INVESTIGATING THE POTENTIAL HIGH-YIELD RICE VARIETIES FOR CLIMATE-RESILIENT AGRICULTURE IN PATUAKHALI DISTRICT

Rana Ghosh[1], Papri Hazra[2], Marzia Sultana Shefa[3], Nafisa Mehzabin[4], Sanjida Hossain Setu[5] Md. Fuad Hasan[*6], Md Shamsuzzoha[7]

[1]Student, Faculty of Environmental Science and Disaster Management, Patuakhali Science and Technology University, Dumki, Patuakhali- 6802, Email address: rana1706022@gmail.com
[2]Associate Professor, Dept. of Environmental Science, Patuakhali Science and Technology University, Dumki, Patuakhali- 6802, Email address: ph7bau@gmail.com
[3]Student, Dept. of Disaster Risk Management, Patuakhali Science and Technology University, Dumki, Patuakhali- 6802, email address: shefa7390@pgs.pstu.ac.bd
[4]Student, Institute of Environmental Science and Disaster Management, Bangladesh Agricultural University, Mymensingh, email address: mehzabinnafisa28@gmail.com
[5]Student, Dept. of Emergency Management, Patuakhali Science and Technology University, Dumki, Patuakhali- 6802, email address: sanjidasetu17@gmail.com
[6]Lecturer, Dept. of Environmental Science and Technology, German University Bangladesh, email address: fuad.dm.pstu@gmail.com
[7]Professor, Dept. of Emergency Management, Patuakhali Science and Technology University, Dumki, Patuakhali- 6802, email address: zohageo@pstu.ac.bd

***Corresponding Author**

ABSTRACT

Rice (*Oryza sativa L.*) is the main staple crop of Bangladesh, but its production in coastal districts such as Patuakhali is increasingly threatened by climate change through rising temperature, erratic rainfall, and salinity intrusion. This study assessed the performance of high-yielding varieties (HYVs) developed by the Bangladesh Rice Research Institute (BRRI) as options for climate-resilient rice cultivation. A mixed-methods approach was used, combining secondary yield data (2016–2022) and a household survey of 50 farmers to evaluate variety performance and farmer awareness. Analysis of variance (ANOVA) showed that HYVs consistently outperformed local varieties across all rice-growing seasons. In the Aus season, BR20, BRRI dhan48, BRRI dhan65, and BR26 achieved mean yields of 3.86–4.16 t/ha (SD 0.37–0.63). In the Aman season, BR20, BR2, BRRI dhan42, and BRRI dhan82 recorded mean yields of 3.99–4.12 t/ha (SD 0.36–0.40). During the Boro season, Janakraj (7.86 t/ha, SD 0.42), Hira (7.14 t/ha, SD 0.45), BRRI dhan89 (6.04 t/ha, SD 0.19), and ACI (6.13 t/ha, SD 0.51) produced the highest yields. Traditional varieties yielded only 1.2–2.1 t/ha, while HYVs produced 2.4–3.8 t/ha. Farmer surveys indicated limited awareness of climate change, with only 2% of respondents aged 60+ and 10% aged 35–45 aware of it, although knowledge of HYVs was higher (60% and 70%, respectively). Climate data identified rising temperature (30%), low rainfall (30%), and frequent natural hazards (30%) as major stressors in Patuakhali. HYVs such as BR20, BRRI Dhan 48, Janakraj, and Hira exhibited higher yield stability and climatic adaptability, indicating strong potential for enhancing rice productivity and resilience in coastal Bangladesh.

Keywords: *HYVs, Climate Resilience, Rice Yield Performance, Food Security*

INTRODUCTION

Rice (Oryza sativa L.) is the principal staple food crop of Bangladesh, accounting for nearly 75% of the total cropped area and contributing over 90% of the country's cereal production (BBS, 2024). It is the foundation of food security, rural livelihoods, and agricultural employment, directly supporting millions of smallholder farmers across diverse agroecological regions (Bala & Hossain, 2010; Binte Mostafiz et al., 2021). Among the major rice-growing areas, the coastal belt, including Patuakhali District, plays a significant role in national rice production due to its fertile deltaic soils and multi-season cropping potential. However, this region is highly exposed to the adverse impacts of climate change, which threaten the sustainability of rice cultivation (Shamsuzzoha et al., 2022).

Climate change in coastal Bangladesh is characterised by rising temperatures, erratic and declining rainfall, frequent cyclones, tidal surges, salinity intrusion, and waterlogging (IPCC, 2023). These climatic stressors directly influence rice productivity by affecting crop phenology, soil fertility, and water availability (Dasgupta et al., 2018; M. S. Islam et al., 2022; Momtaz & Shameem, 2016a). The vulnerability of rice-based farming systems in the Patuakhali district is particularly high because of its low elevation, proximity to the Bay of Bengal, and dependence on seasonal rainfall. Total, 30% of the observed climatic changes in Patuakhali are related to temperature rise, 30% to low rainfall, and 30% to frequent natural hazards (FAO, 2024; IPCC, 2023; A. Islam et al., 2013; Khatun & Saadat, 2021). Such variability disrupts traditional cropping calendars and reduces the reliability of local rice varieties that are less tolerant to climatic stresses.

