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Research Article

COMPARATIVE ECONOMICS OF PADDY UNDER IRRIGATED AND RAINFED CULTIVATION IN TAMIL NADU

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Abstract: Most of the increase in agricultural output over the years has taken place under irrigated conditions. As bringing more area under irrigated cultivation is constrained by availability of cultivable land and investment, it is the need of the hour for policy makers to plan in such a way that improved production for meeting future food grain demand should come from rainfed cultivation. The present study was aimed to estimate the resource use efficiency and technical efficiency of the irrigated and rainfed farms cultivating paddy. The efficiency ratio of human labour, fertilizers Nitrogen, Phosphorus and Potash was more than one as all these inputs were underutilized and for seed it was less than one which indicated that the resources were over utilized. The study indicated that both irrigated and rainfed farms were technically efficient. There will be opportunity for increasing the yield or income of the farms only by using the resources optimally and going for location specific technologies and varieties.

Keywords: Irrigated Farms, Rainfed Farms, Paddy, Resource Use Efficiency, Technical Efficiency

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Introduction

Most of the increase in agricultural output over the years has taken place under irrigated conditions in India. As bringing more area under irrigated cultivation is constrained by availability of cultivable land and investment, it is the need of the hour for policy makers to plan in such a way that improved production for meeting future food grain demand should come from rainfed cultivation. Since the scope to bring additional land under cultivation is limited, significant increase in agricultural production is possible only by raising productivity of different crops and livestock enterprises per unit of land, labour and capital. India ranks first among the countries that practice rainfed agriculture both in terms of extent and value of production. Out of an estimated 140.30 m ha net cultivated area, 76.66 m ha (57 percent) was rainfed, contributing 44 percent of the total food grain production [1]. It was estimated that even after achieving the full irrigation potential; nearly 50 percent of the net cultivated area would remain dependent on rainfall. Rainfed agriculture supports nearly 40 percent of India's estimated population of 1210 million in 2011. Cultivation of coarse cereals (91 percent), pulses (91 percent), oilseeds (80 percent) and cotton (65 percent) predominated rainfed regions [2]. In the rainfed areas, farmers' dependence on livestock, besides arable farming, as an alternative source of income is high. It is estimated that nearly two out of three heads of cattle population in India thrive in rainfed regions. In the case of agricultural sector, Tamil Nadu is one of the waters starved States in India; it is endowed with only three percent of water resources in India. Of the total gross cropped area of 51.40 lakh ha, the gross area irrigated was 29.91 lakh ha (56 percent) and the rest 26.43 lakh hectares (44 percent) was under rainfed cultivation [1]. Rice accounts for about a third of total gross cropped area and nearly 60 percent of irrigated area in Tamil Nadu (over 90 percent of paddy is irrigated). Pulses (18 percent of total cropped area), millets (11 percent) and groundnuts (10 percent) require less water than rice or sugarcane and millets and pulses are grown almost exclusively on un-irrigated land. The Government also supplies external inputs to rainfed farming tracts through programmes and policy instruments that incentivize the adoption of production boosting technologies. But rainfed agriculture is diverse and subject to variable intensity and frequency of rainfall, meaning there is little scope for the adoption of uniform technologies. And the increasing costs of inputs and rapidly worsening incremental capital output ratios mean rainfed farming communities can ill afford these unsuitable technologies even if supplied with price support or subsidies. Far more important for rainfed farming are location specific knowledge, agronomic principles and choice of practices, time dependent decisions and the flow of skills and knowledge into the farming system to ensure effective production. Yet farmer 'practice' is the least acknowledged area; the domination of development policy, knowledge and technology (all designed for irrigated farming) over local farming systems and practices typifies the general approach to rainfed agriculture in India and represents another barrier to helping this system reach its potential. Sivagangai district is one among the tank irrigated districts, where farming practiced under rainfed condition. Several steps are taken by the State government to manipulate the irrigation scenario in the district. An attempt is made in the present study to analyze and compare both irrigated and rainfed farming in terms of economics of cultivation, resource use efficiency and technical efficiency of the farms and to describe the factors responsible for technical inefficiency of the farming economy of the district.

Materials and Methods

Among the rainfed districts of Tamil Nadu, Sivagangai district was purposively selected for the study as out of 109328 ha, of gross cropped area, irrigated area was 43.74 percent and rainfed area was 56.25 percent. The district has 12 blocks, out of which two blocks, Manamadurai and Ilayangudi blocks were purposively selected by considering the cropped area under rainfed and irrigated conditions and with discussions and suggestions from agricultural officers of the district. Primary data were collected from the randomly chosen rainfed and irrigated farmers from the two blocks separately through personal interview. The sampling design followed was three stage random sampling. Manamadurai and Ilayankudi blocks were selected in the first stage as both rainfed and irrigated crops were cultivated which would be used for comparative study.

In the second stage, two villages were selected in each block based on the area under irrigated and rainfed crops. From Manamadurai block, two villages namely Arimandapam and Idaikattur for irrigated and rainfed, respectively were selected. From Ilayangudi block, two villages namely Saalaigramam and Katchathanallur were selected for rainfed and irrigated respectively. 30 irrigated farms and 30 rainfed farms were randomly selected from each block in the third stage. The total sample size was 120 farms. Primary data on socio-economic conditions of the sample farmers like age, education, size of family, family expenditure, number of dependents, size of operational holdings, irrigation sources, cropping pattern, inputs used, yield of different crops, price of output, income, cost of cultivation, crop loans disbursed and the resource availability in the farms were collected.

