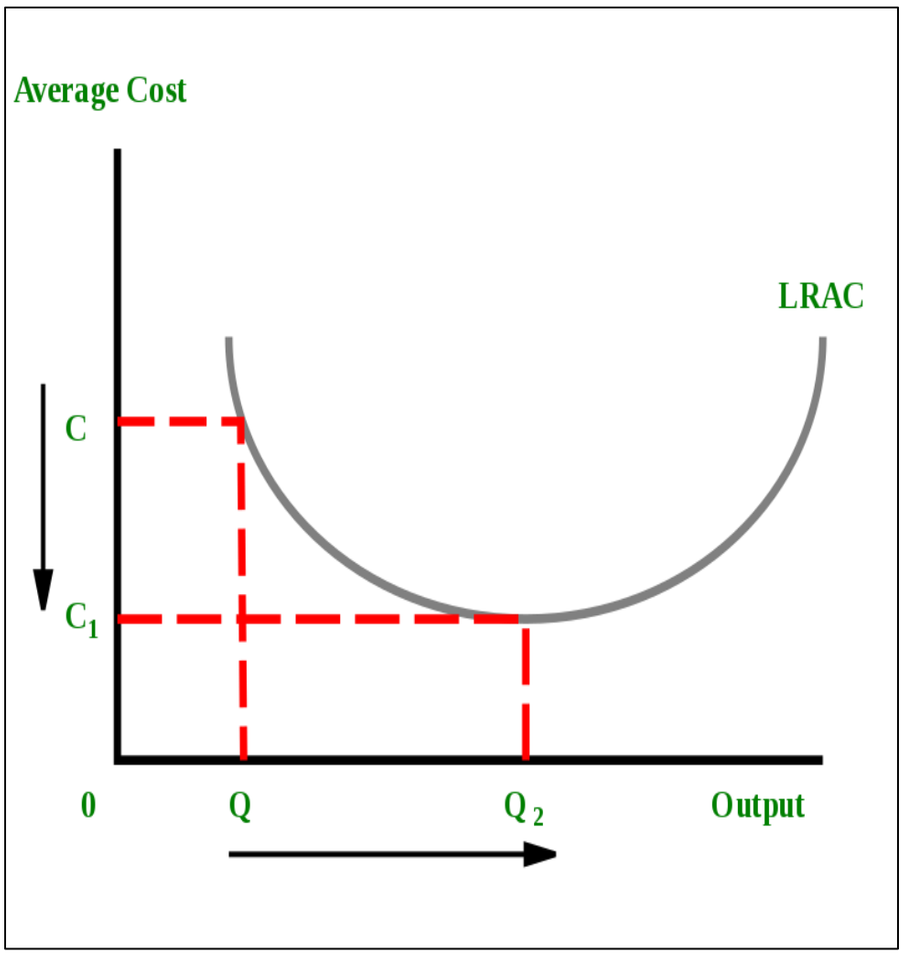
ANNUAL RESEARCH REVIEW WORKSHOP

2022-2023



Economies of scale

XV. AGRICULTURAL ECONOMICS DIVISION

Bangladesh Rice Research Institute (BRRI)
Gazipur-1701

AGRICULTURAL ECONOMICS DIVISION

Personnel

Md. Saiful Islam, MS	Chief Scientific Officer and Head
Mohammad Ariful Islam, PhD	Principal Scientific Officer
Md. Imran Omar, MS*	Senior Scientific Officer
Md. Abdur Rouf Sarkar, MS*	Senior Scientific Officer
Mohammad Chhiddikur Rahman, PhD	Senior Scientific Officer
Afroza Chowdhury, MS	Senior Scientific Officer
Md. Shajedur Rahaman, MS	Senior Scientific Officer
Limon Deb, MS	Senior Scientific Officer
S. M. Mehedy Hasan Noman, MS	Scientific Officer
Saida Akter Jui, MS	Scientific Officer
Md. Enamul Haque, MS	Scientific Officer (TRB project)
Most. Nopur Akter	LDA cum Typist

*Deputed to Higher Studies

CONTENTS

SUMMARY

The adoption of modern varieties were 94.23, 90.50, and 99.67% in Aus, T. Aman, and Boro seasons, of which coverage of BRRI released varieties was about 72.59, 57.24, and 60.93%, respectively. BRRI dhan48 ranked the top position (49.97%) in the Aus season in terms of area coverage, followed by BRRI dhan28 (4.78%). The coverage of Indian varieties in the T. Aman season was about 19.78%, which was 20.11% in 2021-22. BRRI dhan28 and BRRI dhan29 were still the most dominant varieties in the Boro season, covering 26.49% of areas. However, both the varieties accounted for 41.25% of areas in 2021-22. BRRI dhan75 produced the highest yield (4.94 ton/ha) in the Aus season whereas, in T. Aman and Boro seasons, it was BR2 (5.82 ton/ha) and BRRI dhan92 (6.66 ton/ha), respectively. BRRI hybrid dhan1 yielded the highest which was 7.91 ton/ha whereas the average hybrids' yield was 7.39 ton/ha in the Boro season.

Bangladesh is vulnerable to climate change and its agriculture is susceptible to climate-induced disasters, particularly drought. This study was conducted to assess the adoption, profitability, and influencing factors of drought-tolerant rice varieties in drought-prone areas of Bangladesh. The overall adoption rate of drought-tolerant rice cultivars is relatively low (23.69%), but it varies across different regions. Swarna and BRRI dhan51 is the most popular drought-tolerant rice varieties in the study area. The adoption of drought-tolerant rice varieties is more pronounced in Chapainawabganj than in Rajshahi. The profitability analysis shows that planting drought tolerant rice cultivars is more profitable than planting other rice cultivars. The econometric model results indicate that education, land size, training, extension service, participation in field demonstration, membership in any agricultural organization, severity of drought, and total varieties cultivated had a statistically significant effect on the adoption of drought-tolerant rice cultivars. The study suggests that the government should provide subsidies to farmers, conduct awareness campaigns, make drought-tolerant rice varieties more available, and support research and development of new drought-tolerant rice varieties.

The adoption of BRRI dhan87 in Bangladesh has shown promise but faces challenges, particularly in terms of decreased adoption rates over successive years. However, the potential for this variety, characterized by a shorter field duration, higher yield potential, and improved grain and straw quality, remains significant. Farmers also appreciate its medium, slender grain quality with high amylose content, making it a favored choice for consumption. Despite its advantages, several factors have contributed to the decline in adoption rates. Farmers have reported issues related to the alignment of BRRI dhan87 with their preferred cropping patterns and its longer growth duration compared to other short duration varieties. In Sylhet region, this variety got severly affected by Tungro disease which indicates the susceptability of this variety to this disease. Lack of market acceptance because of its' low adoption as a new variety and comparatively coarse grain were also reported as constraints of higher adoption of BRRI dhan87. Additionally, concerns about false smut infestations have affected production. Availability of seeds has also been a challenge, with some farmers unable to obtain BRRI dhan87 seeds from local sources.

Per hectare total variable cost of Boro rice and T. Aman rice cultivation were higher than in T. Aus season. Per hectare gross margin of rice cultivation in Boro season (Tk. 71648) was higher followed by Aman (Tk. 71335) and Aus season (Tk. 48987). BCR based on cash cost was the highest (1.29) in Aman season, followed by 1.18 and 1.13 in Boro and Aus, respectively. Gross profit ratios are 39, 46 and 36 for Aus, Aman and Boro, respectively. A high-profit ratio is an indication that the farmers are selling their produce at a high profit level.

Haor regions are given special attention by the Government for its extreme vulnerability and ample scope. Farmers in haor areas have reduced total cost of paddy cultivation by Tk 15807.04/ha through using combine harvesters rather than conventional manual harvesting. Net return and BCR of paddy cultivation reached to Tk 23610.53/ha and 1.20, respectively for using combine harvester whereas it was only Tk 11686.36/ha and 1.09, respectively in case of conventional harvesting process. On the other hand, investing in combine harvesters has been appeared as very successful ventures in the study area because of highly positive net present worth (Tk. 822663.50) and high internal rate of return

(58.39%). Owners of combine harvesters are enjoying higher net return as the BCR for them was estimated at 1.51 in the study areas. High rental charge, insufficient investment in farm machineries and lack of suitable harvesters for low land were reported as major challenges in the study areas. There is a dearth of detailed investigation about fixation of a justified rental price for combined harvesters to spread out the economic benefit to a large number of user farmers fostering better welfare for the community.

Two-period panel data were used and collected from the International Food Policy Research Institute (IFPRI). IFPRI conducted two nationwide surveys covering 6,500 nationally representative sample rural households in Bangladesh in 2011 and 2015. Out of 6,500 rural households, we selected 3,180 rural households in each period in 2011 (base) and 2015 (follow-up) periods for achieving the goal of the study. Poisson two-way fixed effect model with the Mundlak approach was used to remove the heterogeneity problem. Nutrition security was significantly increased due to the reduction of the poverty gap among households over the periods in different divisions. Agricultural diversity score was also significantly influenced to increase nutrition security. In Bangladesh, presently one of the top policy priorities is to improve food and nutrition security. The poverty gap (increased consumption among poor people up to the poverty line) reduction highly contributed to increasing nutrition security through increasing income.

Assessing the livelihood vulnerability to flood hazards among the households of Kurigram and Jamalpur districts of Bangladesh shows that Kurigram is more vulnerable than Jamalpur. However, considering the adaptive capacity, LVI-IPCC values show that Jamalpur is more vulnerable than Kurigram. The findings of this study would help to identify the causes of household vulnerability in the study areas and plan for drawing policy options for suitable adaptation to reduce vulnerability.

The daily average consumption of rice, vegetables, and milk among the *Garo* tribe respondents exceeded the national average. The assessment of calorie intake within households revealed that approximately 42% of the studied households were classified as non-poor, while the remaining 52% were categorized as ultra-poor, hardcore poor, or absolute poor. When evaluating food consumption scores, 53% of the respondents demonstrated acceptable high consumption, while others fell into categories such as poor consumption, borderline consumption, and acceptable low consumption. Regarding financial aspects, out of a yearly total expenditure of 161,986 taka, a significant portion, equivalent to 56% (or 90,810 taka), was allocated to food expenditures.

PROGRAM AREA I: RURAL INSTITUTION & ECONOMIC CONSEQUENCES

STUDY 1: FARM LEVEL ADOPTION AND EVALUATION OF MODERN RICE CULTIVATION IN BANGLADESH

MS Islam, MA Islam, MC Rahman, A Chowdhury, MS Rahaman, L Deb, SMMH Noman and SA Jui

Introduction

Rice is the staple food in Bangladesh, which provides about 55 and 75% of the total protein and calories of the daily human diet (Siddique et al., 2016). About 75% of the total cropped area is devoted to rice cultivation in the country (BBS 2022). Bangladesh Rice Research Institute has developed 115 high-yielding modern varieties (MVs) along with 8 hybrids for different production environments, which contributed to attaining rice self-sufficiency in Bangladesh. The adoption rate of the cultivated modern varieties (MVs) differs substantially in different regions and seasons in Bangladesh. The study has been designed to verify the adoption status and performance of different rice varieties with the following specific objectives;

- determine the region-wise adoption rate of rice varieties in different seasons; and
- assess the yield of diverse rice varieties in different regions and seasons.

Methodology

Secondary data have been collected from 14 agricultural regions of Bangladesh. Data were collected in three seasons namely, Aus, T. Aman, and Boro. Rice varietal adoption data of 64 districts during 2022-23 directly collected from the Additional Director's (AD) office of the Department of Agricultural Extension (DAE) (see Figure 1 for details). Finally, data were compiled and analyzed using descriptive statistics.

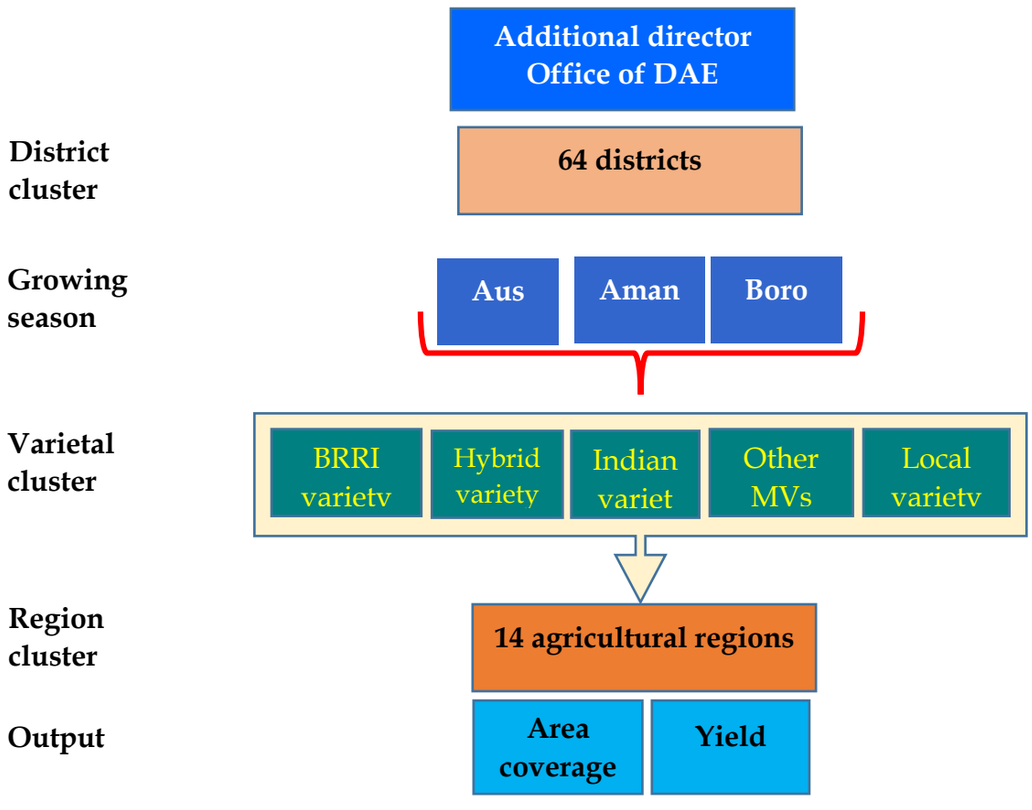


Figure 1. Methodology of the stud

Results and discussion

Aus season

The adoption of modern varieties (MVs) in Aus season was about 94.23%, which was recorded as 93.27% in 2021-22. Adoption of BRRI varieties was 72.59%, which was lower than 2021-22 (74.48%) due to increase in Indian and hybrid rice areas. The highest adoption (95.99%) of BRRI varieties was observed in the Mymensingh (R10) region, while the lowest (20.63%) was recorded in the Rangamati region (R12). Among all BRRI varieties, BRRI dhan48 ranked in the top position (49.97%) regarding area coverage, followed by BRRI dhan28 (4.78%). Other MVs, Indian, and hybrids coverage in the Aus season were about 6.41, 6.50, and 6.05%, respectively. Results also revealed that area coverage of traditional varieties was about 5.77% in Aus season (Table 1).

T. Aman season

The adoption of modern varieties (MVs) in T. Aman season was about 90.50%, which was recorded as 88.02 % in 2021-22 (Table 2). Adoption of BRRI varieties was 57.24%, which was higher than 2021-22 (55.18%). Although adoption of BRRI varieties seemed low, it was substantially higher in some regions like Cumilla (R4), Sylhet (R14), and Dhaka (R5), where BRRI varieties covered 87.25, 81.88, and 80.34%, respectively. BRRI dhan49 covered the highest area in T. Aman season covering 13.64% of the total area. Area coverage of BRRI dhan49 in some regions like Dhaka (R5) (38.56%), Mymensingh (R10) (29.81%), and Sylhet (R14) (27.47%) were remarkable. However, the coverage of BR22 was about 3.81% of the total T. Aman areas. Adoption of this variety is decreasing but still popular in Cumilla (R4) (28.32%) and Sylhet (R14) (12.02%) regions. Adoption of BRRI dhan34 was only 3.14% of the total T. Aman areas. However, this variety occupied a comparatively larger area in Dinajpur (R6) (19.09%), Rajshahi (R11) (5.39%), and Mymensingh (R10) (3.50%) regions. Covedrage of BRRI dhan75 was only 3.76% of the total T. Aman areas. On average, Indian varieties covered 19.78% of areas in T. Aman season. Notably, the adoption of Indian varieties in border regions like Jashore, Dinajpur, Bogura, and Rajshahi was relatively high (36 to 51% of total areas). In comparison, the area coverage of local rice varieties in the Aman season was 9.50%. This local rice varieties adoption decreased from the previous year (11.98%).

Boro season

The adoption of modern rice varieties (MVs) in 2022-23 was 99.67% of total Boro areas, of which 60.93% of areas was covered by BRRI varieties. BRRI dhan28 and BRRI dhan29 were the mega varieties in this season. The area coverage of the two varieties was about 26.49% in 2022-23, whereas those two varieties' adoption was about 41.25% in the year 2021-22. The adoption of those two varieties has been decreasing gradually due to disease (Blast) susceptibility. Besides, the adoption of recently released BRRI dhan89 was notable in the regions of Dhaka (16.75%), Cumilla (11.93%), Mymensingh (10.89%), and Dinajpur (10.63% of total areas). On the other hand, the overall adoption of hybrid and Indian varieties were about 27.97 and 6.59%, respectively (Table 3). Again, significant adoption (21.79%) was recorded for BRRI dhan74 in the Barishal region, while the coverage of this variety was around 5% for other regions.

Table 1. Adoption (%) of different Aus rice varieties by agricultural regions of Bangladesh, 2022-23

Variety name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	BD
BRRI varieties	**65.16**	**71.00**	**80.11**	**87.49**	**94.14**	**69.02**	**57.79**	**65.36**	**55.86**	**95.99**	**67.43**	**20.63**	**70.94**	**89.79**	**72.59**
BR1	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00
BR2	1.87	0.00	0.00	2.43	0.04	0.00	0.00	0.00	2.16	0.00	0.00	0.00	0.00	0.00	0.58
BR3	0.21	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.23	0.07
BR9	0.00	0.00	0.22	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
BR10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.01
BR12	0.52	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
BR14	0.26	0.03	0.18	0.00	0.08	0.00	0.00	0.00	0.60	0.21	0.00	0.00	1.92	1.05	0.30
BR16	0.09	0.00	0.26	0.93	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.13
BR20	0.00	0.00	0.31	4.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.07	0.49
BR21	0.47	1.72	0.27	0.01	0.03	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.00	0.91	0.58
BR24	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.04	0.04
BR25	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BR26	1.99	1.66	1.53	2.48	2.09	0.06	1.30	1.24	3.36	5.13	0.28	0.64	0.86	5.02	1.87
BRRI dhan27	7.73	0.34	6.30	0.69	0.00	0.00	1.37	0.07	2.55	0.00	0.00	0.02	0.00	0.29	2.16
BRRI dhan28	0.07	10.39	1.20	6.70	4.23	31.05	0.27	1.36	3.78	2.45	6.20	0.00	9.85	7.26	4.78
BRRI dhan29	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.04
BRRI dhan30	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
BRRI dhan33	0.00	0.11	0.59	0.00	0.02	0.00	0.59	0.04	0.00	0.00	0.00	0.30	0.00	0.00	0.10
BRRI dhan42	0.76	1.50	1.46	1.69	0.00	0.17	2.31	0.04	0.00	0.00	0.03	0.45	1.54	0.85	0.76
BRRI dhan43	0.86	0.00	1.36	1.84	0.00	0.36	5.49	0.04	0.00	0.00	0.00	0.00	0.61	0.97	0.75
BRRI dhan44	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.03
BRRI dhan48	46.65	47.54	46.47	50.65	75.80	31.23	34.10	54.27	35.39	80.95	49.48	14.26	49.42	59.90	49.97
BRRI dhan50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.06
BRRI dhan55	1.16	2.04	11.61	1.98	0.70	0.23	2.09	1.65	5.39	0.50	1.13	1.35	0.31	3.25	2.66
BRRI dhan56	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.00	0.24	0.00	0.20
BRRI dhan58	0.00	0.00	0.00	1.11	0.27	1.09	0.00	0.69	0.00	0.00	0.00	0.00	0.56	0.00	0.27
BRRI dhan65	0.15	1.02	0.43	0.74	0.12	0.00	2.22	0.07	0.04	0.00	0.84	0.15	0.21	0.15	0.40
BRRI dhan74	0.00	0.00	0.00	0.44	0.00	1.00	0.00	0.82	0.00	0.00	0.02	0.10	0.83	0.00	0.23
BRRI dhan75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.38	0.00	0.00	0.00	0.48
BRRI dhan81	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
BRRI dhan82	1.47	2.48	1.55	2.34	3.49	2.35	3.28	2.77	0.98	2.34	1.00	1.23	2.24	4.18	2.17
BRRI dhan83	0.32	0.07	1.00	0.31	1.63	0.24	2.33	0.07	0.40	0.00	0.00	0.70	0.00	0.62	0.41
BRRI dhan85	0.55	1.20	4.77	8.00	5.48	1.20	1.88	1.65	1.20	4.27	1.53	0.94	1.54	4.89	2.81
BRRI dhan88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan98	0.03	0.19	0.06	0.11	0.12	0.00	0.00	0.08	0.01	0.15	0.00	0.13	0.00	0.08	0.06
BRRI dhan100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.003	0.00	0.00	0.00	0.00	0.00	0.00	0.0005
BINA varieties	**1.19**	**3.07**	**0.25**	**1.07**	**1.72**	**1.09**	**3.19**	**4.01**	**1.79**	**3.19**	**1.66**	**0.82**	**2.82**	**9.81**	**2.69**
Bina dhan-19	1.15	2.33	0.23	1.00	1.63	0.94	3.09	3.46	1.79	2.96	1.15	0.70	2.65	6.95	2.18
All Hybrid	**0.10**	**1.90**	**5.13**	**10.22**	**1.97**	**29.15**	**0.07**	**7.15**	**8.47**	**0.52**	**4.73**	**7.16**	**25.88**	**0.18**	**6.05**
Indian varieties	**1.71**	**13.94**	**0.00**	**0.02**	**0.00**	**0.02**	**0.00**	**19.63**	**7.91**	**0.00**	**19.67**	**0.00**	**0.00**	**0.00**	**6.50**
Other MVs	**26.58**	**1.46**	**5.26**	**1.00**	**0.03**	**0.64**	**2.72**	**3.17**	**0.13**	**0.00**	**5.07**	**0.00**	**0.35**	**0.02**	**6.41**
Gota IRRI	18.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12
MVs	**94.75**	**91.37**	**90.76**	**99.80**	**97.86**	**99.91**	**63.77**	**99.33**	**74.16**	**99.70**	**98.55**	**28.61**	**100.00**	**99.81**	**94.23**
LVs	**5.25**	**8.63**	**9.24**	**0.20**	**2.14**	**0.09**	**36.23**	**0.67**	**25.84**	**0.30**	**1.45**	**71.39**	**0.00**	**0.19**	**5.77**
Grand Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Note: R = Region, R1= Barishal, R2= Bogura, R3=Chattogram, R4= Cumilla, R5= Dhaka, R6= Dinajpur, R7= Faridpur, R8= Jashore, R9=Khulna, R10= Mymensingh, R11= Rajshahi, R12= Rangamati, R13= Rangpur, R14= Sylhet and BD=Bangladesh,
Source: DAE 2022-23.

