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Resource use pattern and efficiency under different irrigation sources in Balasore district of Odisha

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Abstract

The resource use pattern and efficiency were studied in the Balasore district of Odisha under different sources of irrigation. The major sources of irrigation identified in the area were shallow tube-well, lift irrigation and river irrigation. The major crops cultivated in the area during different seasons are paddy, groundnut and pulses. The district of Balasore was selected purposively due to its irrigation potential status and distinct phases of changes in irrigation scenarios. A total of 93 respondents were selected for the study adequately representing different farmers under different sources of irrigation by proportionate random sampling method. The primary data was collected by interview method using a well-structured questionnaire. The secondary data was collected from appropriate sources. The Cobb-Douglas production function was used to study the efficiency of resource use and estimation of the production function. The results depicted how efficiently the resources are used and the relationship of output explained by the given set of explanatory variables.

Keywords

Resource use efficiency; irrigation; Cobb-Douglas Production; paddy; pulses; groundnut

Introduction

Irrigation in India encompasses a network of major and minor canals from Indian rivers, groundwater-based systems, tanks and other rainwater harvesting projects for agricultural activities and according to the World Bank collection of development indicators, agricultural irrigated land in India was reported at 36.79 % in 2013 (1). As per the report of the Economic Survey, 2017-18, even today, agriculture in India is subjected to the peculiarities of weather. The report suggested that 52 % (or 73.2 million ha area out of 141.4 million ha net sown area) of farm fields is still non-irrigated and dependent on rainfall. The net irrigated area to the total cropped area for India is lower at 34.5 % (2).

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) was launched on 1st July 2015 under the motto of "*Har Khet Ko Paani*", which is a comprehensive irrigation scheme launched by integrating the existing irrigation schemes (3). It is a national mission to improve farm productivity and ensure better utilization of the resources in the country having the objective to increase the cultivable area under assured irrigation, improve on-farm water use efficiency to reduce wastage of water, increase the adoption of precision irrigation and other water-saving techniques (More Crop per Drop), promote sustainable conservation practices etc. (4).

Odisha has a total geographical area of 155.71 lakh ha, of which the total cultivated area is about 61.80 lakh ha which comprises 39.69 % of the total geographical area of the state. Out of the total geographical area of the State, 49.90 lakh ha can be brought under irrigation coverage through various irrigation projects. The cropping intensity for the period 2013-14 was 16.7 %. Rice is the major crop that requires more water, grown in the *Kharif* season as are pulses and oilseeds in the *Rabi* season and Odisha has an extensive network of surface water resources and vast groundwater reserves. The estimated water resources of Odisha state are one of the highest in the country, which is 11 % of the country's total surface water resources. The total irrigation potential created in Odisha as of 2016-17 is estimated to be 55.91 lakh ha. The irrigation potential of Odisha is at full development and is estimated to be as much as 37.84 lakh ha in *Kharif* (June-December) and 18.07 lakh ha in *Rabi* (Jan-May) seasons. The irrigated area of Odisha is estimated to be 35.53 lakh ha which is 65 % of the irrigation potential created and 43.4 % of the Gross Command Area (GCA). As water is a critical input in agriculture, judicious use of irrigation water plays an important role in fertilizer application, control of weeds and getting required growth and yield as well as the livelihood of farmers. The low level of net returns and yield attained by the tail-end farmers in the MID-controlled tank region are due to the disparity in economic and physical water use efficiencies (5). Cutting-edge irrigation techniques' adoption for crop production and multiple water uses with the inclusion of fisheries, dairy operations and other farming enterprises has the potential to further improve productivity and water usage efficiency (6). Again, the agro-power subsidy has a visible impact on different socioeconomic strata of rural agrarian communities (7). Many rural families have no idea about the provisions for which rural youth need to be motivated and trained and made aware of the opportunities for their livelihood (8).

The total geographical area of Balasore is 377400 ha and the total cultivated area is 250550 ha (66 % of geographical area). Here, rice is the principal crop and is cultivated in an area of around 220830 ha. The net irrigated area during *Kharif* is 106620 ha and during *Rabi*, it is around 83200 ha. The total irrigation potential created is estimated to be 301.1 thousand ha. Irrigation potential created for the district in *Kharif* is estimated to be 180.75 thousand ha and for *Rabi*, it is estimated to be 120.35 thousand ha. The district has good irrigation potential and ranks first in the irrigation potential created from the use of groundwater. Three out of twelve blocks of the district have flow irrigation. There are 2 Medium Irrigation Projects in the district. There is a total of 1209 LI Projects with a command area of 21604 ha in the district. Focusing on the irrigation potential of the district, this study was conducted to check the resource use pattern and the efficiency under different sources for different crops which may further enable the policymakers and extension personnel to mobilise the farmers for their sustainable livelihood. Here, the potential of the sources was analysed and accordingly, the best source of irrigation for respective crops can be suggested.