Simple average, percentage analyses were employed to study the socio economic variables such as age, education, size of family, number of dependents, consumption pattern and farm oriented variables such as size of operation holding, irrigation sources, cropping pattern, inputs used, cost of cultivation, yield of different crops, price of outputs, farm income, crop loan disbursed and the resource availability in the farm.

Crop Diversification Index

For measuring the extent of crop diversification, the Crop Diversification Index (CDI) was followed. It is obtained by subtracting the Herfindahl index (HI) from one and has a direct relationship with diversification such that its zero value indicates specialization and a movement towards one shows an increase in the extent of crop diversification [3].

The CDI index is calculated as follows:

$$Crop\ Diversification\ Index\ (CDI) = 1 - \sum_{1=1}^{n} P_i^2 = 1 - HI$$

$$Herfindahl\ Index\ (HI) = \sum_{1=1}^{n} P_i^2 = 1$$

$$P_i = \frac{A_i}{\sum_{1=1}^{n} A_i}$$

where,

Pi = proportion of i[th] crop

Ai = area under i[th] crop

$\sum_{1=1}^{n} A_i$ = Total cropped area

i = 1, 2, 3... n (number of crops)

Cobb Douglas Production Function

Cobb Douglas production function was attempted to measure the resource use efficiency in the production of crops. In the study area 65,967 ha was under paddy and hence resource use efficiency for paddy was worked out. The Cobb Douglas production function model specified is furnished below.

Ln(y) = Ln α0 + α1 Ln(x1) + α2 Ln(x2) + α3 Ln(x3) + α4 Ln(x4) +α5 Ln(x5) + α6 Ln(x6) + ui

where,

y = Yield of crop (in qtls / ha)

x1 = Seed (in kg /ha)

x2 = Labor(in man days /ha)

x3 = Nitrogen (in kg/ha)

x4 = Phosphorus (in kg / ha)

x5 = Potash (in kg/ha)

x6 = Quantity of water used (in m3 /ha)

α0 = Regression constant

α1, α2, , α3 , α4 , α5 , α6, are coefficients

u = error term

The Quantity of Water used (m3/ha) for irrigation was measured using the following formula.

Q.W = A * D.I * N.I

where,

Q.W = Quantity of Water used (m^3 / ha)

A = Actual Area (m^2)

D.I = Depth of Irrigation (m)

N.I = Number of Irrigation

In Cobb Douglas function which is a log linear form, the parameters associated with different independent variables would represent the elasticity of production and thus the marginal product should be worked out as a first order partial differential coefficient of yield with respect to each input. The estimated coefficients of significant independent variables are used to compute the marginal value products (MVP) and the resources-use efficiency (r) is worked out [4].

r = MVP/MFC

where,

r = Efficiency ratio

$$MVP_i = \beta_i \frac{\bar{Y}}{\bar{X_i}} P_y$$

MFC = Marginal factor cost

MVPi = Marginal value product of the i[th] input,

$\bar{Y}$ = Geometric mean of the value of output,

$\bar{X_i}$ = Geometric mean of the i[th] input,

βi = Estimated co-efficient (or) elasticity of the i[th] input

Py = Price of output.

The marginal product thus worked out represent the change in yield of the crop resulting from unit change in ith input, keeping all other inputs at constant level. When r < 1, the resources are over utilized and reducing the use of those resource will increase the profit. When r >1, the resources are underutilized, increasing the quantity of those resources will increase the output and hence the profit. When r = 1 it indicates efficient utilization of the resources.

Stochastic Frontier Production Model

Maximum efficiency is attained when it becomes impossible to reshuffle a given resource combination without decreasing the total output. Farrel proposed that the efficiency of a firm consists of two components, namely technical and allocative efficiency components. According to Farrel, technical efficiency is the ability to produce a given level of output with a minimum quantity of inputs under a given technology. It indicates the gains that can be obtained by improving resource management. The production frontier can be viewed as a firm's locus of maximum outputs from various sets of input combination. In this regard, it is possible that a firm, within its scale of operation, is not close to the frontier. On the other hand, there may be firms whose outputs are close to the frontier, given their levels of inputs. A measure of how close a firm is to the maximum output level as defined by the frontier, given its inputs level, is the measure of its technical efficiency. In order to measure the technical efficiency of farm households parametric technique is used. There are two common approaches in the literature for estimating technical efficiency. One approach is based on non-parametric, non-stochastic, linear programming (Data Envelopment Analysis). However, this suffers from the criticism that it takes no account of the possible influence of measurement error and other noise in the data [5]. The second approach uses econometrics to estimate a stochastic frontier function and to estimate the inefficiency component of the error term. The disadvantage of this approach is that it imposes an explicit and possibly restrictive functional form on the technology. However, this approach is chosen here because it considers both random shocks and inefficiencies that is the focus of this paper. The stochastic frontier model is an improvement to the deterministic model since it introduces 'v' into the deterministic model to form a composite error term model (stochastic frontier). The error term in the stochastic model is assumed to have two additive components namely: a symmetric component which represents the effect of statistical noise (such as weather, topography, measurement error and so on). The Influences which are not captured by the function indicating the technical inefficiency is represented by the other error component. The $U_i$in the equation captures the level of farm-specific technical inefficiency and $V_i$is the statistical disturbance term. The Vi's are random variables which are assumed to be iid (Independent and Identically distributed) N (0, δV^2) and independent of the U_i's which are non-negative random variables assumed to account for technical inefficiency in production and are often assumed to be iid N (0, δu^2).

