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Growth and Instability of Area, Production and Productivity of Rice in Bodoland Territorial Area District (BTAD)

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ABSTRACT

Background: The analysis examined the growth and instability of area, production and productivity of autumn rice, winter rice and summer rice in BTAD.

Methods: Data were collected from the Joint Director of Economics and Statistics, BTC. The study used Compound Annual Growth Rate (CAGR) and the Cuddy-Della Valle Index to assess growth and instability.

Result: Autumn rice showed positive growth in area, production and productivity in Period I, but area declined in Period II, despite continued gains in production and productivity. Over the full study period, area and production declined, while productivity increased due to greater use of HYV seeds, irrigation and fertilizers. Winter rice showed consistent growth in all aspects, except for a dip in area during Period II. Summer rice achieved growth in production and productivity across all periods, even as area declined, may be because of improved inputs. Overall, low instability across all rice types indicates stable growth. Expanding autumn and summer rice cultivation can help offset winter losses from flooding. Enhancing irrigation will also allow better use of fallow land during dry seasons, boosting total rice output.

Key words: Area, Compound annual growth rate, Instability growth rate, Production, Productivity, Rice.

INTRODUCTION

Rice holds paramount importance in India, both economically and socially. As a staple food, it sustains approximately 1.2 billion people and serves as a critical source of income for millions of farmers. Beyond its domestic role, rice significantly contributes to India's export earnings and national economy. India is the world's second-largest producer and the leading exporter of rice globally. According to the Press Information Bureau (2023), rice's contribution to agricultural GVA increased from 13.9% in 2011-12 to 18.3% in 2022-23. Farming Cosmos (2023) reports that rice export earnings grew from `24,109 crore in 2011-12 to `38,524.10 crore in 2022-23. Recognizing its strategic importance, the Government of India has implemented numerous initiatives to boost rice production and farmer welfare. These include the National Food Security Mission (NFSM), Sustainable Rice Production Programme (SRPP), National Mission for Sustainable Agriculture (NMSA), Pradhan Mantri Kisan Samman Nidhi (PM-KISAN), Pradhan Mantri Kisan Maan-Dhan Yojana (PM-KMY), Pradhan Mantri Fasal Bima Yojana (PMFBY), Market Intervention Scheme and Price Support Scheme (MISS) and the Agriculture Infrastructure Fund (AIF), (GOI, 2025). Over the decades, India has made significant strides in expanding rice cultivation and output. The area under rice cultivation grew from 40.15 million hectares in 1980-81 to 43.66 million hectares in 2019-20. Rice production was increased from 53.6 million tons in FY 1980 to 120 million tons in FY 2020-21 (MAFW, 2021). Major rice-producing states include West Bengal, Uttar Pradesh, Punjab andhra Pradesh, Bihar, Chhattisgarh, Odisha, Assam and Haryana. These regions play a vital role in ensuring food security and sustaining the livelihoods of millions across the country.

Rice is the principal crop of Assam, playing a vital role in the state's agriculture and economy. The state supports three distinct rice-growing seasons: Sali (winter), Ahu (autumn) and Boro (summer). Among these, Sali rice is the most widely cultivated, benefiting from the monsoon season and contributing the largest share to total production. Ahu rice, sown in spring and harvested before the monsoon, offers an early yield, helping bridge seasonal food gaps. Boro rice, grown in winter with irrigation and high-yielding varieties, boosts off-season production and enhances year-round food availability. Together, these cropping cycles enable continuous rice cultivation, strengthening both food security and rural livelihoods. Rice occupies 2.54 million hectares, over 60% of Assam's gross cropped area (4.16 million hectares) and accounts for 96% of total food grain production (Krishi Jagran, 2025). In 2022-23, Assam produced 6.04 million tons of rice with an

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average yield of 2,652 kg/hectare, up from 5.44 million tones and 2,271 kg/hectare in 2018-19. This growth reflects advances in farming practices, improved seed use and better irrigation infrastructure.

Studies on rice growth and instability have been conducted in various states. Pegu and Hazarika (2016) analyzed growth and instability in rice cultivation in Assam. Jambhulkar *et al.* (2020) studied district-wise patterns in Odisha, Akula *et al.* (2022) focused on Telangana and Jambhulkar *et al.* (2023) examined West Bengal. However, no such study exists for BTAD. Hence, this study aims to estimate the growth and instability of rice area, production and productivity in BTAD.Top of Form Bottom of Form.

