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Productivity, profitability and resource use efficiency of paddy cultivation in Tribal Dominated districts of Assam

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Abstract

The study evaluates resource-use efficiency in paddy production across four tribal-dominated districts of Assam. Data from 400 paddy growers for the 2020-21 crop season were analyzed using farm budgeting and production function techniques, incorporating economic and resource use efficiency tests. A comparison of profitability between beneficiary and non-beneficiary tribal farmers showed that beneficiaries cultivating HYV Ranjit paddy achieved a Benefit-Cost Ratio (BCR) of 1.33, while non-beneficiaries growing local varieties had a BCR of 0.93. Productivity of paddy by beneficiary tribal farmers was higher than the non-beneficiary farmers with an incremental grain and straw yield of 15.97 q/ ha and 10.95 q/ha, respectively. However, resource utilization was inefficient in both beneficiary and non-beneficiary tribal farmers, indicating the need for better resource allocation. Optimizing input use can enhance revenue and improve efficiency in paddy cultivation. The findings highlight the importance of targeted interventions to maximize productivity and profitability in tribal farming communities.

Keywords: Paddy, Tribal agriculture, cobb-Douglas production function, resource-use efficiency, livelihood security

Introduction

Agriculture is vital to the Indian economy, particularly among the tribal population. Tribals comprises 8.6% of the total population and 11.3% of the rural population. In Assam, 23 tribal communities makeup 12.82% of the state's population. These tribes are a marginalized segment of the Indian population (Roy, 1989) [16], often placed at the lower end of indicators for living conditions and household assets (Chaube, 1999; Hanumantha and Grover, 1979) [5, 6]. Their livelihoods continue to depend heavily on agriculture, which remains underdeveloped due to factors like poor-quality seeds, conventional farming methods, inadequate harvest and post-harvest management, poor market intelligence, and an underdeveloped livestock sector (Anon, 2015; Swarnalatha Devi *et al.*, 2015; Lawania and Gupta, 2015; Sharma *et al.*, 2020; Medhi *et al.*, 2020; Patel *et al.*, 2023) [2, 21, 11, 17, 14, 15]. Despite these challenges, agriculture underpins food security and livelihoods in Assam's tribal areas. Tribes practice various occupations depending on the nature of available resources, especially land and human skills (Marchang, 2018) [13]. Studies have shown that providing extension services and training in modern agricultural practices can facilitate the adoption of innovations among tribal farmers, offering relative advantages and compatibility with their field conditions. Economic factors are often more critical than socio-cultural factors in the adoption of new technology on tribal farms (Singh *et al*, 2014) [18]. Intodia and Sharma (1993) [7] opined that there is a wide technological gap in knowledge of tribal fanners about improved farm practices. However, Mandavkar *et al.* (2011) [12] noted that while tribal farmers are aware of agricultural operations, they need detailed knowledge and training, particularly in fertilizer application, transplanting methods, plant protection measures, harvesting techniques, and intercultural operations to use those resources efficiently.

Allocative efficiency of resource use is essential for enhancing productivity and profitability in agriculture of tribals. The goal is to achieve high output with minimal effort or input, ensuring resources are used judiciously and cost-effectively. Effective planning and policies require knowledge of farm resource productivities to achieve the right input mix (Jirgi, 2002) [9]. The Committee on Doubling Farmers' Income (2018) identified resource use efficiency as a key growth area in agriculture, aiming to improve input delivery mechanisms and overall input efficiency. Given the significant tribal population, the country's progress is tied to tribal development. On the contrary, Singh *et al.* (2023) [19] found that non-tribal farm households are more efficient in seed, human labor, and machine use compared to tribal households.

The present study examines the impact of agricultural interventions, such as HYV seeds, better fertilizer use, and farmer training, on resource use efficiency in paddy farming in Assam's tribal areas. Implemented by Assam Agricultural University, these interventions aim to enhance productivity and sustainability. Tribal Sub Plan (TSP) interventions with relevant technologies improved crop productivity, yielding higher returns and cost benefits, ensuring wider technology adoption (Pallavi *et al* 2024) [24]. Given the limited research on this topic, field surveys, data analysis, and stakeholder interviews were conducted to assess their effectiveness. The findings will help policymakers, agricultural planners, and development agencies improve resource use efficiency, promote sustainable farming practices, and enhance livelihoods in tribal communities of Assam.