The estimated value of technical efficiency for each observation is then calculated as follows:

$$TE_i = exp(-U_i)$$

While the unobservable value of V_{it} is obtained from its conditional expectation given the observable value of (V_i-U_i) in equation [6]. It is thus clear that if U_i does not exist or Ui= δ_o^2 = 0, the stochastic frontier production function reduces to a traditional production function. In that case, the observed units are equally efficient and residual output is solely explained by unsystematic influences. The distributional parameters Ui and δu^2 are hence inefficiency indicators, the former indicating the average level of technical inefficiency and the latter representing the dispersion of the inefficiency level across observational farms [7].

The firm specific economic efficiency (EE) is defined as the ratio of minimum observed total production cost (C*) to actual total production cost C which is defined as follows:

$$EE_{it} = E[exp(-U_{it})/E_{it}]$$

Here EE takes values between 0 and 1.

Hence a measure of firm specific allocation efficiency (AE) is thus obtained from technical and economic efficiencies estimated as:

AE=EE/TE

This means that 0 ≤ AE ≤ 1.

Thus given functional and distributional assumptions, the values of unknown coefficients in the equation (*i.e.*, βs, δu^2 and δv^2) are obtained using the maximum Likelihood Method (ML). It is further assumed that the average level of technical efficiency, predicted as TE_i is a function of socio-economic and institutional factors. In this study the factors influencing technical efficiency was estimated from regression analysis.

The stochastic frontier production function estimated for both irrigated and rainfed regions in the study is given below

ln(Y) = α0 + α1 ln(X1) + α2 ln(X2) + α3 ln(X3) + α4 ln(X4) + α5 ln(X5) + α6 ln(X6) + Vi – Ui

where,

Y = Yield of crop (in qtls / ha).

X1 = Seed (in kg /ha)

X2 = Labor (in man days /ha)

X3 = Nitrogen (in kg/ha)

X4 = Phosphorus (in kg / ha)

X5 = Potash (in kg/ha)

X6 = Quantity of water used (in m3 /ha)

V_i = random variability in the production that cannot be influenced by the farmer.

U_i = deviation from maximum potential output attributable to technically inefficiency

Results and Discussion

The data collected during the survey were tabulated and analysed using the statistical tools mentioned in materials and methods. The results are discussed under the sections namely general characteristics of the sample farms, cropping pattern & crop diversification, cost of cultivation, resource use pattern, resource use efficiency and technical efficiency.

General Characteristics of the sample farms

Size of land holding, sources of income and sources of credit are discussed in this section. The size of land holding of sample farmers is furnished in [Table-1].

Table-1 *Size of Land Holdings*

S	Size of land holdings (ha)	No. of respondents		Average land holding per farm(ha)	
		Irrigated	Rainfed	Irrigated	Rainfed
1	0.1 - 1 ha	49 (81.67)	54 (90.00)	0.28	0.38
2	1.1 - 2 ha	7 (11.67)	4 (6.67)	1.02	1.53
3	>2 ha	4 (6.66)	2 (3.33)	3.12	2.82
	Total	60 (100.00)	60 (100.00)	1.47	1.58

(Figures in parentheses indicate percentage to total)

The sample farms were post stratified into three categories namely farms with 0.1 to 1 ha, 1.1 to 2 ha and more than 2 ha of land per farm. Farms with less than 1 ha of land were the major holdings in both irrigated and rainfed farms. About 82 percent of irrigated farmers had a land holding of less than one ha and it was 90 percent for the rainfed farmers. About 12 percent and 6.67 percent of the farmers had land between one to two ha among the irrigated and rainfed farms, respectively. About 6.67 percent of irrigated farmers had a land holding of more than two ha and it was 3.33 percent in case of rainfed farmers. It could be seen from the above table that the average size of the irrigated farm was 1.47 ha; while it was 1.58 ha for rainfed farms. Sixty farmers were practicing rainfed and remaining 60 farms irrigated agriculture. The rainfed farmers were dependent on rainfall for raising crops whereas majority (70 percent) of the irrigated farmers were dependent on wells for irrigation. Among the sources of irrigation wells contributed about 70 percent of the total samples taken followed by tank irrigation with about 30 percent.

Source of Income of the Farm Households

The various sources of income of the sample households per year are tabulated below.

Table-2 *Source of Income of the Farm Households*

Particulars	Irrigated (Rs./farm/year)	Rainfed (Rs./farm/year)
Income from Agriculture (Rs.)	48695.00 (13.76)	35418.00 (10.19)
Income from Livestock (Rs.)	245275.20 (69.34)	271026.00 (78.00)
Non-farm Income (Rs.)	59790.00 (16.90)	40984.00 (11.81)
Total	353760.20 (100.00)	347428.00 (100.00)

(Figures in parentheses indicate percentage to total)

From [Table-2], it could be inferred that the income from livestock was more in rainfed farms compared to irrigated farms and the non-farm income was more in irrigated farms compared to rainfed farms. Income from crop production contributed about 13 percent and 10 percent to the total farm income of irrigated and rainfed farms, respectively. Income from livestock contributed about 69 percent and 78 percent to the total income of irrigated and rainfed farms, respectively. The income from livestock was more than the agriculture and this was due to severe drought in past three years and monsoon failure. The total farm income of the irrigated farm was Rs. 353760.20 per farm per year and it was Rs.347428 per farm per year in case of rainfed farms.

