Conclusion:

The main findings from this chapter are

Average net returns per acre for both irrigated and rainfed areas increased during the study period. However, the returns to irrigation, i.e. the number of times irrigated net returns are higher than rainfed areas net returns have been declining from 1975 to 2014. This phenomenon is observed primarily because of the higher increase in gross returns and costs of rainfed areas. Irrigated areas' gross returns and costs did not increase as much as rainfed areas.

The increase in gross returns and costs for rainfed areas might be due to changes in the contribution of different inputs. During 1975-79, labour, seed and organic material costs accounted for 93% of total cost in rainfed agriculture. During 2009-14, besides labour costs, there was a significant increase in other inputs costs such as fertilisers, machinery and seed costs in rainfed agriculture. This change might have led to increase in costs and simultaneously the gross returns of rainfed agriculture.

These trends are consistent at the village level also. Except for Dokur, in all the villages, returns to irrigation have declined during the study period. In all the villages, gross returns and costs of rainfed agriculture increased at a higher rate than irrigated agriculture.

Even though returns to irrigation have declined during the study period, two broad trends can be observed. In villages such as Shirapur and Dokur, where high water-intensive crops are grown (i.e. paddy and sugarcane), profits from irrigated agriculture are still high. During 2009-14, in Shirapur, net returns from irrigated agriculture were nine times higher than rainfed area net returns.

In villages such as Aurapalle, Kanzara and Kinkheda, where irrigation percentages increased only moderately, returns from irrigated agriculture are not very different from rainfed agriculture during 2009-14. Farmers have stuck to low water-intensive crops like cotton and soybean in these villages. However, they increased their investments in improved varieties and machinery etc. In Kanzara and Kinkheda, farmers used improved HYV varieties in soybean and pigeon pea. In aurapalle, farmers cultivated high-value crops like Bt cotton. These investments might have led to increased returns from rainfed agriculture in these villages.

Coming to productivity, only few crops were grown both during 1975-79 and 2009-14. Two crops, jowar and cotton are considered for the analysis. The results show that the gap between irrigated and rainfed agriculture has declined during the study period.

Chapter -4

Profitability and Productivity of Irrigation among Land Holding Groups.

4.1) Introduction

The importance of irrigation, its role in shifting the cropping pattern, decreasing the uncertainty and increasing the productivity has been studied by several authors. In the previous chapter profitability and productivity of irrigation in semi-arid tropics are studied. Results show that returns to irrigation have been declining during the study period.

This chapter aims to find out how returns have changed under irrigated and rainfed conditions among different land holding groups and also addresses the question of variability. How the household's returns have varied with the presence or(absence) of irrigation is analysed in this chapter.

Results show that the decline in returns to irrigation is evident across all land groups and is much more pronounced among large farmers; this is due to the reason mentioned in chapter 3. Small farmers' returns have been higher compared to other groups, but their returns have high fluctuations.

Regarding the variation of profits, during 1975-79, irrigated households had high variation than rainfed households, and during 2009-14, irrigated households' variation decreased significantly. At the same time, rainfed households' variation has increased.

Section 3.2 deals with the methodology, sections 3.3 and 3.4 deal with the profitability and productivity of irrigation among different land-holding groups. Section 3.5 discusses the variation in profits of irrigated and rainfed households.

4.2) Methodology.

1. VDSA data has categorised households into labour and cultivator households. Labour households own less than 0.2 hectares of land or have daily wage work as a primary or secondary source of income. Cultivator households are the ones who operate more

than 0.2 hectares of land, and they are further divided into small, medium and large based on the operational holdings. (VDSA Manual, 1985).

2. Land-holding data, which can be the basis for categorising small, medium and large farmers, is not uniform across all the villages. (Appendix-A.2.0). In this chapter, only small, medium and large farmers are considered. Labour households are excluded as they possess little or no land.

3. All the analysis in this chapter is carried out at all village level

4. For measuring productivity, yield per acre is used.
   To measure the productivity over time, we need crops which are cultivated during 1975-79 and 2009-14 (both irrigated and rainfed plots) and across all the land holding groups.
   Since the cropping pattern has changed from 1975-79 to 2009-14, the productivity analysis is carried out at all village level (6 villages combined) to get an adequate sample size.
   Only two crops, jowar and cotton, are considered for the analysis. In the previous chapter (chapter -3), five crops are used for the analysis; since they are not cultivated across all land-holding groups, these two crops are used for the analysis.

5. For analysing the variation in profits in irrigated and rainfed households, the coefficient of variation is used (COV). Net returns (A1+FL) are used for the analysis. The analysis is done at the household level, and variation is looked for the period 1975-79 &2009-14.
   Some households might not cultivate consistently all the years; this analysis has taken those households who cultivated for at least three years during 1975-79. Similarly, for 2009-14, only those households cultivated for at least three years were taken.
   Households are divided into three types; say, if a household has consistently irrigated during 1975-79, they are considered as irrigated households. If a household is consistently rainfed, they are categorised as rainfed households. If a household is irrigated for some years and not irrigated for some years, they are categorised as mixed households.

The coefficient of variation is calculated at the household level in each category (irrigated, rainfed and mixed HH), and the average of COV is taken.