Objective

To examine the trends in growth and instability in area, production and productivity of three types of rice in BTAD from 2005-06 to 2020-21.

MATERIALS AND METHODS

The present study was based on secondary data. Rice was selected for the study because rice is the main food item for the people of BTAD. Three types of rice namely, autumn rice, winter rice and summer rice cultivates in BTAD, so these three types of rice have been selected for the study as they are main food crops as well as the farmers grow it for economic purpose.

The data related to area, production and productivity of rice for the BTAD were collected from Joint Director of Statistics and Economics of BTC District Agriculture Office of Udalguri, Statistical Handbook of Bodoland Territorial Council, journals and website.

Selection of study area and crop

The Bodoland Territorial Council (BTC), established on 10th February 2003 under the Sixth Schedule of the Indian Constitution, is one of Assam's largest autonomous councils. It comprises four districts Kokrajhar, Chirang, Baksa and Udalguri collectively known as the Bodoland Territorial Council (BTC), located in western Assam between 26.2°-26.9°N latitude and 89.5°-91.0°E longitude, along the northern bank of the Brahmaputra River and bordering Bhutan. Formed from parts of seven districts, BTC spans an area of 8,970 sq. km. Its economy is predominantly agrarian, with over 73 per cent of the population relying on agriculture, alongside fisheries, livestock and small-scale industries. Rice is the primary crop and dietary staple, cultivated in three seasonal varieties Sali (winter), Ahu (autumn) and Boro (summer). Other key crops include jute, sugarcane, potato, pulses, mustard and maize, while horticultural crops like banana, pineapple, orange and ginger are gaining importance, especially in Baksa and Udalguri, supporting agricultural diversification.

Period of study

The period of study was considered as per the availability of data. The compound growth and instability rates of area, production and productivity of three types of rice in BTAD were estimated for the period from 2005-06 to 2020-21. This period of study was sub-divided into three sub periods as Period-I (2005-06 to 2012-13), Period-II (2014-15 to 2020-21) and overall Period-III (2005-06 to 2020-21).

Methodology

To examine the growth trends and instability growth of area, production and productivity of rice compound annual growth Rate and Cuddy-Della Value Index has been used.

Compound annual growth rate (CAGR)

CAGR provides a simplified measure of the average annual growth of an investment, business, production or any other variable over a specified period, assuming consistent growth each year. It is a valuable tool for investors, entrepreneurs and producers to assess the potential returns or performance trends by indicating the average annual rate of increase or decrease. In this study, CAGR was employed to analyze the percentage change both growth and decline across the selected parameters namely, area, production and productivity of rice over the study period The following is the formula of CAGR –

$$CAGR\ (t_0,t_n) = V(t_n) / V(t_0)^{\frac{1}{t_n - t_0}} - 1 \times 100$$

Where,

$V(t_0)$ = Beginning value of growth of area, production and productivity of three types of rice (*i.e*. 2005-06).

$V(t_n)$ = Final value of growth of area, production and productivity of three types of rice (*i.e*. 2020-21).

$t_n - t_0$ = Number of years.

Cuddy-della value index (CDVI)

CDVI was developed by Cuddy and Valle (1978) for measuring the instability in time series data that characterised by trend. The value of CDVI is indicate as low instability if the value is between 0-15%, medium instability if the value is between 15-30% and high instability if the value is more than 30%. Instability in area, production and productivity of autumn rice, winter rice and summer rice were examined by using CDVI.

$$I = C.V. \times \sqrt{1-R^2}$$

Where,

I= Instability index.

C.V. = Coefficient of variation.

R^2 = Adjusted coefficient of determination.