Materials and Methods

The present study was conducted from January to December 2021. The Assam Agricultural University in Jorhat, Assam, implemented the project "Promotion of Agriculture-Centric Sustainable Livelihood Security for Tribal Farmers of Assam" during 2013-14 in tribal-dominated districts of the state through Krishi Vigyan Kendras (KVKs) and Regional Agricultural Research Stations (RARS). Initially, data were collected from the headquarters to determine the number of extension activities conducted in each district under the project. Based on this information, four districts-Chirang, Kokrajhar, Karbi Anglong, and Dhemaji-where the highest number of extension activities had been conducted over the past three years were selected for the study. A total of 200 beneficiary tribal farmers from these four districts were selected using a proportionate random sampling technique. Additionally, using a matched sampling technique, 200 non-beneficiary tribal farmers from the same districts were selected to serve as a control group. Data were collected through personal interviews using a structured research schedule. The collected data were then pooled for final analysis and conclusions.

The production function analysis was employed to assess the resource-use efficiency of inputs utilized by tribal farmers. In this study, paddy was selected as the commonly demonstrated technology across all four districts. The Cobb-Douglas production function was used to estimate the effects of various inputs on paddy production. Independent variables such as human labor cost, seed cost, fertilizer cost, and plant protection cost were considered, as these factors likely impact crop production. All variables were expressed in monetary terms. The efficiency of resource allocation in the production was determined calculating the Marginal Value Product (MVP). The marginal physical product (MPP) was multiplied by the product price per unit to obtain the Marginal Value Product (MVP). The MVP was estimated by taking resources (Xi) as well as gross return (Y) at their geometric means. Since all the variables of the regression model were measured in monetary value, the slope co-efficient of those explanatory variables in the function represented the MVPs, which were calculated by multiplying the production co-efficient of given resources with the ratio of geometric mean (GM) of gross return to the GM of the given resources.

For profitability analysis Gross Margin (GM), Net Return (NR), Average Rate of Return (ARR) and Benefit - Cost Ratio (BCR) were analyzed. Productivity was measured by comparing the productivity of paddy between beneficiary and non-beneficiary respondents. Productivity was defined as the yield per unit of production, with Sali paddy selected for the study. The average productivity of the crop enterprise over the last three years, in terms of quintals per hectare, was considered. A 'Z' test was performed to assess the significance of differences in productivity between beneficiary and non-beneficiary respondents.

Results and Discussion

In the present study, the production function analysis was used to determine the relationship between the dependent and independent variables for paddy production comparing beneficiary farmers with non-beneficiary farmers in the study area. Again, profitability analysis was done to compare the beneficiary farmers with non-beneficiary farmer's production practices. Ahmed *et al.* (2021) [1] conducted one study to identify the factors affecting tribal farmers' decision on adopting agricultural technologies in Bangladesh. Profitability of different agricultural enterprises under most common farming systems was measured in terms of gross return, gross margin, net return and benefit cost ratio. Kumar *et al* (2023) [10] estimated the Cobb-Douglas production function to find out Resource use efficiency and used the farm budgeting technique for cost and return analysis.

Estimated regression coefficients of the explanatory variables of Cobb-Douglas model for paddy

From Table 1, it is seen that only two variables *viz.* tractor and fertilizer costs per hectare played a positive and significant role in producing HYV Ranjit paddy by the beneficiary group of respondents. Whereas tractor cost per hectare played the same role in case of local paddy production by the non-beneficiary group of respondents. Hence mechanization was the key variable and played a chief role in the cultivation of both local and HYV Ranjit paddy. Anthony *et al* (2024) [23] also found that availability of machinery significantly affects the paddy production. If the tractor cost increased by 1.00 percent, *ceteris paribus* the gross revenue of HYV Ranjit in case of beneficiary tribal farmers and local paddy in case of non-beneficiary tribal farmers would have increased by 1.066 percent and 1.225 percent, respectively. Likewise, variable fertilizer cost per hectare found to be positive and played a significant role in producing HYV Ranjit paddy grown by beneficiary farmers. If the fertilizer cost increased by 1.00 percent, *ceteris paribus* the gross revenue of HYV paddy would have increased by 0.096 percent in case of beneficiary tribal farmers. Whereas variable manure cost per hectare found to play negative and significant role in producing HYV paddy in case of beneficiary tribal farmers. If the manure cost increased by 1.00 percent, *ceteris paribus* the gross revenue of HYV Ranjit paddy would have decreased by 0.109 percent in case of beneficiary tribal farmers.