4.3) Profitability Analysis:

In this section profitability of different land holding groups is discussed. The analysis is done at the group level, i.e., for 1975-79 as one group and 2009-14 as the other. This section includes variables like net returns per acre, gross returns and costs. Along with these variables, a subsection deals with how costs have changed over the years for different land holding groups. This section presents an analysis of all villages combined.

4.3.1) Net returns Per acre.

In this section, net returns per acre have been discussed. Net returns are defined as gross returns minus costs. This section discusses net returns with two types of costs, A1+FL and A2+Fl.

Net returns (A1+FL) = Gross returns – cost (A1+FL)

Net returns (A2+FL) = Gross returns - cost (A2+FL)

Table 4.1: Net returns (A1+FL) per acre of different land classes

[In parenthesis - No of acres cultivated]

Land class	Year	Rainfed (1)	Irrigated (2)	Returns (2/1)
Small	1975 -79 (a)	128.1(1446)	715.3(168)	5.6
	2009 -14 (b)	395.1(1568)	1536.3(1696)	3.9
	(b/a)	3.1	2.1	
Medium	1975 -79 (a)	113.1 (2503)	558.4 (450)	4.9
	2009 -14 (b)	548.6 (1990)	1792.8 (1687)	3.3
	(b/a)	4.9	3.2	
Large	1975 -79 (a)	143.9 (6253)	711.9(1037)	4.9
	2009 -14 (b)	738.4 (2501)	1239.4 (2372)	1.7
	(b/a)	5.1	1.7	

Source: Author’s calculations using VDSA data

Table 4.1 shows net returns (A1+FL) per acre. During 1975-79, small farmers irrigated area's net returns were 5.6 times the rainfed area's net returns. Medium and large farmers irrigated area's net returns were 4.9 times higher than their respective rainfed area's net returns.

During 2009-14, small farmers irrigated net returns were 3.9 times higher than the rainfed area's net returns (returns to irrigation have declined from 5.6 times to 3.9 times).

Similarly, returns to irrigation have declined from 4.9 times to 3.3 times for medium farmers and have declined from 4.9 times to 1.7 times for large farmers

Large farmers ' returns to irrigation have declined so much compared to other land holding groups (a decline from 4.9 times to 1.7 times). This is because large farmers rainfed returns increased so much from 1975-79 to 2009-14. Rainfed returns increased 5.1 times for large farmers against 4.9 and 3.1 for medium and small farmers, respectively. In the same way, irrigated net returns did not increase as much for large farmers compared to others.

Small farmers ' returns to irrigation are higher even during 1975-79 and 2009-14.

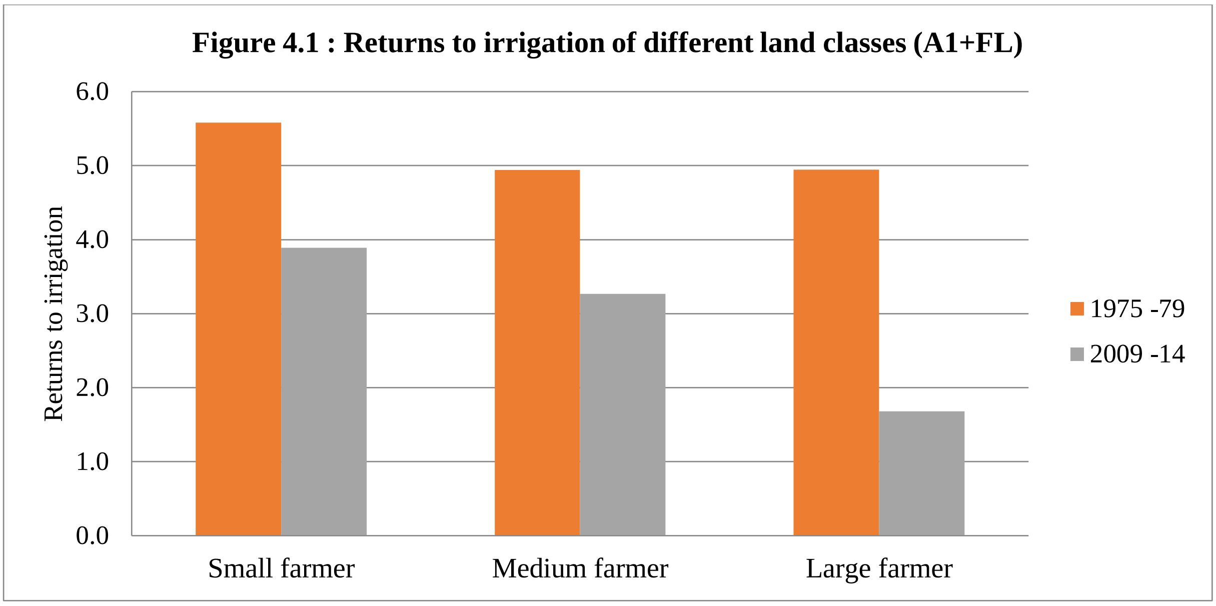
Table 4.2: Net returns (A2+FL) per acre of different land classes

[In parenthesis - No of acres cultivated]