Credit Availability

The financial position of farms would have a bearing on the farm level investment decisions. The scope for further investment on farm assets and permanent improvements largely depend upon the financial position of farms. The sources of credit availability are presented in [Table-3].

Table-3 *Source of Borrowing by the Sample Respondents*

S	Source of credit	No. of respondents	
		Irrigated	Rainfed
1	Friends and relatives	23 (42.59)	29 (48.33)
2	Money lenders	07 (12.96)	10 (16.66)
3	Commercial banks	19 (35.18)	13 (21.67)
4	Co-operatives	5 (9.24)	8 (13.34)
5	No. of farmers availed credit	54 (90.00)	60 (100.00)
	Total no. of farmers	60 (100.00)	60 (100.00)

(Figures in parentheses indicate percentage to total)

It could be seen from [Table-3]. that among the sample farmers 90 percent of the irrigated farmers and all the rainfed farmers had availed credit from one source or the other. About 43 percent of irrigated farmers and 48 percent of the rainfed farmers utilized the credit extended by friends and relatives. About 35 percent irrigated farmers and 22 percent rainfed farmers availed credit from commercial banks. Cooperative credit was availed by nine percent of the irrigated farmers and 13 percent of the rainfed farmers. About 13 percent of the irrigated farmers and 17 percent of the rainfed farmers availed credit from the money lenders.

Cropping Pattern and Crop Diversification

Cropping pattern is the proportion of area under various crops at a point of time as it changes over space and time. The cropping pattern of the study area was that paddy and cotton were cultivated under both irrigated and rainfed conditions; pulses and sugarcane were cultivated only under irrigated conditions. Paddy was the major crop cultivated both under irrigated and rainfed condition.

This was followed by cotton. The cropping pattern found during the study period is given below in [Table-4].

Table-4 *Cropping Pattern of the Sample Farms*

Crops	Irrigated		Rainfed	
	Area (ha)	% to GCA	Area (ha)	% to GCA
Paddy	50.63	81.48	60.53	85.99
Cotton	3.93	6.32	10.55	14.81
Sugarcane	6.94	11.20		
Gross Cropped Area	61.50	100.00	71.08	100.00

Cropping Intensity

Cropping intensity is conceptualized as the percentage of gross cultivated area to the net sown area of the selected farms in an agricultural year. The details of cropping intensity are presented in [Table-5].

Table-5 *Cropping Intensity of the Sample Farms*

Particulars	Details	
	Irrigated	Rainfed
Gross Cropped Area(ha)	61.50	71.08
Net Cropped Area (ha)	42.66	64.20
Cropping Intensity (%)	144	110

The cropping intensity of irrigated farm was 144 percent. It was 110 percent in case of rainfed farms.

Table-6 *Cost of Cultivation of Paddy*

S	Particulars	Value (Rs / ha)	
		Irrigated	Rainfed
1	Labour	10850.45(34.00)	8956.12(38.45)
2	Machine power	3120.62(9.77)	3774.60(16.20)
3	Seed	1612.37(5.05)	1324.00(5.68)
4	Manure and fertilizers	6745.83(21.14)	5257.43(22.57)
5	Plant protection chemicals	2746.28(8.60)	1568.50(6.73)
6	Irrigation charges	5210.15(16.32)	1951.18(8.37)
7	Interest on working capital	1623.45(5.12)	956.72(4.10)
	Total Variable Cost	31909.20(74.00)	23788.60(73.00)
8	Depreciation on fixed capital	660.12(6.00)	436.11(5.21)
9	Land revenue	60.00(0.54)	60.00(0.71)
10	Interest on fixed capital	280.15(2.54)	244.84(2.92)
11	Rental value of owned land	6285(57.13)	4640(55.52)
12	Managerial cost	3714.35(33.79)	2975.95(35.64)
	Total Fixed Cost	11000.10(26.00)	8356.90(27.00)
	Total cost	42909.20(100.00)	32145.45(100.00)

(Figures in parentheses indicate percentage to total)

Crop Diversification Index

For measuring the extent of crop diversification, the Crop Diversification Index (CDI) was used. It is obtained by subtracting the Herfindahl index (HI) from one and has a direct relationship with diversification such that its zero value indicates specialization and a movement towards one shows an increase in the extent of crop diversification. Crop diversification index values moved towards one i.e. the index in case of irrigated farms was 0.98 and rainfed farm was 0.23. This showed that there existed a pattern of crop diversification in irrigated farms. As the rainfed farmers were cultivating only one crop, their crop diversification is very limited. This was also evidenced from the cropping intensity value also. The irrigated farms were having more choice of crops for cultivation because of that their cropping intensity and crop diversification was more when compared to the rainfed farms.

Cost of Cultivation of Paddy

To understand the economics of paddy cultivation, cost and returns of the crop was estimated. Cost concepts given by Directorate of Economics and Statistics, Government of India were used to study cost and returns of the sample farmers. The cost of cultivation of paddy had been worked out for irrigated and rainfed paddy separately, as this would help us to understand the differences among the two categories. The cost of cultivation is presented in [Table-6]. The seed cost was arrived by multiplying the quantity of seeds used by the sample farmer and the farmer purchase price. In our study, the average seed cost for irrigated crop was Rs.1612.37 and Rs.1324 for rainfed.