In response to these challenges, the Bangladesh Rice Research Institute (BRRI) has developed several High-Yielding Varieties (HYVs) with enhanced tolerance to salinity, submergence, drought, and other abiotic stresses. These varieties—including BRRI dhan47, BRRI dhan53, BRRI dhan54, BRRI dhan56, BRRI dhan61, and BINA dhan8—have been widely promoted as potential tools for achieving climate-resilient agriculture in coastal and stress-prone environments. HYVs are characterised by higher yield potential, shorter growing duration, and improved adaptability, making them suitable for the changing climatic conditions of southern Bangladesh (IRRI, 2020). However, despite these technological advancements, the adoption and field-level performance of HYVs vary across regions depending on local environmental conditions, resource availability, and farmers' awareness or willingness to adopt new technologies.

Several studies have shown that HYVs consistently outperform traditional local varieties in terms of yield and stress tolerance (Alam et al., 2019; Arab et al., 2022; Dasgupta et al., 2018; Mahmood & Hayes, 1995; Myint Htun et al., 2023). Yet, empirical data focusing specifically on Patuakhali's coastal ecosystem remain limited. Moreover, the linkage between climatic factors, varietal performance, and farmers' perceptions has not been sufficiently explored. Understanding these interactions is essential for formulating location-specific strategies that promote resilient rice production under changing climate scenarios.

This study aims to evaluate the yield performance and climate resilience of BRRI-developed HYV rice cultivars in Patuakhali District using a mixed-methods approach that integrates quantitative yield data and qualitative farmer perceptions. It also examines farmers' awareness of climate change and their knowledge and use of HYVs to identify barriers and opportunities for large-scale dissemination. By analysing yield variability across the Aus, Aman, and Boro seasons and relating them to local climate conditions, the study provides valuable insights into how improved rice varieties can strengthen food security and adaptive capacity in Bangladesh's coastal regions.

METHODOLOGY

1.1 Methods

Patuakhali is a district in south-central Bangladesh in the Barisal Division. This district is the main entrance to the beach of Kuakata. The area of the district is 3,221.31 km². The population of this district is 1,727,254, and the density of the population is 540 per km2 (Population and Housing Census 2022, 2023). Patuakhali district town is surrounded on three sides by rivers (GoB, 2025). The two major rivers are Laukathi and Lohalia, which are directly connected with the Bay of Bengal. The city has an inland airport used for transport and private travel across the country (Jerin, 2012). Here are 8 upazilas in this district. They are Dumki Upazila, Patuakhali Sadar Upazila, Mirzaganj Upazila, Bauphal Upazila, Galachipa Upazila, Dashmina Upazila, Rangabali Upazila, Kalapara Upazila.

Mixed-Methods Approach: Utilize a mixed-methods approach that combines quantitative data from the Bangladesh Rice Research Institute (BRRI), yearbook of agricultural statistics, the agricultural ministry of Bangladesh, Historical yearly temperature and rainfall data from the Bangladesh Meteorological Department (BMD), with qualitative data from the farmer survey to provide a comprehensive analysis of the potential of high-yield rice cultivars for climate-resilient agriculture.

1.2 Data Collection

Quantitative data can be analysed using descriptive statistics, while qualitative responses can be thematically analysed to identify patterns and trends in farmers' (Dubey & Kothari, 2022; Momtaz & Shameem, 2016b).

i) **Rice Yield Data:** Collect existing data on high-yield rice cultivars, including their characteristics, agronomic performance, and adaptability to varying climatic conditions in Patuakhali District, from BRRI and the yearbook of agricultural statistics. This data is used as a foundation for our study and provide insights into the potential of these cultivars.
ii) **Farmers' Household Survey:** Survey farmers in Patuakhali District in several places to gather information on their current rice cultivation practices, experiences with climate change impacts, knowledge about high-yield rice cultivars, and perceptions of their suitability for climate-resilient agriculture. Use structured questionnaires to collect quantitative data and open-ended questions for qualitative insights.
iii) **High-Yield Rice Cultivar Selection:** Based on the data obtained from BRRI and expert consultation, we select a set of high-yield rice cultivars that have shown promising characteristics in terms of productivity, disease resistance, and adaptability to climate variations in the Patuakhali District.

1.3 Data Analysis

We have collected existing data on high-yield rice cultivars, including their characteristics, agronomic performance, and adaptability to varying climatic conditions in Patuakhali District, from BRRI and the yearbook of agricultural statistics. Also, did a survey among the farmers to understand the perspective of farmers about climate change and high-yield rice cultivation. Also, we did a survey about if they get any government and non-government organizational help. We tried to understand the positive and adverse situations for farmers, for this, we used a specific questionnaire. Collect data on climate variables (temperature, rainfall, and Salinity) from meteorological sources or weather stations in the study area. We have entered the collected data into google sheets and then apply specific methods to determine mean and standard deviation and analyze them (ANOVA) (IBM, 2019; Rahman & Muktadir, 2021). It helps to understand the performance and adaptability of high-yield rice cultivars under different climatic conditions. To visualize the data, we have used Python and its library Pandas and Matplotlib. Its graphics help us to easily understand the perspective of data, and it helps us to take decisions.