The values of adjusted R^2 for HYV Ranjit in case of beneficiary tribal farmers and local paddy by non-beneficiary tribal farmers were 0.991 and 0.974, respectively, which imply that 99.00 percent variations of gross revenue (dependent variable) were explained by the explanatory variables in case of HYV Ranjit paddy and approximately 97.40 percent variations of gross revenue (dependent variable) were created by independent variables of the local paddy in the study area (Table 1).

The values of Return to Scale (RTS) for HYV paddy in case of beneficiary tribal farmers and local paddy by non-beneficiary tribal farmers were 1.008 and 1.009, respectively. This indicated that farmers experienced increasing RTS, i.e., if inputs of paddy production for both HYV Ranjit and local paddy were increased then the gross return of the paddy cultivation would have increased at a faster rate (Table1).

Table 1: Estimated regression coefficients of the explanatory variables of Cobb-Douglas model for paddy

Variables	Non- Beneficiary(n=200)				Beneficiary(n=200)			
	coefficient	stan.error	t-value	sig.	coefficient	stan.error	t-value	sig.
(Constant)	0.129	0.418	0.309	0.758	0.828	0.248	3.337	0.001
Seed	0.005	0.023	0.206	0.837	0.006	0.012	0.448	0.655
Hunam labour	0.009	0.032	0.289	0.773	0.007	0.017	0.389	0.698
Bullock labour	-0.082	0.069	-1.187	0.237	-0.047	0.038	-1.231	0.220
Tractor	1.225*	0.116	10.552	0.000	1.066***	0.086	12.464	0.000
Fertilizer	0.019	0.020	0.988	0.324	0.096*	0.057	1.677	0.095
Manure	-0.143	0.098	-1.462	0.145	-0.109**	0.054	-2.006	0.046
plant protection	-0.024	0.021	-1.137	0.257	-0.011	0.012	-0.950	0.343
Return to scale ∑bi	1.009				1.008			
AdjustedR^2	0.974				0.991			
F	1076.392			0.000	3269.533			0.000

Profitability analysis for paddy

Estimated cost for paddy production

Table 2.1 shows the difference of cost of the production between beneficiary and non-beneficiary group of respondents growing HYV and local paddy, respectively.

The variable costs (93.69% in case of non-beneficiary and 63.72% in case of beneficiary) dominated the whole production. Tractor operating cost was the major cost with 37.51 percent and 37.66 percent of the total variable cost for HYV and local paddy, respectively. Another important cost was human labor occupying approximately 33.76 percent and 33.90 percent of the total variable cost for HYV and local, respectively (Table 2.1).

The total fixed cost consisted of land revenue and rental value of land during the production season that together added 6.31 percent and 6.70 percent to the total cost of production of both non-beneficiary and beneficiary tribal farmers, respectively (Table 2.1).

During the data collection period, the fixed cost, variable cost, and total cost per hectare incurred by the HYV paddy cultivation were Rs. 5362.50, Rs. 79,983.75 and Rs.85,346.25, respectively for beneficiary farmers. For non-beneficiary farmers the fixed cost, variable cost and total cost per hectare incurred by the paddy cultivation were found to be Rs. 5362.50, Rs. 79,657.50 and Rs. 85,020.00, respectively. The cost of cultivation of HYV and local were almost equal for both beneficiary and non-beneficiary tribal farmers in the study areas (Table 2.1).

