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RICE PRODUCTION AND ITS DETERMINANTS IN BODOLAND TERRITORIAL REGION (BTR), ASSAM, INDIA

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ABSTRACT

Rice production is still the primary source of livelihood of the majority of the population of Bodoland Territorial Region (BTR). The study reveals the production of rice among different types of farmers in the study area. The study found that majority of farmers belong to marginal category but the small farmers have the higher share of total production of rice. Moreover, the Cobb Douglas production function method is used to understand the factors affecting the production in the region and also this study highlights the needs for sustainable agricultural practices to improve the production of rice. The study shows that the compound annual growth rate of area and production has been decreasing over the years but the extensive use of fertilizers has been increasing. This study also revealed the estimated value of the coefficient and related statistics of Cobb-Douglas Production function of rice production. Econometric analysis results revealed that the total area for cultivation and irrigated area contributed significantly to the production of rice in the region.

Keywords: Area, Production, CAGR, Irrigate Area, Fertilizers

1. INTRODUCTION

Rice (Oryza Sativa) contributes 689 kcal/capita/ day of the food supply in India (Pradhan et.al, 2023) and is considered that calorie intake from rice is highest compared to other food items. That is why it is considered one of the most staple foods of the country. The production of rice has been increasing over the period of time but the area for cultivation has been decreasing at a marginal rate (Daimary & Barman, 2023). Moreover, the diversification of rice production into HYV has a significant impact on its annual growth rate. The production of rice has a significant effect with the use of fertilizers. It is found that there is change in the production of rice in the area treated with fertilizers (Prasanna et. al 2009). However, excessive use of fertilizers caused the imbalance in the productivity (Jayanti, 2012). In the future, rice production must become more efficient and eco-friendly, utilizing less land, water, and labour while being resilient to climate change and producing fewer greenhouse gas emissions (Pathak et. al., 2018). In addition, inadequate soil moisture, low soil fertility, soil erosion, drought, flooding, flash floods, waterlogging, unpredictable monsoons, and ineffective fertilizer use pose significant challenges for rice cultivation (Bhattacharya, 2022). The increasing demand of rice can be achieved by horizontal expansion and by vertical expansion (Bandumula et. al., 2022). The scope of horizontal expansion of area used for cultivation is very limited whereas the vertical expansion of production can be increased using enhanced technologies. In Assam, rice stands as the most significant crop covering 2.35 million hectare of total area for rice cultivation. The recommended seed rate in Assam is 70-80 kg/ha. The use of fertilizer in Assam increased from 9.91 kg/ha in 1991 to 65.41 kg/ha in 2020-11 (Pegu and Hazarika, 2016). Lack of proper knowledge of fertilizers, lack of proper soil testing facility and lack of transportation facilities are the major constraints for farmers to increase its production (Lakra et. al., 2017). However, the Assam Statistical Handbook reported that in 2022, the fertilizer consumption in Assam was 61.63 kg/ha. In Assam, loamy soil is suitable for rice cultivation, with Joha being the main rice variety. The productivity of rice in Assam is significantly lower than the national average due to inadequate irrigation systems and recurring floods (Sharma and Sharma, 2015). According to Directorate of Economics and Statistics 2020, Assam produced 5213852 tonnes of rice which accounts for more than 90 per cent of total food grains produced in the state during 2019-2020.

The objectives of the study are (a) to examine the growth of rice production and (b) to estimate the elasticity of the rice production in Bodoland Territorial Region (BTR), Assam.

2. METHODOLOGY

The study was conducted in Bodoland Territorial Region (BTR), Assam which constitutes four districts Baksa, Chirang, Kokrajhar and Udalguri. The secondary data were collected from the Statistical Handbook of Assam (2018-2023). The analysis of growth in area and production were estimated using compound annual growth rate. The primary data were collected to analyse the elasticity of the output with respect to its input. A sample consists of 170 farmers from all the districts of BTR. The farmers were distributed into marginal, small and medium farmers according to the land holding size. However, no large farmers were found during the primary data collection. The required data were collected through the personal interview method by using structured questionnaire. The questionnaire were designed to collect the information about the area, production, fertilizers input, area under irrigated and non-irrigated and other miscellaneous determinants associated with farming.

Compound Annual Growth Rate (CAGR) calculates the average annual growth rate over a specific period of time. CAGR is used to estimate the growth analysis in area and productivity (Rani et. al., 2017). The CAGR is estimated using the following formula.

$$\text{CAGR}(\%) = (\text{Anti log } b-1) \times 100$$

Where, b is the regression coefficient.