ANALYSISANALYSIS AND RESULTS

1.4 Overview of Data

The study followed a holistic move combining both descriptive and quantitative approaches in data analysis. Chapter four presents key findings related to climate change associated with rice production in the Patuakhali district. We especially focused on different cultivars, rice production, and their relations to climate change. We have collected Secondary Data (2016-2022) From BRRI reports, and the yearbook of agricultural statistics and analyzed them through Analysis of Variance (ANOVA).

1.5 Performance of High-Yield Rice Cultivars

In this Patuakhali district Farmers mainly practice rice cultivation in the Aman and Boro seasons among three seasons (Aus, Aman, Boro). While Aus rice cultivation is not as prevalent in the Patuakhali

district, some farmers might opt for it on a smaller scale, depending on their access to water resources and irrigation facilities.

1.5.1 Aus Season

In Patuakhali district, Bangladesh, the Aus season is one of the three main rice seasons. Though rice cultivation is limited in this season because of water shortage. The Aus season in Patuakhali typically begins around April and extends until August. It occurs during the dry season when water availability may be limited, requiring farmers to rely on irrigation systems or rainwater for cultivation.
During the Aus season, farmers in Patuakhali cultivate specific varieties of rice suitable for this season. Aus rice varieties are generally short-duration and drought-tolerant, allowing those to withstand the water scarcity typically experienced during this season. These varieties are adapted to grow in relatively dry conditions and have shorter maturity periods compared to other rice varieties.

Table 1: Rice HYV ANOVA Table of Aus Season (BRRI)

Varieties Name	Aus Rice Production Rate in Patuakhali Region (t/ha)							Mean	STD
	2016	2017	2018	2019	2020	2021	2022		
BR2	3.42	4	4.3	3.81	2.96	3.56	3.74	3.68	0.43
BR20	4.48	3.85	4.06	3.48	3.9	4.52	4.17	4.07	0.37
BR21	3.71	4.2	3.2	4.34	3.78	3.49	3.94	3.81	0.39
BR26	4.26	3.49	4.34	4.2	3.2	3.71	3.93	3.88	0.43
BRRI dhan27	4.1	3.1	4.34	3.78	3.49	5.3	4	4.02	0.7
BRRI dhan28	3.6	3.81	2.96	3.56	3	2.9	3.33	3.31	0.36
BRRI dhan33	4.34	3.78	3.49	3.71	4.2	3.2	3.94	3.81	0.39
BRRI dhan42	3.81	2.96	3.56	2.5	4.48	3.85	3.54	3.53	0.64
BRRI dhan43	3.1	3.8	4.34	3.78	3.49	3.71	3.71	3.7	0.37
BRRI dhan48	4.34	3.78	3.49	5.3	4.5	3.6	4.1	4.16	0.63
BRRI dhan55	3.8	4.4	3.6	4.34	3.78	2.5	3.79	3.74	0.63
BRRI dhan65	4.2	3.2	4.34	3.78	3.49	4.17	3.87	3.86	0.41
BRRI dhan82	4.06	4.3	3.9	2.3	5.11	5.5	4.13	4.19	1.02

Table 1 above presents the Aus season rice production rate, mean production, and standard deviation of selected high-yield rice varieties in Patuakhali District. These measures are used to assess the performance and variability of different rice varieties in terms of their yield potential. Here, all varieties are high-performing rice varieties, each with a unique quality. According to BRRI, they have extra adaptation quality towards temperature, salinity, water scarcity, etc. We can easily decide on a high-performing variety by using our analysis table and its graphical representation. Based on the data provided, let's pick four rice varieties that stand out as the best performers: BR20, BRRI dhan48, BRRI dhan65, and BR26. These varieties have demonstrated relatively high production rates and consistent performance compared to other varieties studied. Here, mean production represents one year's average productivity of particular varieties, and STD represents how consistent a particular variety is.BR 20 exhibited an average production rate of 4.07t/ha and a standard deviation of 0.37 t/ha. BRRI dhan48 showed a slightly higher production rate of 4.16 t/ha and a lower standard deviation of 0.63 t/ha. BRRI dhan65, on the other hand, displayed a mean production of 3.86 t/ha and a standard deviation of 0.41 t/ha. BR26 displayed a mean production of 3.88 t/ha and a standard deviation of 0.43 t/ha.
The relatively high production rates and consistent performance of these four varieties make them promising options for farmers in this region. These varieties have shown the potential to deliver stable and high yields, which are crucial for ensuring food security and increasing farmers' incomes.