Table-7 *Paddy Costs and Returns*

Details		Irrigated	Rainfed
Yield (Qtl/ha)		38.45	27.38
Price (Rs/Qtl)		1100	1100
Gross return (Rs/ha)	Main product	42295	30118
	By product	6400	5300
	Total	48695	35418
Gross cost (Rs/ha)		42909.20	32145.45
Net return (Rs/ha)		5785.80	3272.55
B:C Ratio		1.13	1.10

It could be inferred that the seed cost for rainfed paddy was less than the irrigated paddy. The labour cost for rainfed paddy was more than the irrigated and it accounts for about 34 percent of the total variable cost in case of irrigated region and 38.45 percent of the total variable cost in case of rainfed region. The machine power for irrigated paddy charge was about Rs.3120.62 and for rainfed it was Rs.3744.60. The amount spent on manures and fertilizers in irrigated condition was more than the amount spent on rainfed paddy. It contributed about 21.14 percent and 22.57 percent of the total variable cost for irrigated and rainfed paddy, respectively. In case of plant protection chemicals, Rs.2746.28 and Rs.1568.50 was spent on irrigated and rainfed paddy cultivation, respectively. In irrigated paddy, irrigation cost included labour cost for irrigating the field at the prevailing market wage rate and the electricity charges paid by the sample farmers. Irrigation charges for paddy under irrigated condition were Rs.5210.15 which contributes 16.32 percent of the total variable cost. Interest on working capital means that in the cultivation process inputs were not used at a time but at different points of time according to the requirement of the crop hence the interest rate calculated on the working capital was reduced to half the crop period. The crop duration of paddy was for about three months so interest rate for working capital was calculated only for three months. In this study, the interest on working capital was Rs.1623.45 and Rs.956.72 in irrigated and rainfed farms, respectively. It could be observed from the table that the total variable cost, total fixed cost and total cost were high for irrigated crop than the rainfed crop. For irrigated crop, the total variable cost was Rs.31909.20 per ha and Rs.23788.60 for rainfed crop. The total fixed cost was Rs. 11000.10per ha for irrigated paddy and Rs.8356.90 for rainfed paddy. Obviously, the total cost which is the sum of total fixed cost and total variable cost was Rs.42909.20 for irrigated crop and Rs.32145.45 for rainfed paddy. The gross return from cultivation was Rs.48695 and Rs.35418 for irrigated and rainfed farms, respectively. The net return was Rs.5785.80 for irrigated farm and Rs.3272.55 for rainfed farm. The B:C ratio for irrigated and rainfed farms were 1.13 and 1.10 respectively.

Resource Use Pattern

The resources used such as seed in kg per ha, labor measured in standardized man days equivalent of eight hours per ha, Nitrogen, Phosphorus and Potash fertilizer measured in kg per ha, irrigation measured in m3/ha of water used per ha and yield measured in kg per ha, for paddy in the sample farms were computed and presented in [Table-8]. The utilization of different inputs by the sample farmers and recommended level inputs is presented in [Table-8]. It could be revealed from the table that human labour used per ha was 92 man days for irrigated region and 76 man days in rainfed region. The difference in the use of human labour in irrigated and rainfed region was mainly due to the different crop production techniques adopted in these regions. The seed rate in irrigated farm was 27.32kg per ha in the irrigated region and for rainfed it was 25.84kg. The level of plant nutrients applied through fertilizers were 136.42kg, 68.45kg, 57.15 of Nitrogen, Phosphorus and Potash, respectively in the irrigated region and 111.28kg, 62.16kg, 52.76kg of Nitrogen, Phosphorus and Potash respectively, was used in case of rainfed farms. The application of fertilizers, such a costly input, is associated with the availability of moisture in the soil. The use of fertilizers coupled with irrigation responds well in boosting the production. Because of this reason, the consumption of fertilizers was more in irrigated farm. When comparing the recommended level of inputs, irrigated farms were using more of N and P than the recommended level. Farmers were underutilizing other inputs namely seeds, Potash and water requirement. This would be one of the reasons for low level of yield.

Rainfed farmers were utilizing all the inputs below the recommended level due to deficit rainfall.

Table-8 *Resource Use Pattern of Paddy Production*

S	Variables	Standard requirement	Irrigated	Rainfed
1	Seed in Kg/ha	60	27.32	25.84
2	Labour in Man days/ha	80	92	76
3	Machine hours in Hrs/ha	7.50	4.50	3.70
4	Nitrogen in Kg/ha	120	136.42	111.28
5	Phosphorus in Kg/ha	40	68.45	62.16
6	Potash in Kg/ha	40	57.15	52.76
7	Irrigation in m^3/ha	52	25.51	5.6
8	Yield in Kg/ha	4750	3845	2738

Resource Use Efficiency in Paddy Production

An understanding of the average output response to the change in inputs is useful to understand the resource use efficiency of different inputs used in crop production. Cobb Douglas production function was employed to compute the production elasticity of different inputs. The input variables included for the Cobb Douglas production function models were seed in kg per ha, labor measured in standardized man days equivalent of eight hours per ha, Nitrogen, Phosphorus and Potash fertilizer measured in Kg per ha, irrigation measured in m3/ ha of water used per ha for irrigated and rainfed crop. The descriptive statistics of the variables taken for the study is presented in [Table-9].