Table 2: Estimated cost of cultivation for paddy

Particulars	Non- Beneficiary(n=200)	Beneficiary(n=200)
	Cost (Rs./ha) (% to total cost)	Cost (Rs./ha) (% to total cost)
Variety	**Local**	**HYV Ranjit**
A. Fixed cost		
a) Land revenue	112.50 (2.10)	112.50(2.10)
b) Rental value of land	5250.00(97.90)	5250.00 (97.90)
Total fixed cost (A)	5362.50 (6.31)	5362.50(6.70)
B. Variable cost		
a) Seed	3450.00 (4.33)	2092.50(2.62)
b) Hunam labour	27000.00 (33.90)	27000.00(33.76)
c) Bullock labour	9000.00(11.30)	9000.00(11.25)
d) Tractor	30000.00 (37.66)	30000.00(37.51)
e) Fertilizer	2940.00 (3.69)	4623.75(5.78)
f) Manure	487.50 (0.61)	487.50(0.61)
g) Plant protection	6780.00 (8.51)	6780.00 (8.48)
Total variable cost (B)	79657.50 (93.69)	79983.75(93.72)
Total Cost (A+B)	85020.00 (100.00)	85346.25 (100.00)

Estimated Returns from paddy

Table 2.2 shows the different components of return and profit of paddy cultivation per hectare. Return from the paddy cultivation was in terms of yield and by product (straw). By adding the values of grain yield and straw yield, the researcher obtained gross return of the paddy production. The gross return of HYV paddy grown by beneficiary tribal farmers was Rs. 106659.38/ha which was higher than that of local paddy grown by non-beneficiary tribal farmers (Rs.73743.75/ha) under the study.

The profitability analysis was done by computing Gross Margin (GM) and Net Return (NR) which were Rs. 26675.63/ ha and Rs. 21313.13/ha, respectively, for beneficiary tribal farmers compared to negative values for non-beneficiary tribal farmers growing local varieties (GM= Rs. -5913.75/ha and NR=Rs-11276.25/ha). Average Rate of Return(ARR) value for beneficiary group of respondents was found to be 31.25 which was also found to have negative value for non-beneficiary tribal group of respondents (ARR= - 6.90). It implied that the cultivation of HYV paddy by beneficiary tribal farmers was profitable than the local paddy production by non-beneficiary farmers in the study areas. The Benefit - Cost Ratio in variable cost basis was 1.33 for beneficiary farmers compared to 0.93 for non-beneficiary tribal farmers (Table 2.2).

Table 3: Estimated return from paddy

Particulars	Non- Beneficiary (n=200)	Beneficiary (n=200)
	Amount (Rs./ha) (% to total amount)	Amount (Rs./ha) (% to total amount)
Variety	**Local**	**HYV Ranjit**
Sale paddy	55893.75 (75.79)	77859.38 (73.00)
Sale of straw	17850.00 (24.21)	28800.00 (27.00)
Total gross income	73743.75 (100.00)	106659.38 (100)
Gross Margin	-5913.75	26675.63
Net Return	-11276.25	21313.13
Average Rate of Return (%)	- 6.90	31.25
Benefit - Cost Ratio (BCR)	0.93	1.33

In the present study, production function analysis was employed to examine the relationship between dependent and independent variables in paddy production, comparing beneficiary farmers with non-beneficiary farmers. Additionally, profitability analysis was conducted to evaluate differences in production practices and economic returns between these two groups. The findings revealed that mechanization, particularly tractor usage, played a crucial role in paddy cultivation for both beneficiary and non-beneficiary farmers. The regression analysis indicated that tractor and fertilizer costs significantly influenced the production of HYV Ranjit paddy among beneficiary farmers, whereas only tractor cost was a significant factor for non-beneficiary farmers cultivating local varieties.

Traditionally, tribal farmers grow paddy without the consideration of profit and for home consumption. The project provided interventions to increase the productivity leading to profit generation. The profitability analysis indicated that variable costs dominated total production costs, with tractor operation and human labor being the major cost components. While total costs for both groups were similar, gross returns were significantly higher for HYV Ranjit paddy (Rs. 106,659.38/ha) compared to local varieties (Rs. 73,743.75/ha). Beneficiary farmers experienced positive gross margins (Rs. 26,675.63/ha) and net returns (Rs. 21,313.13/ ha), whereas non-beneficiary farmers had negative values for both, implying unprofitable local paddy cultivation. The benefit-cost ratio further highlighted this disparity, with a value of 1.33 for beneficiary farmers compared to 0.93 for non-beneficiary farmers.