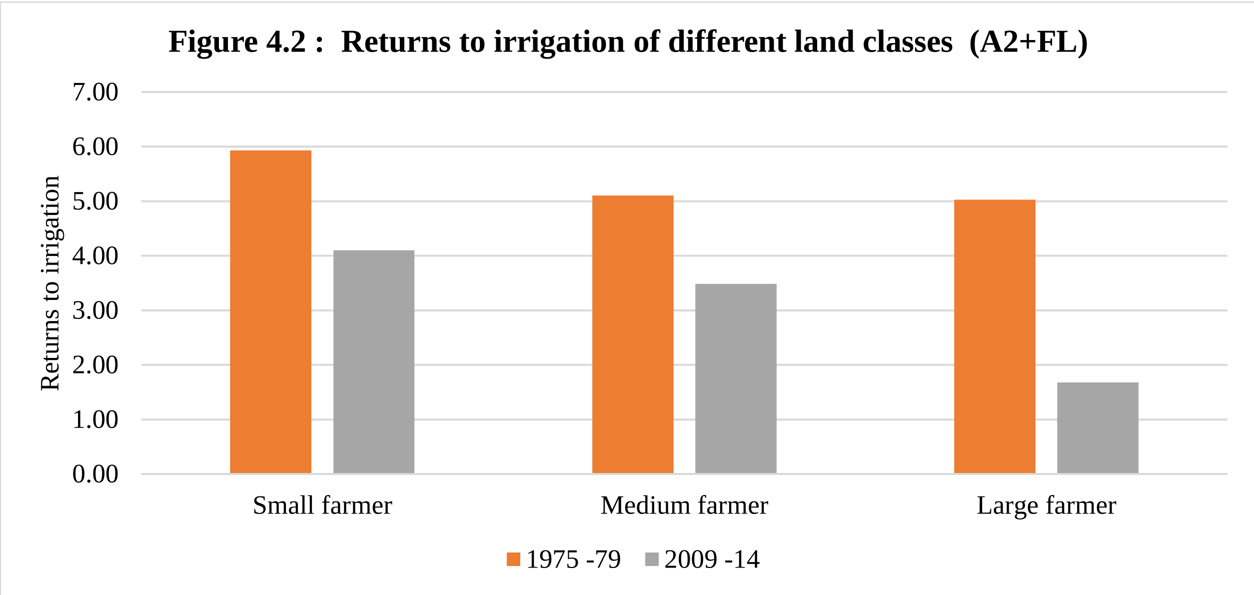
Land class	Year	Rainfed (1)	Irrigated (2)	Returns (2/1)
Small	1975 -79	120.29	713.56	5.9
	2009 -14	332.10	1361.30	4.1
Medium	1975 -79	106.36	542.96	5.1
	2009 -14	502.37	1751.25	3.5
Large	1975 -79	140.70	706.94	5.0
	2009 -14	683.39	1148.39	1.7

Source: Author’s calculations using VDSA data

Table 4.2 shows net returns per acre (A2+FL). The results are similar to A1+FL results. Returns to irrigation of all land holding groups have declined during the study period. Returns to irrigation for large farmers have declined so much compared to other groups (a decline from 5.0 to 1.7 times), and returns to irrigation for small farmers have been higher during 1975-79 & 2009-14.



Source: Author’s calculations using VDSA data



Source: Author’s calculations using VDSA data

Figure 4.1 and Figure 4.2 shows the returns to irrigation of net returns per acre (A1+FL & A2+FL). The returns to irrigation have declined across all the land classes. The decline is much more pronounced for large farmers.

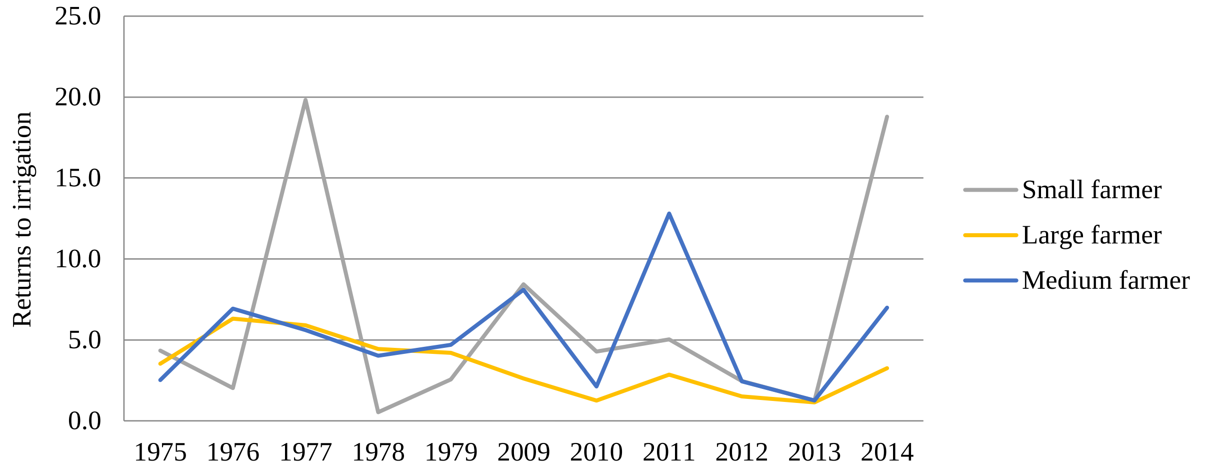


Figure 4.3 :Year wise returns to irrigation of different landclasses (A1+FL)

Source: Author's calculations using VDSA data

Figure 4.3 shows year-wise returns to irrigation of net returns per acre (A1+FL). Results show that returns to irrigation for large farmers have clearly declined during the study period. From the above graphs, we have seen that returns to irrigation of small farmers are higher than large and medium farmers, but there have been fluctuations in small farmers' returns to irrigation.