Cobb-Douglas production function technique is used to analyse the relationship between the production of rice and other determinants (Lama, 2018). Using the concept of production function, the effort is made to examine the relationship of productivity of rice with inputs. The linear regression analysis with the following form of a model is used

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + U_i$$

Where

Y= Total production

X_1= Area under rice

X_2= Area under Irrigation

X_3= Fertilizers used

U_i = Disturbance term

β_0, β_1, β_2 and β_3 are the regression coefficients.

Cobb Douglas production function is used for this analysis

$$Y = \beta_0 . X_1^{\beta_1} . X_2^{\beta_2} . X_3^{\beta_3}$$

$$\log Y = \log \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + U_i$$

Where β_0 = intercept

β_1, β_2 and β_3 are regression coefficients.

Technology used in considered as constant. Moreover, the labours are not considered due to huge variations in the use of labour force.

3. RESULTS AND DISCUSSION

The rice cultivation in Bodoland Territorial Region mainly depends on the rain fed areas. But due to significant increase in flood prone areas in the region, the production of rice is increasing only at marginal rate since the last decade (Daimary & Barman, 2023).

Table 1 Area, production and productivity of rice in BTR

Year	Area (in hectare)	Production (in tonnes)	Productivity (kg/hectare)	Fertilizers used (kg/hectare)	Average Rainfall (in mm)	Area under Irrigation (in hectare)
2018-19	325457	692059	2126	5.01	203.91	102235
2019-20	320777	677212	2111	3.85	243.66	109770
2020-21	302287	647844	2143	5.21	331.43	137868
2021-22	291642	563620	1874	13.65	387.19	101994
2022-23	291175	721800	2536	113.13	464.29	87213
CAGR (%)	-3.13*	-0.98	2.36	111.70	23.48*	-3.84

Source: Statistical Handbook of Assam, Area=hectare, Production= in tonnes, Productivity= in kg/ hectare
indicates significant at 1 % level, 5% and 10% level respectively

Over the past five years, the area for sowing rice in the study area has seen a decline in compound annual growth rate of 3.13% due to the consistent challenge of recurring floods caused by unpredictable climate conditions. This condition is supported by increase in average rainfall at the rate of 23.48 per cent over the period of last five years. This has greatly impacted around 1 million hectares of paddy cultivation area in the state. Because of this recurring flood, winter paddy fields incur substantial losses and these negatively impact the food security to small and marginal farmers in the study area. Moreover, the production of rice declined by 0.98 per cent over the period of time. However, the productivity of rice grew at the rate of 2.36 per cent over the period of five years. The increase in area for cultivation for HYV varieties in the region has a significant effect in the productivity of rice. Moreover the soil of the study area is categorised under alluvial soil which are clayey and has high water holding capacity (Sumarsono et.al., 2022). This resulted in potash rich and suitable for rice cultivation. Hence, the increase in use of fertilizers over the last five years also boosts the production of rice. The use of fertilizers increased at compound rate of 111.70 % over the period of five years. However, the use of fertilizers fluctuates over the period of five years. In 2022-23, the use of fertilizers increased to 113.13 kg per hectare from 13.65 kg per hectare in 2021-22. Moreover due to significant increase in rainfall over the last five years in the region, the area under irrigation declined at 3.84 per cent.

The farmers in the study area are categorised into marginal (holding less than 1 hectare), small (holding 1-2 hectare) and medium farmers (holding 2-10 hectare). The findings show that majority (53.53%) belong to marginal farmers, 39.41% belong to small farmers and the rest 7.06% are found to be medium farmers. However, there was no large farmers were found during primary data collection. The total area of rice cultivation and production by different categories of farmers are shown in table 2.

Table 2 Production of rice in the study area based on distribution of type of farmers

	Marginal	Small	Medium
No. of Farmers	91 (53.53%)	67 (39.41%)	12 (7.06%)
Total Area (in hectare)	57.38	92.17	32.45
Total Production(in tonnes)	244.44	382.88	132.40
Average Production (tonnes per hectare)	4.26	4.15	4.08
Average Production per farmer(in tonnes)	2.69	5.71	11.03

Source: Author's calculation based on primary data

Table 2 reveals that during the study period, the total production of the marginal farmers considered, is found to be 244.44 tonnes; average land holding size of this category of farmer is 0.63 hectares, resulting in an average production of 4.26 tonnes per hectare and average per farmer produce 2.69 tonnes.