Table-9 *Descriptive Statistics of the Variables*

Variables	Descriptive Statistics							
	Irrigated				Rainfed			
	Mean	Min	Max	SD	Mean	Min	Max	SD
Seeds	27.32	25	43.47	3.08	25.84	24	52	10.43
Human labour	92	38	120	10.02	76	31	95	8.48
Nitrogen	136.42	91	180	13.33	111.28	101	159	15.48
Phosphorus	68.45	51	80	8.36	62.16	31	77	11.46
Potash	57.26	20	65	6.25	52.76	23	63	8.04
Water use	25.51	2.6	42	13.33	5.68	0.27	12.65	4.02
Yield	3845	1156	3964	119.01	2738	860	2914	143.76

From [Table-9], it could be inferred that variability was very less in case of seed, Potash and Phosphorus utilization in case of irrigated farms. In case of rainfed farms, variability was less in case of water and Potash. But the variability in yield was very high both in case of irrigated and rainfed farms. While comparing yield variability it was very high in rainfed farms compared to irrigated farms. The estimated Cobb Douglas production function for Paddy is furnished in [Table-10].

Table-10 *Resource Use Efficiency in Paddy Production*

S	Variables	Irrigated	Rainfed
1	Human labour (man-days)	0.2282***(0.0421)	0.2753***(0.0806)
2	Seed rate (Kg)	- 0.2553(0.0844)	-0.0461(0.0261)
3	Nitrogen (Kg)	0.1952***(0.0531)	0.8023***(0.1609)
4	Phosphorus (Kg)	0.2180***(0.0779)	0.1710**(0.0817)
5	Potassium (Kg)	0.0976**(0.0450)	0.2433***(0.0754)
6	Water use (m^3/ ha)	0.0218(0.0118)	-0.0461(0.0189)
7	Intercept	4.6774(0.4039)	0.2444(0.5771)
	R^2	0.79	0.84
	F	34.39	49.97

(Figures in parentheses indicate standard error of the variables)

(Note: **, *** indicates significance at 5 % and 1% level respectively)

The coefficient of multiple determination (R2) indicates the proportion of total variation in the dependent variable (*i.e.*, crop output) explained by the independent variables jointly. At the same time, the regression coefficients of individual resource variables are the production elasticities of respective resources in Cobb Douglas production function framework which indicate the percentage change in crop output associated with a percentage change in concerned input at its geometric mean level. On the whole, these results are of paramount importance as they provide readily the information relative to probable effects of resource use changes on crop output. The estimated parameters of the production function of the crop as a whole are presented in [Table-10]. for the sample farms in the irrigated and rainfed regions. The six resource variables included in the production function analysis had explained jointly 79.56 percent of the total variation in output at the overall level of irrigated region. In the irrigated region, the regression coefficients of all the resource variables except seed rate had turned out to be positive and significant at the overall level. The regression coefficient of human labour and fertilizers were highly significant at one percent level which indicated that output was highly responsive to the inputs in the irrigated region. The regression coefficient of water use was significant at five percent level. The significant and positive regression coefficient of the entire input variable except seed rate clearly indicate that human labour, fertilizers and water use of the crop exerted significant influence on output. The coefficient of variables such as human labour, Nitrogen, Phosphorus, Potash were positive and significant at one percent level with coefficients of 0.228, 0.195, 0.218 and 0.097, respectively, implying that one percent increase in the above said variables from the existing mean level would increase the yield of paddy by 22.80, 19.50, 21.80 and 9.70 respectively. The value of R^2 in the production function estimated at the overall level for the rainfed region indicated that the included variables had jointly explained 84.97 percent variation in the output. The regression coefficients of human labour, fertilizers Nitrogen and Potash were more positive and significant, whereas the fertilizer phosphorus was at five percent level of significance. The seed rate and water use in the rainfed region showed negative significance. The high significance of the variables proved to be important in explaining variation in the output, at the overall level, in the rainfed region. On the whole, the resource variables fertilizers, human labour had shown significant influence on the crop output in both the irrigated and rainfed regions.

Table- 11 *Marginal Value Product and Efficiency Ratio*

S	Variables	MVP		Efficiency (r)	
		Irrigated	Rainfed	Irrigated	Rainfed
1	Seeds (kg)	-16.64	-1.07	-3.37	-0.18
2	Labour (Man-days)	12.08	9.90	3.02	2.61
3	Nitrogen (kg)	3.25	7.66	1.95	2.55
4	Phosphorus (kg)	8.07	4.24	1.36	3.59
5	Potash (kg)	7.87	8.73	8.64	8.46
6	Irrigation (m^3/ ha)	2.45	11.28	9.64	-

The estimated production functions underlying the crop production activity enable us to proceed further for evaluation of the efficiency of prevalent factor proportions in agriculture in the region. The production function analysis had been generally used to determine economic efficiency of resource use which requires estimation of marginal value product of the resources. A resource or input is considered to be used most efficiently if its marginal value product just offsets its cost equality of marginal value product to factor cost, the basic condition that must be satisfied to optimal resource use. The marginal value products of the resources so obtained at the geometric mean level from the estimated production function of crop production of the sample farms in the irrigated and rainfed regions are presented in [Table-11]. The efficiency ratio is more than one for human labour, fertilizers Nitrogen, Phosphorus and Potash and water use in irrigated region. This means that a unit increase in each input would increase the value of output and hence the profits, meaning that all these inputs were underutilized. The efficiency ratio of seed rate is -3.37 which is less than one and indicates that the resources were over utilized and reducing the use of those resources would increase the profit. In case of rainfed region, the efficiency ratio is more than one for human labour, fertilizers Nitrogen, Phosphorus and Potash. This mean that a unit increase in each input would increase the value of output and hence the profits, meaning that all these inputs were underutilized. The efficiency ratio of seed rate is -0.18 which is less than one indicating over utilization of resources and reducing the use of those resources would increase the profit.