4.3.2) Gross return and costs

The above section shows us that returns to irrigation have been declining for all the land classes during the study period. In this section, we examine gross returns and costs for land groups

From 1975-79 to 2009-14, gross returns for rainfed area increased at a much higher rate than GR of irrigated area for all the land-holding groups. Among land groups, the rainfed area's gross returns increased significantly for medium and large farmers than for small farmers. (an increase of 5.5 times for large and medium farmers against 3.9 times for small farmers).

Similarly, from 1975-79 to 2009-14, costs for rainfed areas increased at a much higher rate than irrigated areas for all the land-holding groups. Among land groups, the costs of the rainfed area increased more for medium and large farmers than for small farmers. (6.2 and 5.8 times increase for medium and large farmers as against 4.7 times for small farmers)

Overall, gross return and costs of the rainfed areas increased at a higher rate compared to irrigated areas gross returns and costs. This has been true for all the land-holding groups. Among land groups, large and medium farmers rainfed area's GR and costs increased at a higher rate than small farmers.

This result has been consistent with chapter 3 results; the decline in returns to irrigation is due to a higher rate of increase in gross returns and costs of rainfed areas. This is true for all the land-holding groups. Among different land groups, large and medium farmers' rainfed returns increased at a higher rate than small farmers. Irrigated areas' returns and costs increased at a much higher rate for medium and small farmers.

The decline in returns to irrigation is sharp for large farmers as large farmers rainfed returns increased at higher rates than others. However, large farmers irrigated returns and costs did not increase much compared to other groups.

Table 4.3: Gross returns and costs (A1+FL) per acre of different land classes

		Gross returns				**Cost**		
Land class	Year	Rainfed (1)	Irrigated (2)	Returns (2/1)		Rainfed (1)	Irrigated (2)	Returns (2/1)
Small	1975 -79	253.8	1548.2	6.1		125.6	832.9	6.6
	2009 -14	990.2	3009.1	3.0		595.1	1472.7	2.5
		3.9	1.9			4.7	1.8	
Medium	1975 -79	240.3	1377.3	5.7		127.2	818.9	6.4
	2009 -14	1333.4	3300.6	2.5		784.7	1509.8	1.9
		5.5	2.4			6.2	1.8	
Large	1975 -79	295.9	1536.9	5.2		152.0	825.1	5.4
	2009 -14	1623.9	2591.5	1.6		885.5	1352.1	1.5
		5.5	1.7			5.8	1.6	

Source: Author’s calculations using VDSA data

4.3.3) Cost composition

In the previous section, we have seen that for all the land classes, large farmers, in particular decline in returns to irrigation, is due to an increase in gross returns and costs of rainfed agriculture. This section discusses how the cost profile has changed for different land groups during the study period (1975 -79 to 2009-14) for irrigated and rainfed agriculture.

A1+FL cost is used for this analysis. The share of different inputs to total cost is presented in this section.

Table 4.4: Percentage of different inputs to total costs for rainfed agriculture of different land classes

Cost	small farmer			Medium farmer			large farmer	
	1975-79	**2009-14**		**1975-79**	**2009-14**		**1975-79**	**2009-14**
	Rainfed	Rainfed		Rainfed	Rainfed		Rainfed	Rainfed
Family labour/livestock	41%	24%		41%	25%		41%	20%
Hired labour/livestock	38%	30%		36%	27%		32%	27%
Seed	12%	16%		14%	16%		14%	16%
Machinery	1%	15%		1%	14%		1%	16%
Fertilizer/Growth Hormone/micro nutrient	2%	8%		3%	9%		5%	10%
Organic material	6%	1%		5%	2%		7%	3%
Pesticide/Fungicide/weedicide	0%	6%		0%	7%		1%	8%
Others	0%	0%		0%	0%		0%	0%

Source: Author's calculations using VDSA data

Table 4.4 shows the percentage of different inputs to total costs of rainfed agriculture during 1975-79 to 2009-14. We could see that during 1975-79, in rainfed agriculture, labour costs contributed around 73 % to 79 % of the total cost (for small farmers, it is 79%, and for large farmers, it is 73%).

Besides labour cost,seed is also a prominent input for all land classes (it contributed around 12% to 14%). Together these two costs (labour and seed) would make up 87 % to 91% of the total cost in rainfed agriculture (87% for medium, 91% for large and small farmers). During 1975-79, there was only a little difference in how land classes spent on rainfed agriculture.

During 2009-14, labour costs (hired and family labour) reduced to around 47% to 54% (47% for large farmers and 54% for small farmers), machinery share has increased from 1% to 15% (16% for large farmers, 14% for medium and 15% for small farmers)and fertilisers share increased approximately from 3% to 10%. (increased to 8% for small farmers, 9% for medium and 10% for large farmers).