Materials and Methods

The study was conducted to realize the existing water potential and total water demand of the district, Baliapal block had been selected for the above study purposively after interacting with the officers of the block office and discussing with the farmers as it was identified that there are 3 dominant sources of irrigation in the block namely shallow, lift and river. One gram panchayat (GP) was selected randomly and adjacent 3 GPs were selected as a cluster. The different sources of irrigation were listed under the villages of the GP. There were 3 types of irrigation in the area namely shallow tube-well, lift irrigation and river irrigation. The villages having the highest concentration of the sources were identified. Three villages having the highest sources of irrigation were selected namely Srirampur, Nepura and Nikhira. In Srirampur village, shallow tube-well was the dominant source of irrigation, in Nepura, Lift irrigation was the primary source and in Nikhira, river irrigation using motor or pump sets from the river Subarnarekha were the presiding sources. The major crops cultivated in the area were identified. *Ex-post facto* was employed for the formulation of the research design in this study. Regression analysis was followed for the analysis of the collected data.

The resource use efficiency of the crops was calculated using the Cobb-Douglas production function. The independent variables, taken for the study were land, human labour, machine labour, fertilizers and seeds whereas the dependent variable taken was yield. The major crops in the area, used for the study were mainly paddy, pulses and groundnut. This study through the coefficient of determination shows the percentage of variation in yield explained by the given set of explanatory variables used.

Selection of household and sample size

After proportionate random sampling, a total of 93 respondents were selected for the purpose of the study (Table 1). The selected farmers were interviewed personally using a structured schedule. The best effort was made to elicit accurate information from the sample farmers. Local leaders were also used to contact the farmers. This was helpful in boosting the confidence of the respondents.

Table 1. Selection of household and sample size.

Village	Numbers of household	Sample size
Srirampur	240	48
Nepura	75	15
Nikhira	150	30
Total	465	93

The study was based on Primary data and secondary data on cropping patterns, yield and inputs used for various crops. The data collected were used for analysis.

Cobb-Douglas Production Function

Cobb-Douglas production function was used to study the resource-use efficiencies. This function was fitted to the farm-level data. Cobb-Douglas is widely used to represent the technological relationship between the amounts of two or more inputs and the amount of output that can be produced by those inputs. The Cobb-Douglas form was developed by Charles Cobb and Paul Douglas during 1927-1947. The Cobb-Douglas production function is represented as:

$$Y = a\, X_1^{b1}, X_2^{b2}, X_3^{b3}, X4^{\,b4}, X_5^{b5}\, e_u$$

In logarithmic form, it assumed a log-linear equation as under:

$$\text{Log}\,(Y) = \beta 0 + \beta 1\ \text{Log}\,(X1) + \beta 2\ \text{Log}\,(X2) + \beta 3\ \text{Log}\,(X3) + \beta 4\ \text{Log}\,(X4) + \beta 5\ \text{Log}\,(X5) + u$$

Where, Y = yield of crops (in kg), X_1 = Land (farm size in ha), X_2= Labour (man-days), X_3 = quantity of fertilizer (in kg), X_4 = Machine labour (h/ha), X_5 = quantity of seed (in kg), a = Constant/intercept term, u = Random variable, e = 2.718, b1 to b5 represented production elasticities of respective inputs.

The coefficient of multiple determination (R^2) was also worked out to test the goodness of fit of the model. Subsequently, the Marginal Value Product was calculated to analyse the resource use efficiency.

Results

Costs and Returns from Crops

Table 2 represents the income and returns from different crops per hectare. The average data was taken for all the farmers to the gross returns, cost of cultivation and net returns.

Table 2. Costs and returns from crops.

Crops	Gross income (per ha) (Rs.)	Cost of cultivation (per ha) (Rs.)	Net income (per ha) (Rs.)
Paddy	77700	25000	52700
Pulses	69600	9500	60100
Groundnut	172500	36000	136500

ha: hactare, **Rs.**: Rupees.

Estimated values of coefficients of the crops

The coefficient of determination of the crops is represented in Table 3. The R^2 value and the regression coefficients of the independent variables were calculated. For paddy, the regression coefficient was 0.73 which means that 73 % of the variation in yield was due to the variations in the given independent variables. The independent variables taken for the study were area, human labour, machine labour, fertilizers and seed. The regression coefficient for pulses was 0.82 which indicates that 82 % of the variation in yield was due to the given independent variables. The regression coefficient of groundnut was 0.62 which shows that 62 % of the variation in yield is due to the independent variables. The sum of the elasticity coefficients shows the returns to scale. While the paddy and groundnut show decreasing returns to scale, pulses indicate increasing returns to scale.