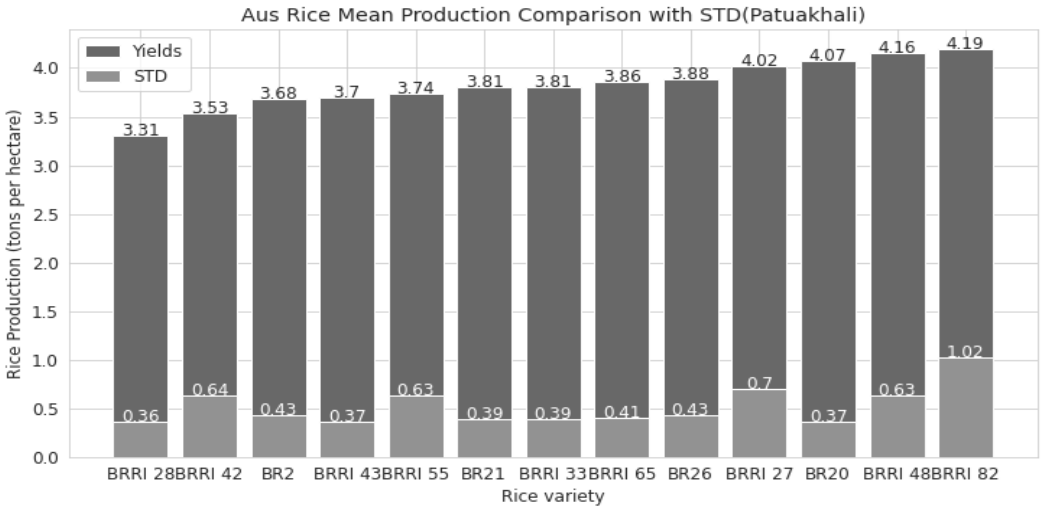

Figure 1: HYV Mean Yield & STD Graphical Representation (Aus Season) (BRRI)

However, it is important to note that other rice varieties listed in the table also contribute to the overall diversity of rice cultivation in the district. Further analysis and comparison of the performance of these varieties, along with considerations such as adaptability to local conditions, disease resistance, and market demand, should be conducted to provide a comprehensive understanding of the best rice varieties for Patuakhali District farmers.

Based on the provided data, BR20, BRRI dhan48, BRRI dhan27, and BR26 demonstrate promising performance in terms of production rate, mean production, and relatively lower variability. Further research and field trials are recommended to validate these findings and guide farmers in selecting the most suitable rice varieties for their specific agroecological conditions and production goals in Patuakhali District.

1.5.2 Aman Season

This rice season is widely practiced in Patuakhali region because of water availability. There are two different Aman, mainly practice D.Aman and T.Aman. The Aman season in Patuakhali typically begins around June and extends until November. It coincides with the monsoon season, when rainfall is abundant, providing natural irrigation for rice cultivation.

Table 2: Rice HYV ANOVA Table of Aman Season (BRRI)

Varieties Name	Aman Rice Production Rate in Patuakhali Region (t/ha)							Mean	STD
	2016	2017	2018	2019	2020	2021	2022		
BR11	4.42	4	3.9	4.81	3.96	3.56	4.16	4.12	0.4
BR22	4.48	3.85	4.06	3.48	3.9	4.52	3.98	4.04	0.36
BR23	3.71	4.2	3.2	4.34	3.78	3.49	4.07	3.83	0.4
Bina dhan17	4.26	3.49	3.34	4.2	3.2	3.71	3.58	3.68	0.41
Bina dhan11	4.1	3.1	4.34	3.78	3.49	5.3	4	4.02	0.7
Bina dhan7	3.6	3.81	3.96	3.56	3.8	4.2	3.94	3.84	0.22
BRRI dhan30	4.34	3.78	3.49	3.71	4.2	3.2	3.94	3.81	0.39
BRRI dhan52	3.81	3.96	3.56	4.5	4.48	3.85	4.3	4.07	0.36
BRRI dhan39	3.1	3.8	4.34	3.78	3.49	3.71	3.79	3.72	0.37
BRRI Hybrids	4.34	3.78	3.49	5.3	4.5	3.6	5.45	4.35	0.79

Varieties Name	Aman Rice Production Rate in Patuakhali Region (t/ha)							Mean	STD
	2016	2017	2018	2019	2020	2021	2022		
BRRI dhan34	3.8	4.4	3.6	4.34	3.78	2.5	3.75	3.74	0.63
Pajam	4.2	3.2	4.34	3.78	3.49	4.17	3.79	3.85	0.41
Hori Dhan	4.06	4.3	3.9	3.3	4.11	4.5	3.79	3.99	0.39

Table 2 above presents the Aman season rice production rate, mean production, and standard deviation of selected high-yield rice varieties in the Patuakhali District. These measures are used to assess the performance and variability of different rice varieties in terms of their yield potential.
Based on the data provided, four rice varieties stand out as the best performers: BR20, BR2, BRRI 42, and BRRI 82. These varieties have demonstrated relatively high production rates and consistent performance compared to other varieties studied.