Districts covered by the regions

Region 1 (Barishal): Barishal, Barguna, Bhola, Jhalokhati, Patuakhali, and Pirojpur;
Region 2 (Bogura): Bogura, Joypurhat,Pabna and Sirajganj;
Region 3 (Chattogram): Chattogram, Cox's Bazar, Feni, Laxmipur and Noakhali;
Region 4 (Cumilla): Cumilla, B.Baria, and Chandpur;
Region 5 (Dhaka): Dhaka, Gazipur, Kishoreganj, Manikganj, Munshiganj, Narshingdi, Narayanganj, and Tangail;
Region 6 (Dinajpur): Dinajpur, Panchagarh and Thakurgaon;
Region 7 (Faridpur): Faridpur, Gopalganj, Madaripur Rajbari and Shariotpur;
Region 8 (Jashore): Kushtia, Chuadanga, Jashore, Jhenaidah, Meherpur, and Magura;
Region 9 (Khulna): Khulna, Bagerhat, Narail and Satkhira;
Region 10 (Mymensingh): Mymensingh, Jamalpur, Netrakona and Sherpur;

Region 11 (Rajshahi): Rajshahi, C.Nawabganj, Naogaon, and Natore;
Region 12 (Rangamati): Rangamati, Bandarban and Khagrachari;
Region 13 (Rangpur): Rangpur, Gaibandha Kurigram, Lalmonirhat, and Nilphamari;
Region 14 (Sylhet): Sylhet, Habiganj, Moulvibazar and Sunamganj.

Table 2. Adoption (%) of different T. Aman rice varieties by agricultural regions of Bangladesh, 2022-23

Variety name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	BD
BRRI Varieties	**63.08**	**44.82**	**66.03**	**87.25**	**80.34**	**35.88**	**62.22**	**52.61**	**66.36**	**58.49**	**40.43**	**66.91**	**38.62**	**81.88**	**57.24**
BR2	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BR3	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BR4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
BR10	0.05	0.00	0.20	0.56	0.00	0.00	0.00	0.14	12.88	0.00	0.00	0.50	0.00	0.78	0.78
BR11	**11.00**	**1.17**	**3.26**	**0.97**	**1.41**	**0.17**	**0.36**	**0.25**	**3.69**	**1.47**	**0.01**	**10.85**	**8.02**	**7.03**	**3.62**
BR22	**5.45**	**1.57**	**6.76**	**28.32**	**7.63**	**0.00**	**0.03**	**0.00**	**0.64**	**0.00**	**0.00**	**1.67**	**0.54**	**12.02**	**3.81**
BR23	13.11	0.27	5.48	5.73	0.57	0.00	0.03	0.08	12.70	0.73	0.00	0.29	0.17	5.01	3.35
BR25	0.01	0.00	0.00	0.28	5.26	0.00	0.00	0.00	0.00	0.20	0.00	1.81	0.00	0.00	0.32
BR26	0.00	0.03	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
BRRI dhan28	0.00	0.09	0.00	0.18	0.06	0.00	0.00	0.00	0.00	0.09	0.05	0.00	0.48	0.00	0.08
BRRI dhan29	0.00	0.02	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.03
BRRI dhan30	0.07	0.00	0.06	0.00	0.06	0.00	0.00	0.22	3.80	0.00	0.04	0.06	0.00	0.08	0.24
BRRI dhan31	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan32	0.11	0.22	0.92	5.52	1.22	0.00	0.00	0.00	0.00	3.63	0.00	0.63	0.03	3.04	1.01
BRRI dhan33	0.04	1.02	1.27	0.01	0.05	0.00	4.75	1.77	0.52	0.11	0.30	3.83	0.41	0.17	0.65
BRRI dhan34	**0.15**	**3.24**	**0.01**	**0.90**	**0.90**	**19.09**	**0.16**	**0.18**	**0.12**	**3.50**	**5.39**	**0.22**	**1.59**	**1.49**	**3.14**
BRRI dhan36	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
BRRI dhan37	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan39	0.01	2.62	0.74	0.56	0.35	0.00	12.85	1.84	2.36	1.00	0.97	5.25	0.28	1.37	1.33
BRRI dhan40	1.11	0.01	2.72	0.00	0.00	0.00	0.02	0.00	0.00	0.04	0.00	1.80	0.00	0.09	0.43
BRRI dhan41	1.33	0.01	1.55	0.17	0.04	0.00	0.03	0.00	0.09	0.18	0.00	1.16	0.02	0.46	0.38
BRRI dhan44	1.71	0.13	0.21	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.30	0.24
BRRI dhan46	0.16	0.00	1.05	6.28	0.16	0.00	0.00	0.00	0.00	0.13	0.00	0.76	0.00	1.42	0.49
BRRI dhan47	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan49	**2.86**	**15.34**	**16.74**	**20.29**	**38.56**	**2.54**	**5.50**	**9.19**	**8.97**	**29.81**	**5.81**	**15.86**	**3.21**	**27.47**	**13.64**
BRRI dhan51	**1.07**	**3.92**	**3.00**	**0.65**	**4.64**	**7.65**	**1.82**	**9.83**	**0.72**	**4.31**	**17.11**	**1.85**	**2.64**	**4.76**	**4.97**
BRRI dhan52	**18.04**	**1.81**	**12.07**	**1.25**	**1.46**	**1.13**	**2.64**	**0.62**	**3.82**	**3.93**	**0.19**	**2.28**	**7.96**	**5.15**	**5.57**
BRRI dhan53	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
BRRI dhan54	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
BRRI dhan55	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan56	0.04	0.21	0.00	0.00	0.04	0.05	0.64	0.07	0.01	0.07	0.03	1.16	0.35	0.05	0.11
BRRI dhan57	0.01	0.03	0.01	0.01	0.01	0.02	0.53	0.20	0.00	0.00	0.02	0.56	0.17	0.02	0.07
BRRI dhan58	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
BRRI dhan59	0.05	0.13	0.00	0.02	0.04	0.01	0.26	0.24	0.21	0.12	0.01	0.01	0.00	0.13	0.08
BRRI dhan62	0.05	0.13	0.00	0.02	0.04	0.01	0.26	0.24	0.21	0.12	0.01	0.01	0.09	0.13	0.09
BRRI dhan63	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
BRRI dhan64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
BRRI dhan65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00
BRRI dhan66	0.00	0.00	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
BRRI dhan67	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.01
BRRI dhan70	0.01	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.04	0.00	0.01	0.41	0.04	0.00	0.02
BRRI dhan71	0.16	0.90	0.62	0.21	0.30	0.01	1.03	2.79	0.49	2.99	0.38	2.71	1.51	0.68	1.05
BRRI dhan72	0.42	0.12	1.35	0.24	0.54	0.06	0.92	0.37	0.47	1.13	0.10	0.75	0.20	0.76	0.53
BRRI dhan73	0.23	0.00	0.17	0.02	0.00	0.00	0.00	0.04	0.32	0.00	0.00	0.42	0.01	0.00	0.07
BRRI dhan74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.01	0.03	0.00	0.00	0.00	0.01
BRRI dhan75	**0.32**	**4.25**	**1.31**	**3.74**	**5.10**	**0.99**	**13.47**	**11.56**	**5.44**	**1.95**	**4.10**	**4.25**	**3.24**	**3.06**	**3.76**
BRRI dhan76	2.61	0.09	0.37	0.00	0.00	0.00	0.06	0.00	1.20	0.10	0.00	1.00	0.01	0.06	0.41

Variety name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	BD
BRRI dhan77	0.98	0.00	0.14	0.00	0.00	0.00	0.02	0.00	0.17	0.00	0.00	0.00	0.04	0.00	0.13
BRRI dhan78	0.28	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.08	0.00	0.09
BRRI dhan79	0.02	0.01	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.05	0.03
BRRI dhan80	0.00	0.37	0.86	0.85	1.02	0.14	0.12	0.85	0.84	0.26	0.22	1.41	0.81	0.26	0.49
BRRI dhan81	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan82	0.00	0.00	0.00	0.01	0.00	0.00	0.12	0.01	0.00	0.00	0.00	0.18	0.00	0.02	0.01
BRRI dhan85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan87	**1.32**	**4.48**	**4.48**	**9.36**	**10.29**	**1.31**	**15.72**	**11.76**	**5.76**	**2.47**	**4.77**	**4.66**	**3.75**	**5.20**	**5.14**
BRRI dhan88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan90	0.00	1.41	0.04	0.00	0.17	0.73	0.02	0.11	0.13	0.01	0.00	0.00	0.09	0.11	0.21
BRRI dhan91	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.09	0.01	0.00	0.00	0.09	0.00	0.02
BRRI dhan93	0.01	0.01	0.07	0.25	0.04	1.71	0.00	0.00	0.01	0.00	0.23	0.00	1.16	0.09	0.33
BRRI dhan94	0.00	0.02	0.01	0.35	0.03	0.05	0.00	0.03	0.00	0.00	0.09	0.00	0.62	0.16	0.11
BRRI dhan95	0.01	0.04	0.15	0.40	0.04	0.17	0.00	0.00	0.05	0.02	0.15	0.01	0.66	0.38	0.17
BRRI hybrid dhan2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI hybrid dhan4	0.00	0.06	0.01	0.03	0.05	0.00	0.21	0.04	0.01	0.03	0.00	0.00	0.01	0.03	0.03
BRRI hybrid dhan5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI hybrid dhan6	0.00	0.07	0.00	0.02	0.05	0.01	0.23	0.07	0.10	0.07	0.00	0.00	0.20	0.04	0.06
BRRI hybrid dhan8	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BINA Varieties	**0.50**	**7.83**	**0.62**	**4.59**	**2.42**	**1.28**	**17.19**	**10.07**	**3.34**	**3.88**	**5.24**	**7.02**	**3.23**	**4.80**	**4.19**
Bina dhan-17	0.15	3.86	0.38	1.51	0.78	0.90	8.83	5.09	0.68	0.58	2.97	0.82	1.39	1.49	1.79
Bina dhan-7	0.14	3.52	0.12	2.51	1.36	0.27	6.74	4.15	2.06	2.38	2.14	0.03	1.00	2.31	1.81
All Hybrids	**0.15**	**5.81**	**2.06**	**1.90**	**5.45**	**9.92**	**9.77**	**9.42**	**6.24**	**13.98**	**0.59**	**2.44**	**11.25**	**0.14**	**6.11**
Indian Varieties	**6.19**	**36.84**	**8.62**	**1.33**	**1.92**	**50.89**	**0.39**	**23.95**	**5.32**	**4.16**	**40.69**	**0.74**	**44.38**	**2.83**	**19.78**
Guti swarna	5.94	17.75	0.00	0.28	0.79	33.75	0.39	21.19	3.47	0.58	39.62	0.00	33.63	1.22	13.79
Ranjit	0.00	9.29	0.29	0.24	1.12	1.47	0.00	0.09	0.00	2.40	0.26	0.00	2.33	1.61	1.53
Swarna-5	0.00	6.57	0.00	0.00	0.00	13.72	0.00	0.00	0.00	1.18	0.00	0.00	5.16	0.00	2.40
Other MVs	**1.55**	**2.94**	**9.38**	**0.33**	**0.37**	**1.68**	**0.09**	**3.38**	**0.32**	**5.47**	**6.64**	**18.91**	**0.50**	**0.74**	**3.17**
Pajam	0.00	0.74	6.48	0.22	0.00	0.00	0.00	0.00	0.00	2.12	0.66	5.43	0.03	0.07	1.05
MVs	**71.46**	**98.24**	**86.72**	**95.39**	**90.50**	**99.65**	**89.66**	**99.43**	**81.58**	**85.98**	**93.59**	**96.03**	**97.98**	**90.38**	**90.50**
LVs	**28.54**	**1.76**	**13.28**	**4.61**	**9.50**	**0.35**	**10.34**	**0.57**	**18.42**	**14.02**	**6.41**	**3.97**	**2.02**	**9.62**	**9.50**
Grand Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Note: R = Region, R1= Barishal, R2= Bogura, R3=Chattogram, R4= Cumilla, R5= Dhaka, R6= Dinajpur, R7= Faridpur, R8= Jashore, R9=Khulna, R10= Mymensingh, R11= Rajshahi, R12= Rangamati, R13= Rangpur, R14= Sylhet and BD=Bangladesh
Source: DAE 2022-2023

Table 3. Adoption (%) of different Boro rice varieties by agricultural regions of Bangladesh, 2022-23

Variety name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	BD
BRRI Varieties	**50.15**	**58.78**	**49.30**	**79.20**	**82.05**	**63.77**	**53.85**	**60.58**	**37.84**	**63.98**	**37.87**	**45.76**	**54.19**	**70.28**	**60.93**
BR2	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
BR3	0.07	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.02
BR11	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001
BR12	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.01
BR14	0.00	0.00	0.33	0.00	0.19	0.00	0.00	0.00	0.00	0.06	0.00	0.05	2.70	0.41	0.36
BR16	0.00	0.59	1.26	0.75	0.00	3.84	0.00	0.00	0.00	0.04	0.00	0.39	2.09	0.00	0.60
BR19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.02
BR26	0.00	0.00	0.05	0.01	0.12	0.00	0.00	0.00	0.00	0.83	0.00	0.17	0.00	0.08	0.14
BRRI dhan28	4.34	10.42	7.23	13.32	13.68	9.66	4.59	5.28	11.33	14.01	8.44	7.53	10.89	17.34	11.03
BRRI dhan29	3.65	18.08	4.89	17.83	35.49	23.46	16.41	0.83	0.39	18.66	5.28	3.87	10.05	22.06	15.46
BRRI dhan33	0.00	0.72	0.60	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.50	0.02	0.00	0.11
BRRI dhan36	0.00	1.17	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	1.29	0.05	0.00	0.00	0.21
BRRI dhan39	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.78	0.00	0.00	0.01
BRRI dhan45	0.01	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.01	0.11	0.02
BRRI dhan47	7.12	0.00	0.44	0.02	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.05	0.02	0.00	0.31
BRRI dhan48	0.00	0.00	1.01	1.21	0.00	0.00	0.00	0.13	0.00	0.00	0.03	0.08	0.00	0.36	0.19
BRRI dhan49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.0002
BRRI dhan50	0.19	0.25	0.30	0.37	0.62	0.25	1.24	15.61	1.48	0.11	0.14	0.78	0.33	0.29	1.55
BRRI dhan55	0.12	0.01	0.74	0.01	0.00	0.01	0.22	0.03	0.00	0.00	0.00	0.37	0.03	0.27	0.09
BRRI dhan57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00

Variety name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	BD
BRRI dhan58	0.99	3.16	4.06	7.49	4.50	4.91	6.70	5.58	2.10	5.07	1.50	4.80	5.17	3.92	4.34
BRRI dhan59	0.02	0.02	0.01	0.01	0.00	0.01	0.05	0.02	0.00	0.08	0.00	0.08	0.04	0.00	0.02
BRRI dhan60	0.00	0.01	0.00	0.01	0.00	0.00	0.03	0.02	0.00	0.01	0.00	0.01	0.23	0.00	0.03
BRRI dhan61	0.24	0.08	0.03	0.01	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.03
BRRI dhan62	0.00	0.11	0.13	0.00	0.00	0.01	0.11	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.02
BRRI dhan63	0.01	0.48	0.11	0.71	0.10	0.08	0.69	10.40	1.79	0.13	0.21	0.30	0.20	0.24	1.10
BRRI dhan64	0.61	0.09	0.04	0.04	0.04	0.00	0.11	0.37	0.23	0.13	0.00	0.07	0.02	0.15	0.12
BRRI dhan65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.003
BRRI dhan66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0002
BRRI dhan67	5.17	0.02	4.89	1.00	0.08	0.01	1.41	0.09	8.16	0.69	0.00	1.39	0.01	0.65	1.19
BRRI dhan68	0.09	0.01	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.02	0.03
BRRI dhan69	0.43	0.02	0.01	0.05	0.00	0.01	0.00	0.02	0.00	0.13	0.00	0.26	0.21	0.08	0.07
BRRI dhan71	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.001
BRRI dhan72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.001
BRRI dhan74	21.79	0.57	6.59	4.62	0.43	1.58	4.18	2.85	1.63	1.38	0.27	5.15	6.17	1.18	3.14
BRRI dhan75	0.00	0.00	1.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	1.75	0.04	0.00	0.00	0.19
BRRI dhan76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.01
BRRI dhan79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.001
BRRI dhan80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.001
BRRI dhan81	0.18	3.00	0.25	1.95	0.57	1.63	2.02	7.97	2.54	1.05	4.51	0.52	1.31	0.48	2.04
BRRI dhan82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan84	0.11	0.52	1.35	1.13	0.87	0.29	0.75	0.62	1.76	1.06	0.57	1.30	0.84	1.51	0.91
BRRI dhan86	0.01	0.50	0.34	0.42	0.12	0.02	0.01	0.57	0.61	0.09	0.74	0.41	0.43	0.13	0.31
BRRI dhan87	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan88	0.17	2.78	2.80	7.17	4.33	1.07	1.49	1.69	2.42	7.59	0.69	3.47	2.25	6.17	3.69
BRRI dhan89	3.68	9.12	5.54	11.93	16.75	10.63	8.18	4.77	1.49	10.89	4.31	6.09	7.03	9.57	8.82
BRRI dhan90	0.00	3.59	0.00	0.00	0.00	2.02	0.00	0.00	0.00	0.00	5.95	0.00	0.00	0.01	0.88
BRRI dhan91	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00
BRRI dhan92	0.37	2.56	4.24	6.75	3.14	3.91	4.56	2.18	0.71	1.29	1.77	4.63	3.21	4.46	2.97
BRRI dhan96	0.01	0.19	0.05	1.71	0.23	0.01	0.05	0.21	0.03	0.15	0.02	0.12	0.15	0.30	0.25
BRRI dhan97	0.17	0.00	0.05	0.01	0.00	0.00	0.02	0.00	0.06	0.00	0.00	0.03	0.00	0.00	0.01
BRRI dhan98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0002
BRRI dhan99	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.09	0.00	0.00	0.02
BRRI dhan100	0.0568	0.6030	0.4017	0.4720	0.4605	0.1975	0.5959	1.2703	0.4838	0.3550	0.3274	1.4617	0.4756	0.1060	0.46
BRRI dhan101	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0004
BRRI dhan102	0.0000	0.0000	0.0072	0.0000	0.0000	0.0056	0.0000	0.0000	0.0000	0.0000	0.0019	0.0041	0.0288	0.0000	0.004
BRRI hybrid dhan1	0.05	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.004
BRRI hybrid dhan2	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.01
BRRI hybrid dhan3	0.08	0.01	0.00	0.02	0.04	0.05	0.01	0.03	0.10	0.02	0.00	0.01	0.01	0.05	0.03
BRRI hybrid dhan4	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
BRRI hybrid dhan5	0.11	0.02	0.01	0.00	0.01	0.03	0.01	0.03	0.16	0.01	0.00	0.01	0.10	0.00	0.03
BRRI hybrid dhan6	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
BINA Varieties	**7.37**	**0.38**	**0.93**	**0.42**	**0.18**	**0.04**	**1.39**	**0.56**	**1.90**	**0.16**	**0.16**	**2.83**	**0.27**	**0.84**	**0.77**
Bina dhan-10	4.98	0.01	0.53	0.26	0.13	0.00	0.79	0.27	1.23	0.04	0.00	0.52	0.16	0.42	0.44
Bina dhan-14	0.14	0.05	0.02	0.10	0.03	0.03	0.33	0.26	0.45	0.06	0.02	0.15	0.09	0.31	0.13
All Hybrids	**37.03**	**11.12**	**48.23**	**20.18**	**17.36**	**18.69**	**43.11**	**15.91**	**55.97**	**35.72**	**8.40**	**51.33**	**43.38**	**28.00**	**27.97**
Indian Varieties	**3.55**	**8.50**	**0.00**	**0.00**	**0.00**	**16.03**	**0.00**	**22.79**	**3.04**	**0.00**	**39.08**	**0.00**	**0.31**	**0.00**	**6.59**
Other MVs	**0.62**	**20.57**	**1.41**	**0.16**	**0.00**	**1.47**	**0.36**	**0.16**	**1.24**	**0.06**	**14.48**	**0.00**	**1.60**	**0.04**	**3.40**
MVs	**98.73**	**99.35**	**99.87**	**99.95**	**99.59**	**100.00**	**98.71**	**100.00**	**100.00**	**99.92**	**99.99**	**99.92**	**99.74**	**99.17**	**99.67**
LVs	**1.27**	**0.65**	**0.13**	**0.05**	**0.41**	**0.00**	**1.29**	**0.00**	**0.00**	**0.08**	**0.01**	**0.08**	**0.26**	**0.83**	**0.33**
Grand Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Note: R = Region, R1= Barishal, R2= Bogura, R3=Chattogram, R4= Cumilla, R5= Dhaka, R6= Dinajpur, R7= Faridpur, R8= Jashore, R9=Khulna, R10= Mymensingh, R11= Rajshahi, R12= Rangamati, R13= Rangpur, R14= Sylhet and BD=Bangladesh
Source: DAE 2022-2023

Yield of modern rice varieties

Aus season

In the Aus season, the average yield of BRRI varieties was about 4.08 ton/ha; among them, BRRI dhan75 produced the highest yield (4.94 ton/ha) and BRRI dhan29 and BRRI dhan81 ranked the second and third position with an average yield of 4.65, and 4.63 ton/ha, respectively. Prominent BRRI variety like BRRI dhan48 did not peform well in terms of yield potentiality in all reasons which reduced the average yield. The yield performance of the hybrid varieties was 5.31 ton/ha. Indian varieties yield was 3.95 ton/ha in this season. The average yield of all MVs in the Aus season was 4.47 ton/ha (Table 4).

Table 4. Average yield (t/ha) of different Aus rice varieties by agricultural regions of Bangladesh, 2022-23.