Table 3. Estimated values of coefficients of the crops.

Crop	Area	Human labour	Machine labour	N	P	K	Micronutri-ents	Seed	R^2
Paddy	0.54^c	0.15^d	0.03^d	-0.08	0.02^d	0.32^c	-0.41	0.29^c	0.73
Pulses	1.28^c	-0.34	0	-0.01	0.03^d	0	0.59^c	0.13^d	0.82
Groundnut	-0.9	-0.42	0	-0.04	0	0.53^c	0.10^d	0.51^c	0.62

^{c} Significant at 1 % level, ^{d} Significant at 5 % level.S

Resource use efficiency of crops

Resource use efficiency of paddy

We found the marginal value product (MVP) of the inputs of area, human labour, phosphorus, potassium and seed (Table 4) which were greater than one and positive indicating that farmers can increase the yield by using more of these inputs per ha of land. The MVPs whose values were less than one indicated no significant profit in utilising these inputs to increase the yield.

Table 4. Resource use efficiency of paddy.

Variables	Regression coefficients	Standard error	MVP
Constant	1.376	0.068	
Area	0.54^c	0.045	2.80
Human labour	0.15^d	0.032	1.70
Machine labour	0.03^d	0.016	0.84
N	-0.08	0.019	0.95
P	0.03^d	0.033	1.20
K	0	0.028	1.09
Micronutrients	-0.41	0.044	0.79
Seed	0.29^c	0.026	2.50

^{c} Significant at 1 % level, ^{d} Significant at 5 % level.

Resource use efficiency of pulses

We found the MVP of the inputs of area, phosphorus, micronutrients and seed were greater than one and positive (Table 5) indicating that farmers can increase the yield of pulses by using more of these inputs per ha of land. The MVPs whose values were less than one indicated, there is no significant profit in utilising these inputs to increase the yield.

Resource use efficiency of groundnut

We found the MVP of the inputs of potassium, micronutrients and seeds are greater than one and positive (Table 6) indicating that farmers can increase the yield of groundnut by using more of these inputs per ha of land. The MVPs whose values were less than one indicated, there is no significant profit in utilising these inputs to increase the

Table 5. Resource use efficiency of pulses.

Variables	Regression coefficients	Standard error	MVP
Constant	1.576	0.063	
Area	1.28[c]	0.054	2.34
Human labour	-0.34	0.037	0.65
Machine labour	0.00	0.000	0.00
N	-0.01	0.027	0.74
P	0.02[d]	0.034	1.35
K	0.32[c]	0.034	2.03
Micronutrients	0.59[c]	0.049	1.05
Seed	0.13[d]	0.033	2.32

[c] Significant at 1 % level, [d] Significant at 5 % level.

Table 6. Resource use efficiency of groundnut.

Variables	Regression coefficients	Standard error	MVP
Constant	1.768	0.055	
Area	-0.9	0.042	0.49
Human labour	-0.42	0.056	0.56
Machine labour	0.00	0.000	0.00
N	-0.04	0.015	0.62
P	0.00	0.000	0.0
K	0.53[c]	0.067	2.17
Micronutrients	0.10[d]	0.038	1.19
Seed	0.51[d]	0.078	1.78

[c] Significant at 1 % level, [d] Significant at 5 % level.

yield.

Discussion

The R^2 value of paddy, pulses and groundnut suggests that the yield of the crops is significantly affected by the independent variables that we have accounted for in the analysis namely, land, labour, machine labour, the quantity of fertilizer used, amount of seed (9, 10). Therefore, policy implications and other interventions should be directed towards these factors of production to increase the yield of respective crops which in turn can increase the income of the farmers. The marginal value product of various crops determines the important inputs which when varied change the yield of the crops (11, 12). The yield of the crops increases or decreases in proportion to the change in the inputs. This in turn provides a clear picture of the use of these inputs by the farmers. Further, the policymakers can also take note of this to make changes in the policies towards this direction.

Conclusion

Yield was majorly affected by land, human labour, machine labour, fertilizers and seeds. The MVP shows the resource-use efficiency and increase in the production of crops with a per unit increase of the variables. Further, the economic and technical efficiency of the inputs for different crops can also be made as an extension to the study of resource use efficiency in crops.

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Authors' contributions

AN conceptualized the study, conducted the data collection and analysed it. DSR designed the study and drafted the manuscript. Both authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The authors have no conflicts of interest to declare. Both co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report. We certify that the submission is original work and is not under review at any other publication.

Ethical issues: None.

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