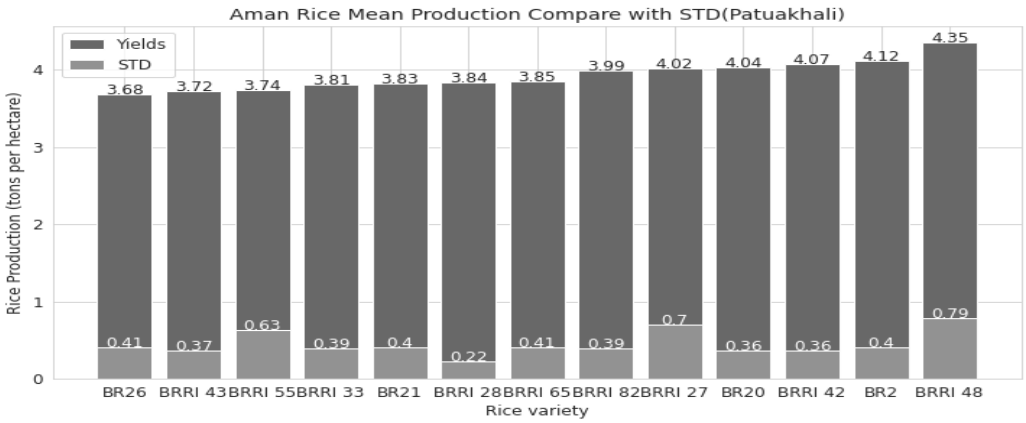

Figure 2: HYV Mean Yield & STD Graphical Representation (Aman Season) (BRRI)

BR20 exhibited an average production rate of 4.04 t/ha and a standard deviation of 0.36 t/ha. BR2 showed a slightly higher production rate of 4.12 t/ha and a lower standard deviation of 0.4 t/ha. BRRI 42, on the other hand, displayed a mean production of 4.07 t/ha and a standard deviation of 0.36 t/ha. BRRI 82 displayed a mean production of 3.99 t/ha and a standard deviation of 0.39 t/ha.
The relatively high production rates and consistent performance of these four varieties make them promising options for farmers in Patuakhali District. These varieties have shown the potential to deliver stable and high yields, which are crucial for ensuring food security and increasing farmers' incomes.
However, it is important to note that other rice varieties listed in the table also contribute to the overall diversity of rice cultivation in the district. Further analysis and comparison of the performance of these varieties, along with considerations such as adaptability to local conditions, disease resistance, and market demand, should be conducted to provide a comprehensive understanding of the best rice varieties for Patuakhali District farmers.

1.5.3 Boro Season

We Have Collected Quantitative data from BRRI and also conducted surveys among the farmers to get our data quality, farmers' perspectives, and understanding of the environment.
The Boro season takes place during the dry winter period, from November to April. Farmers in the district rely on irrigation systems such as deep tube wells and irrigation pumps to provide water for Boro rice cultivation. The availability of water resources in the area supports the cultivation of Boro rice, which is a high-yielding variety.

Table 3: Rice HYV ANOVA table of Aus Season (BRRI)

Varieties Name	Boro Rice Production Rate in Patuakhali region (t/ha)							Mean	STD
	2016	2017	2018	2019	2020	2021	2022		
BRRI popular	5.8	4.9	4.6	5.9	6.6	5.9	5.71	5.63	0.67
BR14	7.02	6	5.1	4.02	5.09	6.6	5.62	5.64	1.01
BR26	6.05	5.3	7.02	5.8	5.5	5.1	5.77	5.79	0.63
BRRI dhan28	6	5.1	4.02	7.02	6.02	5.1	5.53	5.54	0.94
BRRI dhan29	4.92	5.09	6.6	5.8	5.9	6.6	5.79	5.81	0.65
BRRI dhan47	5.8	5.9	6.1	4.6	5.1	6.08	5.56	5.59	0.56
BRRI dhan50	4.02	5.09	6.6	5.92	5.09	6.6	5.52	5.55	0.92
BRRI dhan74	5.8	5.9	6.6	6.2	5.92	5.09	5.93	5.92	0.46
BRRI dhan84	5.09	6.6	5.8	7.02	6	5.8	6.05	6.05	0.62
BRRI dhan89	6.02	6.3	5.8	6.09	6.2	5.8	6.05	6.04	0.19
ACI	5.8	5.9	6.6	7.02	6	5.5	6.1	6.13	0.51
Hira	7.12	6.92	8.09	6.9	6.7	7.08	7.19	7.14	0.45
Janakraj	8.02	7.6	8.1	7.09	8.06	7.8	8.38	7.86	0.42

Table 3 above presents the boro season rice production rate, mean production, and standard deviation of selected high-yield rice varieties in Patuakhali District. These measures are used to assess the performance and variability of different rice varieties in terms of their yield potential.

Based on the data provided, four rice varieties stand out as the best performers: BRRI dhan89, ACI, Janakraj, and Hira. These varieties have demonstrated relatively high production rates and consistent performance compared to other varieties studied. BRRI dhan89 exhibited an average production rate of 6.04 t/ha and a standard deviation of 0.19 t/ha. ACI showed a slightly higher production rate of 6.13 t/ha and a lower standard deviation of 0.51 t/ha. Hira, on the other hand, displayed a mean production of 7.14 t/ha, and a standard deviation of 0.45 t/ha. Janakraj displayed a mean production of 7.86 t/ha and a standard deviation of 0.42 t/ha.