In rainfed agriculture, the contribution of different inputs has changed so much from 1975 to 2014. This change is evident across all the land groups. (labour share for all land groups has decreased by approximately 20%, and other inputs share such as fertilisers and machinery have increased). This input share change has led to increased rainfed costs and its returns.

Although the pattern is the same across all the land groups, large farmers have a slightly higher share of other inputs such as fertiliser, machinery and pesticides when compared to others**.**

Table 4.5: Percentage of different inputs to total costs for irrigated agriculture of different land classes

cost	small farmer			Medium farmer			large farmer	
	1975-79	**2009-14**		**1975-79**	**2009-14**		**1975-79**	**2009-14**
	Irrigated	Irrigated		Irrigated	Irrigated		Irrigated	Irrigated
Family labour/livestock	31%	28%		22%	26%		23%	22%
Hired labour/livestock	25%	30%		22%	31%		23%	26%
Seed	8%	10%		18%	11%		13%	13%
Machinery	17%	11%		21%	10%		19%	18%
Fertilizer/Hormone/micro nutrient	11%	16%		11%	17%		15%	15%
Organic material	7%	1%		4%	2%		6%	2%
Pesticide/Fungicide/weedicide	0%	2%		1%	2%		1%	3%
Others	0%	1%		0%	1%		0%	0%

Source: Author's calculations using VDSA data

Table 4.5 shows the percentage of different costs to irrigated agriculture; during 1975-79, labour costs (hired and family labour) contributed around 44% to 56% of the total cost (44% for medium farmers, 46% for large and 56% for small farmers. Fertilisers contributed around 11 to 15% (11% for small and medium farmers and 15% for large farmers). Seed contributed around 8% to 18% of the total cost (8% for small farmers, 18% for medium farmers).

During 2009-14, the labour cost (hired and family) increased slightly (it increased to 49% for large farmers, 57% for medium farmers and 58% for small farmers). Fertiliser costs increased for small and medium farmers and remained constant for large farmers (it increased from 11% to 16% for small farmers,11% to 17% for medium farmers and remained at 15% for large farmers). Share of machinery cost declined for small, medium and large farmers (it decreased from 17% to 11% for small farmers, 21% to 10% for medium farmers and 19% to 18% for large farmers).

As seen in the previous chapter, in irrigated agriculture, the contribution of different inputs like fertilisers, pesticides and seeds was significant from 1975-79. This is seen in all land classes. Even during 2009-14, there have been only slight changes like rise in the share of labour and a decrease in the share of fertilisers and machinery, but overall, there have been no significant changes.

Among different land classes, large farmers' share of different inputs has remained almost constant, but machinery share has declined for small and medium farmers, and fertiliser share has increased.

Overall, there have been no significant differences in how different land classes spend on different costs.

4.4) Productivity analysis.

This section discusses how the productivity of different land groups' irrigated and rainfed plots has changed over time. Productivity is measured as yield per acre. For measuring productivity, we took those crops which were prominent both during 1975-79 and 2009-14 . In the previous chapter, for analysis of productivity, five crops were considered. However, all the land classes do not cultivate these five crops uniformly. For this purpose, only two crops were considered for the analysis, i.e. Jowar and cotton.

The analysis is at all village level. Yield is calculated as quantity per acre.

Table 4.6: Quantity per acre of Jowar by land groups

(In parenthesis - no of plots cultivated)

Land class	Year	Rainfed (1)	Irrigated (2)	Returns to irrigation (2/1)
Small	**1975-79**	137.1 (524)	316.5 (31)	2.3
	2009-14	153.8 (302)	298.2 (115)	1.9
Medium	**1975-79**	118.4 (669)	359.8 (49)	3.0
	2009-14	159.9 (222)	346.4 (75)	2.2
Large	**1975-79**	144.2 (1044)	359.5 (85)	2.5
	2009-14	236.3 (112)	297.6 (32)	1.3

Source: Author’s calculations using VDSA data

Table 4.6 shows the quantity per acre of jowar during 1975-79 and 2009-14. Similar to profitability analysis, returns to irrigation have decreased during the study period for all the land groups.

During 1975-79, irrigated area yield was 2.3,3.0 and 2.5 times higher than the rainfed yield for small, medium and large farmers. During 2009-14, returns declined from 2.3 to 1.9 times for small farmers, from 3.0 to 2.2 for medium farmers and from 2.5 to 1.3 for large farmers.

From 1975-79 to 2009-14, the jowar rainfed area's yield increased for all land groups, while irrigated area's yield declined in absolute value for all the land groups. This is the reason for the decline in returns to irrigation.

Table 4.7 shows the quantity per acre of cotton during 1975-79 and 2009-14. Cotton during 1975-79 is cultivated in only very few irrigated plots. So, this interpretation may not be accurate due to this issue.

During 1975-79, Irrigated area yield was 3.0,4.4 and 3.6 times higher than the rainfed yield for small, medium and large farmers. During 2009-14, Returns declined from 3.0 to 1.5 times for small farmers, from 4.4 to 1.4 for medium farmers and from 3.6 to 1.2 for large farmers.