Resource-use efficiency of beneficiary and non-beneficiary respondents for paddy

The optimal utilization of resources or inputs was derived by the analysis of resource-use efficiency for paddy which is shown in Table 3. The results revealed that all the factors of production were not efficiently utilized by both the beneficiary and non-beneficiary group of respondents in paddy production. Since Marginal Factor Cost (MFC) was assumed to be 1, only Marginal Value Product (MVP) indicated the optimum utilization of inputs used in paddy production by both beneficiary and non-beneficiary tribal farmers under study. If MVP > 1, < 1 and = 1, then the resources were under, over and optimum utilized, respectively. It further reveals that in the study area, all of the factors of production were in-efficiently utilized.

The seed (beneficiary R = 0.009; non-beneficiary R =0.007), human labour (beneficiary R = 0.008; non-beneficiary R = 0.010), bullock power (beneficiary R = -0.060 ; non-beneficiary R = -0.103), fertilizer(beneficiary R =0.133 ; non-beneficiary R =0.028), manure(beneficiary R =-0.207; non-beneficiary R =-0.271) and plant protection (beneficiary R = -0.015 ; non-beneficiary R = -0.032) costs were over utilized as MVP < 1, in case of both beneficiary and non-beneficiary group of respondents. Hence, if both the group of respondents reduces the amount spent on these resources in their production process the profit will increase. Whereas tractor cost (beneficiary R = 1.197; non-beneficiary R = 1.337) was underutilized as MVP > 1 for HYV and local paddy production by both the group. This means that if tractor cost is increased, the output will alsoincrease, and efficiency or optimal utilization of resources will be attained.

Table 4: Resource-use efficiency of inputs used by beneficiary and non-beneficiary respondents for paddy

Variables	Non beneficiary (n=200)						Beneficiary(n=200)					
	coefficient	GM	MVP	MFC	*R*	Efficiency	coefficient	GM	MVP	MFC	*R*	Efficiency
Seed	0.005	7.527	0.007	1	0.007	Over utilized	0.006	7.412	0.009	1	0.009	Over utilized
Hunam labour	0.009	9.583	0.010	1	0.010	Over utilized	0.007	9.982	0.008	1	0.008	Over utilized
Bullock labour	-0.082	8.407	0.103	1	-0.103	Over utilized	-0.047	8.805	0.060	1	0.060	Over utilized
Tractor	1.225	9.730	1.337	1	1.337	Under utilized	1.066	10.127	1.197	1	1.197	Under utilized
Fertilizer	0.019	7.403	0.028	1	0.028	Over utilized	0.096	8.238	0.133	1	0.133	Over utilized
Manure	-0.143	5.596	0.271	1	-0.271	Over utilized	-0.109	5.996	0.207	1	0.207	Over utilized
Plant protection	-0.024	8.180	0.032	1	-0.032	Over utilized	-0.011	8.575	0.015	1	0.015	Over utilized
Output		10.625						11.367				

Comparing productivity between beneficiary and non-beneficiary respondents for paddy

In the present study, the productivity of paddy was measured comparing beneficiary with non-beneficiary tribal farmers in terms of production per unit. To test the significance of differences of mean score of productivity for both beneficiary and non-beneficiary farmers, a Z-test for two sample mean was done.

The findings presented in the Table 3. reveals that the productivity of paddy crop of beneficiary tribal farmers was higher than the non-beneficiary farmers after adopting scientific practices with an incremental grain yield of 15.97 quintals per hectare and straw yield of 10.95 q per hectare. The calculated 'Z' value for grain 55.42 and straw 27.43 were found to be significant at 0.05 level of probability.