Variety name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	BD
BRRI varieties	**3.84**	**4.06**	**3.99**	**4.30**	**4.06**	**4.45**	**3.77**	**4.57**	**4.08**	**4.03**	**4.68**	**4.13**	**3.79**	**3.72**	**4.08**
BR1		4.18												3.57	3.88
BR2	3.67			4.08	3.18				3.96						3.76
BR3	3.67		3.28									3.58		3.68	3.60
BR9			4.33	4.06											4.15
BR10								4.10							4.10
BR12	4.03		4.25												4.14
BR14	3.74	3.88	3.60		3.13				4.18	3.93			4.03	3.60	3.74
BR16	3.84		3.61	4.13			3.73						3.74		3.78
BR20			4.18	4.19								3.88		3.36	3.96
BR21	4.06	4.19	3.82	4.18	3.73						3.86			3.70	3.92
BR24			3.91									3.88		3.62	3.83
BR25					3.28										3.28
BR26	3.91	3.94	3.85	4.20	3.68	4.48	3.87	4.42	3.84	3.80	4.28	4.14	3.54	3.67	3.92
BRRI dhan27	3.88	4.16	4.01	4.15			3.80	4.63	4.15			3.73		3.76	3.98
BRRI dhan28	3.81	3.69	4.04	4.31	4.15	4.29	3.58	4.29	4.03	3.82	5.03		3.83	3.64	4.08
BRRI dhan29						5.07							4.23		4.65
BRRI dhan30							3.90								3.90
BRRI dhan33		3.97	4.27		3.36		4.27	3.76				4.63			4.13
BRRI dhan42	3.65	3.78	3.99	4.17		3.12	3.81	4.25			3.05	4.40	3.37	3.50	3.77
BRRI dhan43	3.61		3.83	4.17		4.60	3.88	4.04					3.37	3.83	3.83
BRRI dhan44		3.58										3.88			3.73
BRRI dhan48	3.89	4.32	4.18	4.52	4.29	4.43	3.90	4.62	4.10	4.15	5.11	3.88	4.06	4.01	4.24
BRRI dhan50								4.18							4.18
BRRI dhan55	3.86	4.22	4.01	4.68	4.37	4.67	3.20	4.82	4.03	3.69	4.79	4.24	3.41	3.88	4.19
BRRI dhan56	4.18										4.85		4.40		4.48
BRRI dhan58				4.73	4.20	4.49		5.15					3.84		4.54
BRRI dhan65	3.71	3.73	4.00	4.40	3.65		3.29	4.26	3.66		4.59	3.87	3.60	3.47	3.84
BRRI dhan74				4.36		5.15		4.48			4.30	3.73	4.15		4.37
BRRI dhan75											4.94				4.94
BRRI dhan81			4.33		4.48						5.07				4.63
BRRI dhan82	3.81	4.16	4.12	4.10	4.11	4.46	3.77	4.79	4.07	4.22	4.80	4.20	3.91	3.85	4.17
BRRI dhan83	3.84	4.28	3.85	4.39	3.85	4.78	3.59	4.84	4.38			3.95		3.69	4.02
BRRI dhan85	3.96	4.14	4.05	4.40	4.35	4.26	4.05	4.72	4.07	4.09	4.78	4.33	3.83	3.81	4.21
BRRI dhan88								4.09							4.09
BRRI dhan92								3.98							3.98
BRRI dhan98	5.22	4.27	4.42	4.48	4.54			4.87	4.86	4.29	4.64	4.79		3.88	4.58
BRRI dhan100								4.18							4.18
BINA varieties	**3.97**	**3.78**	**4.02**	**4.39**	**4.21**	**4.35**	**3.85**	**4.62**	**4.17**	**4.02**	**4.70**	**3.96**	**3.72**	**3.90**	**4.15**
Bina dhan-19	3.96	3.67	3.99	4.41	4.24	4.39	3.76	4.71	4.17	3.99	4.65	3.99	3.83	3.87	4.12
All Hybrid	**5.13**	**4.49**	**5.68**	**5.48**	**5.28**	**5.34**	**5.02**	**5.52**	**4.94**	**4.40**	**5.95**	**5.14**	**5.25**	**5.25**	**5.31**

Variety name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	BD
Indian Varieties	**3.30**	**3.86**		**4.06**		**3.88**		**4.68**	**3.81**		**4.04**				**3.95**
Other MVs	**3.79**	**3.79**	**3.90**	**3.84**	**4.10**	**4.17**	**3.27**	**4.35**	**3.32**		**4.88**		**3.21**	**4.48**	**3.95**
Gota IRRI	3.63														3.63
MVs	**3.95**	**4.08**	**4.29**	**4.74**	**4.33**	**4.97**	**3.84**	**5.01**	**4.43**	**4.07**	**4.95**	**4.36**	**4.67**	**3.90**	**4.47**
LVs	**2.07**	**2.05**	**2.07**	**2.61**	**1.93**	**2.84**	**1.89**	**1.87**	**1.98**	**1.70**	**2.39**	**1.93**		**1.86**	**2.02**
Grand Total	**3.52**	**3.89**	**3.85**	**4.56**	**4.13**	**4.92**	**3.07**	**4.83**	**3.94**	**3.83**	**4.66**	**3.08**	**4.67**	**3.75**	**4.09**

Note: R = Region, R1= Barishal, R2= Bogura, R3=Chattogram, R4= Cumilla, R5= Dhaka, R6= Dinajpur, R7= Faridpur, R8= Jashore, R9=Khulna, R10= Mymensingh, R11= Rajshahi, R12= Rangamati, R13= Rangpur, R14= Sylhet and BD=Bangladesh
Source: DAE 2022-23

T. Aman season

Among BRRI varieties, BR2 was the top yielder (5.82 ton/ha), followed by BRRI dhan74 (5.04 ton/ha), BRRI dhan81 (4.96 ton/ha), and BRRI dhan94 (4.79 ton/ha) in T. Aman season. On the other hand, the average yield of BINA varieties, hybrids, and Indian varieties were 4.43, 5.66, and 4.33 ton/ha, respectively. The average yield of BRRI varieties was 4.47 ton/ha. Widely adopted BRRI varities average yield was lower due to lower yield of some rigions. This season's overall yield of modern varieties (MVs) was 4.27 ton/ha (Table 5).

Table 5. Average yield (t/ha) of different T. Aman rice varieties by agricultural regions of Bangladesh, 2022-23.

Variety name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	BD
BRRI Varieties	**4.19**	**4.68**	**4.51**	**4.41**	**4.48**	**4.90**	**4.55**	**4.94**	**4.30**	**4.39**	**4.87**	**4.18**	**4.33**	**4.32**	**4.47**
BR2							5.82								5.82
BR3	3.88														3.88
BR4												3.73			3.73
BR10	3.82		4.51	3.86				4.69	4.45			3.94		4.19	4.27
BR11	**4.15**	**4.50**	**4.48**	**3.93**	**3.94**	**5.30**	**4.34**	**5.32**	**4.43**	**4.19**	**4.54**	**3.93**	**4.47**	**4.11**	**4.34**
BR22	**4.01**	**4.46**	**4.34**	**4.33**	**4.21**		**4.55**		**4.28**			**4.05**	**4.16**	**4.14**	**4.21**
BR23	4.09	4.34	4.24	4.27	4.08		3.77	4.28	4.29	4.25		4.42	4.11	4.17	4.19
BR25	3.79			4.18	4.01					4.00		3.89			3.96
BR26		4.70					4.21								4.46
BRRI dhan28		4.90		4.43	4.93					4.10	4.76		4.22		4.56
BRRI dhan29		4.48			4.10		4.18				5.15				4.61
BRRI dhan30	3.91		4.21		4.22			4.37	4.07		4.67	3.73		4.04	4.12
BRRI dhan31	3.79														3.79
BRRI dhan32	4.00	4.61	4.28	3.97	4.23				3.61	4.22	4.70	3.88	3.58	4.07	4.14
BRRI dhan33	4.16	4.46	4.25	3.39	4.08		4.28	4.86	4.16	3.98	4.48	4.15	4.07	4.14	4.24
BRRI dhan34	**3.84**	**3.73**	**3.73**	**3.76**	**3.51**	**3.89**	**3.58**	**3.90**	**4.46**	**3.78**	**3.82**	**3.96**	**4.00**	**3.94**	**3.84**
BRRI dhan36		4.32													4.32
BRRI dhan37		4.18		4.30											4.24
BRRI dhan39	3.89	4.63	4.17	4.02	3.94		4.43	4.67	3.82	4.47	4.93	3.96	4.10	4.00	4.23
BRRI dhan40	4.01	4.48	4.24		4.27		4.22			4.21		4.21		4.25	4.18
BRRI dhan41	4.13	4.48	4.27	4.13	4.51		4.10		4.07	4.10		4.09	4.09	4.10	4.17
BRRI dhan44	4.12	4.78	4.57	4.27								4.81		4.20	4.33
BRRI dhan46	4.09		4.39	4.03	4.34					4.05		4.18		3.94	4.13
BRRI dhan47			4.52												4.52
BRRI dhan48								4.78							4.78
BRRI dhan49	**4.19**	**4.82**	**4.61**	**4.80**	**4.65**	**4.90**	**4.45**	**4.93**	**4.34**	**4.47**	**4.95**	**4.26**	**4.41**	**4.29**	**4.57**
BRRI dhan51	**4.09**	**4.81**	**4.39**	**4.31**	**4.29**	**5.04**	**4.56**	**4.76**	**4.35**	**4.33**	**5.59**	**4.23**	**4.39**	**4.09**	**4.49**
BRRI dhan52	**4.35**	**4.78**	**4.67**	**4.27**	**4.31**	**4.95**	**4.54**	**4.83**	**4.22**	**4.38**	**4.99**	**4.18**	**4.48**	**4.30**	**4.52**
BRRI dhan53	4.09											4.18			4.13
BRRI dhan54	4.31								3.85			4.25			4.21
BRRI dhan55		4.55													4.55
BRRI dhan56	4.24	4.90	4.48		4.13	4.63	4.63	4.70	4.14	4.18	4.76	4.26	4.15	4.24	4.41
BRRI dhan57	4.22	4.68	3.90	4.27	4.03	4.78	4.75	4.36	4.10		4.33	4.24	4.25	4.16	4.33
BRRI dhan58	4.18				5.15										4.66

Variety name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	BD
BRRI dhan59	4.14	4.45		4.40	4.85	4.34	4.37	4.47	4.21	4.22	3.90	4.18		4.16	4.32
BRRI dhan62	4.06	4.45		4.40	4.85	4.34	4.37	4.47	4.21	4.22	3.90	4.18	3.93	4.16	4.26
BRRI dhan63	4.00														4.00
BRRI dhan64													4.43		4.43
BRRI dhan65												4.63			4.63
BRRI dhan66		4.18	4.03				4.48	5.22	3.73		4.48		3.98	3.93	4.20
BRRI dhan67							4.93		4.47						4.62
BRRI dhan70	4.01	4.08			4.03	4.83		4.55	4.31		4.65	4.17	4.19		4.35
BRRI dhan71	4.26	4.58	4.94	4.39	4.42	4.68	4.64	4.83	4.28	4.37	4.79	4.18	4.39	4.36	4.51
BRRI dhan72	4.28	4.32	4.68	4.28	4.67	4.61	4.58	5.12	4.31	4.39	4.72	4.23	4.36	4.35	4.53
BRRI dhan73	4.34		4.36	4.28	4.64			4.75	4.37			4.20	4.45		4.38
BRRI dhan74					4.18			4.93		6.24	4.84				5.04
BRRI dhan75	**4.75**	**4.64**	**4.61**	**4.66**	**4.57**	**4.91**	**4.72**	**5.01**	**4.31**	**4.41**	**4.96**	**4.28**	**4.34**	**4.23**	**4.61**
BRRI dhan76	4.58	4.44	4.26	4.48		4.76	4.48		4.51	3.88		4.22	4.48	4.32	4.42
BRRI dhan77	4.35		4.22			4.85	4.48		4.34	4.42			4.03		4.33
BRRI dhan78	4.29		4.27			5.22			3.50				3.79		4.17
BRRI dhan79	4.23	4.33	4.36		5.22					4.03			4.30	4.54	4.39
BRRI dhan80		4.78	4.54	4.62	4.57	4.95	4.78	4.91	4.19	4.34	4.91	4.22	4.39	4.23	4.59
BRRI dhan81					5.30		4.63								4.96
BRRI dhan82	4.16			4.48			4.33	4.64				4.45		4.42	4.38
BRRI dhan85	4.48														4.48
BRRI dhan87	**4.35**	**4.95**	**4.91**	**4.83**	**4.78**	**5.12**	**4.50**	**5.25**	**4.32**	**4.52**	**5.22**	**4.31**	**4.51**	**4.40**	**4.72**
BRRI dhan88								4.66							4.66
BRRI dhan90	4.27	4.66	4.40	4.78	4.81	4.64	4.20	4.83	4.29	4.22			4.44	4.37	4.52
BRRI dhan91			4.83		3.28		4.45		4.18	4.10	4.48		4.13		4.32
BRRI dhan93	4.42	4.93	4.57	4.63	4.68	5.28	4.48		4.34	4.07	5.09	3.73	4.52	4.21	4.65
BRRI dhan94	4.30	4.43	4.64	4.69	4.61	5.10		5.52			5.19		4.60	4.97	4.79
BRRI dhan95	4.30	4.88	4.62	4.82	4.07	5.44		5.48	4.46	4.32	5.09	3.81	4.67	4.51	4.67
BRRI hybrid dhan2														4.63	4.63
BRRI hybrid dhan4		5.97	5.60	5.83	6.00	5.67	5.61	6.20	5.68	5.56	5.04		5.07	5.36	5.70
BRRI hybrid dhan5					5.84										5.84
BRRI hybrid dhan6	5.46	6.00	5.64	5.69	6.17	5.62	5.64	6.64	5.51	5.72	5.69	6.00	5.28	5.42	5.76
BRRI hybrid dhan8			4.48	4.48											4.48
BINA Varieties	**4.15**	**4.58**	**4.49**	**4.48**	**4.45**	**4.66**	**4.59**	**5.02**	**4.30**	**4.15**	**4.84**	**4.15**	**4.07**	**4.25**	**4.43**
Bina dhan-17	4.40	4.93	4.45	5.04	4.54	5.01	4.51	5.16	4.32	4.28	5.09	4.48	4.43	4.25	4.62
Bina dhan-7	4.03	4.58	4.43	4.52	4.34	4.37	4.45	4.79	4.47	4.08	4.59	4.10	4.18	4.17	4.37
All Hybrids	**5.10**	**6.02**	**5.95**	**5.50**	**5.71**	**5.60**	**5.80**	**5.97**	**5.77**	**5.66**	**6.20**	**9.06**	**4.92**	**5.14**	**5.66**
Indian Varieties	**4.31**	**4.64**	**4.26**	**3.19**	**4.28**	**4.88**	**3.69**	**4.78**	**4.29**	**3.96**	**4.82**	**3.88**	**4.01**	**4.01**	**4.33**
Guti swarna	4.32	4.64		3.04	4.31	5.09	3.69	4.82	4.29	4.04	5.33		4.51	4.18	4.48
Ranjit		4.70	4.10	3.25	4.23	4.80		4.45		3.80	4.40		4.37	3.93	4.25
Swarna-5		4.71				5.08				4.23			4.59		4.70
Other MVs	**4.11**	**4.61**	**4.07**	**3.26**	**5.46**	**4.45**	**4.26**	**4.66**	**4.09**	**4.25**	**4.27**	**4.17**	**3.57**	**3.06**	**4.18**
Pajam	3.73	4.35	4.47	4.03						4.15	3.58	4.04	3.38	3.67	4.02
MVs	**4.27**	**4.99**	**4.74**	**4.59**	**4.64**	**5.17**	**4.91**	**5.20**	**4.56**	**4.66**	**4.92**	**4.81**	**4.47**	**4.34**	**4.72**
LVs	**2.51**	**2.52**	**2.49**	**2.81**	**2.49**	**2.94**	**2.55**	**2.57**	**2.63**	**2.50**	**2.89**	**2.08**	**3.32**	**2.22**	**2.56**
Grand Total	**3.61**	**4.74**	**4.22**	**4.25**	**4.06**	**5.05**	**4.32**	**5.01**	**3.98**	**4.00**	**4.74**	**4.49**	**4.35**	**3.80**	**4.27**

Note: R = Region, R1= Barishal, R2= Bogura, R3=Chattogram, R4= Cumilla, R5= Dhaka, R6= Dinajpur, R7= Faridpur, R8= Jashore, R9=Khulna, R10= Mymensingh, R11= Rajshahi, R12= Rangamati, R13= Rangpur, R14= Sylhet and BD=Bangladesh

Source: DAE 2022-23

Boro season

In the Boro season, the average yield of BRRI varieties in 2022-23 was about 6.11 ton/ha. Among BRRI varieties, BRRI dhan92 was the top yielder (6.66 ton/ha), followed by BRRI dhan90 (6.61 ton/ha), BRRI dhan102 (6.60 ton/ha), and BRRI dhan89 (6.58 ton/ha). The average yield of the hybrid

was 7.39 ton/ha, whereas for Indian varieties was 6.05 ton/ha. The overall yield of modern varieties in Boro season was about 6.81 ton/ha (Table 6).

Table 6. Average yield (t/ha) of different Boro rice varieties by agricultural regions of Bangladesh, 2022-23.

Variety name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	BD
BRRI Varieties	**6.26**	**6.06**	**5.72**	**6.01**	**6.33**	**6.31**	**6.34**	**6.45**	**5.85**	**6.00**	**6.94**	**5.38**	**6.18**	**5.83**	**6.11**
BR2	5.67														5.67
BR3	5.84			5.60										4.93	5.49
BR11			5.67												5.67
BR12			4.70									5.07			4.89
BR14			5.36		5.88					5.45		5.15	5.90	5.27	5.54
BR16		5.97	5.18	5.57		6.76	6.16			5.22		4.77	5.67		5.47
BR19														4.48	4.48
BR26			5.64	5.22	5.48					5.56		4.75		5.97	5.40
BRRI dhan28	5.84	5.75	5.29	5.43	5.54	6.08	5.84	5.82	5.74	5.60	6.70	5.09	5.97	5.22	5.71
BRRI dhan29	6.25	6.43	5.69	6.15	6.63	6.72	6.56	6.48	5.88	5.97	7.18	5.20	6.27	5.97	6.28
BRRI dhan33		6.45	5.10					5.75				5.03	5.22		5.44
BRRI dhan36		5.97				6.34					6.58	4.78			5.84
BRRI dhan39			5.07									5.18			5.15
BRRI dhan45	5.60	5.97		5.30								5.15	5.97	5.97	5.60
BRRI dhan47	5.86		5.70	2.31			6.14					5.15	5.67		5.59
BRRI dhan48			5.43	5.51				6.19			6.13	5.02		4.93	5.46
BRRI dhan49												5.07			5.07
BRRI dhan50	5.81	5.90	5.08	4.96	5.64	5.96	5.82	6.42	5.77	5.45	6.66	5.14	5.67	5.47	5.73
BRRI dhan55	5.98	6.27	5.64	5.97		5.97	6.27	6.31				5.27	5.87	5.78	5.83
BRRI dhan57											6.72				6.72
BRRI dhan58	6.13	6.13	5.56	6.15	6.42	6.31	6.44	6.41	5.79	5.60	6.95	5.40	6.00	5.90	6.12
BRRI dhan59	6.33	5.60	5.64	5.75		5.22	5.90	6.42		6.47		5.90	5.82		5.97
BRRI dhan60		5.82		5.60			5.97	6.12		5.67		4.48	6.07		5.76
BRRI dhan61	5.80	6.12	5.61	5.67			6.09			5.82		5.37	5.82		5.84
BRRI dhan62		6.10	5.70	5.67		5.43	5.90			5.22			5.07		5.54
BRRI dhan63	6.04	5.30	5.57	5.63	6.01	5.92	6.14	6.22	5.83	5.97	6.66	5.50	6.34	5.67	5.99
BRRI dhan64	5.68	6.24	5.46	5.75	5.15		6.37	5.52	5.81	5.60	5.97	5.02	5.72	5.97	5.71
BRRI dhan65											6.70				6.70
BRRI dhan66		5.67													5.67
BRRI dhan67	5.79	5.51	5.35	6.57	5.83	5.81	6.07	6.37	5.81	5.97		5.42	5.97	5.86	5.83
BRRI dhan68	6.15	5.76	5.51	5.60	6.57					5.97				5.87	5.91
BRRI dhan69	5.81	6.57	5.48	5.75		6.97		5.97		5.93		5.40	5.82	5.97	5.90
BRRI dhan71		5.54													5.54
BRRI dhan72													5.97		5.97
BRRI dhan74	6.46	5.58	5.80	6.38	6.00	6.34	6.46	6.42	5.69	6.31	6.86	5.57	6.27	5.78	6.18
BRRI dhan75			6.10	5.54							6.86	6.82			6.50
BRRI dhan76													5.82		5.82
BRRI dhan79													5.97		5.97
BRRI dhan80												5.67			5.67
BRRI dhan81	5.91	6.04	5.59	6.26	5.97	6.19	6.25	6.24	5.73	5.90	7.09	5.32	5.97	5.93	6.03
BRRI dhan82								5.97							5.97
BRRI dhan84	6.14	6.07	5.64	6.14	5.96	6.23	6.15	6.08	5.76	5.93	6.80	5.55	5.97	5.97	6.02
BRRI dhan86	6.57	5.88	5.67	6.02	6.03	6.28	5.97	6.39	5.70	5.92	6.87	5.42	5.97	5.97	6.06
BRRI dhan87			5.69												5.69
BRRI dhan88	6.30	6.06	5.72	6.58	6.32	6.20	6.38	6.16	5.77	5.93	7.04	5.49	5.97	5.97	6.15
BRRI dhan89	6.46	6.69	6.04	6.82	7.11	6.70	6.78	6.97	5.79	6.34	7.53	5.77	6.57	5.97	6.58
BRRI dhan90		5.85	5.70			6.28					6.89			7.46	6.61
BRRI dhan91		5.97										5.34			5.66
BRRI dhan92	6.38	6.58	6.38	6.97	7.15	6.61	6.79	6.88	5.69	6.79	7.46	5.81	6.99	5.97	6.66
BRRI dhan96	6.25	6.21	5.80	6.75	6.30	5.90	6.44	6.44	5.78	6.34	6.94	5.21	6.02	5.97	6.21
BRRI dhan97	5.22		5.44	5.90			5.22		5.76			5.09	4.48		5.43
BRRI dhan98		6.27													6.27
BRRI dhan99			6.03						5.84			5.46			5.86

Variety name	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	BD
BRRI dhan100	6.84	5.64	6.04	6.46	6.54	6.32	6.57	6.74	5.77	5.97	7.18	5.57	6.33	6.01	6.35
BRRI dhan101			5.97									5.33			5.65
BRRI dhan102			6.08			6.87					6.90	5.28	7.43		6.60
BRRI hybrid dhan1	7.75				8.22										7.91
BRRI hybrid dhan2	7.83												7.67		7.75
BRRI hybrid dhan3	7.86	7.31	7.71	7.01	8.01	7.24	8.66	8.07	7.05	7.46		6.72	7.48	7.46	7.62
BRRI hybrid dhan4					7.45										7.45
BRRI hybrid dhan5	7.90	7.76	9.07	7.16	7.17	7.28	8.56	7.66	7.22	7.46		6.83	7.71		7.58
BRRI hybrid dhan6	7.91		6.72												7.31
BINA Varieties	**5.95**	**5.93**	**5.39**	**6.12**	**6.09**	**6.46**	**6.50**	**6.46**	**5.67**	**6.09**	**6.85**	**5.38**	**6.12**	**5.92**	**6.03**
Bina dhan-10	6.09	5.78	5.56	6.55	5.95	6.72	6.49	6.27	5.79	6.72		5.15	5.56	5.82	6.03
Bina dhan-14	6.13	5.99	5.08	5.88	6.13	6.59	6.47	6.29	5.62	5.97	7.06	5.46	5.97	5.92	6.04
All Hybrids	**7.62**	**7.23**	**7.12**	**7.20**	**7.68**	**7.32**	**7.59**	**7.66**	**7.11**	**7.41**	**8.10**	**6.89**	**7.33**	**7.41**	**7.39**
Indian varieties	**5.31**	**6.04**				**6.49**		**6.01**	**5.62**		**6.64**		**5.26**		**6.05**
Other MVs	**5.72**	**5.97**	**4.79**	**5.36**		**6.32**	**6.24**	**6.15**	**5.10**	**5.67**	**6.56**		**5.26**	**5.92**	**5.87**
MVs	**6.95**	**6.69**	**6.30**	**6.59**	**6.97**	**6.94**	**7.01**	**6.98**	**6.66**	**6.90**	**7.36**	**6.18**	**6.95**	**6.72**	**6.81**
LVs	**3.02**	**2.74**	**2.72**	**2.88**	**2.99**		**2.64**			**3.13**	**3.64**	**3.13**	**2.73**	**2.92**	**2.96**
Grand Total	6.77	6.57	6.29	6.49	6.56	6.94	6.70	6.98	6.66	6.66	7.27	6.14	6.89	6.30	6.67

Note: R = Region, R1= Barishal, R2= Bogura, R3=Chattogram, R4= Cumilla, R5= Dhaka, R6= Dinajpur, R7= Faridpur, R8= Jashore, R9=Khulna, R10= Mymensingh, R11= Rajshahi, R12= Rangamati, R13= Rangpur, R14= Sylhet and BD=Bangladesh

Source: DAE 2022-23

Trend changes in adoption and yield level

A comparative picture of overall changes in MV adoption and yield level is given in table 7. The overall adoption of modern varieties in the Boro season increased from 88.93% in 1990-91 to 99.49 % in 2021-22. But in the case of modern T. Aman varieties, the changes increase was higher (53.74%) compared to the Boro season. In addition, MV adoption in the Aus season increased from about 17% in 1990-91 to about 91.32% in 2021-22, resulting in a 74.02% increase in Aus season MV rice adoption. Yield increased in 2021-22 about 54.37, 32.41, and 56.65% compared to 1990-91 in the Boro, T. Aman, and Aus seasons, respectively. It might be due to adopting high-yield potential BRRI-developed rice varieties.and good management practices.