A significant potential for increased overall production lies with small farmers, who make up 39.41 per cent of the total sample size and have an average holding of 1.37 hectares. Given access to irrigated areas, these farmers, produced 382.88 tonnes with an average production of 4.15 tonnes per hectare, have the capacity for higher production. Moreover, the production per farmer among small farmers stands at 5.71 tonnes.

Medium-scale farmers, comprising just 7.06 per cent of the total farming sample size, play a crucial role in driving agricultural productivity and growth in the region. With an average landholding of 2.70 hectares, these farmers have the resources and capacity to adopt modern farming technologies, implement efficient production practices, and achieve higher yields, thus leading to total production of 132.40 tonnes with an average production of 4.08 tonnes per hectare. However, the production per farmer of among them was 11.03 tonnes.

While examining the average production per farmer, medium farmers lead the way with 11.03 tonnes, followed by small farmers at 5.71 tonnes and marginal farmers at 2.69 tonnes. This is because marginal and small farmers often face challenges in achieving economies of scale, limiting their ability to resources, technology and infrastructure.

With an average production of 2.69 tonnes per farmer, marginal farmers demonstrate remarkable efficiency in utilizing their limited land holdings. This suggests the potential for even greater production gains through targeted support and the adoption of innovative farming practices. Similarly small farmers showcase a higher level of production compared to their marginal counterparts. This highlights the importance of empowering small-scale farmers and ensuring they have access to the necessary resources and tools to further enhance their output.

The table 3 illustrates the farmers accessible to irrigated and non-irrigated area. It was found that 33.53% of farmers in the study area are accessible to irrigated area while 66.47% do not have the irrigation facilities. Among the farmers accessible to irrigated area they cultivated in 66.76 hectares producing 275.16 tonnes, with an average production of 4.12 tonnes per hectare. Meanwhile, those who do not have irrigation facilities cultivated in 115.24 hectares of land and produced 484.56 tonnes of rice. This results in average production of 4.20 tonnes per hectare and per individual production stands at 4.29 tonnes. The analysis shows that there was no significant difference among the farmers those who are accessible to irrigated area and non-irrigated area. This is because majority of the farmers depends on rain-fed area for cultivation in the study area.

Table 3 Production of rice under irrigated and non-irrigated areas

	Irrigated Area	**Non-Irrigated Area**
No. of Farmers	57 (33.53%)	113 (66.47%)
Total Area (in hectare)	66.76	115.24
Total Production (in tonnes)	275.16	484.56
Average Production (tonnes per hectare)	4.12	4.20
Average Production per farmer (in tonnes)	4.83	4.29

Source: Author's calculation based on primary data

Table 4 Production of rice under irrigated and non-irrigated areas of marginal farmers

	Irrigated Area	**Non-Irrigated Area**
No. of Farmers	30 (32.97%)	61 (67.03%)
Total Area (in hectare)	17.55	39.83
Total Production (in tonnes)	71.24	173.20
Average Production (tonnes per hectare)	4.06	4.35
Average Production per farmer (in tonnes)	2.37	2.84

Source: Author's calculation based on primary data

Table 5: Production of rice under irrigated and non-irrigated areas of small farmers

	Irrigated Area	**Non-Irrigated Area**
No. of Farmers	18 (26.87%)	49 (73.13%)
Total Area (in hectare)	24.87	67.30
Total Production(in tonnes)	100.72	282.16
Average Production (tonnes per hectare)	4.05	4.19
Average Production per farmer(in tonnes)	5.60	5.76

Source: Author's calculation based on primary data

The data presented in tables 4 and 5 compares the production levels of marginal and small farmers in both irrigated and non-irrigated areas. It shows that marginal farmers achieved higher average production in non-irrigated areas compared to irrigated areas, while small farmers achieved slightly higher average production in irrigated areas compared to non-irrigated areas. For instance, 67.03% of marginal farmers cultivated non-irrigated areas and achieved an average production of 4.35 tonnes per hectare, while 32.97% cultivated irrigated areas and achieved an average production of 4.06 tonnes per hectare. Similarly, among small farmers, 26.87% achieved an average production of 4.05 tonnes per hectare in irrigated areas, while 73.13% achieved an average production of 4.19 tonnes per hectare in non-irrigated areas.