From 1975-79 to 2009-14, the rainfed area's yield increased at a higher rate for all land groups, while irrigated area's yield also increased for all land groups, it did not increase as much as the rainfed area's yield. This is the reason for the decline in returns to irrigation. Unlike in Jowar's case, the absolute yield of the irrigated area increased for cotton from 1975-79 to 2009-14.

Figures 4.4 and 4.5 show us how returns to irrigation (of quantity per acre) have declined over time for both jowar and cotton crops.

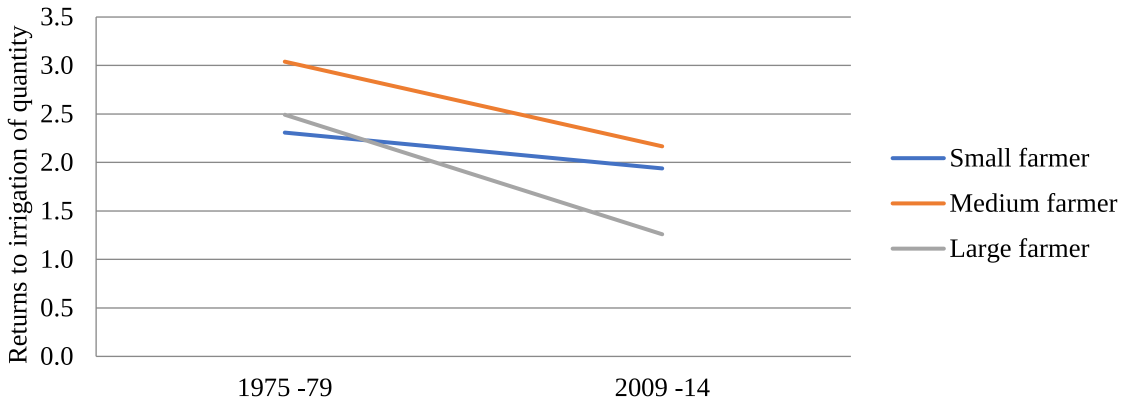
Table 4.7: Quantity per acre of cotton by land groups

(In parenthesis - no of plots cultivated)

Land class	**Year**	**Rainfed (1)**	**Irrigated (2)**	**Returns to irrigation (2/1)**
Small	**1975-79**	94.3 (95)	280 (1)	3.0
	2009-14	442.1(88)	681.7 (21)	1.5
Medium	**1975-79**	105.9 (146)	468.1(5)	4.4
	2009-14	507.1 (222)	698.8 (45)	1.4
Large	**1975-79**	106.4 (302)	382.8 (6)	3.6
	2009-14	523.9 (245)	624.4 (91)	1.2

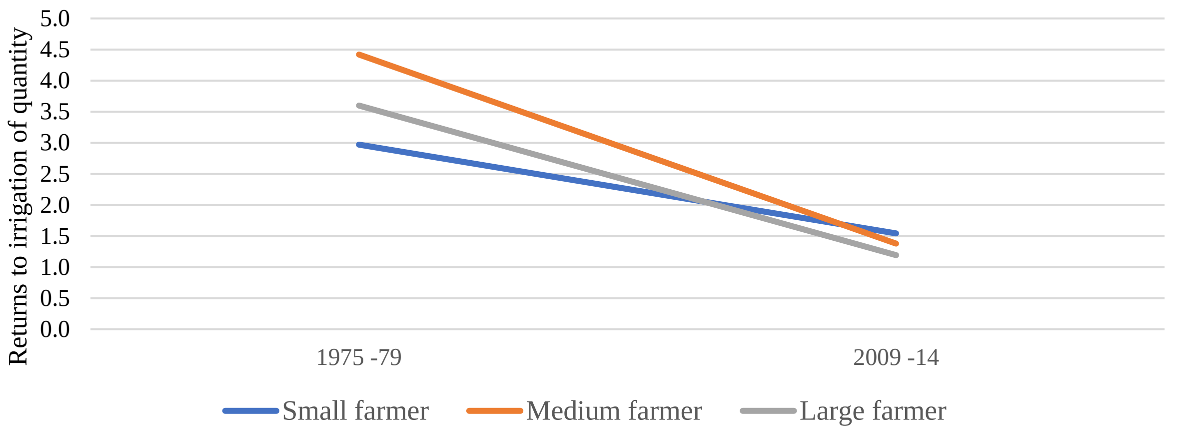
Source: Author’s calculations using VDSA data

Figure 4.4 :Returns to irrigation (quantity per acre) of Jowar for different land classes