Technical Efficiency of the Sample Farms

The stochastic frontier production function was estimated using FRONTIER software version 4.1 and the results are furnished in [Table-12]. All the factor inputs involved in the stochastic frontier production function were statistically significant and had positive signs except seed rate. The negative sign of the input shows that the resource is being over utilized. The positive signs of the factors indicate that there are chances of increasing productivity by using these inputs. The technical efficiency of sample farmers is provided below in [Table-12].

Table-12 *Stochastic Frontier Function for Technical Efficiency*

Variable	Parameter	Coefficients	
		Irrigated	Rainfed
Constant	b0	0.4732**(0.3995)	0.2727(0.5166)
Seed rate (kg)	b1	-.2415***(0.0934)	-0.0396(0.0236)
Human labour (man-days)	b2	0.2351***(0.0366)	0.2995***(0.0722)
Water use (m^3/ ha)	b3	0.0275(0.0119)	-0.0360**(0.0181)
Nitrogen (kg)	b4	0.2428***(0.0780)	0.8254***(0.1450)
Phosphorus (kg)	b5	0.1151**(0.0945)	0.1779**(0.0810)
Potassium (kg)	b6	0.1299**(0.0392)	0.1876***(0.0834)
	σ^2	0.7644(0.0036)	0.0167(0.0059)
	γ	0.9045(0.1867)	0.7507(0.2072)
	Log likelihood	89.26	57.7
	Mean Technical Efficiency	0.93	0.91

(Figures in parentheses indicate standard error of the variables)
(Note: ***, ** indicates significance level at 1% and5%level respectively)

The study revealed that the generalized log likelihood function was 89.60 and 57.70 for irrigated and rainfed regions respectively. The log likelihood function implies that inefficiency exist in the data set. The log likelihood ratio value represents the value that maximizes the joint densities in the estimated model. Thus, the functional form of Cobb Douglas used in this estimation is an adequate representation of the data. The value of gamma (γ) is estimated to be 90.45 percent and 75.07 percent for irrigated and rainfed regions. This implies that 90 and 75 percent of the random variation in the yield of the farmers was due to the farmers' inefficiency in their respective sites and not as a result of random variability. Statistically significant σ^2 indicates a good fit and correctness of the specified distributional assumptions of the composite error terms while the gamma γ indicates the systematic influences that are unexplained by the production function and the dominant sources of random error. This means that the inefficiency effects make significant contribution to the technical inefficiencies of rice farmers. However, the estimated coefficients of human labour, Nitrogen, Phosphorus, Potash, water use were positive and significant at one percent, five percent level of probability and hence play a major role in rice production in the study area while the estimated coefficients of seed rate was negative in case of irrigated region. The average technical efficiency for the irrigated farmers was 0.93 and 0.91 in rainfed farms implying that, on an average, the respondents are able to obtain 93 and 91 percent of potential output from a given mixture of production inputs respectively. Thus, in a short run, there is minimal scope of increasing the efficiency by adopting the technology and techniques used by the most economically efficient farmer. The estimated coefficient of human labour was 0.235 and 0.299 in irrigated and rainfed farms which was positive and statistically significant at one percent level. The implication of the positive coefficient of human labour was that it contributes positively to technical efficiency in rice farming in the study area and a unit increase in labour will increase the output. This shows that labour is an important variable in rice farming in the study area.

The estimated coefficient for seed was -0.241 and -0.039 for irrigated and rainfed regions respectively which were negative and statistically not different from zero. The estimated coefficient of seed implies that increasing seed rate by one percent will decrease rice output by less than one percent which means, all things being equal the output is elastic to changes in the quantity of seed used. The significance of seed quantity is however, due to the fact that seed determines to a large extent the output obtained. If correct seed rates and quality seeds are not used, output will be low even if other inputs are in abundance. The estimated coefficient for quantity of Nitrogen was 0.242 and 0.825 in irrigated and rainfed regions respectively which was positive and statistically significant at one percent level. This implies that a one percent increase in fertilizer will increase rice output by 24.20 and 82.50 percent in irrigated and rainfed regions. The estimated coefficient for quantity of Phosphorus was 0.115 and 0.177 in irrigated and rainfed regions respectively which was positive and statistically significant at five percent level. This implies that a one percent increase in fertilizer will increase rice output by 11.50 and 17.70 percent in irrigated and rainfed regions. The estimated coefficient for quantity of Potash was 0.129 and 0.187 in irrigated and rainfed regions respectively which was positive and statistically significant at five percent level for irrigated farms and one percent significant for rainfed farms. This implies that a one percent increase in fertilizer will increase rice output by 12.9 and 18.7 percent in irrigated and rainfed regions. Fertilizer is a major land augmenting input because it improves the quality of land by rising yield per ha. The estimated coefficient for quantity of water use was 0.027 and -0.036 in irrigated and rainfed regions respectively which was positive for irrigated farms and negative for rainfed farms.

Frequency of Technical Efficiency of Irrigated and Rainfed Farmers

The frequency of technical efficiency of sample farmers is provided below in [Table-13].