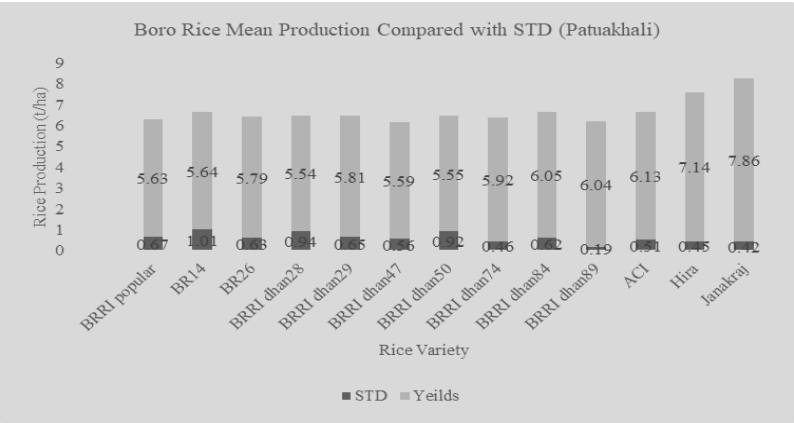

Figure 3: HYV Mean Yield & STD Graphical Representation (Boro Season) (BRRI)

The relatively high production rates and consistent performance of these four varieties make them promising options for farmers in Patuakhali District. These varieties have shown the potential to deliver stable and high yields, which are crucial for ensuring food security and increasing farmers' incomes.

However, it is important to note that other rice varieties listed in the table also contribute to the overall diversity of rice cultivation in the district. Further analysis and comparison of the performance of these

varieties, along with considerations such as adaptability to local conditions, disease resistance, and market demand, should be conducted to provide a comprehensive understanding of the best rice varieties for Patuakhali District farmers. Based on the results, BRRI dhan89, ACI Janakraj, and Hira demonstrate promising performance in terms of production rate, mean production, and relatively lower variability. Further research and field trials are recommended to validate these findings and guide farmers in selecting the most suitable rice varieties for their specific agroecological conditions and production goals in Patuakhali District.

1.6 Comparison with Local Varieties

There are some local traditional rice varieties like Kataribhog, Tulsi Mala, Kalojira, Kalabhat, Chinigura, and Kalo Nunia. The yearbook of Agricultural Statistics-2023 shows a yield production comparison between local variety and HYRV (BBS, 2024). The yield estimates of Aus rice presented in the Yearbook 2021 reveal a significant difference in productivity between local and High Yielding Varieties (HYV) over the two consecutive agricultural years (2019–2020 and 2020–2021). During 2019–2020, the yield rate of local Aus varieties was 14.92 maunds per acre (equivalent to 1.376 metric tons per hectare), while HYV recorded a substantially higher yield of 25.99 maunds per acre (2.397 metric tons per hectare). In the following year (2020–2021), the yield of local varieties declined to 13.20 maunds per acre (1.218 metric tons per hectare), whereas HYV yields increased remarkably to 32.22 maunds per acre (2.972 metric tons per hectare). This variation reflects the improved genetic potential and adaptive performance of HYV rice, which benefits from modern breeding techniques, better nutrient uptake efficiency, and higher resistance to abiotic stress compared to traditional local cultivars. The decline in yield of local Aus varieties may be attributed to their susceptibility to adverse climatic conditions, pest infestation, or the limited use of modern agronomic inputs. Conversely, the steady increase in HYV yield demonstrates successful adoption of high-yield cultivars, possibly facilitated by favourable weather conditions, timely input supply, and improved management practices during 2020–2021.

Table 4: Estimates of Yield Rates by Type of Aus Crop (Local & HYV)

Variety	2019-2020		2020-2021	
	Yield per acre (Maund)	Yield per hectare (M.Ton)	Yield per acre (Maund)	Yield per hectare (M.Ton)
Local	14.92	1.376	13.20	1.218
HYV	25.99	2.397	32.22	2.972

According to the Yearbook 2021, the yield rates of Aman rice exhibit notable differences between Local Transplanted (L.T.) and High Yielding Varieties (HYV) across the two consecutive years. In 2019–2020, the yield of local Aman was 12.39 maunds per acre (1.143 metric tons per hectare), while HYV Aman recorded a substantially higher yield of 30.91 maunds per acre (2.851 metric tons per hectare). In 2020–2021, local Aman yield increased slightly to 13.19 maunds per acre (1.216 metric tons per hectare), whereas HYV yield declined marginally to 29.46 maunds per acre (2.717 metric tons per hectare). This pattern indicates that while the productivity of local varieties showed slight improvement, HYV Aman maintained a clear advantage, producing more than double the yield of local cultivars. The increase in local yield may be linked to better field management, improved seed selection, or favorable monsoon conditions. On the other hand, the small reduction in HYV yield could result from environmental factors such as irregular rainfall, flood exposure, or pest and disease stress during the growing period.

Despite year-to-year fluctuations, HYV Aman consistently demonstrates higher yield potential due to its improved genetic traits, efficient nutrient use, and responsiveness to fertilizer and irrigation. These findings highlight the continuing importance of HYV adoption in enhancing rice productivity and ensuring national food security under Bangladesh's monsoon-dependent agricultural system.