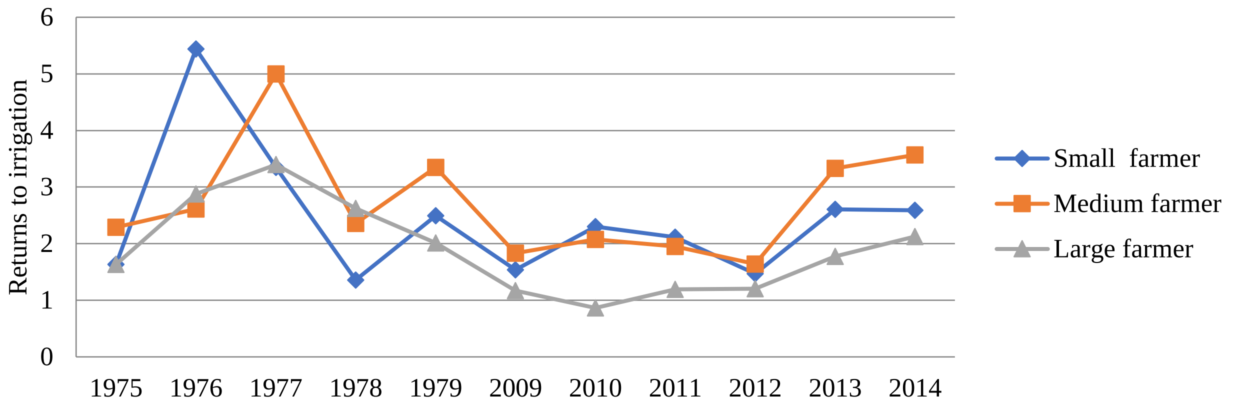
Source: Author's calculations using VDSA data

Figure 4.5 :Returns to irrigation (quantity per acre) of cotton for different land classes



Source: Author's calculations using VDSA data

Figure 4.6 :Year wise returns to irrigation (quantity per acre) of Jowar for different land classes



Source: Author's calculations using VDSA data

The figure shows year-wise returns to irrigation of quantity per acre of Jowar. Though returns to irrigation fluctuate over the years, we could see a declining trend from 1975 to 2014 across all the land classes.

4.5) Variation of profits in irrigated and unirrigated conditions

The coefficient of variation is used to understand the variation between irrigated and rainfed households. For-profits, net returns (A1+FL) of households are used. The analysis was done at the household level. Variation is looked for the period for 1975-79 & 2009-14. How has the variation in net returns of rainfed, irrigated and mixed households during 1975-79, and how has it changed during 2009-14.

The analysis is done at all village level. Since there may not be adequate households who have consistently cultivated through irrigation or rainfed in every village, analysis is done only at all village level.

Table 4.8: Average of coefficient of variation

(In parenthesis - no of households cultivated)

Years	Rainfed	Irrigated	Mixed
1975-79	90.42457	193.47	77.024
	(80)	(46)	(49)
2009-14	253.1	33.94	89.91
	(33)	(129)	(133)

Source: Author's calculations using VDSA data

Table 4.8 shows the average of coefficient of variation. During 1975-79, the average COV for rainfed households was 90.4, for irrigated households, it was 193.4, and for mixed households, it was 77. There is high variation in irrigated households than in rainfed households.This is contrary to the understanding and needs to studied further.

During 2009-14, average COV in rainfed households was 253.1; it was 33.94 for irrigated households and 89.91 for mixed households.

From 1975 to 2014, the variation in net returns for rainfed households increased significantly, from 90.4 to 253.1. The variation among irrigated households declined from 193.4 to 33.9 during 1975-79 to 2009-14. Variation among mixed households has increased a little from 77 to 89.9.

4.6) Conclusion:

The main findings from this chapter are

Similar to chapter 3 results, the returns to irrigation, i.e. the number of times irrigated net returns are higher than rainfed areas net returns have been declining across all land classes from 1975 to 2014.

The decline is much more pronounced among large farmers. Small farmers' returns from irrigation are higher than other than land groups during 1975-79 &2009-14; however, there have been considerable fluctuations in their returns.

Gross returns and costs of rainfed areas increased at a higher rate for all the land-holding groups; more importantly, rainfed areas gross returns and costs increased much more for large farmers than small farmers. The decline in returns to irrigation might be due to an increase in gross returns and costs of rainfed agriculture. This is true for all land-holding groups and especially for large farmers

As seen in chapter 3, The increase in gross returns and costs for rainfed areas might be due to changes in the contribution of different inputs. This is true for all land-holding groups. During 1975-79, in rainfed agriculture, labour and seed costs would make up to 87% to 91% of total cost (87% for medium and 91% for small and large farmers). During 2009-14, there was a significant increase in inputs costs such as fertilisers, machinery and seed costs in rainfed agriculture; this change is evident across all the land groups. Although the pattern is the same across all the land groups, large farmers have a slightly higher share of other inputs such as fertiliser, machinery and pesticides when compared to others.

Among all land classes, in irrigated agriculture, the contribution of different inputs like fertilisers, pesticides and seeds was significant from 1975-79. Even during 2009-14, there have been only slight changes among land holding groups, but overall, there have been no significant differences in how land classes spend on different costs.

Coming to productivity, only two crops, jowar and cotton, were used for the analysis. The results show that returns to irrigation have declined during the study period across all land groups. In the case of jowar, the absolute yield of irrigated jowar has declined during 2009-14 across all land groups, and the returns to irrigation declined much more for large farmers than small and medium farmers.

Regarding the variation in profits in irrigated and unirrigated conditions, results show that during 1975-79, variation in irrigated households was higher than variation in rainfed households; this is contrary to the understanding and needed to be studied further. During 2009-14, there was a considerable increase in variation of rainfed households and variation in irrigated households decreased a lot during the same time.