Table-13 *Frequency of Technical Efficiency*

Efficiency range	Frequency	
	Irrigated	Rainfed
< 80	-	1(1.67)
80 - 85	2(3.33)	6(10.00)
85 - 90	12(20.00)	8(13.33
90 - 95	19(31.67)	29(48.33)
> 95	27(45.00)	16(26.67)
Total	60(100.00)	60(100.00)

(Figures in parentheses indicate percentage to total)

It could be evidenced from [Table-13]. that the technical efficiency of the irrigated farms was more than 80 percent and about 96 percent of the irrigated farms were having technical efficiency of more than 85 percent. About 98 percent of the rainfed farms had the technical efficiency of more than 80 percent. The frequency distribution of the estimated technical efficiency indices are presented in [Table-13]. The predicted technical efficiency indices varied from 0.83 to 0.98 in irrigated and 0.75 to 0.98 in rainfed regions with a mean of 0.93 and 0.91 in irrigated and rainfed regions respectively, which suggests significant technical inefficiency in crop production in the study area. This implies that the farmers can improve the output by almost seven and nine percent in irrigated and rainfed region respectively without additional resources through proper and more efficient use of the existing resources. By improving technical efficiency, sample farms would reduce their production costs and consequently increase gross margin. The socio-economic factors influencing technical efficiency of the farms taken for the study include gender of the household, age, education of the household, family size, farming experience and area under paddy. The regression estimates of the factors influencing technical efficiency of the farmers are given in [Table-14].

Table-14 *Factors Influencing Technical Efficiency*

Variables	Coefficient	
	Irrigated	Rainfed
Constant	0.0019 (0.5634)	2.2348(3.5742)
Gender (male-1, female-0)	0.16835(1.2053)	1.3519(1.2406)
Age (years)	0.0537(0.1190)	0.1920**(0.0892)
Education (no. of schooling years)	0.2256**(0.1304)	0.2817(0.2058)
Family size (no.)	0.0554(0.0573)	-0.6982(0.6982)
Farming Experience (years)	0.0005(0.0054)	0.1828**(0.0686)
Area under paddy (ha)	0.6701***(0.2201)	0.1336**(0.0749)
Log-likelihood	41.32	58.01

(Figures in parentheses indicate standard error of the variables)
(Note: ***, ** indicate significance at 1% and 5% level respectively)

From [Table-14], it could be inferred that the farmers with more years of formal schooling were more efficient than their counterparts in irrigated farms. In general, more educated farmers are able to perceive, interpret and respond to new information and adopt improved technologies such as fertilizers, pesticides and planting materials much faster than their counterparts. The literacy level had positively influenced the technical efficiency of the irrigated farmers. Area under paddy also showed a positive and highly significant relationship with technical efficiency in irrigated farms and five percent significance on rainfed farms. The value of the estimated coefficient of the operational area is positive and significant, which indicated that farmers with large area under paddy were more efficient in producing rice. Area under paddy had bearing on the capacity of farmers to adopt improved technologies and new farm practices. Farming experience and age was found to be a significant factor in rainfed farms.

This was possibly due to the fact that the farmers learn from their previous mistakes during the cultivation of rice and rectify them in the ensuing seasons. The farmers become more cautious in decision making in the operation and management of their farm. With respect to gender however, this study found no statistically significant relationship. This was possibly because these variables did not directly influence the efficiency but rather indirectly through decisions on variable input use levels.

Conclusion

Paddy was the major crop cultivated both in irrigated and rainfed conditions whereas pulses, cotton and sugarcane were cultivated in irrigated farms. Only few farmers were cultivating cotton under rainfed condition. This has resulted in the more diversification in irrigated farms than the rainfed farms and the cropping intensity was also more in irrigated farms. When the cost and returns of paddy cultivation was compared, the net return from irrigated and rainfed, there was not much difference between these two category of farms. Though the irrigated farms were using the inputs more than the recommended levels, the yield when compared with the State yield it was very less. Both irrigated and rainfed farms were technically efficient and there was no significant difference in their efficiency. This indicated that the farmers are efficiently using the available resources. There will be opportunity for increasing the yield or income of the farms only by using the resources optimally and going for location specific technologies and varieties both for irrigated and rainfed farms. Though the irrigated farms were using the inputs more than the recommended levels, the yield when compared with the State yield it was very less. Therefore the reasons for the yield gap should be analyzed and policy measures to bridge those gaps are an immediate need in irrigated farms. Crop diversification index is very less in rainfed farms because of limited choices of crops for rainfed cultivation. Suitable choice of crops, varieties and technologies are the need of the hour for improving rainfed productivity. Creating awareness on already available rainfed technologies, choice of crops - pulses and millets which require less water than paddy can be cultivated. Various schemes and subsidies for cultivation of pulses and minor millets are available but awareness among the farmers is the urgent need for the rainfed farmers for improving rainfed agriculture thereby increasing the income and productivity from agriculture. Though they are aware, farmers hesitate for a change of crop. So training programmes providing awareness about the schemes and subsidies available should be given to the farmers through proper extension agency contact. There was no water harvesting structures at farm level both in irrigated farms and rainfed farms. Investments are required in local institutions for water management. Farmer organizations, small-scale credit schemes, private banking partnerships and other institutional arrangements need to go hand in hand with policy advances. Microcredit schemes for water resources management investments are especially important. Rainfed farmers generally cannot afford the large initial investments required even for small-scale water resources management systems, despite high benefit to cost ratio and the positive impact on long-term risk reduction. Improved water resources management needs to be supported by investments in infrastructure, transport, markets, communication and roads.

Application of Research: Study useful to the cultivators to improve their resource use and efficiency with the available resources. Also, helpful to create awareness among farmers to adopt recommended technologies and inputs to maximize their returns.

Research Category: Production Economics

Abbreviations: MVP – Marginal Value Product, MFC- Marginal Factor Cost & GCA- Gross Cropped Area

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