Table 5: Comparing productivity of beneficiary and non-beneficiary respondents for enterprises

Productivity	Non-beneficiary (n=200)	Beneficiary (n=200)	Difference	Z value
Paddy (q/ha)	40.65	56.63	15.97	55.42**
Paddy Straw (q/ha)	17.85	28.8	10.95	27.43**

N.B: ***, ** and * are 1%, 5% and 10% level of significance, respectively

The high-yielding variety (HYV) Ranjit was found to produce more straw compared to local varieties along with incremental grain yield in the studied areas. This increased straw yield is primarily attributed to the plant's stature and tillering habit. HYV Ranjit exhibited greater tillering, which led to a higher straw yield than traditional varieties. "Research has shown that semi-tall and tall varieties generally produce more straw than dwarf varieties" (Jamir and Gohain, 2017) [8]. Whereas, Bapari (2016) [3] "analyzed the costs and benefits of both conventional and high-yielding rice cultivation, measuring returns in terms of yield and byproducts like straw. The study reported that both conventional and high-yielding rice varieties produced an equal amount of straw, about 240 kg per bigha".

Subramani *et al*. (2014) [20] also supported these findings, noting that "Ranjit, with a growth period of 155-160 days, recorded the highest grain yield-3,975 kg/ha at a research farm and 2,829 kg/ha at farmers' fields. Similarly, Ranjit produced a higher straw yield of 4,443 kg/ha at the research farm and 3,813 kg/ha at farmers' fields, surpassing traditional photosensitive varieties. HYV Ranjit demonstrated a higher energy ratio due to the greater output energy resulting from its higher grain and straw yields.

Resource-use efficiency analysis suggested inefficient utilization of production factors by both groups. Inputs such as seed, human labor, fertilizer, and manure were overutilized, indicating that reducing their usage could enhance profitability. Conversely, tractor costs were underutilized, implying that increasing mechanization could improve efficiency and output. Productivity comparison between beneficiary and non-beneficiary farmers confirmed a significant yield advantage for HYV Ranjit paddy, with an incremental grain yield of 15.97 quintals per hectare and straw yield of 10.95 quintals per hectare. The Z-test results confirmed statistically significant differences in productivity levels. The superior performance of HYV Ranjit was attributed to its enhanced tillering capacity and higher straw yield compared to traditional varieties, aligning with previous research findings.

Barla (2013) [4] evaluated the impact of new agricultural technology on tribal farming in Ranchi district of Jharkhand stated that one of the major problems of tribal regions in general and the study area in particular is low level of agricultural production and productivity. The study aimed at examining the impact of new agricultural technology on production, productivity and income. The results showed that the gross output obtained on account of the adoption of new agricultural technologies was estimated higher than the gross produce obtained without adoption of new agricultural technologies.

Productivity was considered as output per unit in case of paddy, while efficiency was operationalized as best possible output per unit by utilizing production inputs in right combination. Productivity was found higher and profitable in case of beneficiary tribal farmers adopting recommended practices after getting assistance from the project compared to non-beneficiary farmers following traditional practices. On the other hand, resources were utilized in-efficiently in case of paddy by both the beneficiary and non-beneficiary group of respondents. This might be due to the fact that even though the beneficiary farmers were getting profit from their production units, lack of farm budgeting and understanding of recommended doses of inputs, they did not get the potential output from inputs used. The finding is in line with Singh *et al* (2014) [18], Bapari (2016) [3] and Tasila Konja *et al*. (2019) [22] for paddy production. These studies stated that "all resources were economically misallocated in the production activities in the respective study areas. However, scientific farming was more profitable than conventional one in every case.

Overall, the study underscores the positive impact of project interventions on paddy production, profitability, and resource efficiency. The adoption of HYV Ranjit and increased mechanization have demonstrated significant economic benefits for beneficiary farmers, reinforcing the importance of continued support for modern agricultural practices in the region.

Conclusion

Paddy is a crucial crop for food and livelihood security in Assam's tribal areas. Efficient resource use is essential to enhance production and maximize returns. A comparison of profitability showed that beneficiary tribal farmers growing HYV paddy had higher production and productivity than non-beneficiary farmers cultivating traditional varieties. The study found that inputs like seeds, labor, bullock power, fertilizers, manure, and plant protection were overutilized, requiring cost reduction for optimal allocation. Meanwhile, tractor usage was underutilized in both groups and needed an increase for better efficiency. The findings highlight the need for wise resource utilization to maximize returns. To improve farm income, agencies promoting tribal agriculture must focus on providing technical knowledge, raising awareness, and encouraging good agricultural practices.

Strengthening these aspects will enhance resource efficiency, ensuring sustainable paddy farming and better livelihoods for tribal farmers in Assam.

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