RESULTS AND DISCUSSION

Compound annual growth rates of area, production and productivity of rice

Table 1 illustrate the CAGR for the area, production and productivity of autumn, winter and summer rice in the BTAD across three study periods. During Period I, autumn rice experienced notable growth, with production and productivity increasing by 3.69 per cent and 22.22 per cent,

respectively. This improvement was largely driven by a 3.9 per cent expansion in cultivated area, which contributed to the overall rise in output and yield. In Period II, despite a -10.22 per cent decline in the area under autumn rice cultivation, both production and productivity continued to grow, registering 1.18 per cent and 12.7 per cent increases, respectively suggesting enhanced efficiency in rice farming practices. Over the entire study period, the CAGR for area and production of autumn rice declined by -4.54 per cent and -0.26 per cent, while productivity improved by 4.48 per cent. Production decreased because of declined in area under autumn rice cultivation. The contraction in cultivation area is attributed by the factors such as land-use changes and shifting preferences toward alternative crops. These findings are corroborated by the study, including Answari and Answari (2023). Winter rice is the most important rice crop in the BTAD, making a vital contribution to regional food security. Over the study periods, the area, production and productivity of winter rice showed consistent growth, with the exception of Period II, where the cultivated area declined marginally by -0.06 per cent. In Period I, the area under cultivation increased by 2.94 per cent, while production and productivity rose by 7.17 per cent and 26.76 per cent, respectively, reflecting favorable growing conditions and improved management. Although in Period II, there was reduction in area, production and productivity continued to grow by 10.25 per cent and 10.32 per cent driven by advancements in agricultural techniques. Sary *et al.* (2024) found from their study that use of ferlitiser has significant impact on the output of wet season paddy. As per Statistical Handbook of BTC, fertilizer has also increased. In Annual Period, all three indicators area, production and productivity again recorded positive growth, underscoring ongoing improvements in farming practices, technology adoption and resource efficiency in the region.

The cultivation of winter rice in Assam is often affected by floods during the monsoon season. As a result, summer rice has become an important crop in the BTAD, particularly in flood-prone areas, as it is relatively less susceptible to flood damage. As per District irrigation plan, 2016-20, summer rice cultivation have received more attention to avoid flood and other natural calamities to make the study region self-sufficient in rice production. Despite a negative growth rate of the area under summer rice cultivation by -0.05 per cent during Period I, - 6.21 per cent during Period II and -5.12 per cent in Annual period, but the production and productivity have increased in two study periods. Production has increased by 1.79 per cent during Period I and Annual Period by 1.96 per cent. And productivity has increased from 7.22 per cent in Period I, 5.99 per cent in Period II and 7.47 per cent in Annual period. But in Period II, productivity has increased to 5.99 per cent even than there has been negative growth rate of area and production of summer rice. As per Statistical Handbook of BTC, there has been increased in irrigated area and consumption of fertilizer also support in the cultivation of summer rice.

In The use of fertilizers, vermin compost, foliar sprays and appropriate crop management practices during the cultivation, panicle initiation and flowering stages all of which contribute to higher yields may be responsible for the improvement in productivity in the case of autumn rice, even though both area and production have decreased. Udhaya *et al.* (2024) support the findings of this study. Similarly, for winter rice, both production and productivity have increased due to an expansion in the area under cultivation, which is consistent with the findings of Saikia and Hazarika (2025). Although the area under summer rice cultivation has decreased, production and productivity have increased due to the adoption of improved rice varieties, the use of fertilizers and effective plant protection measures, as noted by Shankar *et al.* (2025).

Instability in area, production and productivity of rice of BTAD

CDVI has been used to analysis the instability in area, production and productivity of three types of rice and result was presented in Table 2. The results indicate notable fluctuations in the cultivated area, production and productivity of autumn rice across different sub-periods. During Period I, the area under cultivation grew at a rate of 1.48 per cent, which declined to 1.3 per cent in Period II and further to 0.93 per cent over the overall annual period. Production exhibited an initial increase from 4 per cent in Period I to 5 per cent in Period II, followed by a decline to 2.4 per cent in the annual period. In contrast, productivity consistently declined from 8.1 per cent in Period I to 3.8 per cent in Period II and 3 per cent in the annual period. Overall, the growth trends in area, production and productivity of autumn rice reflect low instability, as all values fall within the 0 to 15 per cent range.

In case of winter rice, the area under cultivation declined from 0.93 per cent in Period I to 0.3 per cent in Period II.

Table 1: Compound annual growth rates of area, production and productivity of rice.