Table 7. Adoption rate, production, clean rice yield, and growth rate of modern rice varieties over the years

Season/items	Period		Differences	Growth rate (%)**
	1990-91*	2021-22		
Aus:				
Adoption (%)	17.30	91.32	74.02	-1.88
Production (%)	27.91	95.94	68.03	1.21
Yield (t/ha)	1.73	2.71	0.98 (56.65)	3.33
T. Aman:				
Adoption (%)	29.28	83.02	53.74	-0.047
Production (%)	41.78	90.78	49.00	1.80
Yield (t/ha)	2.16	2.86	0.70 (32.41)	1.91
Boro:				
Adoption (%)	88.93	99.49	10.56	2.11
Production (%)	93.60	99.77	6.17	3.84
Yield (t/ha)	2.63	4.06	1.43 (54.37)	1.73

Source: BBS, '*' means national average. The figure in the parentheses indicates the percentage. **means exponential growth model addressing the autocorrelation problem (data: 1990-91 to 2021-22).

Conclusion

Adoption of modern varieties were 94.23, 90.50, and 99.67% in Aus, T. Aman, and Boro seasons, respectively. Coverage of BRRI varieties were about 72.59, 57.24, and 60.93%, in Aus, T. Aman, and Boro seasons, respectively. It is worthwhile to mention that there is a common debate on the depletion of water resources that are affected mainly by Boro cultivation using underground water. To address this issue, the government launched incentives and other subsidy programs for Aus cultivation that motivated the farmers to grow more Aus, which mainly shifted from the Boro area. With the broader disbursement of incentives, BRRI dhan48 ranked the top position (49.97%) in the Aus season in terms of area coverage, followed by BRRI dhan28 (4.78%). The coverage of Indian varieties in the T. Aman season was about 19.78%, which was 20.11% in 2021-22. BRRI dhan28 and BRRI dhan29 were still the dominant varieties in the Boro season, covering 26.49% of areas. However, both the varieties accounted for 41.25% of areas in 2021-22. BRRI dhan75 produced the highest yield (4.94 ton/ha) in the Aus season whereas, in T. Aman and Boro seasons, it was BR2 (5.82 ton/ha) and BRRI dhan92 (6.66 ton/ha), respectively. BRRI hybrid dhan1 yielded the highest which was 7.91 ton/ha whereas the average hybrids' yield was 7.39 ton/ha in the Boro season.

STUDY 2: ADOPTION DETERMINANTS AND PROFITABILITY OF STRESS-TOLERANT (DROUGHT) RICE IN SELECTED AREAS OF BANGLADESH

MS Rahaman, MC Rahman, SA Jui, MA Islam, MAR Sarkar and MS Islam

Introduction

Bangladesh is among the world's most at-risk nations regarding the effects of climate change. Although it was ranked as the most climate-vulnerable nation in 2010 by the Global Climate Risk Index (GCRI) (Kreft et al., 2017), Bangladesh ranked sixth in that category in 2017 (Harmeling, 2009). According to the Global Climate Risk Index (GCRI) 2010, which looks at the years 1990-2008, natural disasters in Bangladesh claimed the lives of an average of 8,241 people each year, caused an average of US $1.2 billion in annual damages, and resulted in a yearly GDP loss of 1.81 percent (Harmeling, 2009).

Bangladesh's agriculture is particularly vulnerable to climate-induced calamities, which limit the country's ability to produce enough food to feed its population and threaten food security. Bangladesh's agroecological zones (AEZ) suffer from climate-induced disasters that affect agricultural production. The hydro-climatic factors affecting the agricultural sector in the country include rising temperatures, erratic and unpredictable rainfall, winter shortening, foggy conditions, rising sea levels, increasing floods, and increased intensity of cyclones and storm surges (Mondal et al., 2012). Rahman et al. (2017) reported that unfavorable conditions could be exacerbated in developing countries like Bangladesh. Drought, a climate-related hazard, has the most damaging effects on rice production. Drought significantly reduces rice grain yield as well as vegetative growth (Dar et al., 2020). It has impacted approximately half of the world's rice cultivation area, posing a severe threat to food security (Bouman et al., 2005; Dar et al., 2020).

Drought significantly impedes sustainable crop production and food security in Bangladesh. Drought mostly impacts Bangladesh's northwestern region, where 1.2 million hectares of land are used to farm rice during the dry season (Islam et al., 2017). Bangladesh faced severe drought in this area in 1999, 2000, 2006, 2009, and 2012. Bangladesh suffered the longest drought in 50 years in 1999, going more than four months without rain. Crop production decreased by 25%–30% as a result of the prolonged drought, posing a severe threat to food grain supply. Bangladesh's Ministry of Agriculture reported that moderate to extreme drought had affected approximately 57% of the country's total net cultivated land. Nonetheless, owing to the increasing severity of drought and crop production losses, adaptation to drought problems through the use of climate-smart agricultural practices has been emphasized in recent years (Islam et al., 2017).

The Bangladeshi government has implemented drought management initiatives to mitigate the impact of droughts. Farmers in Bangladesh's drought-prone areas can now look forward to a more plentiful rice harvest with the release of many drought-tolerant rice varieties (BRRI dhan56, BRRI dhan66, BRRI dhan71) by the Bangladesh Rice Research Institute (BRRI). Drought-tolerant rice varieties are those that can produce a reasonable yield even when soil moisture is less than 20% and the perch water table depth is more than 70–80 cm from the surface level (Kader et al., 2019). All of these varieties can reach maturity in 105–115 days. Drought-tolerant varieties can produce at least 3.5–5 t/ha without watering throughout the reproductive period (Kader et al., 2019). Traditional rice varieties in

Bangladesh die within 10–12 days if water is not available, while drought-tolerant cultivars may survive without rain for up to 27 days (Islam, 2011). Drought-tolerant varieties also outperform traditional varieties in terms of yield. Drought-tolerant varieties were tested in northwestern Bangladesh and demonstrated better performance in adverse situations (Ahmed et al., 2017). As a result, rice farmers in those areas began to adopt these drought-tolerant rice varieties.

Adopting drought-tolerant rice varieties can play an important role in developing the agricultural sector, maintaining food grain supply, and improving the well-being of a substantial number of people. However, the decision to adopt is complicated, and several factors may affect it. Identifying these factors is critical for the sector's future growth. According to Mottaleb et al. (2014), land characteristics, access to credit, infrastructure, and irrigation facilities significantly affect the adoption of modern rice varieties. The adoption of stress-tolerant rice varieties is substantially influenced by education (Ahmed et al., 2016). Cho and Kim (2019) found that household assets, credit, and involvement in farmers' field school positively impact the adoption of drought-tolerant rice varieties in the Philippines. A few studies (Kumar et al., 2008; Arouna and Aboudou, 2019) have assessed the production effect of drought-tolerant rice varieties worldwide and concluded that these varieties provide a higher yield than traditional varieties. Islam (2018) indicates that adopting improved rice varieties increases household income and food grain availability.

It is evident from the preceding literature review that many studies identify the determinants of modern rice variety adoption and its impact on productivity. However, there is a dearth of studies regarding the factors that influence the intensity of adoption of drought-tolerant rice varieties.

Therefore, this study has been undertaken to assess the current level of adoption of climate-resilient rice varieties and the profitability and adoption determinants of rice production in drought-prone regions during the Aman season. This study hopes to facilitate a successful rice revolution and is expected to provide valuable data helpful in formulating an appropriate policy for the widespread cultivation of rice in drought-prone areas of Bangladesh.

Specific objectives:

- determine the adoption status of drought-tolerant rice varieties in the Aman season;
- compare profitability between drought-tolerant rice varieties and other rice cultivars; and
- identify the factors affecting the adoption of drought-tolerant rice varieties.

Methodology

Study area and data

The sample for this study was chosen using purposive sampling. The study was conducted in two northwestern districts of Bangladesh, namely Rajshahi and Chapainawabganj (Figure 2). For the past three decades, Bangladesh's northwestern region has been suffering from drought (Habiba et al., 2013). The average annual rainfall in these areas ranges from 1,400 to 1,650 mm. Several studies indicate that the drought-affected region receives approximately 1,000 mm less rainfall per year compared to the rest of Bangladesh (Shahid and Hazarika, 2010; Habiba et al., 2013). During summer, the average temperature frequently exceeds 40°C. Due to the frequent drought incidents, farmers in these districts

grow drought-tolerant rice varieties. Thus, in the first stage, these two districts (Chpainawabganj and Rajshahi) were selected purposively for the study. In the second stage, in consultation with the local extension office and BRRI Regional Station, Rajshahi, one Upazila (Nachole from Chpainawabganj and Godagari from Rajshahi districts) was selected from each district. In the third stage, four villages were selected from each Upazila to conduct the face-to-face interviews. The data were obtained from both primary and secondary sources. From each Upazila, 70 sample farmers were randomly selected, resulting in a total of 140 farmers (Table 8) interviewed. The interviews aimed to collect socio-demographic and farm-level data to identify factors influencing the adoption decision of climate-resilient (drought-tolerant) rice varieties. Additionally, an expert panel interview was conducted in both Upazilas involving the Sub-assistant Agricultural Officer (SAAO) and the Upazila Agriculture Officer (UAO).

Table 8. Sampling distribution

Districts	Upazila	Number of villages selected	Sample size
Rajshahi	Godagari	4	70
Chapainwabganj	Nachole	4	70
Total sample size			140

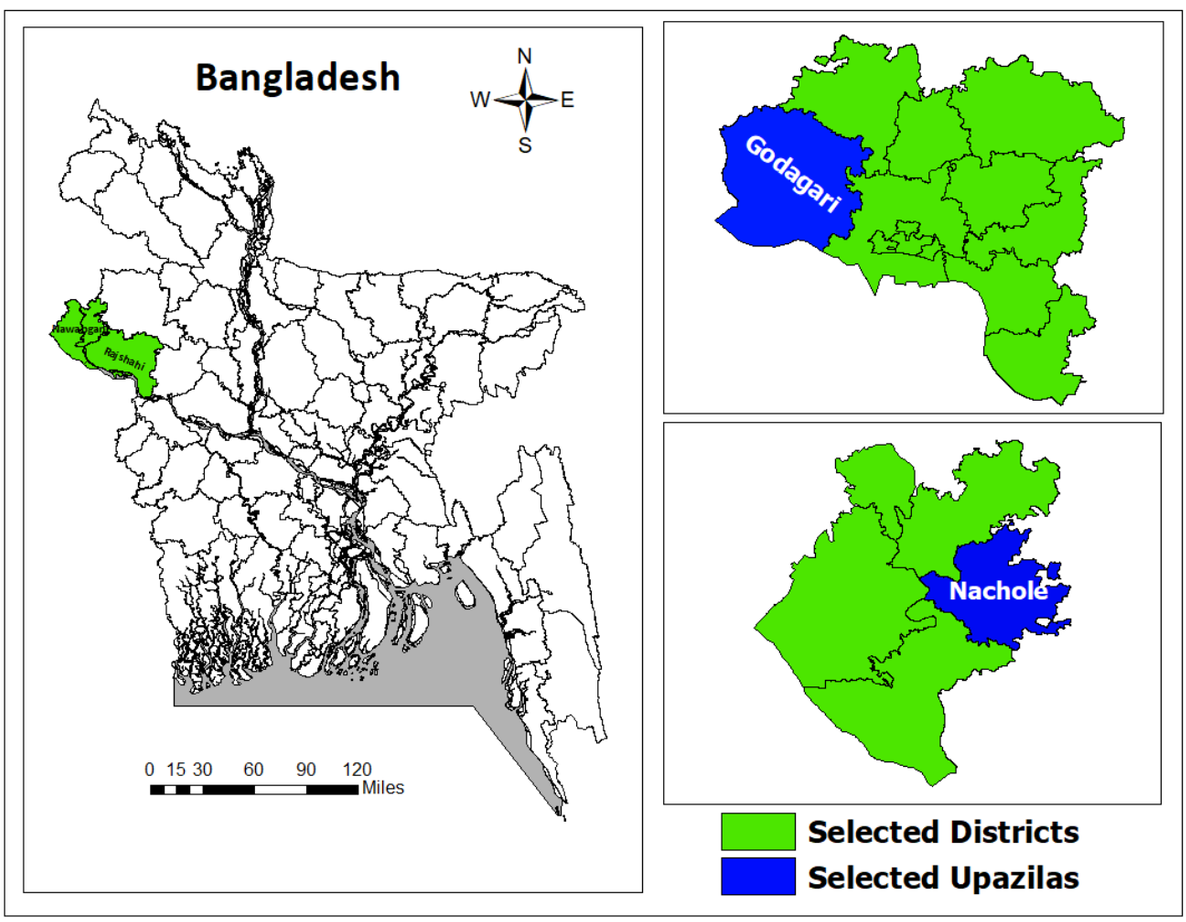


Figure 2: Study area map

Cultivated rice varieties

In the study area farmers cultivated different types of rice cultivars in T. Aman season. They cultivated differents types of Swarna, BRRI dhan51, BRRI dhan56, BRRI dhan57, BRRI dhan66, BRRI dhan71, and Binadhan-19 as the drought-tolerant cultivars. On the other hand, they also cultivated different

types of hybrids (like BRRI hybrid dhan4, BRRI hybrid dhan6, Arize-7006, S-1203, Shakti, Tej gold, etc.), inbred (BR10, BR11, BRRI dhan34, BRRI dhan49, other newly released BRRI varieties), and local varieties in their field during Aman season. The farmers of the study area highly opined about the drought-tolerant capabilities of the BRRI dhan51 and Swarna cultivars (Similar results found by Kabir et al. 2019). They recommended these two varieties performed better than the varieties released as drought-tolerant. Therefore, in this study, analysis was performed considering the BRRI dhan56, BRRI dhan57, BRRI dhan66, BRRI dhan71, Binadhan-19, BRRI dhan51, and Swarna are drought-tolerant varieties.

Analytical technique

Profitability was calculated in terms of gross return, gross margin, net return, and the benefit-cost ratio (BCR).

Gross return: The gross return was calculated by multiplying the total volume of rice output with the per unit price received by the farmers. It consisted of the sum of the volume of the main product and its by-product (Dillon and Hardaker, 1993).

Gross Return = Σ (Q x P)

Where Q = Quantity of the output; and P = Price of the output.

Gross margin:

The difference between total return and variable cost.

Gross Margin = Gross return − Total variable cost

Net return:

Net return was obtained by deducting all costs (variable and fixed) from gross return. ,

Net return, $\pi = \Sigma P_y Q_y - \Sigma (P_{xi} X_i) - TFC$.

Where, P_y = Per unit price of output; Q_y = Total quantity output; P_{xi} = Per unit price of i-th inputs; X_i = Quantity of the ith inputs; TFC = Total fixed cost (Tk); and i = 1, 2, 3,....., n (number of inputs).

Benefit-cost ratio (BCR): The BCR is a relative measure used to compare benefit per cost unit. The BCR estimated gross returns and gross costs as a ratio. The formula (undiscounted) for measuring BCR is shown below:

Benefit-cost ratio = Gross benefit / Gross cost

The econometric model

This study aimed to identify socioeconomic and demographic factors that affect farmers' decision to adopt drought-tolerant rice varieties during the T. Aman season. Because a response model links the likelihood of an occurrence to several independent factors, it is ideal for the farmers' dichotomous character. To provide a detailed analysis of the adoption decision of drought-tolerant rice cultivars, we applied a probit model. The probit model is a statistical probability model with two categories in the dependent variable (Liao 1994). Probit analysis is based on the cumulative normal probability distribution. The binary dependent variable takes on the values of zero and one (Aldrich and Nelson 1984). Therefore, the probit analysis can provide statistically significant results to identify the factors that influence the farmers to cultivate/adopt drought-tolerant rice cultivars in the Aman season.

In the binary probit model, farmers who cultivated/adopted drought tolerant rice cultivars were taken as 1, while not cultivated/adopted as 0. The probability P_i of choosing any alternative over not choosing it can be expressed as in (1), where φ represents the cumulative distribution of a standard normal random variable (Greene 2011):

$$P_i = prob[Y_i = 1|X] = \int_{-\infty}^{x_i'\beta} (2\pi)^{-\frac{1}{2}} \exp\left(-\frac{t^2}{2}\right) dt \quad (1)$$

$$P_i = \Phi\,(x_{i'}\,\beta) \quad (2)$$

The relationship between a specific variable and the probability outcome is interpreted by means of the marginal effect, which accounts for the partial change in the probability. The marginal effect associated with continuous explanatory variables X_k on the probability $P(Y_i = 1 \mid X)$, holding the other variables constant, can be derived as follows (Greene, 2011):

$$\frac{\partial P_i}{\partial x_{ik}} = \phi(x_i'\beta)\beta_k \quad (3)$$

where ϕ represents the probability density function of a standard normal variable. The marginal effect on dummy variables should be estimated differently from continuous variables. Discrete changes in the predicted probabilities constitute an alternative to the marginal effect when evaluating the influence of a dummy variable. Such an effect can be derived from the following (Greene 2011):

$$\Delta = \Phi(\bar{x}\beta, d = 1) - \Phi\,(\bar{x}\beta, d = 0) \quad (4)$$

Where, Δ represents marginal effect. The marginal effects provide insights into how the explanatory variables shift the decision of cultivating/adopting drought-tolerant rice cultivars. Using the econometric software, marginal effects were calculated for each variable.

Both literature review and focus group discussions were conducted to identify potential factors that independently influence the decision to adopt drought-tolerant rice varieties during the Aman season. The anticipated impact of these independent variables on the dependent variable was hypothesized based on insights gathered from a theoretical review of previous studies (Birhanu, 2015; Cheffo et al., 2015; George, Olaoye, Akande, & Oghobase, 2010; Ofuoku, Olele, & Emah, 2008) and the outcomes of the focus group discussions. The potential variables are presented in the table below (Table 9).

Table 9. Definition of Socio-economic variables included in the model

Variables	**Definitions**	**Expected sign**
Dependent variable		
Adoption of drought tolerant rice varieties	1=Adopters, 0=Otherwise	
Independent variable		
Age	Years	+
Education	Years of schooling	+
Occupation	1= Only farming	+
Family size	Number	+
Family members involve in farming	Number	+
Land size	Hectare	+
Market demand	1= Yes	+

Variables	Definitions	Expected sign
Yield difference	Kg/ha	+/-
Distance to UAO	Kilometer	-
Distance to local market	Kilometer	-
Training	1= received training	+
Extension service	1= received extension service	+
Participate in field demonstration	1= yes, 0=otherwise	+
Membership in any agricultural organization	1= yes, 0=otherwise	+
Credit	1= received	+
Severity of Drought	1 if the respondent faces low severity, 2 for moderate severity, 3 for high severity, and 0 for no severity. The data was then normalized as the perception of drought severity may vary among respondents. The normalized value of severity was used in the model.	+
Disease infestation	Farmer perceives disease infestation in drought-tolerant rice varieties (1= higher than other varieties)	-
Total varieties cultivated	Number	+

Results and discussion

Adoption situation of drought-tolerant rice cultivars in Bangladesh

The adoption rate of drought-tolerant rice in various agricultural regions during the Aman season of 2022–2023 was 23.69% (Table10). The adoption was highest in Rajshahi region (57.16%) followed by Dinajpur (56.01%), Rangpur (45.14%), Jashore (35.83%), and Bogura (29.37%). In the remaining regions, the adoption rate was found around 7 to 10 percent. During the Aman season, BRRI and BINA developed many drought-tolerant rice varieties (BRRI dhan56, BRRI dhan57, BRRI dhan66, and BRRI dhan71, BRRI dhan51 and Binadhan-19) which was cultivated across the country. In 2022-23, among the different drought-tolerant rice cultivars, Swarna (17.48%), was the most popular followed by BRRI dhan51 (4.97%) and BRRI dhan71 (1.05%). However, Swarna (Indian) varieties were the most popular in most of the regions. Besides, BRRI dhan51 was the most adopted drought-tolerant rice cultivar in Faridpur, Mymensingh, and Rangamati regions. On the other hand, among the varieties recognized and released as drought tolerant for drought areas, the BRRI dhan71 was the most popular in all regions followed by BRRI dhan56, BRRI dhan57, BRRI dhan66, and Binadhan-19.

Table 10. Adoption (%) of drought-tolerant rice cultivars in different agricultural regions of Bangladesh in the Aman season, 2022-23

Varieties	Barishal	Bogura	Chattogram	Cumilla	Dhaka	Dinajpur	Faridpur	Jashore	Khulna	Mymensingh	Rajshahi	Rangamati	Rangpur	Sylhet	Grand Total
Drought Tolerant	**7.21**	**29.37**	**12.01**	**1.96**	**5.78**	**56.01**	**4.42**	**35.83**	**4.70**	**9.13**	**57.16**	**7.03**	**45.14**	**6.74**	**23.69**
Binadhan-19	-	0.01	-	-	-	-	-	-	0.01	-	-	0.02	0.01	-	0.00
BRRI dhan56	0.04	0.21	-	-	0.04	0.05	0.64	0.07	0.01	0.07	0.03	1.16	0.35	0.05	0.11
BRRI dhan57	0.01	0.03	0.01	0.01	0.01	0.02	0.53	0.20	-	-	0.02	0.56	0.17	0.02	0.07
BRRI dhan66	-	-	0.04	-	-	-	0.02	-	-	-	-	-	0.01	0.01	0.01
BRRI dhan71	0.16	0.90	0.62	0.21	0.30	0.01	1.03	2.79	0.49	2.98	0.38	2.71	1.51	0.68	1.05
BRRI dhan51	1.07	3.92	3.00	0.65	4.64	7.65	1.82	9.83	0.72	4.31	17.11	1.85	2.64	4.76	4.97
Swarna	5.94	24.30	8.34	1.08	0.79	48.28	0.39	22.93	3.47	1.75	39.62	0.74	40.44	1.22	17.48
Other Varieties	**92.79**	**70.63**	**87.99**	**98.04**	**94.22**	**43.99**	**95.58**	**64.17**	**95.30**	**90.87**	**42.84**	**92.97**	**54.86**	**93.26**	**76.31**
Grand Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: DAE

Adoption status of drought-tolerant rice cultivars in the study areas

Figure 3 represents the yearly adoption of drought-tolerant rice varieties in the study areas from 2018/19 to 2022/23.The figure revealed that the adoption of drought-tolerant rice cultivars is declining in the study areas. In Rajshahi, the adoption rate of drought-tolerant varieties was highest (72.40%) in the 2019-20 followed by a gradual decline to 63.10% in 2022-23. On the contrary, in Chapainawabganj, the adoption rose gradually over time and was highest (85%) in the 2018-19 , but in the 2022-23 , adoption declined sharply to 74.03%. The main reason for the declining adoption of drought tolerant rice cultivars is the introduction of newly released rice cultivars and the adoption of hybrid rice in that area.