Table 5: Estimates of Yield Rates by Type of Aman Crop (Local & HYV)

Variety	2019-2020		2020-2021	
	Yield per	Yield per	Yield per	Yield per

	acre (Maund)	hectare (M.Ton)	acre (Maund)	hectare (M.Ton)
Local Transplant (L.T.)	12.39	1.143	13.19	1.216
High Yielding Variety (HYV)	30.91	2.851	29.46	2.717

According to the Yearbook 2021, the yield rates of Boro rice show a clear distinction between Local and High Yielding Varieties (HYV) across the two agricultural years. In 2019–2020, the yield of local Boro rice was 23.16 maunds per acre (2.136 metric tons per hectare), while HYV Boro recorded a significantly higher yield of 34.62 maunds per acre (3.193 metric tons per hectare). In 2020–2021, local Boro yield declined to 19.82 maunds per acre (1.828 metric tons per hectare), whereas HYV Boro yield increased remarkably to 41.23 maunds per acre (3.80 metric tons per hectare). This contrasting trend suggests that local Boro varieties may have been more affected by environmental stresses or reduced input use, while HYV varieties performed better, likely due to their enhanced tolerance, higher responsiveness to fertilizer, and adoption of improved irrigation and cultivation practices. The strong upward trend in HYV yield reflects technological advancement and farmers' increasing reliance on modern rice varieties to achieve greater productivity.

Table 6: Estimates of Yield Rates by Type of Boro Crop (Local & HYV)

Variety	2019-2020		2020-2021	
	Yield per acre (Maund)	Yield per hectare (M.Ton)	Yield per acre (Maund)	Yield per hectare (M.Ton)
Local	23.16	2.136	19.82	1.828
High Yielding Variety (HYV)	34.62	3.193	41.23	3.80

1.7 Patuakhali Climate Summary

Patuakhali district, located in the southern coastal belt of Bangladesh, has been experiencing notable climatic variations over the past several years. These changes have significantly influenced the region's agricultural systems, particularly rice production. According to Amir et al. (2013), several indicators reflect the ongoing impacts of climate change in the area.

Table 7: climate change indicator

Indicators of climate change	Percentage
Temperature rising	30
Low rainfall	30
Shifting season	10
Frequent occurrences of natural hazards	30
Increase the level of a tidal wave	0
Others	0

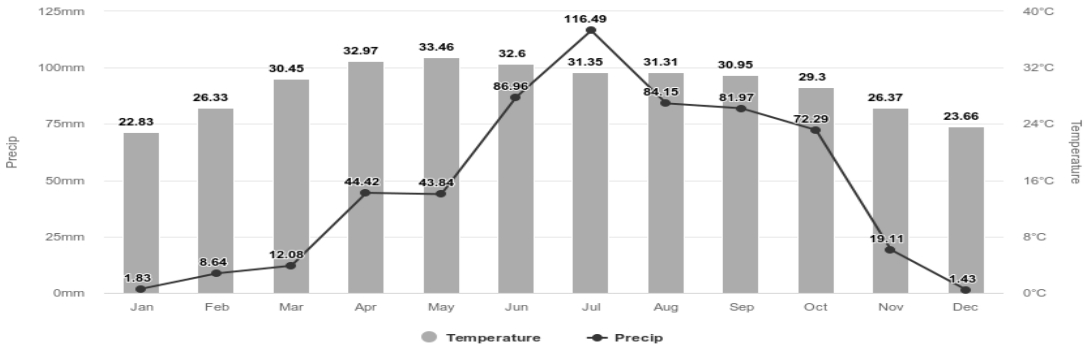

Figure 8: Average Temperature and Precipitation in Patuakhali (2015-2020) *(source-BMD)*

The data clearly indicate that rising temperature, irregular rainfall, and frequent natural hazards are the dominant climate change factors in Patuakhali. These climatic stresses have profound implications for livelihoods, socio-economic stability, and particularly for rice cultivation patterns. To understand the agricultural implications more clearly, an analysis of the annual mean temperature and precipitation trends in Patuakhali between 2015 and 2020 was conducted (BMD, 2020). The figure shows that rainfall peaks between June and October, while December and January receive the least precipitation. Given that the Aus and Boro cultivation seasons occur primarily from January to May and November to December, respectively, these dry periods necessitate supplementary irrigation. Therefore, the adoption of water-resilient HYV rice is critical to sustaining crop productivity during the dry months.

1.8 Climate-Resilient HYV Assessment

According to the Bangladesh Rice Research Institute (BRRI), several High-Yielding Varieties (HYV) have demonstrated strong adaptability to the climatic conditions of southern Bangladesh, including Patuakhali. Wet season varieties: BRRI dhan54 was identified as the most suitable genotype with wide adaptability, followed by BRRI dhan40 and BRRI dhan53. Dry season varieties: BRRI dhan47 was recognized as the most stable, followed by BRRI dhan61 and BINA dhan8.
Climate-tolerant categories:

- Salt-tolerant: BRRI dhan47, 53, 54, 55, 61; BINA dhan8 and 10
- Submergence-tolerant: BRRI dhan51, 52; BINA dhan11, 12
- Drought-tolerant: BRRI dhan56, 57

Participatory varietal selection by farmers revealed that BRRI dhan53 was the most preferred wet-season variety due to its short duration and desirable grain quality, followed by BRRI dhan54 and BRRI dhan40. In the dry season, BRRI dhan47 was most popular, followed by BRRI dhan61. The ranking aligned with yield performance, confirming that modern varieties outperform traditional ones in both productivity and farmer acceptance. Hence, these HYVs should be prioritized for large-scale seed production and dissemination to enhance climate resilience in the Patuakhali region.