Rice	Autumn rice			Winter rice			Summer rice		
Period	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Period I (2005-2012)	3.9	3.69	22.22	2.94	7.17	26.76	-5.05	1.79	7.22
Period II (2013-20)	-10.22	1.18	12.7	-0.06	10.25	10.32	-11.51	-6.21	5.99
Annual period (2005-06 to 2020-21	-4.54	-0.26	4.48	1.63	8.93	7.18	-5.12	1.96	7.47

Statistical handbook BTC (Various Issues).

CAGR Calculated by the scholar.

Table 2: Instability growth in area, production and productivity of rice of BTAD.

Rice	Autumn rice			Winter rice			Summer rice		
Period	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Period I (2005-2012)	1.48	4	8.1	0.93	4	7.3	1.6	3	3
Period II (2013-20)	1.3	5	3.8	0.3	2	2.2	4	2.8	0.8
Annual period (2005-20)	0.93	2.4	3	0.4	1.28	2.6	1.4	1.65	0.79

Statistical handbook BTC (Various Issues).

CAGR Calculated by the scholar.

Growth instability during the annual period remained low, with values falling within the 0-15 per cent range. A consistent decline was observed in production, decreasing from 4 per cent in Period I to 2 per cent in Period II and further to 1.28 per cent annually. A similar trend was noted in productivity, which fell from 7.3 per cent in Period I to 2.2 per cent in Period II, although a slight increase to 2.6 per cent was recorded during the annual period. Overall, the growth trends in area, production and productivity of winter rice exhibited low levels of instability throughout the study period because the value lies on 0-15 per cent.

The area under summer rice cultivation increased sharply from 1.6 per cent in Period I to 4 per cent in Period II, with low growth instability at 1.4 per cent during the annual period. Production declined from 3 per cent to 2.8 per cent, with an annual growth rate of 1.65 per cent. Similarly, productivity dropped from 3 per cent to 0.8 per cent, with an annual growth of 0.79 per cent. Overall, the values for area, production and productivity remained within the 0–15 per cent range, indicating low growth instability throughout the study period.

The implication of the current study

The study highlights important policy implications for enhancing rice production in the region. A positive growth trend in the area, production and productivity of winter rice suggests its continued importance. While only productivity has improved for autumn rice, summer rice has demonstrated increased production and productivity despite a decline in cultivated area. These trends underscore the potential of autumn and summer rice cultivation to offset losses from flood-affected winter rice. Given rice's role as the staple food in the study area, the findings call for strategic investment in irrigation infrastructure. Expanding and improving irrigation facilities would allow for the productive use of currently fallow lands, which remain uncultivated due to insufficient rainfall during the Zaid and Rabi seasons. This, in turn, would enhance cropping intensity, reduce seasonal vulnerability and contribute to greater food security and rural income stability.

CONCLUSION

The present study examines the compound annual growth rate (CAGR) of area, production and productivity for autumn rice, winter rice and summer rice. In Period I, both production and productivity of autumn rice increased, primarily due to an expansion in the area under cultivation. In Period II, although the area decreased, production and productivity still rose, likely due to the adoption of new technologies. Over the entire period, the growth rates for area and production were negative, while the growth rate for productivity was positive. For winter rice, area, production and productivity increased across all three periods, except for the area in Period II. Summer rice is particularly important in Assam because it is a relatively risk-free crop, especially in flood-prone areas. Despite a decrease in the area under summer rice cultivation, production and productivity increased in all three periods due to expanded irrigation and increased fertilizer use. The result also reveals that there was low instability in the area, production and productivity of autumn rice, winter rice and summer rice in the study area. This low instability can be attributed to the steady and consistent growth in area, production and productivity of all three types of rice across the periods.

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Author contribution

Conceptualization: Papina Basumatary and Kandarpa Kumar Barman Methodology: Papina Basumatary and Kandarpa Kumar Barman, Data Collection: Papina Basumatary and Kandarpa Kumar Barman, Formal Analysis: Papina Basumatary and Kandarpa Kumar Barman. Writing-original Draft Preparation: Papina Basumatary and Kandarpa Kumar Barman, Writing- Review and Editing: Papina Basumatary and Kandarpa Kumar Barman.

Conflict of interest

The authors declare no conflict of interest.

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