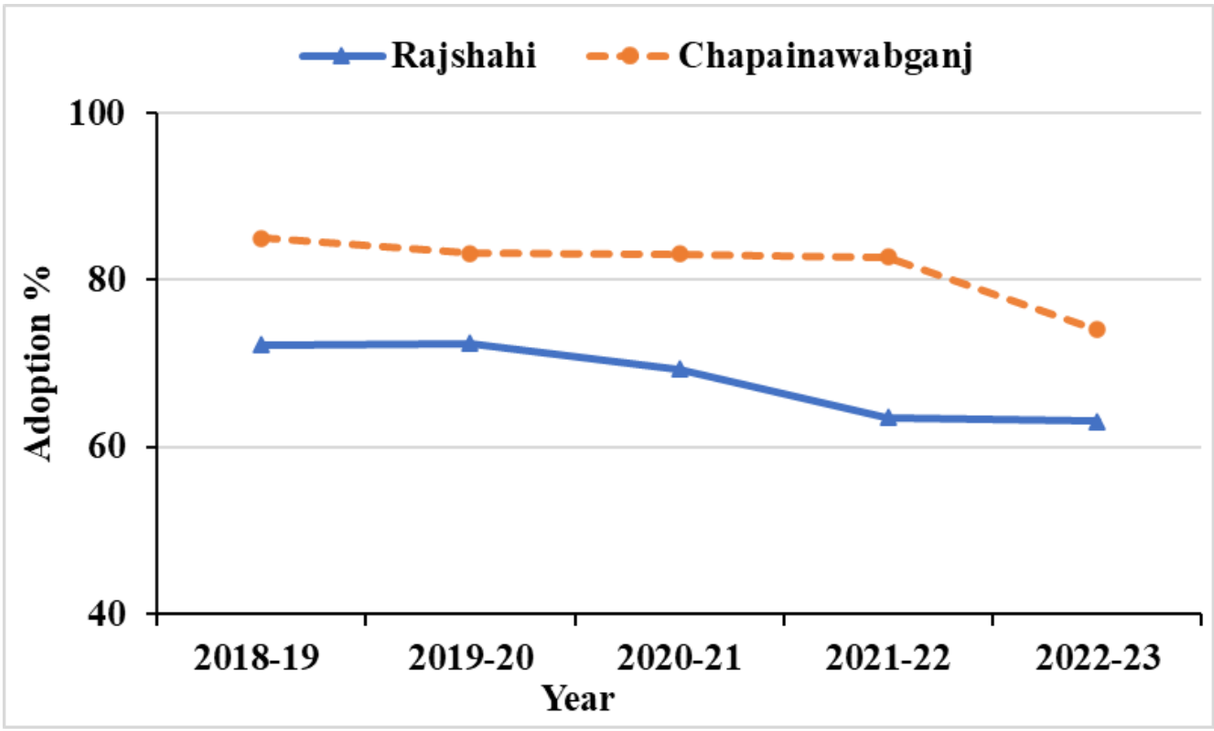


Figure 3. Yearly adoption of drought-tolerant rice varieties in the study areas from 2018/19 to 2022/23

The adoption rate of BRRI-developed drought-tolerant rice varieties in the Rajshahi and Chapainawabganj districts from 2018–19 to 2022–23 is illustrated in Figure 4. The figure clearly

shows that the BRRI dhan71 was the most popular and highest adopted drought-tolerant rice variety both in Rajshahi and Chapainawabganj districts from 2018-19 to 2022-23. On the other hand, BRRI dhan66 and BRRI dhan57 were the lowest adopted rice varieties in Rajshahi and Chapainawabganj districts respectively.

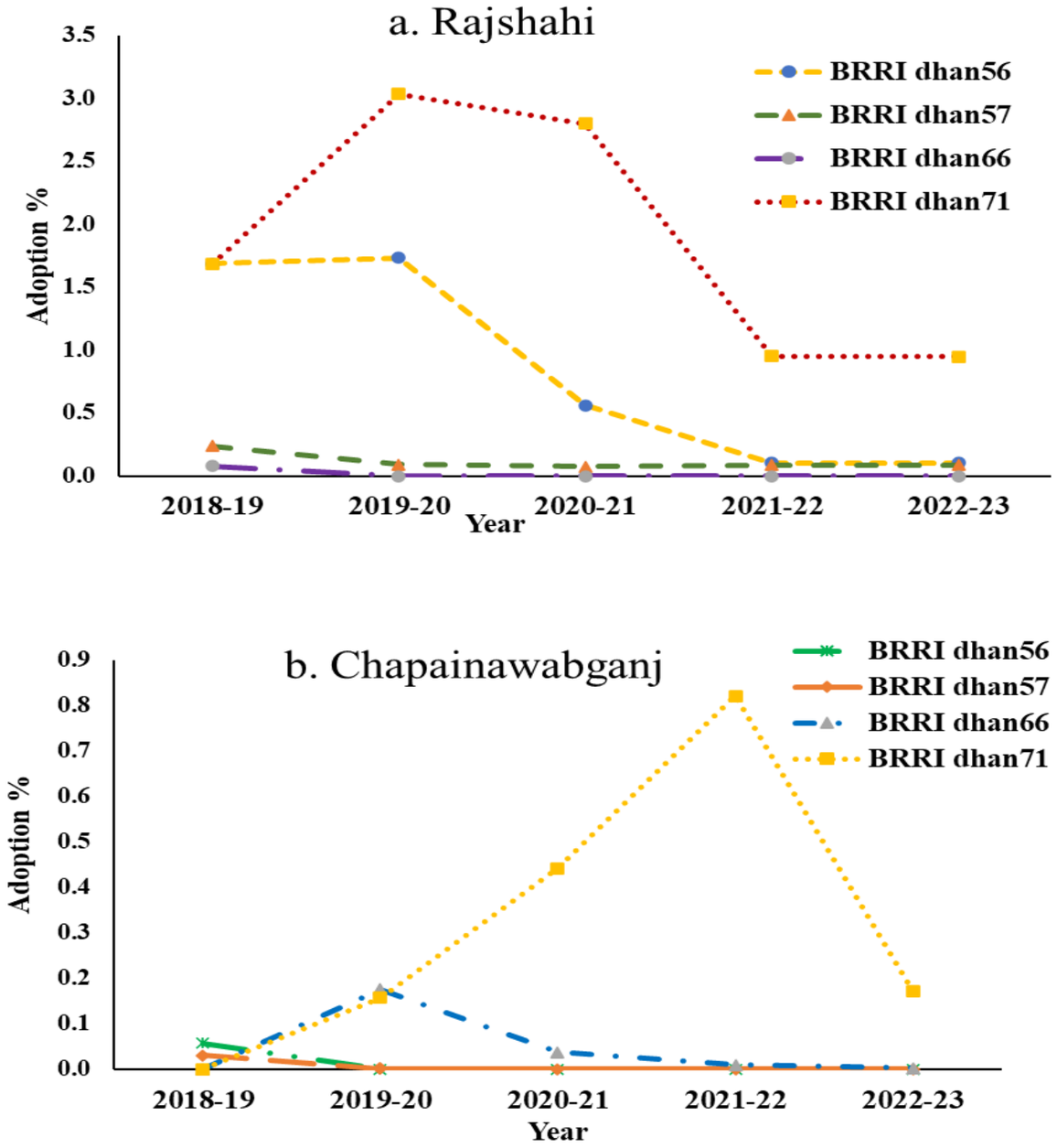


Figure 4. Yearly adoption trend of BRRI developed drought-tolerant rice varieties in Rajshahi and Chapainawabganj district from 2018/19 to 2022/23

Table 11, depicts the adoption of BRRI developed drought-tolerant and other popular grown rice varieties cultivated within the study area during the period of 2022-23. The adoption of drought-tolerant rice varieties is more pronounced in Chapainawabganj compared to Rajshahi. However, over time, the adoption of drought-tolerant rice varieties has been on a decline. Among the drought-tolerant rice varieties, the adoption of BRRI dhan51 and BRRI dhan71 are increasing more rapidly than the adoption of other drought-tolerant rice varieties. This may be because BRRI dhan51 and BRRI dhan71 are high-yielding varieties that also tolerant to drought.

Conversely, within both study areas, aside from recognized drought-tolerant rice varieties, BRRI dhan51 and Swarna rice varieties are the most popular among farmers to cultivate in Aman season as these varieties show the capability of drought tolerance according to the farmers. In the 2022-23

period, the adoption of BRRI dhan51 accounts for 33.16% in Rajshahi and 45.25% in Chapainawabganj districts, respectively. Correspondingly, the adoption of Swarna stands at 28.81% and 28.61% in Rajshahi and Chapainawabganj districts, respectively. It is evident from Table 11 that the adoption of BRRI dhan51 is rapidly increasing in both districts, while the adoption of Swarna varieties is gradually declining.

Table 11. Adoption (%) of BRRI-developed drought-tolerant and other popular rice varieties in the study areas in 2022-23

Varieties	Rajshahi (%)					Chapainawabganj (%)				
	2018-19	2019-20	2020-21	2021-22	2022-23	2018-19	2019-20	2020-21	2021-22	2022-23
BRRI dhan56	1.69	1.73	0.56	0.1	0.1	0.06	0	0	0	0
BRRI dhan57	0.24	0.09	0.07	0.09	0.09	0.03	0	0	0	0
BRRI dhan66	0.08	0	0	0	0	0	0.18	0.04	0.01	0
BRRI dhan71	1.68	3.03	2.8	0.95	0.95	0	0.16	0.44	0.82	0.17
BRRI dhan51	14.81	24.45	35.16	33.4	33.16	20.06	35.56	48.55	43.3	45.25
Swarna	53.76	43.06	30.75	29.02	28.81	64.84	47.35	34.13	38.65	28.61
Drought-tolerant varieties	**72.26**	**72.36**	**69.34**	**63.56**	**63.11**	**84.99**	**83.25**	**83.16**	**82.78**	**74.03**
All other varieties	27.75	27.63	30.66	36.44	36.9	15.01	16.76	16.84	17.22	25.97
Grand Total	100	100	100	100	100	100	100	100	100	100

Source: Field survey and DAE

Data in Table 12 shows the average yield (t/ha) of BRRI-developed drought-tolerant and other popular rice varieties cultivated in the study area in 2022-23. The table shows that the average yield of drought-tolerant rice varieties is higher than the average yield of other rice varieties. In 2022-23, the average yield of drought-tolerant varieties was 4.78 t/ha in Rajshahi and 5.20 t/ha in Chapainawabganj. In comparison, in Rajshahi, the average yield of the drought-tolerant rice cultivars BRRI dhan51 and Swarna were 5.63 t/ha and 5.42 t/ha, respectively, while in Chapainawabganj it was 5.72 t/ha and 5.27 t/ha in 2022-23. Overall, the adoption of BRRI dhan51 is increasing in the study area due to its higher yield and better quality trait.

Table 12. Average yield (t/ha) of drought tolerant and other popular varieties in the study areas in 2022-23

Varieties	Rajshahi yield (t/ha)					Chapainawabganj yield (t/ha)				
	2018-19	2019-20	2020-21	2021-22	2022-23	2018-19	2019-20	2020-21	2021-22	2022-23
BRRI dhan56	4.68	4.51	4.69	4.76	4.56	4.03	-	-	-	-
BRRI dhan57	4.98	4.40	4.63	4.63	4.33	4.03	-	-	-	-
BRRI dhan66	4.48	-	-	-	-	-	4.38	4.48	5.08	-
BRRI dhan71	4.94	4.77	4.59	4.64	4.65	-	4.52	4.70	4.82	4.85
BRRI dhan51	4.84	4.8	4.83	4.93	5.63	4.62	4.65	4.76	5.06	5.72
Swarna	4.91	4.83	4.89	4.9	5.42	4.48	4.7	4.72	4.95	5.27
Drought-tolerant varieties	**4.85**	**4.74**	**4.76**	**4.83**	**4.78**	**4.37**	**4.58**	**4.70**	**4.91**	**5.2**
All other varieties	4.61	4.61	4.76	4.87	4.81	3.82	4.25	4.42	4.83	5.08
Grand Total	4.64	4.61	4.75	4.86	4.80	3.84	4.27	4.44	4.83	5.07

Source: Field survey and DAE

Comparative input use pattern and profitability of drought- tolerant and othere rice cultivation in the study area

Input use pattern

Figures 5 and 6 represent per hectare input utilization for drought-tolerant and other popular Aman rice cultivation in 2022-23 in the study area. Regarding the three primary labor-intensive tasks involving transplanting, harvesting, and transportation, farmers frequently hire labours on a contractual basis. Conversely, activities such as post-harvest processing, weeding, the application of fertilizers and pesticides, as well as land preparation, are carried out by employing daily-wage laborers. Furthermore, during the Aman season, farmers opt to utilize power threshers through custom hiring to thresh rice grains. An average of 105.5 laborers per hectare are engaged in a comprehensive range of tasks, spanning from sowing paddy seeds, performing weeding, applying fertilizers and pesticides, harvesting, threshing, managing cleaning procedures, drying operations, and finally storing paddy grains (Figure 5).

Farmers used an average of 38.5 kg/ha of seed. In the surveyed area, farmers' normally use more seed (40 kg/ha) for other rice varieties compared to drought-resistant rice cultivars (37 kg/ha). Moreover, within the study areas, the farmers applied higher amounts of Urea, and DAP for cultivating other rice varieties in Aman season, as opposed to the cultivation of drought-tolerant rice varieties. Conversely, the application of MoP, Gypsum, Zinc, Theovit, Boron, and Sulphur displayed similarity for both types of varieties (Figure 6).

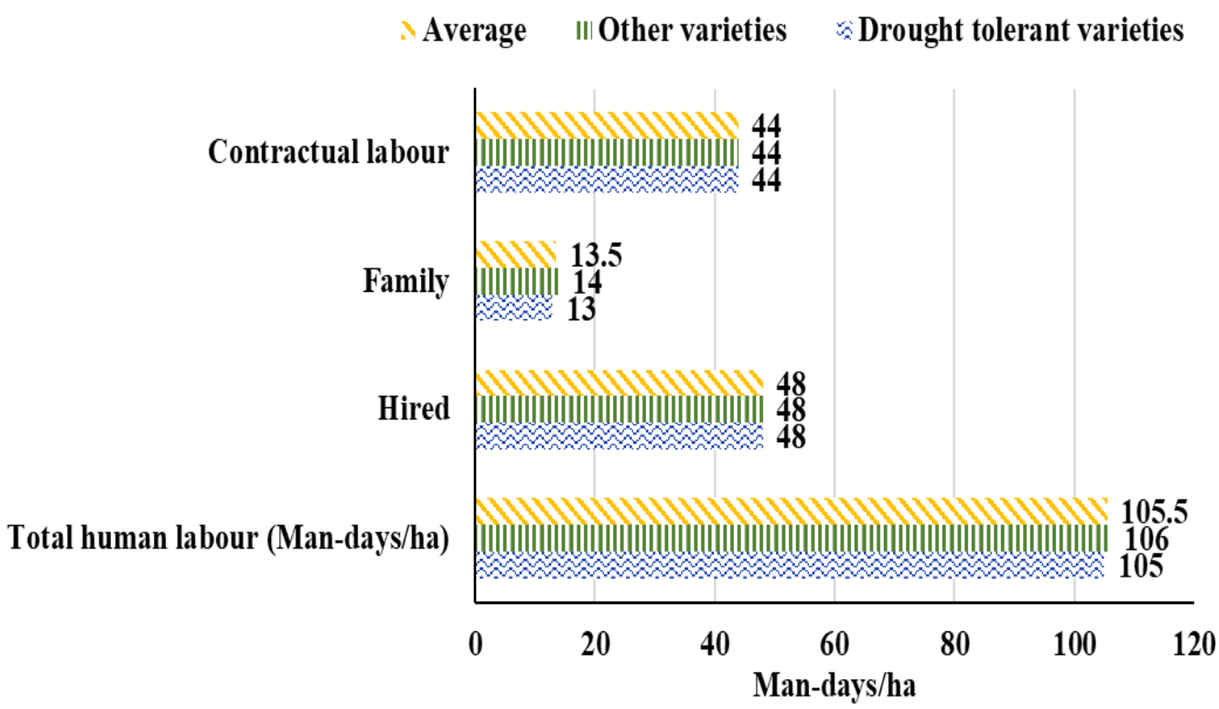


Figure 5. Per hectare labour used for rice cultivation in the study area in 2022-23
Source: Prepared by authors from survey data.

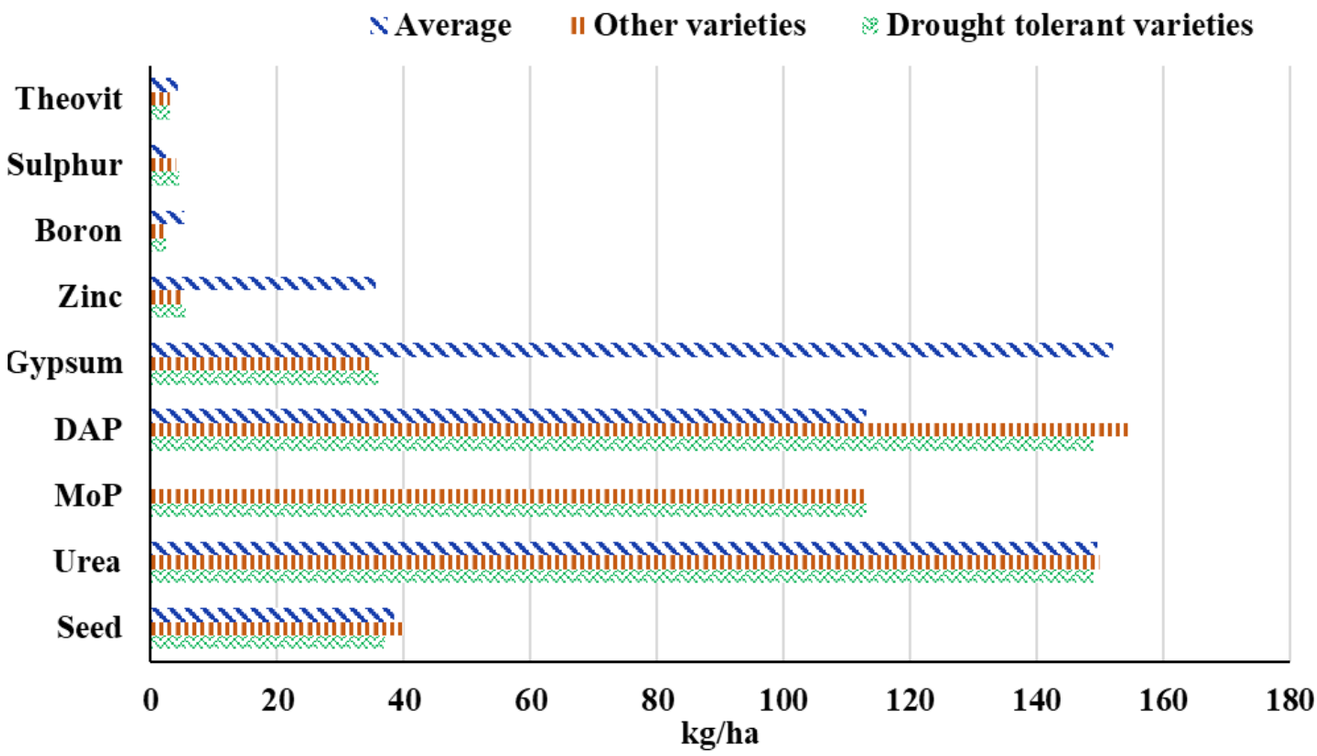


Figure 6. Per hectare seed rate and fertilizer application for paddy cultivation in the study area in 2022-23. Source: Prepared by authors from survey data.

Production cost

Table 13 represents the expenses incurred per hectare for cultivating drought-tolerant and other popular rice varieties within the study areas during the period of 2022-23. The cost of human labor per hectare for cultivating drought-tolerant rice varieties amounted to Tk. 51,450, while it was Tk. 51,940 for the cultivation of other rice varieties. These figures account for 33.74 percent and 34.07 percent of the total production cost, respectively. The fertilizer cost of cultivating other varieties (Tk. 12,058/ha) was slightly higher than the drought-tolerant varieties (Tk 12,044/ha). This is noteworthy considering that paddy cultivation in Bangladesh during the Aman season primarily relies on natural rainfall. But during the last 2022-23 Aman season, insufficient rainfall made it difficult for the farmers to plant paddy on time. Farmers had to pay additional money for supplementary irrigation of the rice field. The average irrigation cost of cultivating paddy in the study area was 8,413 Tk./ha, which is 5.52 percent of the total cost of production in the Aman season. In 2022-23 Aman season, on average, cultivating drought varieties incurred more cost than other cultivars in the study area (Table 13).

Profitability

Table 14 shows the per hectare profitability of drought-tolerant and other rice varieties cultivation in Aman season in the study area, 2022-23. In the study location, drought tolerant rice varieties have higher yields than other varieties. The average yield of drought-tolerant varieties was 5,313 kg/ha, while the yield of other varieties was 5,008 kg/ha. Due to the favorable climate, low paste and disease infestation, and considerable irrigation facilities, Aman season rice yield was higher than last year. The table also shows that the profitability of drought tolerant rice varieties is higher than the profitability of other rice varieties cultivation. The gross margin (GM) of drought-tolerant varieties was 84,258 TK/ha, while the GM of other varieties was 68,415 TK/ha. The net return (NR) of drought-tolerant varieties was 31,051 TK/ha, while the NR of other varieties was 16,236 TK/ha. The results also revealed that the BCR (benefit-cost ratio) of drought rice varieties cultivation is higher than the BCR

of other rice varieties cultivation. In 2022-23, the BCR of drought-tolerant varieties was 1.20 (full cost basis), while the BCR of other popular varieties was 1.11 (full cost basis) (Table 14).

Table 13. Per hectare cost of different types of rice cultivation in the study area in 2022-23

Cost items	Drought tolerant varieties		Other varieties		Average	
	TK./ha	% of total cost	TK./ha	% of total cost	TK./ha	% of total cost
Seed	2923	1.92	2820	1.85	2871.5	1.88
Seedling development	2988	1.96	3050	2.00	3019	1.98
Land preparation (ploughing and laddering)	11205	7.35	11205	7.35	11205	7.35
Human labour:	51450	33.74	51940	34.07	51695	33.90
Hired	23520	15.42	23520	15.43	23520	15.43
Family	6370	4.18	6860	4.50	6615	4.34
Hired contract (transplanting, weeding and harvesting)	21560	14.14	21560	14.14	21560	14.14
Fertilizer cost	12044	7.90	12058	7.91	12051	7.90
Irrigation	7845	5.14	8981	5.89	8413	5.52
Pesticide:	13472	8.83	13098	8.59	13285	8.71
Herbicide	748	0.49	748	0.49	748	0.49
Insecticide and fungicide	12724	8.34	12350	8.10	12537	8.22
Power thresher	3742	2.45	3966	2.60	3854	2.53
Total variable cost	**99299**	**65.11**	**100258**	**65.77**	**99778.5**	**65.44**
Interest on operating capital	1712	1.12	1794	1.18	1753	1.15
Land rent	45125	29.59	43525	28.55	44325	29.07
Total fixed cost	**53207**	**34.89**	**52179**	**34.23**	**52693**	**34.56**
Total Cost	152506	100.00	152437	100.00	152471.5	100.00

Source: Prepared by authors from survey data, 2022-23.

Table 14. Per hectare profitability of drought-tolerant and other popular rice varieties cultivation in Aman season in the study area, 2022-23

Items	Drought tolerant varieties	Popular varieties	Average
Total costs (TK./ha)	152506	152437	152471.5
Total variable costs (TK./ha)	99299	100258	99778.5
Total fixed cost (TK./ha)	53207	52179	52693
Yield (kg/ha)	5313	5008	5160.5
Market value of paddy (TK./ha)	160825	144280	152552
Market value of straw (TK./ha)	22732	24393	23563
Gross benefit (GB) (TK./ha)	183557	168673	176115
Gross margin (GM) (TK./ha)	84258	68415	76336
Gross profit ratio ((GM*100)/GB)	45.90	40.56	43.23
Net return (TK./ha)	31051	16236	23643
Cost of production (TK./kg)	28.70	30.44	29.57
Selling price of grain (TK./kg)	30.27	28.81	29.54
BCR (cash cost basis)	1.85	1.68	1.77
BCR (full cost basis)	1.20	1.11	1.16

Source: Prepared by authors from survey data, 2022-23.

Risk analysis of rice varieties in drought-prone areas

We present a comprehensive risk analysis of rice varieties cultivated in drought-prone regions of Bangladesh. Our investigation focused on evaluating the economic viability of drought-tolerant and non-drought-tolerant rice varieties under varying climate and market conditions.