1.9 Farmers Perceptions

A household survey involving 50 farmers was conducted to assess their awareness of climate change and High-Yielding Varieties (HYV). Results showed that awareness of climate change remains relatively low, particularly among older farmers, while knowledge of HYV varieties is comparatively higher.

Table 8: Farmers' perceptions on climate change and HYV

Age Group	Percentage of Aware Farmers of Climate Change	Percentage of Aware Farmers who know about HYV
60+	2%	60%
35-45	10%	70%

It's impressive that, while only a small proportion of farmers recognized climate change as a significant issue, a larger number were familiar with HYV rice cultivation. This suggests that while scientific understanding of climate change is limited, practical knowledge related to improved rice varieties is spreading more effectively, possibly through agricultural extension programs or peer-to-peer learning. Further exploration of these perceptions and practices is discussed in the limitations section.

1.10 Policy Implications

The study highlights the need for targeted policies to enhance climate-resilient rice production in coastal Bangladesh. Large-scale promotion and dissemination of high-yielding, stress-tolerant rice varieties such as BR20, BRRI dhan48, Janakraj, and Hira through seed support, demonstration plots, and extension services can substantially increase productivity. Complementary climate-smart agricultural practices, including efficient irrigation, salinity management, and short-duration cropping systems, should be integrated into local farming. Strengthening farmer awareness and providing practical training on HYV cultivation and adaptive management can bridge knowledge gaps, while continued

research and monitoring of varietal performance and climate impacts will ensure informed policy decisions. Collectively, these measures can improve yields, reduce vulnerability to climate variability, and support sustainable livelihoods in Patuakhali and other coastal districts.

CONCLUSION

The findings of this study highlight the significant potential of high-yielding rice cultivars (HYVs) for achieving climate-resilient agriculture in Patuakhali District, Bangladesh. The analysis of yield data from 2016 to 2022 demonstrated that HYVs consistently outperformed local varieties across all three rice-growing seasons, confirming their superior adaptability and productivity under coastal climatic conditions. In the Aus season, varieties such as BR20, BRRI dhan48, BRRI dhan65, and BR26 recorded mean yields ranging from 3.86 to 4.16 t/ha with low variability (SD 0.37–0.63), indicating stable performance. During the Aman season, BR20, BR2, BRRI dhan42, and BRRI dhan82 achieved yields between 3.99 and 4.12 t/ha (SD 0.36–0.40), maintaining consistent productivity even under monsoon variability. The Boro season showed the highest yield performance, with Janakraj (7.86 t/ha, SD 0.42), Hira (7.14 t/ha, SD 0.45), BRRI dhan89 (6.04 t/ha, SD 0.19), and ACI (6.13 t/ha, SD 0.51) demonstrating excellent results under irrigation-supported conditions. In contrast, traditional local rice varieties produced only 1.2–2.1 t/ha, nearly half the yield of HYVs (2.4–3.8 t/ha). Climate data analysis identified rising temperature (30%), low rainfall (30%), and frequent natural hazards (30%) as the main stressors affecting rice cultivation in Patuakhali. Despite these challenges, the high and stable yields of HYVs confirm their suitability for coping with climatic variability and resource limitations in coastal ecosystems. Farmer perception data revealed a limited understanding of climate change, with only 2% of farmers aged 60+ and 10% aged 35–45 aware of it. However, knowledge about HYVs was considerably higher—60% among older farmers and 70% among middle-aged farmers—indicating a growing acceptance of improved rice varieties despite limited climate literacy. These results clearly demonstrate that HYVs such as BR20, BRRI dhan48, Janakraj, and Hira possess strong yield stability, stress tolerance, and adaptability to the changing coastal climate. Wider adoption of these varieties, supported by farmer training and climate-smart agricultural policies, can play a pivotal role in enhancing rice productivity, food security, and climate resilience in the coastal districts of Bangladesh, particularly in Patuakhali.

ACKNOWLEDGEMENT

The authors would like to express their profound gratitude to all those who participated in the study.

DECLARATION OF USE OF AI

The authors acknowledge the use of generative AI tools, specifically ChatGPT and DeepL, for the sole purpose of improving the language, clarity, and readability of the manuscript. These tools were not used to generate ideas, conduct data analysis, interpret findings, or contribute to the scientific content of the study. All intellectual work, including data collection, analysis, and formulation of conclusions, was performed independently by the authors. All AI-assisted outputs were carefully reviewed, corrected, and verified to ensure accuracy and compliance with academic standards.

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