Appendix

Table -A.2.0: Farm size classification based on operational holdings (ha) in different study villages of India's SAT				
		Farm size class (Land holding code)		
Village	Village code	Small (1)	Medium (2)	Large (3)
Aurepalle	A	0.20-2.50	2.51-5.26	>5.26
Dokur	B	0.20-1.01	1.02-3.04	>3.04
Shirapur	C	0.20-2.50	2.51-5.87	>5.87
Kalman	D	0.20-6.07	6.08-10.77	>10.77
Kanzara	E	0.20-2.26	2.27-5.59	>5.59
Kinkheda	F	0.20-3.00	3.01-5.60	>5.60

Source: VDSA Manual,1985.

Table A.2.1: Main source of irrigation in Aurepalle		
Year	Main source of irrigation	percentage of Irrigated area
1975-1979	Well with electric motor	94%
2009-2014	Borewell	72%
	Open well	16%

Source: Author’s calculations using VDSA data

Table A.2.2: Main source of irrigation in Dokur		
Year	Main source of irrigation	percentage of Irrigated area
1975-1979	Tank	38%
	Well with oil engine	37%
	Well with electric motor	24%
2009-2014	Borewell	67%
	Tank/pond	20%

Source: Author’s calculations using VDSA data

Table: A.2.3 Main source of irrigation in Shirapur		
Year	Main source of irrigation	percentage of Irrigated area
1975-1979	Well with electric motor	70%
	Well with oil engine	30%
2009-2014	Open well	64%
	Borewell	18%
	River	13%

Source: Author’s calculations using VDSA data

Table A.2.4: Main source of Irrigation in Kalman		
Year	Main source of irrigation	percentage of Irrigated area
1975-1979	Well with electric motor	52%
	Well with oil engine	24%
	Well, with traditional device	24%
2009-2014	Open well	97%

Source: Author's calculations using VDSA data

Table: A.2.5: Main source of Irrigation in Kanzara		
Year	Main source of irrigation	percentage of Irrigated area
1975-1979	Well with the electric motor	100%
2009-2014	Open well	56%
	Canal	32%

Source: Author's calculations using VDSA data

Table - A.2.6: Main source of Irrigation in Kinkheda		
Year	Main source of irrigation	percentage of Irrigated area
1975-1979	Well with electric motor	100%
2009-2014	Canal	78%
	Open well	21%

Source: Author's calculations using VDSA data

Table A.3.1: Average net returns per acre (A2 +FL)			
			[In parenthesis - cultivated area]
year	**Rainfed (1)**	**Irrigated (2)**	**Returns to irrigation (2/1)**
1975-79	125.9 (10580)	683.2 (1696)	5.4
2009-14	508.1 (6205)	1439.2 (5915)	2.8

Source: Author's calculations using VDSA data

Table A.3.2: Average cost (A2 +FL) per acre			
year	**Rainfed (1)**	**Irrigated (2)**	**No of times than rainfed Cost (2/1)**
1975-79	145.8	838.6	5.8
2009-14	834.0	1535.3	1.8

Source: Author's calculations using VDSA data

Table A.3.3: Average Net Returns Per Acre (A2+FL) [village level]				
Village		**Rainfed (1)**	**Irrigated (2)**	**Returns to Irrigation (2/1)**
Aurepalle	**1975-79**	115.5	511.6	4.4
	2009-14	358.5	621.6	1.7
Dokur	**1975-79**	31.9	577.1	18.1
	2009-14	-35.9	1061.5	30.3
Shirapur	**1975-79**	106.9	1465.5	13.7
	2009-14	224.8	2721.9	12.1
Kalman	**1975-79**	90.9	519.4	5.7
	2009-14	143.6	744.2	5.2
Kanzara	**1975-79**	179.5	485.8	2.7
	2009-14	987.1	1314.2	1.3
Kinkheda	**1975-79**	175.7	278.1	1.6
	2009-14	448.8	566.5	1.3

Source: Author's calculations using VDSA data

Table A.3.4 : Quantity per acre of cotton				
Year	crop	Rainfed	Irrigated	returns to irri
1975	Cotton	106.3	76.9	0.7
1976	Cotton	112.5	514.5	4.6
1977	Cotton	113.4	479.2	4.2
1978	Cotton	82.9	382.3	4.6
1979	Cotton	112.8	449.6	4.0
2009	Cotton	304.1	329.0	1.1
2010	Cotton	627.9	678.9	1.1
2011	Cotton	317.6	801.3	2.5
2012	Cotton	715.4	751.9	1.1
2013	Cotton	736.1	611.3	0.8
2014	Cotton	240.2	729.9	3.0

Source: Author's calculations using VDSA data

Table A.3.5 : Quantity per acre of Jowar				
Year	crop	Rainfed	Irrigated	returns to irri
1975	Jowar	119.3	209.6	1.8
1976	Jowar	152.8	458.7	3.0
1977	Jowar	128.3	516.5	4.0
1978	Jowar	138.1	328.4	2.4
1979	Jowar	130.1	317.6	2.4
2009	Jowar	214.9	346.6	1.6
2010	Jowar	164.2	264.4	1.6
2011	Jowar	169.6	283.2	1.7
2012	Jowar	182.6	277.7	1.5
2013	Jowar	148.4	388.2	2.6
2014	Jowar	137.3	385.5	2.8

Source: Author’s calculations using VDSA data

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