Table 6 Production of rice under irrigated and non-irrigated areas of medium farmers

	Irrigated Area	**Non-Irrigated Area**
No. of Farmers	9 (75%)	3 (25%)
Total Area (in hectare)	24.34	8.11
Total Production (in tonnes)	103.20	29.20
Average Production (tonnes per hectare)	4.24	3.60
Average Production per farmer (in tonnes)	11.47	9.73

Source: Author's calculation based on primary data

Among the medium farmers, 75% cultivated in 24.34 hectares of irrigated area, producing 103.20 tonnes of rice at an average of 4.24 tonnes per hectare, while the remaining 25% cultivated in 8.11 hectares of non-irrigated area, resulting in a total of 29.20 tonnes and an average of 3.60 tonnes per hectare. The average production among farmers with access to irrigated area surpasses that of those without access, indicating that medium farmers with better resources are able to adopt modern technology for cultivation.

Table 7 Estimated value of the coefficient and related statistics of Cobb-Douglas Production function of rice production

Explanatory variables	**Estimated coefficient**	**Standard error**
Intercept	0.928105	0.095133
Total Area (X_1)	1.117663	0.072431
Area under Irrigation (X_2)	0.011516	0.101278
Fertilizers used (X_3)	-0.23512	0.048131
R Square	0.721406	-----
Adjusted R Square	0.716371	----

Source: Author's calculation based on primary data

4. TOTAL AREA FOR RICE CULTIVATION

The log-linear model indicates that total area for rice cultivation is a major driver of production levels. A 1 per cent increase in total rice area is associated with a 1.12 per cent increase in production, holding other factors constant. This highlights the importance of expanding arable land dedicated to rice farming as a means to boost overall output. Factors that can influence total rice area include the availability of suitable land, land use policies, and competition from other agricultural crops. Careful land use planning and efficient allocation of resources are crucial to ensure rice production keeps pace with growing demand.

5. IRRIGATION AND ITS IMPACT

The model shows that a 1 per cent increase in the area under irrigation is associated with a 0.01 per cent increase in rice production. While the elasticity is relatively low, improved access to reliable irrigation can still have a meaningful impact on overall yields. Expanding irrigation infrastructure requires significant capital investment and on-going maintenance. Factors like water scarcity, competing demands, and climate change can also pose challenges to the effectiveness of irrigation systems.

6. THE ROLE OF FERTILIZERS

The model indicates that a 1 per cent increase in fertilizer use is associated with a 0.24 per cent decrease in production, suggesting the potential for diminishing returns or over-application of fertiliser. Though fertilizers help to replace the nutrients depleted from the soil through repeated rice cultivation, enabling higher yields per unit of land but excessive use of fertilizers had reverse affect due to overabundance of nutrients and imbalance in the soil's ecosystem. This condition is supported as compound growth rate of use of fertilizers over the period of 2018-19 to 2022-23 increased at the rate of 111.70 %.

The model also suggests that total rice area is the most influential factor. Prioritizing interventions that target these key drivers can yield the greatest impact on production.

7. OPTIMIZING RICE PRODUCTION STRATEGIES

1) Land Expansion- Increase the total area dedicated to rice cultivation, prioritizing the use of suitable, underutilized land.
2) Irrigation Improvements - till Invest in and optimize irrigation systems to ensure reliable water access and efficient water use.
3) Fertilizer Management - Implement precision agriculture techniques to optimize the application of fertilizers, balancing productivity and environmental concerns.
4) Flood Tolerance rice- Increase the cultivation of flood tolerance HYV in the study area to enhance the production and meet the growing demand of rice.
5) Research and Innovation – Continuous investment in agriculture research, development and the adoption of new technologies can further enhance rice production in the study area.

8. CONCLUSIONS

The analysis shows that majority of the farmers belong to marginal category but the small farmers share higher portion of production of rice in the study area. Moreover, farmers those who do not have access to irrigation facilities have higher production rate than those compared to farmers accessible to irrigated area. The log-linear production function provides valuable insights into the key factors influencing rice production. By focusing on strategies that optimize total rice area, irrigation, and fertilizer management, policymakers and agricultural professionals can take significant steps towards improving overall rice productivity and ensuring food security. However, a comprehensive approach that also leverages complementary strategies, such as research, extension services, supportive policies, and farmer education, can further strengthen the resilience and sustainability of rice production systems. Continued collaboration and innovation will be essential to meet the growing global demand for this staple crop. The study does not account for other potential factors, such as weather and socioeconomic conditions, which may also impact rice production. A more comprehensive analysis would incorporate these additional variables.

CONFLICT OF INTERESTS

None.

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