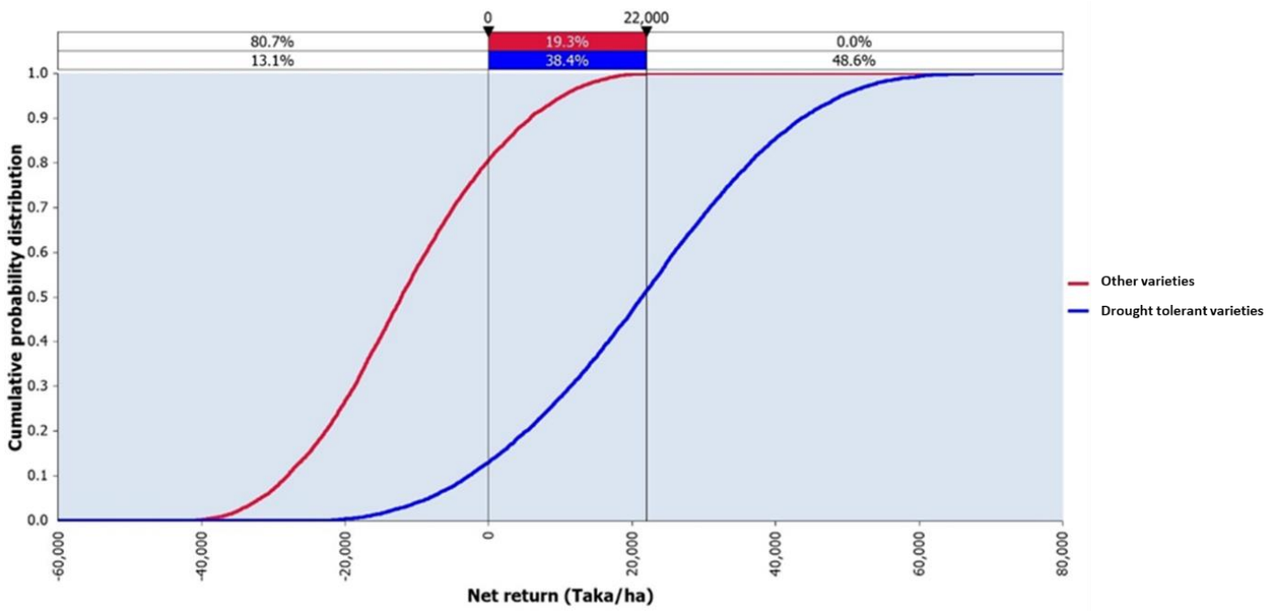


Figure 7. Cumulative probability distribution of net return for drought-tolerant and other popular rice varieties

To assess the economic prospects of the different rice varieties, we constructed a cumulative probability distribution of net return (Figure 7). This analysis was conducted based on farmers' perceptions of climate-induced yield variations and market price fluctuations. Our findings reveal distinct patterns in the economic risk associated with drought-tolerant and non-drought-tolerant rice varieties. Other rice varieties (non-drought-tolerant) exhibited a notable probability range of negative net returns, above 80%. In contrast, the corresponding drought-tolerant varieties was comparatively narrower, 13. Other rice cultivars demonstrated a maximum net return of 22000 BDT/ha. Conversely, the probability of achieving net returns exceeding 22000 BDT/ha was observed to be 48.6% for drought-tolerant varieties.

Within the category of drought-tolerant rice varieties we identified varying levels of economic risk. BRRI dhan51 emerged as the least risky option in terms of economic returns, followed by Guti Swarna, BRRI dhan71, BRRI dhan57, BRRI dhan56, and BRRI dhan66 (Figure 8). Surprisingly, in drought-prone areas, BRRI dhan51 displayed lower economic risk compared to other rice varieties due to its inherent drought-tolerant capacity. Although originally recognized for its submergence tolerance, field observations indicated its substantial drought-tolerant potential stemming from its parental lineage (Swarna-type) with multi-stress tolerance capabilities. Guti Swarna stood out as the second least risky option. Its multi-stress tolerant capacity contributed to its resilience under stress conditions and potential for yielding higher outputs.

In conclusion, our analysis underscores the greater economic risk associated with other rice varieties compared to their drought-tolerant counterparts. This discrepancy can be attributed to the lower-yielding capacity in drought prone areas. Conversely, the drought-tolerant varieties often medium to long-growth duration varieties exhibit an unexpected degree of drought tolerance, resulting in higher

yields. These findings call for a reevaluation of breeding strategies in drought-prone regions. Future breeding programs should focus on elucidating the physiological underpinnings of drought tolerance in BRRI dhan51 and Guti Swarna. By capitalizing on these insights, rice breeders can design targeted breeding initiatives aimed at developing medium to long-duration drought-tolerant varieties with optimal yield potential.

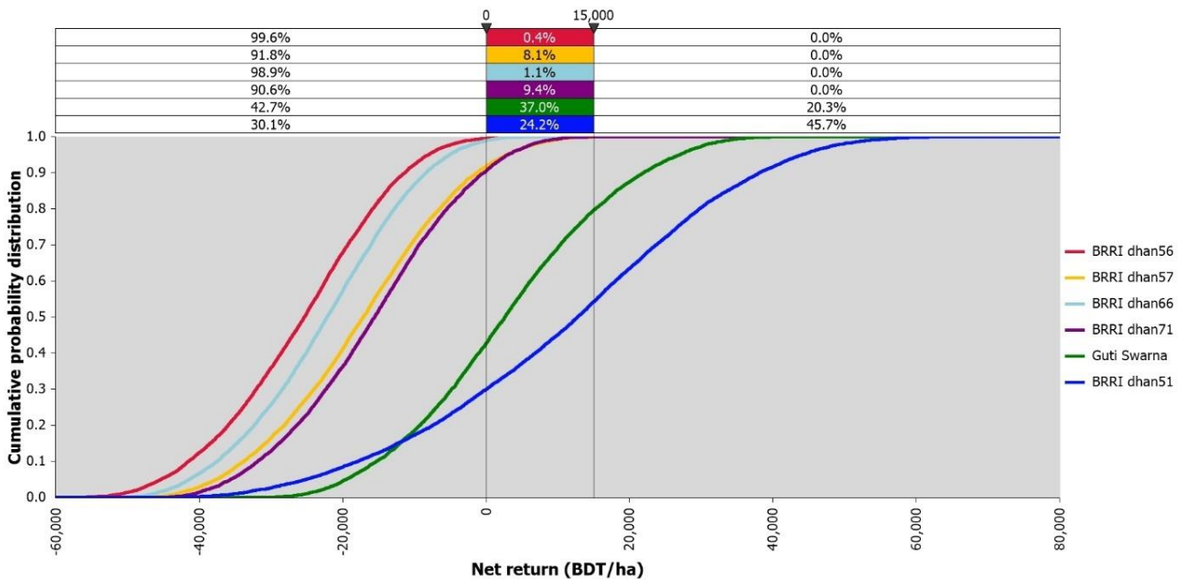


Figure 8. Cumulative probability distribution of net return among different drought tolerant rice varieties

Determinants of adopting drought-tolerant rice varieties

The influential factors that affect the paddy farmer's decision to cultivate drought-tolerant rice varieties in the study area are illustrated in Table 15. Multicollinearity was also tested before proceeding with model estimation. In this analysis, the variance inflation factor (VIF) was reported to be 3.62, below the conventional threshold value of 10. The chi-square value is statistically significant at less than 1% significance level and the Pseudo R^2 value was 0.79. This indicates that the overall model is good fit. The marginal effects of variations in explanatory variables on the likelihood of adoption were calculated to classify the determinants of drought-tolerant rice cultivar's adoption (see Table 15).

The adoption decision of climate-resilient rice cultivars was influenced by socioeconomic, market, and institutional factors. The factors e.g. education, land size, training, extension service, participation in field demonstration, membership in any agricultural organization, severity of drought, and total varieties cultivated had positive and statistically significant effect on the adoption of drought-tolerant rice cultivars in the study region. The probability of adopting drought-tolerant rice cultivars will increase by 3.90, 8.20, 9.50, 6.10, 7.20, 2.00, 11.20, and 1.1% if the farmer's education year, land size, training, extension service, participation in field demonstration, membership in any agricultural organization, severity of drought, and total varieties cultivated increase by 1 percent.

On the other hand, yield differences were found to be statistically significant and negative. This implies that if the yield difference increases by 1 percent (compared to other cultivars), the adoption of drought-tolerant rice cultivars will decrease by 18.00% in the study area.

Table 15. Estimated Probit results for the adoption decision of drought-tolerant rice varieties

Variables	Coefficient	Standard Error	Marginal Effect
Age	0.003	0.035	0.001
Education	0.052**	0.001	0.039**
Occupation	0.097	0.085	0.005
Family size	0.022	0.064	0.003
Family members involve in farming	0.155	0.100	0.011
Land size	0.133***	0.040	0.082***
Market demand	0.304	0.359	0.005
Eating quality	0.023	0.031	0.009
Yield difference	-0.371***	0.072	0.180***
Distance to UAO	-0.135	0.092	0.029
Distance to local market	-0.011	0.023	0.003
Training	0.109***	0.038	0.095***
Extension service	0.131**	0.051	0.061**
Participate in field demonstration	0.013**	0.006	0.072**
Membership in any agricultural organization	0.136*	0.079	0.020*
Credit	0.012	0.018	0.011
Severity of Drought	0.132**	0.064	0.112**
Disease infestation	0.027	0.033	0.005
Total varieties cultivated	0.014**	0.008	0.011**
Constant	0.843**	0.376	
Log likelihood	-402.296		
Number of Observation	220.000		
Wald $Chi^2(17)$	76.480		
Prob> chi^2 =	0.000		
Pseudo R^2	0.79		

Note: *, **, and *** mean significant at 10%, 5%, and 1% probability level, respectively.
Source: Field survey 2022-23

Conclusion

Bangladesh's vulnerability to climate change is underscored by its shifting ranking in the Global Climate Risk Index. The country's agriculture faces susceptibility to climate-induced disasters, particularly drought which threatening food security. To address this, the study aimed to assess the adoption, profitability, and influencing factors of drought-tolerant rice varieties in drought-prone areas, with the goal of providing insights for policies that can enhance rice cultivation in these areas.

According to the findings, the overall adoption rate of drought-tolerant rice cultivars is 23.69%, with variations across different regions of Bangladesh. Among different drought-tolerant rice cultivars, Swarna is the most popular variety (17.48%)in Bangladesh. The adoption of drought-tolerant rice varieties is more pronounced in Chapainawabganj compared to Rajshahi. In 2022-23 the overall adoption rate of drought-tolerant cultivars in Rajshahi was 63.11% and in Chapainawabganj it was 74.03%. Among the drought-tolerant rice varieties, the adoption of BRRI dhan51 is rapidly increasing in both districts, due to its higher yield and better quality, while the adoption of Swarna varieties is gradually diminishing. The profitability analysis depicts that planting drought tolerant cultivars was comparatively more profitable than the other rice cultivars. The BCR of drought-tolerant rice cultivars was 1.20, and 1.11 for other cultivars in the study area.

Additionally, the econometric model results indicated that the education, land size, training, extension service, participation in field demonstration, membership in any agricultural organization, the severity of drought, and total varieties cultivated had a statistically significant effect on the adoption of drought-tolerant rice cultivars. The study's findings suggest that in order to expand the cultivation of drought-tolerant cultivars in the study region, particular attention should be paid to the existing variability in socio-economic, marketing, and institutional aspects. However, the adoption of drought-tolerant rice cultivars was constrained by price and yield disparities. To enhance the adoption rate, special care must be taken to raise the price and yield of drought-tolerant rice cultivars.

To increase the adoption of drought-tolerant rice varieties, the government should provide subsidies to farmers, conduct awareness campaigns, make drought-tolerant rice varieties more available, and to support research and development of new drought-tolerant rice varieties. The government could also set up a fund to provide loans to farmers who want to cultivate drought-tolerant rice varieties, work with agricultural universities and research institutes to develop new drought-tolerant rice varieties, provide training to farmers on how to cultivate drought-tolerant rice varieties, set up more demonstration of new technologies and work with agricultural extension agencies to promote the use of drought-tolerant rice varieties among farmers. By taking these steps, the government can help to increase the adoption of drought-tolerant rice varieties in Bangladesh and help farmers to adapt to climate change.

STUDY 3: RAPID ASSESSMENT REPORT: PROSPECTS AND CONSTRAINTS OF CULTIVATING BRRI dhan87 IN SOME SELECTED AREAS OF BANGLADESH

MS Islam, MA Islam, A Chowdhury, MS Rahaman, L Deb, SMMH Noman and SA Jui

Introduction

BRRI has so far developed 107 inbred and eight hybrid rice cultivars with higher yield potential, aiming to ensure the country's food security. On an average scale, the adoption of BRRI cultivars during the Aman season has increased. Additionally, for the T. Aman season, BRRI has introduced numerous short-duration rice varieties with substantial yield capabilities. BRRI dhan87 had an adoption rate of 2.07% in Aman season during the 2021-22 period, as reported by Agricultural Economics Division, BRRI (2021-22). Nevertheless, the acceptance rate of BRRI dhan87 remained limited in several regions. This study was undertaken with the following objectives;

- evaluates the adoption status and constraints to adoption of BRRI dhan87; and
- other popular varieties in the five regions of Bangladesh.

Methodology

Focus Group Discussion (FGD) and expert interview tools were conducted using a structured questionnaire to gather data for the study. Data were also collected from secondary sources for the study. Upazila-wise adoption data of different rice varieties in the Aman season and their yield were collected from the Upazila Agriculture Office, the Department of Agricultural Extension (DAE). Farmers were selected purposively, mainly those who cultivated BRRI dhan87 in the last Aman season. Farmers' perceptions, drivers, and drawbacks of adoption of different Aman rice cultivars were collected through focus group discussion (FGD). A total of 15 FGDs were conducted in 15 Upazilas of Rangpur, Dinajpur, Bogura, Sylhet and Kushtia district using a pre-structured questionnaire. A total of 150 key informants i.e., 10 from each selected Upazila. Moreover, an expert panel session with DAE personnel including Sub Assistant Agriculture Officer (SAAO), Agriculture Extension Officer, and Upazila Agriculture Officer was conducted in each Upazila to identify drivers and drawbacks of the adoption of Aman rice cultivars and validate farmer's observations. Collected data were analyzed using descriptive statistics.

Results and discussion

Location: Rangpur and Dinajpur regions

Land topography, cropped areas, and major cropping patterns in the study locations

Table 16 illustrates basic agricultural statistics for different Upazilas within the Dinajpur and Rangpur regions. The table provides information on land topography, cropped areas, and cropping patterns for each Upazila. More than 80% of the entire arable land in the study areas constitutes high and medium-high lands, primarily employed for double or triple cropping systems. Consequently, the regions exhibit notably heightened cropping intensity (Table 16). Even though both regions possess arable land exceeding 80% comprised of high to medium-high lands, an average of approximately 50% of the area in each Upazila is allocated to the Rice-Fallow-Rice cropping pattern, indicating that non-rice crop areas are used for rice cultivation in the dry season in the location. Additionally, a cropping pattern involving the Aman-Robi crop+Boro-Fallow cropping pattern has gained popularity recently in this region (Table 17). The land topography and land usage pattern distinctly suggest substantial prospects for diffusion of short-duration rice varieties with higher yield potential in this region.

Table 16. Basic agricultural statistics of surveyed Upazilas of Dinajpur and Rangpur regions, 2023

Item	Dinajpur region				Rangpur region						Grand total	% of total
	Thakurgaon district		Panchagarh district		Rangpur district							
	Sadar (ha)	% of total cropped area	Debiganj (ha)	% of total cropped area	Pirganj (ha)	% of total cropped area	Kaunia (ha)	% of total cropped area	Taraganj (ha)	% of total cropped area		
Land topography:												
High land	29125	52.85	8685	49.02	10366	31.60	3128	24.90	3987	34.51	55291	42.61
Medium high land	21758	39.48	0	0.00	16993	51.81	5883	46.83	7369	63.78	52003	40.08
Medium low land	4228	7.67	9034	50.98	3831	11.68	2957	23.54	196	1.70	20246	15.60
Low land	-	-	-	-	1610	4.91	595	4.74	1	0.01	2206	1.70
Total	55111	100	17719	100	32800	100	12563	100	11553	100	129746	100
Land use pattern:												
Single cropped land	1988	3.61	1776	6.51	1148	3.50	480	3.79	300	1.57	5692	3.87
Double cropped land	24690	44.81	16105	59.03	15744	48.00	5055	39.96	5050	26.37	66644	45.34
Triple cropped land	26200	47.55	9400	34.46	13940	42.50	7015	55.45	5802	30.29	62357	42.42
Quadruple cropped area	2227	4.04	-	-	1968	6.00	100	0.79	8000	41.77	12295	8.36
Total	55105	100	27281	100	32800	100	12650	100	19152	100	146988	100

Source: DAE, 2023

Table 17. Major cropping patterns of surveyed Upazilas of Dinajpur and Rangpur regions, 2023

Cropping Patterns	Dinajpur region						Rangpur region						Grand average (%)
	Thakurgaon district				Panchagarh district		Rangpur district						
	Pirganj		Sadar		Debiganj		Kaunia		Pirganj		Taraganj		
	Area (ha)	% area	Area (ha)	% area	Area (ha)	% area	Area (ha)	% area	Area (ha)	% area	Area (ha)	% area	
Boro-Fallow-T. Aman	14860	45	21790	31	9580	64	5832	46.1	15750	48	6440	55.74	48.31
Boro-Fallow-Fallow	328	1											0.17
Maize-Fallow- T. Aman					1200	8							1.33
Mustard+Potato-Boro- T. Aman									492	1.5			0.25
Mustard+Potato-Vegetable-Aus- T. Aman	1148	3.5							1155	3.5			1.17
Potato+Boro-Fallow- T. Aman			3905	7									1.17
Potato+Maize-Fallow- T. Aman			6000	11									1.83
Potato-Aus- T. Aman	1660	5							1640	5	760	6.57	2.76
Potato-Boro- T. Aman	4968	15					1568	12.4	4920	15			7.07
potato-Jute- T. Aman	2296	7					1500	11.9	2200	7	665	5.75	5.28
Potato-Maize- T. Aman									670	2			0.33
Potato-Maize-Vegetable- T. Aman	820	2.5							880	2.5			0.83
Vegetables-Fallow-Groundnut					600	4							0.67
Vegetables-Fallow-Vegetable									1320	4			0.67
Wheat-Fallow- T. Aman			5100	9									1.50
Wheat-Jute- T. Aman					2530	17							2.83
Wheat-Maize- T. Aman			3950	7									1.17
Major cropping pattern total	25912	79	40745	65	13910	93	8900	70.4	27609	88.5	7865	68.06	77.33

Source: DAE, 2023

Adoption, yield, and market price of the adopted varieties in Aman season 2022-23 in Dinajpur district

Table 18 illustrates the adoption percent, yield, and market price of different rice varieties cultivated in different Upazilas of the Dinajpur region.

In Sadar Upazila of Thakurgaon district, the most adopted variety was Guti Swarna (49.21% from DAE statistics and 60% from survey results). According to DAE statistics, BRRI dhan87 and Binadhan-17 were adopted in 0.11 and 0.33 % areas of Sadar Upazila. Farmers opined that the adoption of BRRI dhan87 and Binadhan-17 was 1 and 2 % of the Aman areas, respectively. According to DAE the yield of Guti Swarna, BRRI dhan87, and Binadhan-17 were 4.88, 5.07, and 5.07 t/ha, respectively, whereas the survey result shows a bit higher yield (5.53, 5.34, and 5.43 t/ha) in the study area (Table 18). The selling price of paddy is on average Tk. 1200/40kg in this area (Figure 9).

According to DAE, Sumon Swarna (29.71%) was the popular variety adopted in Pirganj Upazila of Thakurgaon district, whereas the survey results show that Guti Swarna (60%) was the most adopted variety. BRRI dhan87 and Binadhan-17 adopted 0.60 and 0.48 % in the Aman areas, respectively. In contrast, the survey result shows that it was 2 and 7%, respectively. According to DAE, the yield of Sumon Swarna, Guti Swarna, BRRI dhan87, and Binadhan-17 were 5.09, 5.24, 4.06, and 5.15t/ha, respectively, whereas the survey result shows a bit higher yield 5.34, 5.53, 4.94, and 5.34 t/ha, respectively (Table 18). The market price of paddy is, on average, Tk.1200/40kg in this area (Figure 9).

In Debiganj Upazila of Panchagarh district, according to the DAE, Guti Swarna was the highest adopted variety and the area was covered by 52.40%, whereas in the FGD result, Guti Swarna was also the highest adopted rice varieties in the study location and was covered by 60.% of the study area. DAE results revealed that BRRI dhan87 and Binadhan-17 covered 3.28 and 3.32 % of the Aman areas; on the other hand, the FGD result, the area coverage was 5 and 15 percent, respectively. The yield of Guti Swarna, BRRI dhan87, and Binadhan-17 according to DAE were 5.00, 4.78, and 4.85 t/ha, respectively, on the contrary, the survey result shows higher yields 5.39, 4.79, and 5.09 t/ha (Table 18). The farmers of Debiganj Upazila received, on average, Tk.1150/40kg for selling paddy in the market (Figure 9).

Table 18. Adoption (%), yield (t/ha), and market price (Tk/40kg) of different varieties in Aman season of Dinajpur region, 2022-23

Region	District	Upazila	Types	Variety name	DAE		Survey		Market price (Tk/40kg)
					Area %	Yield (t/ha) Paddy	Area %	Yield (t/ha) Paddy	
Dinajpur	Thakurgaon	Sadar	Hybrid	Dhanigold	6.17	5.37	20	5.93	1200
			BRRI	BRRI dhan34	7.99	4.33	-	-	-
			BRRI	BRRI dhan49	7.20	5.37	-	-	-
			BRRI	BRRI dhan51	9.30	5.37	5	5.93	1200
			BRRI	**BRRI dhan87**	**0.11**	**5.07**	**1**	5.34	**1200**
			BINA	**Binadhan-17**	**0.33**	**5.07**	**2**	5.43	**1200**
			BINA	Binadhan- 7	0.08	4.78	2	3.46	1150
			Indian	Ranjit Swarna	0.70	4.85	-	-	-
			Indian	Sumon Swarna	11.33	5.07	10	5.34	1200
			Indian	**Guti Swarna**	**49.21**	**4.88**	**60**	5.53	**1150**
				Other Varieties	7.58	-	-	-	-
		Pirganj	Hybrid	Dhanigold	8.82	5.87	5	5.93	1050
			BRRI	BRRI dhan34	3.97	4.21	2	3.95	2250
			BRRI	BRRI dhan49	4.17	4.63	-	-	-
			BRRI	BRRI dhan51	12.71	5.27	4	5.93	1150
			BRRI	**BRRI dhan87**	**0.60**	**4.06**	**2**	4.94	**1150**
			BINA	**Binadhan-17**	**0.48**	**5.15**	**7**	5.34	**1200**
			BINA	Binadhan-7	0.38	4.18	-	-	-
			Indian	**Sumon Swarna**	**29.71**	**5.09**	**20**	5.34	**1200**
			Indian	Guti Swarna	23.87	5.24	60	5.53	1150
				Other Varieties	15.29	-	-	-	-
	Panchagarh	Debiganj	Hybrid	Dhanigold	9.72	5.79	10	5.99	950
			BRRI	BRRI dhan34	2.47	4.03	-	-	-
			BRRI	BRRI dhan75	4.14	4.70	-	-	-
			BRRI	**BRRI dhan87**	**3.28**	**4.78**	**5**	4.79	**1150**
			BINA	**Binadhan-17**	**3.32**	**4.85**	**15**	5.09	**1200**
			Indian	**Guti Swarna**	**52.40**	**5.00**	**60**	5.39	**1150**
			Indian	Ranjit Swarna	4.14	4.85	10	5.09	1200
				Other Varieties	20.54	-	-	-	-

Source: Field survey, 2023

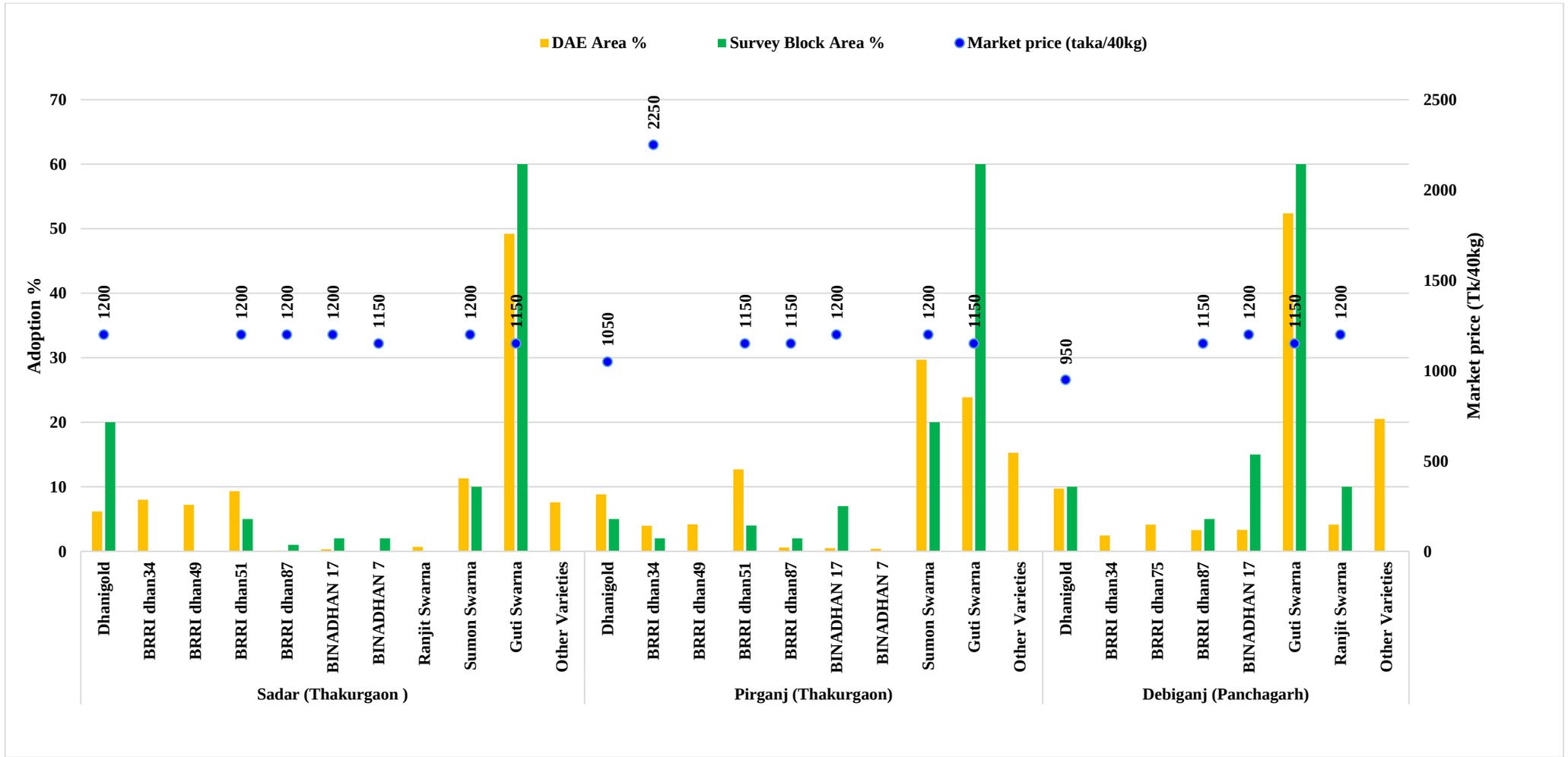


Figure 9. Adoption (%) and Market price (Tk/40kg) of different Aman rice varieties cultivated in the study locations in Dinajpur region 2022-23

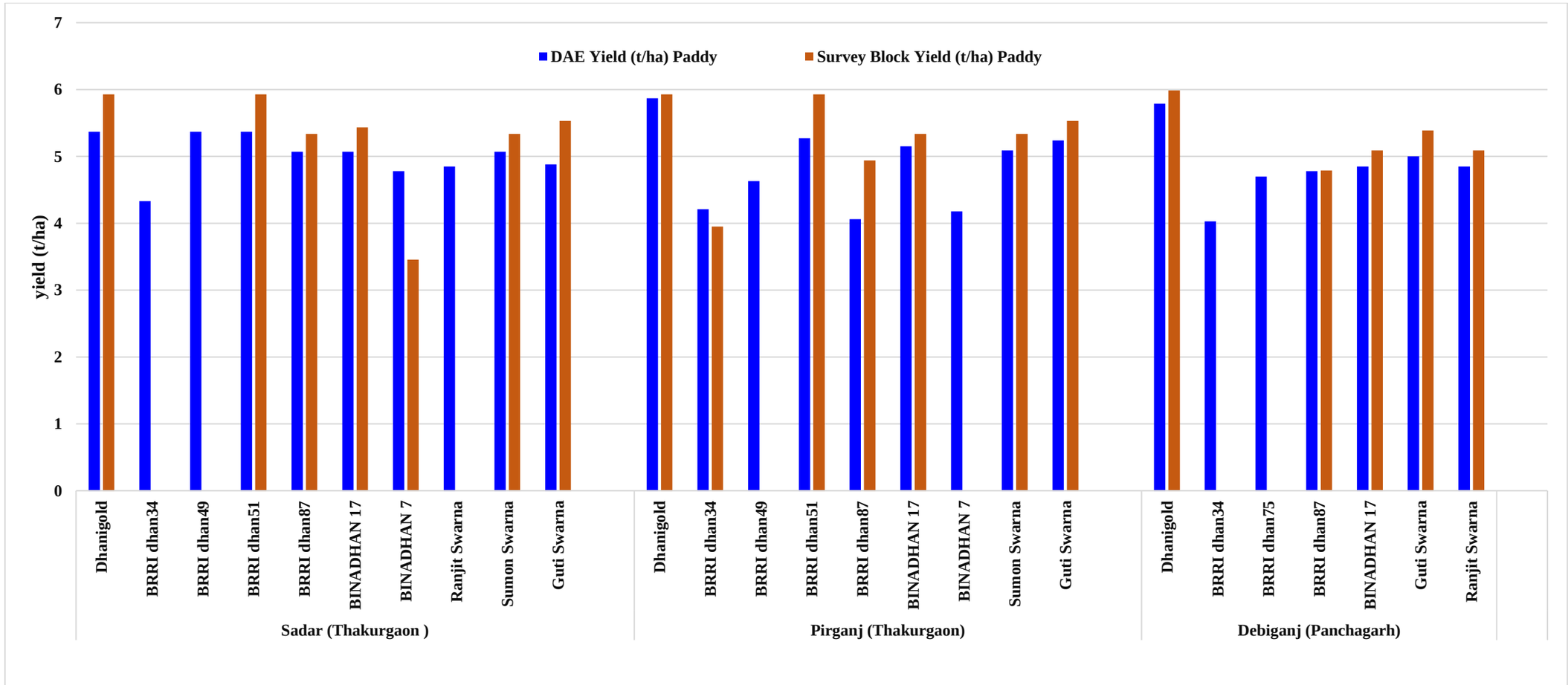


Figure 10. Yield (t/ha) performance of Aman different Aman rice varieties cultivated in the study locations in Dinajpur region, 2022-23

Table 19 illustrates the adoption percent, yield, and market price of different rice varieties cultivated in different Upazilas of the Rangpur region.

In the Rangpur region, findings indicated that Guti Swarna stood out as the preferred choice among rice varieties for the Aman season. As reported by the Department of Agricultural Extension (DAE), the rate of adoption for Guti Swarna was 37.58%. However, the field survey demonstrated a higher rate of 50% in Pirganj Upazila. Similarly, in Taraganj and Kaunia Upazilas, the DAE showed adoption rates of 27.72% and 31.06% for Guti Swarna, but the survey results unveiled higher percentages of 40% and 48%, respectively (Table 19 and Figure 11).

The adoption rate of BRRI dhan87 differed between the reports from the DAE and the survey results. In Pirganj Upazila, according to the DAE, the adoption rates stood at 2.5 and 10% based on the survey results. Similarly, in Taraganj Upazila, the adoption rate was 5.45% in the DAE statistics and 5% as per the survey results, while in Kaunia Upazila, they were 2.23% (DAE) and 2% (survey). On the other hand, the adoption of Binadhan-17 exhibited similar variations between the DAE statistics and the survey results. In Pirganj Upazila, the adoption rate increased by 1.33%, according to the DAE. In Taraganj Upazila, the rates were 6.44% (DAE) and 5% (survey), and in Kaunia Upazila, they were 0.79% (DAE statistics) and 2% (survey results), respectively (Table 19 and Figure 11).

The yield of the most adopted variety, Guti Swarna, showed differing yields according to both DAE statistics and the survey results: 4.25 t/ha and 5.25 t/ha in Pirganj, 4.42 t/ha and 5.30 t/ha in Taraganj, and 4.33 t/ha and 5.14 t/ha in Kaunia Upazilas, respectively. DAE statistics indicated that BRRI dhan87 gives a yield of 4.07 t/ha, 5.49 t/ha, and 4.15 t/ha in Pirganj, Taraganj, and Kaunia Upazila, while survey outcomes give slightly higher yields at 4.35 t/ha, 5.53 t/ha, and 4.35 t/ha, respectively. For Binadhan-17, according to DAE data, the yield was reported as 5.16 t/ha in Pirganj, 4.72 t/ha in Taraganj, and 5.04 t/ha in Kaunia. Conversely, the survey results indicated a yield of 5.53 t/ha in Taraganj and 5.14 t/ha in Kaunia. On average, the farmers of the Rangpur region received a paddy price of Tk. 1130 /40 kg (Table 19 and Figure 11).

Table 19. Adoption (%), yield (t/ha), and market price (Tk/40kg) of different aman season rice varieties in the Rangpur region, 2022-23

Region	District	Upazila	Types	Variety name	DAE		Survey		Market price (Tk/40kg)
					Area %	Yield (t/ha) Paddy	Area %	Yield (t/ha) Paddy	
Rangpur	Rangpur	Pirganj	Hybrid	Dhanigold	1.79	5.04	5	5.53	1100
			BRRI	BR11	9.83	4.21	-	-	1150
			BRRI	BRRI dhan51	4.21	3.96	-	-	-
			BRRI	BRRI dhan52	7.55	4.16	5	4.15	1050
			BRRI	BRRI dhan75	1.69	4.39	10	4.74	1200
			BRRI	**BRRI dhan87**	**2.53**	**4.07**	**10**	**4.35**	**1150**
			BINA	**Binadhan-17**	**1.33**	**5.16**	**-**	**-**	**1200**
			Indian	**Guti Swarna**	**37.58**	**4.25**	**50**	**5.24**	**1150**
			Indian	Ranjit Swarna	6.88	4.22	20	4.94	1200
				Other Varieties	26.59	-	-	-	-
		Taraganj	Hybrid	Hybrids All	29.70	6.01	25	6.34	1000
			Indian	**Guti Swarna**	**27.72**	**4.42**	**40**	**5.30**	**1050**
			Indian	Ranjit Swarna	10.40	4.36	15	4.84	1100
			BRRI	BR11	6.93	4.30	5	4.61	1050
			BRRI	BRRI dhan75	8.71	5.27	5	4.61	1100
			BRRI	**BRRI dhan87**	**5.45**	**5.49**	**5**	**5.53**	**1050**
			BINA	**Binadhan-17**	**6.44**	**4.72**	**5**	**5.53**	**1100**
				Other Varieties	4.65	-	-	-	-
		Kaunia	Hybrid	All Hybrids	8.29	5.04	5	5.14	1050
			BRRI	BR11	24.21	4.25	20	4.35	1050
			BRRI	BRRI dhan49	7.24	4.25	5	4.35	1350
			BRRI	BRRI dhan51	9.51	4.03	8	4.35	1050
			BRRI	BRRI dhan52	11.87	4.22	8	4.54	1050
			BRRI	BRRI dhan75	2.05	4.33	2	4.74	1350
			BRRI	**BRRI dhan87**	**2.23**	**4.15**	**2**	**4.35**	**1200**
			BINA	**Binadhan-17**	**0.79**	**5.04**	**2**	**5.14**	**1200**
			Indian	**Guti Swarna**	**31.06**	**4.33**	**48**	**5.14**	**1100**
				Other Varieties	2.76	-	-	-	-

Source: Field survey, 2023

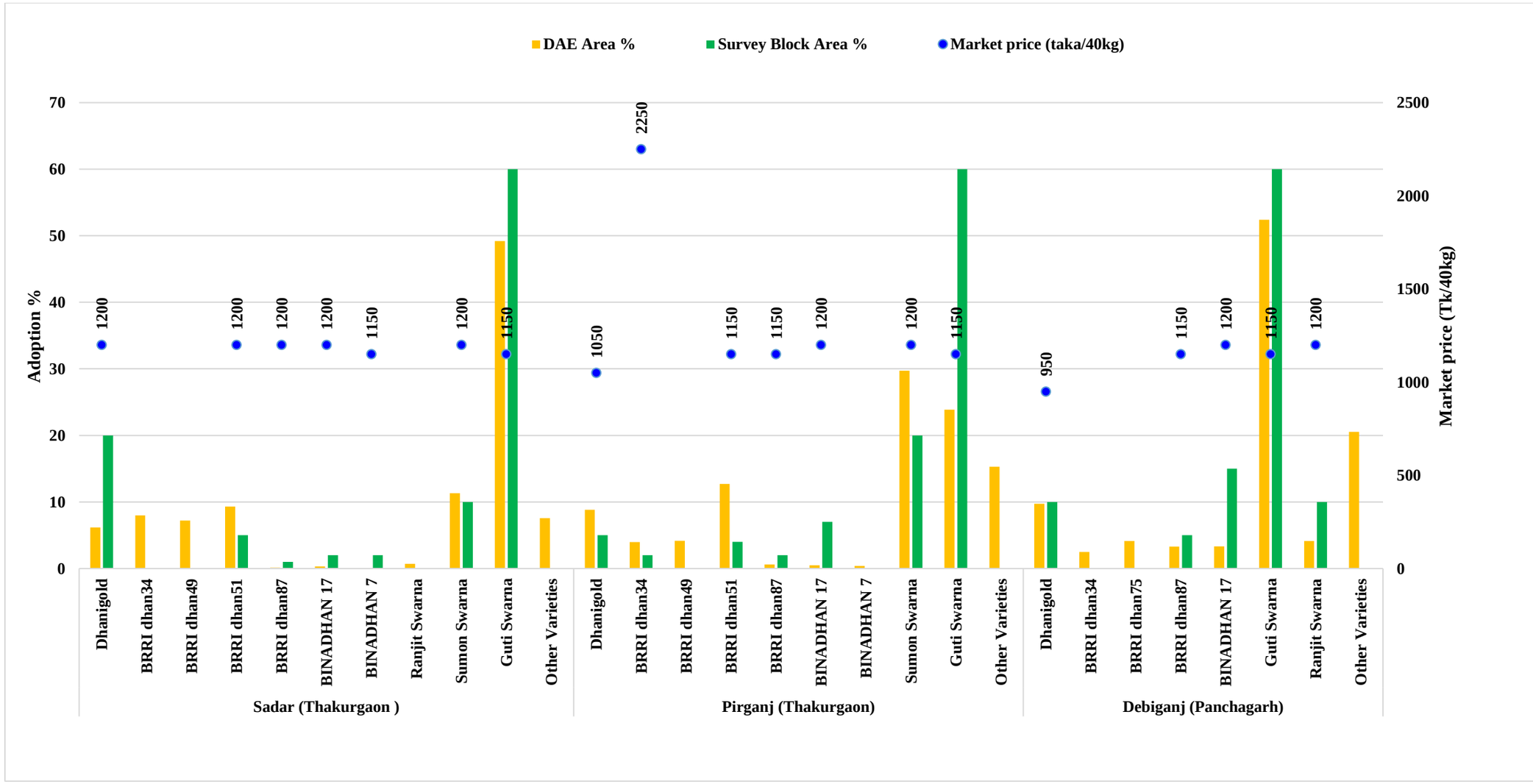


Figure 11. Adoption (%) and Market price (Tk/40kg) different Aman rice varieties cultivated in the study locations in the Rangpur region, 2022-23

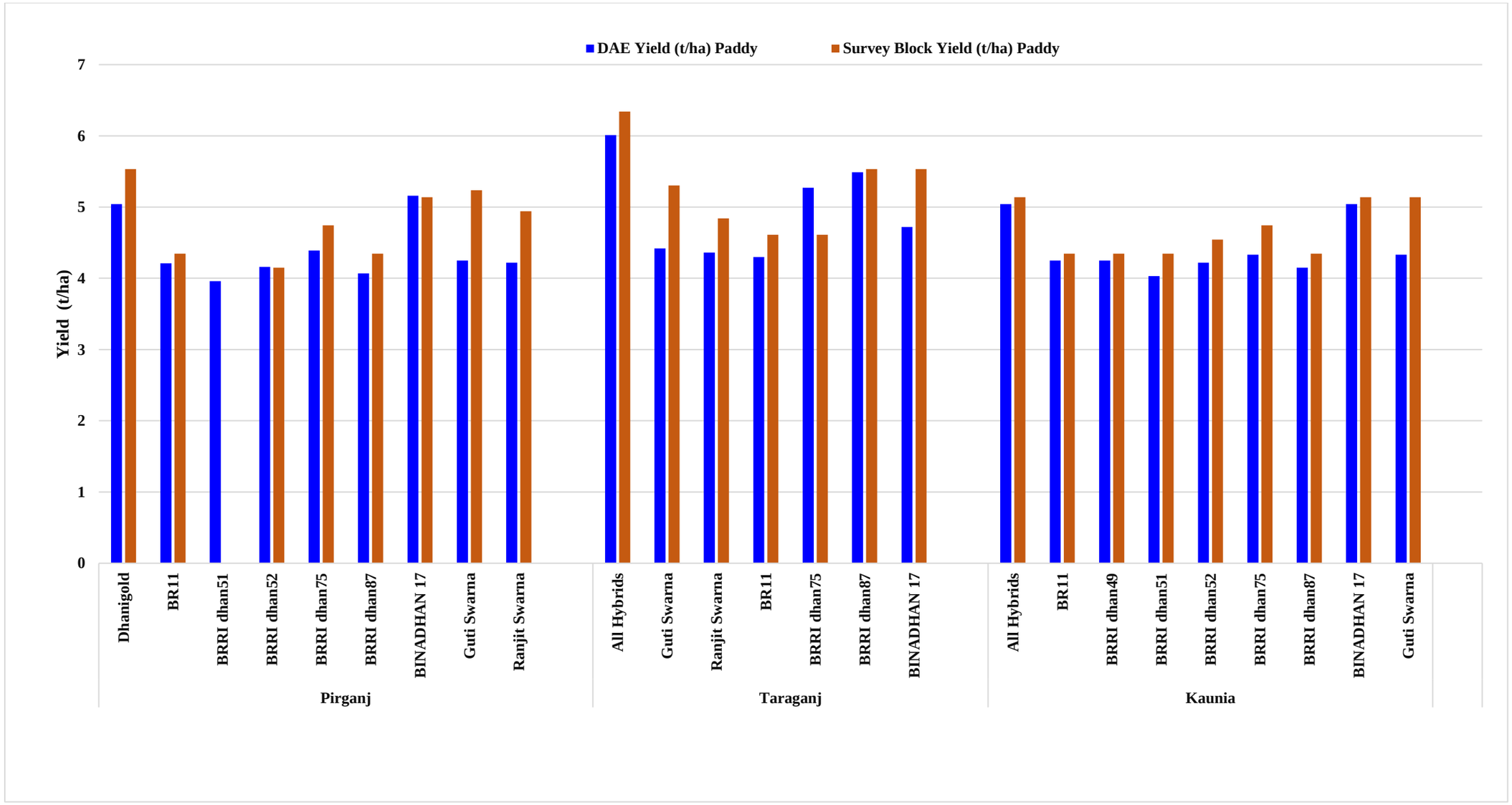


Figure 12. Yield (t/ha) performance of different Aman rice varieties cultivated in the study locations in the Rangpur region, 2022-2

In the Dinajpur and Rangpur regions, the Aman rice varieties predominantly chosen by farmers were Guti Swarna and Sumon Swarna. During group discussions, farmers unanimously concurred that the adaptability of Guti Swarna and Sumon Swarna remains consistent regardless of the prevailing seasonal conditions, land types, and management practices. Moreover, even though these cultivars have a longer growth duration, it is feasible to timely plant dry season (DS) crops right after harvesting by ensuring early transplantation of the paddy. Respondents also emphasized that the significant spread of these cultivars relies on their capacity to endure environmental stresses (both biotic and abiotic) and their suitability within three-crop-based systems. Furthermore, the average yield of different varieties was found to be higher than DAE statistics in the farmer's group discussions (Figures 10 and 12).

Varietal traits of adopted rice cultivars

The majority of farmers in the Dinajpur and Rangpur regions opined that BRRI dhan87 was a relatively recent variety for the Aman season. Farmers shared their views on this variety during group discussions, highlighting its characteristics as a short-duration, high-yielding cultivar. Most participants in the focus group reported that the grains are medium slender, and when cooked, they carry a pleasing taste, possess a non-sticky texture, and remain fresh even when stored for an extended time, which greatly appeals to farmers. The variety also boasts a strong and vigorous stem, yielding high-quality straw. The medium slender grains quality has enabled farmers to receive a higher price in the market (Table 20). Conversely, a significant number of farmers expressed the opinion that BRRI dhan87 is not suitable for all types of land, particularly in low-lying areas. Many farmers also mentioned about its vulnerability to false smut, BPH, and Stemborer infestations. Moreover, farmers pointed out that BRRI dhan87 struggles to withstand drought conditions, which can ultimately result in sterility (Table 20).

The majority of farmers emphasized that Binadhan-17 possesses a crucial advantage in its short growth duration, allowing for harvest 10 to 15 days earlier than BRRI dhan87, coupled with a high yield potential. Additionally, the grains of Binadhan-17 are medium slender and bargain a pleasing taste, making it an attractive choice for farmers. However, the most notable drawback of Binadhan-17, as expressed by most farmers, is its vulnerability to BPH infestation, which resulted in significant crop losses during the previous season. Furthermore, Binadhan-17 is susceptible to root rot, a fungal disease capable of causing crop damage. Additionally, the variety exhibits a high susceptibility to false smut, another fungal disease that can lead to discoloration of the grains and render them unsuitable for getting better market price. (Table 20).

Guti Swarna boasts qualities such as superior grain and straw yields, a high demand in the local market, and a consistent performance even in the face of varying weather conditions It also demonstrates resilience to environmental stresses and is particularly well-suited for double transplanting as an adaptation to climate change. The variety also showcases rapid and synchronized panicle emergence, exhibits suitability for cultivation across diverse terrains, and shows resistance to lodging. Furthermore, Guti Swarna demands fewer resources in terms of fertilizer and seed, yields heftier grains, and its straw is highly regarded as cattle feed. Moreover, cooked rice remains fresh for extended periods. However, there are certain downsides including a bold grain type, a lengthier growth duration,

and susceptibility to specific pests, which may cause its non-suitability in certain agricultural contexts (Table 20).

Most notably, Swarna (5), Sumon Swarna receives unanimous praise for its medium slender grain with excellent taste, making it highly appealing to consumers opined by the majority of the respondents. Its ability to command a higher market price, as indicated by 95% of respondents, underscores its economic significance. Moreover, most of the farmers precise, regarding the quality of its straw further accentuates its utility. With an 85% positive response, its high yield potential aligns with the preferences of many farmers. The strong market demand, echoed by 85% of respondents, makes it clear that this variety is in high demand and additionally, they gave positive responses regarding non-sticky rice with excellent taste and leftovers signifies its appeal to households. However, it's essential to consider that many respondents, 65%, mentioned no shattering problem, indicating easier harvesting. Conversely, certain traits raise concerns; for example, the extended growth duration, a concern for many of the respondents, might limit adaptability in regions with shorter growing seasons. Furthermore, lodging and sterility problems during strong winds are highlighted by many, at 75%, as potential challenges. Likewise, the incompatibility with low-lying land, mentioned by 75% of respondents, restricts its suitability to specific terrains. Lastly, the hindrance of Robi crop cultivation due to the somewhat extended growth period, a concern for many at 90%, underscores the importance of considering crop rotation when cultivating Swarna5/Sumon Swarna (Table 20).

Table 20. Traits of different rice varieties as opined by the farmers in relation to varietal adoption in Rangpur and Dinajpur regions in Aman season, 2022-23

Variety name	**Positive traits**	**% response**	**Negative traits**	**% response**
BRRI dhan87	Short duration variety.	65	Not suitable for low-lying land	85
	High yield potential.	70	Susceptible to false smut	55
	Medium slender grain, good taste, non-sticky, and left-over rice is also good.	85	BPH and Stemborer infestation	60
	The market price is higher	85	Can’t cope with drought resulting in sterility	65
	The stem is strong.	70	Due to a bit long duration compared to other short-duration varieties (Binadhan-17) it hampers *Robi* crop cultivation	95
	Good quality straw	80	-	-
Binadhan-17	High yield potential.	95	BPH infestation	65

Variety name	Positive traits	% response	Negative traits	% response
	High market demand.	80	Susceptible to root rot.	75
	Medium slender grain, good taste, non-sticky, and left-over rice is also good.	90	Highly susceptible to false smut	90
	Short duration variety.	95	-	-
Guti Swarna	Higher grain and straw yield	80	Bold grain type	100
	Higher demand for paddy at the local market	95	Long duration	85
	Consistent yield despite variation in seasonal weather and agronomic practices	100	Not suitable for Robi crop cultivation	80
	Higher adaptive capacity to shocks and abiotic stress (floods, cold, and droughts)	60	Comparatively lower market price except for Swarna5/Sumon Swarna	90
	Highly suitable for double transplanting which is an important adaptation strategy of farm households to climate change	60	BPH and stemborer infestation	75
	Quickly emerge panicle throughout the fields at a time	85	-	-
	Suitable for cultivating in different topography areas (high, medium, and low land) without much compensation of yield	90	-	-
	Less or no lodging, even if rain and storms occurred at the reproductive stage	85	-	-
	The higher number of effective tillers and long panicles with mostly filled grain than that of other varieties including BRRI cultivars	85	-	-
	Require less fertilizer (one top dress of N) and seed, seed is available at home	85	-	-

Variety name	Positive traits	% response	Negative traits	% response
	Higher grain weight and more milling outturn than other varieties	100	-	-
	Soft straw is a preferred feed for cattle	85	-	-
	Cooked rice is not only good to eat but also leftover rice remains fresh for eating even in the following days	90	-	-
Swarna5/Sumon Swarna	Medium slender grain good test	100		
	The market price is higher	95	Long duration	90
	Good quality straw	80	Lodging and sterility problems during strong wind	75
	High yield potential.	85	Doesn't fit in the low-lying land.	75
	High market demand.	85	Due to a bit long duration, it hampers *Robi* crop cultivation	90
	Medium slender grain, good taste, non-sticky, and left-over rice is also good.	100	-	-
	No shattering problem.	65	-	-
	Farmers get Tk 50-100/40kg more than Guti Swarna.	90	-	-

Source: Field survey, 2023

Changes in adoption of BRRI dhan87

Table 21 represents changes in adoption of BRRI dhan87 by the surveyed farmers from different locations in two consecutive years, 2022-23 and 2023-24. The respondent who cultivated BRRI dhan87 in 2022-23 Aman season were selected. Therefore, in the 2022-23 period, all locations displayed an adoption areas of BRRI dhan87.

However, in the following year 2023-24, there was a decline in adoption areas in all locations in the surveyed participants that indicate decreased percentages. For instance, Pirganj (Thakurgaon) saw a drop from 590 decimal arear to 442.5 decimal areas, representing a decrease of 25 percentage. Similarly, other locations like Sadar (Thakurgaon), Debiganj (Panchagarh), Pirganj (Rangpur), Kaunia (Rangpur), and Taraganj (Rangpur) also experienced reduced adoption rates, showing decreases of 29, 63, 25, 29, and 33% respectively (Table 21).

The decrease in the adoption of BRRI dhan87 across these regions over successive years is linked to specific attributes or factors that farmers identified during the Focus Group Discussions (FGD). The majority of these farmers indicated that this variety does not align well with the Aman-Mustard/Potato/Vegetables-Boro/Maize cropping patterns. Despite being promoted as a short-duration option suitable for early potato or mustard growth before Boro cultivation, the reality experienced by farmers was quite the opposite. It actually took 10 to 15 days longer to harvest compared to expectations. Additionally, farmers expressed dissatisfaction with its yield compared to other short-duration varieties that yield more and can be harvested sooner in this regions. Conversely, farmers exhibit a lack of interest in cultivating BRRI dhan87 due to its longer growth duration, resulting in lower yields compared to other well-liked varieties in the region such as Guti Swarna, Sumon Swarna, BRRI dhan49, BRRI dhan52, and hybrid varieties.The farmers highlighted that they can successfully plant dry season (DS) crops immediately after harvesting by ensuring the early transplantation of the mentioned varieties (Table 20).

Another contributing factor, as reported by farmers, was the substantial impact of false smut infestations, significantly reducing production in the study area. Furthermore, participants noted that the seed of BRRI dhan87 was unavailable at local seed dealer shops, and they did not receive any seed support from the local Department of Agricultural Extension (DAE) office. Consequently, some farmers chose not to cultivate BRRI dhan87 during that particular season.

However, experts, including Sub-Assistant Agricultural Officers (SAAOs), Agricultural Extension Officers (AEOs), and Upazila Agricultural Officers (UAOs) hold a viewpoint contrary to that of the farmers. They believe that the adoption of BRRI dhan87 will grow in the upcoming years due to its advantageous combination of high yield and a short growth duration. Nonetheless, the key requirement is an increased supply of seeds and comprehensive demonstration support for farmers, accompanied by training in contemporary rice cultivation techniques.

Table 21. Changes in the area devotion (%) to BRRI dhan87 by the surveyed participants in Rangpur and Dinajpur regions during Aman season, 2023-24

Location	2022-23 Adoption (decimal)	2023-24 adoption (decimal)	Percent change in area devotion (area)
Pirganj (Thakurgaon)	590	442.5	25(↓)
Sadar (Thakurgaon)	520	369.2	29(↓)
Debiganj (Panchagarh)	330	125.4	62(↓)
Pirganj (Rangpur)	500	375.0	25(↓)
Kaunia (Rangpur)	375	266.3	29(↓)
Taraganj (Rangpur)	650	435.5	33(↓)

Source: Field survey, 2023

Preferred variety for Aman-Mustard/Potato/Vegetables-Boro/Maize cropping pattern

Farmers from the Rangpur and Dinajpur regions were requested to provide information about the characteristics of the Aman season variety they preferred. The traits are outlined below.

- ✓ Shorter field duration (110-115 days)

- ✓ Potential for higher grain (5.5-6 t/ha) and straw yields with improved quality
- ✓ Medium slender grain with high amylose content, providing a good taste
- ✓ Consistently reliable performance even under varying stresses (biotic and abiotic)
- ✓ Sturdy stems that prevent lodging, even during heavy rain, long panicles with shiny golden-colored grains and no sterility issues
- ✓ Uniform plant height, increased effective tiller count, and erect, dark green leaves
- ✓ Exhibits a certain level of adaptability to agronomic practices, maintaining consistent yields regardless of changes in planting dates, fertilizer dose, and application timings

Conclusion

The adoption of BRRI dhan87 in Rangpur and Dinajpur regions has shown promise but faces challenges, particularly in terms of decreased adoption rates over successive years. However, the potential for this variety, characterized by a shorter field duration, higher yield potential, and improved grain and straw quality, remains significant. Farmers also appreciate its medium slender grain quality with high amylose content, making it a favored choice for consumption. Despite its advantages, several factors have contributed to the decline in adoption rates. Farmers have reported issues related to the alignment of BRRI dhan87 with their preferred cropping patterns and its longer growth duration compared to other short duration varieties. Availability of seeds at farm level is also a challenge for speedy adoption of BRRI dhan87 .

However, experts believe that BRRI dhan87 holds promise for the future, especially if there is an increase in seed supply and comprehensive support for farmers, including training in modern rice cultivation techniques.

Recommendations

Among farmers to enhance the adoption of BRRI dhan87 and to promote its adoption in the Rangpur and Dinajpur regions, certain steps need to be initiated by the government and relevant authorities. Drawing insights from conversations with expert professionals and key informant farmers, the following strategies are likely to be impactful in increasing the adoption of BRRI dhan87 in those regions.

Cropping pattern alignment: BRRI and DAE should work with farmers to explore suitable cropping patterns that can accommodate BRRI dhan87, addressing concerns about its longer growth duration. Highlight the benefits of growing BRRI dhan87 in combination with other crops in the Aman-Mustard/Potato/Vegetables-Boro/Maize cropping pattern. The rice farming systems division of BRRI, along with DAE, can work on this.

Demonstration and training: BRRI, in collaboration with DAE, should set up more demonstration plots and training sessions for farmers to showcase the advantages of BRRI dhan87, including its yield potential and adaptability to varying agronomic practices. This will help build farmer confidence in the variety and help farmers make decisions based on actual observations.

Awareness campaigns: Organizing more awareness campaigns to educate farmers about the benefits of BRRI dhan87, cooking quality, and its potential for higher income, which will motivate farmers to adopt the variety.

Availability of seed : Relevant authorities should ensure the availability of high-quality seeds of BRRI dhan87 a t fair price through local seed dealers at the doorsteps of the farmers.

Collaboration with extension officers: BRRI should strengthen the collaboration with DAE persnnel and provide accurate information about BRRI dhan87's advantages. Their endorsement and support can positively influence farmers' decisions.

Technical support: Providing comprehensive technical support to farmers, including guidance on proper agronomic practices, pest and disease management, and post-harvest techniques specific to BRRI dhan87, will help to build farmers' confidence in successfully cultivating the variety.

Market access: Facilitating farmers' access to markets and ensuring that they receive fair prices for their BRRI dhan87 produce will contribute to increasing the adoption of BRRI dhan87.

Research and development: BRRI and other research organizations should conduct research to address the challenges identified by farmers, such as false smut infestations. Continue research efforts to improve BRRI dhan87's resistance to pests and diseases while maintaining its desirable traits. Developing targeted solutions will demonstrate responsiveness to farmers' concerns and enhance their trust in the variety.

Continuous monitoring and evaluation: Establishing a monitoring and evaluation system to track the adoption progress of BRRI dhan87 over time. This will provide valuable insights into the effectiveness of the recommendations and guide any necessary adjustments.

By implementing these recommendations, there is potential to increase the adoption of BRRI dhan87 in the Rangpur and Dinajpur regions, contributing to improved rice productivity, food security, and increase the livelihoods of local farmers.

Location: Dhunot and Sherpur Upazila of Bogura District

During the visits to the two locations, it was observed that paddy cultivation dominated the landscape, covering more than 90% of the land. In contrast, all other crops, primarily vegetables, were cultivated on less than 10% of the total land area.

Level of adoption of different rice varieties during the study year

In the reporting year, the adoption pattern in the surveyed area showed that BRRI dhan49 covered more than 34% of the land. Ranjit and BRRI dhan32 each occupied around 15-20% of the area, while Swarna and Ranjit individually covered around 20 and 16% areas, respectively in surveyed villages.Data from the Department of Agricultural Extension (DAE) for the Bogura district, the adoption of major rice varieties in terms of cultivated areas are given in Table 22. However, survey result on varietal adoption is different from DAE. Adoption of BRRI dhan49, Poroshmoni and Katarivog were observed as much higher than the DAE estimation though the percentage of adoption is still less for Poroshmoni and Katarivog but the trend of growth is much higher than before as mentioned by the respondents in the study areas.

Table 22. Adoption of major rice varieties in two upazilas of Bogura district

Variety	DAE data		Survey data
	Area covered (ha)	Percent of total rice area (%)	Percent of total rice area (%)
BRRI dhan49	40259	23.09	34.40
Swarna	38505	22.08	19.56
Ranjit	29885	17.14	15.69
Guti Swarna	10505	6.03	5.34
BRRI dhan51	9475	5.43	7.85
BRRI dhan87	3009	1.73	2.97
Poroshmoni	685	0.40	4.88
Katarivog	1405	0.80	7.20
Other varieties	42712	23.30	2.11
Total	174350	100	100

Source: DAE, 2022-23 and Field Survey

It is apparent from the table 23 that BRRI dhan49 yielded highest (5.84 t/ha) in the study area followed by BRRI dhan51 (5.79 t/ha), Swarna (5.69 t/ha), Ranjit (5.60 t/ha) and BRRI dhan87 (5.39 t/ha).

Table 23. Yield and price of major rice varieties in the study areas

Variety	Yield (t/ha)	Price Range (Tk/40kg)
BRRI dhan49	5.84	1150-1350
Swarna	5.69	1050-1220
Ranjit	5.60	1150-1250
BRRI dhan51	5.79	1100-1200
BRRI dhan75	4.79	1150-1250
Kataribhog	5.09	1500-1650
BRRI dhan87	5.39	1000-1150

Source: Field survey, 2023

As for the average prices of different rice varieties, BRRI dhan49, Ranjit, BRRI dhan51 and BBRI dhan75 were sold at an average price range of 1100-1350 taka per 40 kgs. Meanwhile, BRRI dhan87 and Swarna had a lower average price range of 1000-1220 taka per 40 kgs. In case of BRRI dhan87 it is reported by the respondents that there was less market acceptance as this variety is new in this area and marketed quantity was insignificant compare to other varieties. They also stated that BRRI dhan87 has got comparatively coarse grain which ultimately affect the market price. Price of Katarivog was recorded as the highest among all which was ranged between 1500-1650 taka per 40 kgs.

Table 24 provide an illustration of the major cropping patterns in the two studied upazila namely Dhunot and Sherpur. Boro-Fallow-T Aman and Mustard-Boro-Fallow-T Aman were two major cropping pattern in the study areas which accounted for approximately 66 percent of the total cultivable land in the two upazila. For this cropping pattern, BRRI dhan49, Swarna and Ranjit were reported as better variety not only for good yield and market acceptance but also for less input requirement characteristics of those varieties especially in case of Swarna and Ranjit. BRRI dhan87 is getting noticeable appeal in the land having cropping pattern like Mustard-Boro-Fallow-T Aman

because of its short growth duration compare to other varieties but at the same time farmers demand for varieties with more shortened life cycle and fine grain quality.

Table 24. Major cropping patterns practiced by the farmers of Dhunot and Sherpur Upazila

Cropping Pattern	Land area (ha)	Percent covered
Boro-Fallow-T Aman	26938	58.21
Mustard-Boro-Fallow-T Aman	3720	8.04
Potato-Boro-Fallow-T Aman	1430	3.09
Boro-Aus-T Aman	1330	2.87
Boro-Aus-Fallow	680	1.47
Mustard-Boro-Aus-T Aman	652	1.41
Maize-Aus-Vegetables	582	1.26
Mustard-Boro-Jute-Fallow	530	1.15

Furthermore, Table 24 also outlines the prospects for BRRI dhan87 as Potato-Boro-Fallow-T Aman, Boro-Aus-T Aman and Mustard-Boro-Aus-T Aman cropping pattern accounted for about 7% of the total cultivable land. But as a comparatively new variety BRRI dhan87 has less market acceptance. Moreover, due to its coarse grain BRRI dhan87 usually deserve lower price compared to other varieties as mentioned by the sample respondents.

Land classification in Bogura

Bogura takes pride in possessing a significant stretch of land within the high and mid-high elevation categories, which collectively account for approximately 73 percent of the total land area, equivalent to 160 thousand hectares (Table 25). These specific areas hold the potential to be highly suitable for the cultivation of BRRI dhan87, presenting a promising avenue. However, BRRI dhan87 is facing the challenge of low market price and demand in the study areas because of its coarse grain and limited volume in the markets.

Table 25. Coverage of land area under different land elevation category in Bogura district

Land Elevation	Total Land Area (Hectares)		
	Dhunot	Sherpur	Bogura District
High	2007 (10)	9395 (36.73)	66386 (30.07)
Mid-High	8229 (41)	14300 (55.91)	94290 (42.71)
Mid-Low	8830 (44)	1883 (7.36)	52429 (23.75)
Low	1004 (5)	0 (0)	7684 (3.48)
Total	20070 (100)	25578 (100)	220789 (100)

N.B.: Figures in parenthesis denote percentage of total.

Characteristics of major rice varieties are as follows:

BRRI dhan49: This variety is known for its high yield, good eating quality, resistance to insect pests and diseases, no shattering and its ability to avoid lodging due to its shorter length. Additionally, it enjoys high demand in the market.

BRRI dhan51: This variety is well-suited for areas with stagnant water conditions and can produce fine rice with high yield. Blast attack occurs sometimes.

Ranjit: Ranjit is known for its high yield and its resistance to insect pests and diseases. It offers good eating quality with fine rice and can also tolerate drought during the Ashwin-Kartik months.

Swarna: Less fertilizer is required. It also experiences fewer insect pest attacks. Price is less.

Katarivog: This variety is getting popularity because of its premium quality rice. Level of consumers' demand and market price is very good but somehow susceptible to blast.

Poroshmoni: This variety is well known for its early maturity which is 10-12 days earlier than BRRI dhan49 . Farmers who grow mustard or maize after Aman, are adopting this variety for this earliness. However, it is coarse grain and price is lower than BRRI dhan49.

BRRI dhan87: Good yield and early maturing variety but a bit coarse rice and low demand in the market.

Table 26: Scenario of farmers' practices on BRRI dhan87 cultivation in the study areas

Specific cultivating particulars	Time, dose and amount
Seed sowing date	June 20 - July 10
Seedling age	25-35 days
Date of transplanting	July 25 - Aug 15
Date of harvesting	November 20 - December 15
Fertilizer Dose per bigha (33dc)	Urea: 20, TSP: 12, MOP: 10
Weeding	Usually, one person once does the weeding
Use of insecticides and pesticides	2-3 times and 500-1000 taka per bigha (33 dc)

Source: Field survey, 2023

Situation and perspectives of BRRI dhan87

In Dhunot upazila of Bogura district, farmers are inclined towards early rice varieties such as BRRI dhan87 and BRRI dhan75. This preference stems from their practice of cultivating Mustard and Maize after harvesting Aman rice. This year marks their second cultivation of these varieties, with the hope that if these options mature 7-10 days earlier than BRRI dhan49, they could potentially replace varieties like BRRI dhan49, Poroshmoni, and Swarna.

However, in Sherpur upazila of Bogura district, farmers have a preference for fine rice varieties like Kataribhog. This choice is influenced by the high demand and favorable market prices for Kataribhog. As a result, they show reluctance in cultivating BRRI dhan87.

Recommendations

Given its promising potential, BRRI dhan87 should be given importance for those areas where Mustard/Maize are being cultivated after Aman harvesting as BRRI dhan87 has an advantage of coming earlier than BRRI dhan49 and other popular varieties. In that case high and medium-high land should be given special attention as Bogura is abundant with those type of land.

Other short duration varieties with relatively better grain quality, price and higher yield could make it challenging but as a new variety it will obviously take some time for BRRI dhan87 to better integrate into the cropping patterns and markets.

Location: Sylhet Sadar and Gowainghat

During the visits to the two locations, it was observed that paddy cultivation dominated the landscape, covering more than 95% of the land. In contrast, all other crops, primarily vegetables, were cultivated on less than 5% of the total land area. The Aman season witnessed the cultivation of several popular rice varieties, including BRRI dhan49, Ranjit, BRRI dhan51, BR22, BR11, BRRI dhan32, BRRI dhan34, and Binadhan-7.

Level of adoption of different rice varieties during the study year

In the study year 2023,, the cultivation pattern in the surveyed area shows that BRRI dhan49 covers around 33% of the land. Ranjit and BRRI dhan32 occupy around 15% and 10% of the areas respectively, while BR11, BR22, and BRRI dhan51 are cultivated on an average of 5-10% of the land. According to the data from the Department of Agricultural Extension (DAE) for the Sylhet district, the adoption of major rice varieties in terms of cultivated areas was as follows, and the adoption found in the survey is given in Table 27. However, survey result on varietal adoption is different from DAE. Adoption of BRRI dhan49, Ranjit and BRRI dhan32 were observed as much as higher in the study areas.

Table 27. Adoption of major rice varieties in Sylhet district

Variety	DAE data		Survey data
	Covered Area (ha)	Percent of total rice area (%)	Percent of total rice area (%)
BRRI dhan49	27,618	23.83	33.39
BR22	11,709	10.15	9.80
BR11	11,707	10.15	5.95
BRRI dhan52	11,702	10.15	10.25
BRRI dhan51	9,564	8.26	7.98
Ranjit	8,710	7.51	15.23
BRRI dhan87	7,377	6.38	5.24
BR23	7,220	6.24	-
BRRI dhan32	4,090	3.53	10.29
Other Varieties	20,242	13.80	1.87
Total	115,849	100	100

Source: DAE, 2022-23 and Field Survey, 2023

Yield and price of major rice varieties

The data presented in Table 28 unequivocally highlights that Ranjit and BRRI dhan49 stand as the principal competitors of BRRI dhan87 in the Sylhet region. Ranjit exhibits superiority over BRRI dhan87 in terms of both yield and price, as evident from the yield values of 5.24 tons per hectare and the price range of 1100-1300 Tk/40 kg in comparison to BRRI dhan87's yield of 5.09 tons per hectare and the price range of 1050-1200 Tk/40 kg. It is to be noted that the price of BRRI dhan87 was lowest among other varieties except BR11 in the study areas. According to respondents, this is because BRRI dhan87 is yet to get market access as it is new variety to those areas.

Table 28. Yield and price of major rice varieties observed in the study areas

Variety	Yield (Ton/Ha)	Price (Tk/40kg)
BRRI dhan49	4.94	1100-1250
Ranjit	5.24	1100-1300
BR11	4.64	900-1050
BR22	4.79	1100-1200
BRRI dhan87	5.09	1050-1200

Source: Field survey, 2023

Existing cropping patterns as followed in the study areas

Fallow-Aus-T. Aman dominated the cropping pattern with the highest land coverage (32.74%) in the two surveyed upazila of Sylhet district. Boro-Fallow-T. Aman and Boro-Fallow-Fallow each cropping pattern had accounted around 20% of the total cultivable land. Fallow-Fallow-T. Aman and B. Aman-Fallow-Fallow had around 10% of the total cultivable land in Sylhet sadar and Gowainghat upazila (Table 29).

It is evident that cropping intensity is relatively low in Sylhet, which makes short-duration varieties less effective for farmers. They prefer BRRI dhan49 and Ranjit due to their higher yield and better prices compared to BRRI dhan87.

Table 29. Major cropping patterns followed by the farmers in the surveyed area

Cropping Pattern	Land area (ha)	Percent of total area
Fallow-Aus-T Aman	10271	32.74
Boro-Fallow-T Aman	6075	19.36
Boro-Fallow-Fallow	5953	18.97
Fallow-Fallow-T Aman	3490	11.12
B. Aman-Fallow-Fallow	3000	9.56
Vegetables/Wheat-Fallow-Fallow	1110	3.54
Vegetables-Aus-T Aman	765	2.44
Vegetables-Fallow-T Aman	710	2.26

Land classification in Sylhet

Sylhet Sadar has 55% of its land classified as high and mid-high category, with the remaining 45% being low-lying land (Table 30). In Gowainghat, only 13% of the land is categorized as high, while the remaining 87% consists of low-lying areas. Though low-lying land dominates Sylhet district with 56% of land, high and mid high land area is 44% which hold the potential to be highly suitable for the cultivation of BRRI dhan87. BRRI dhan87 encounters challenges in the study areas due to its medium slander grain and limited presence in the market, resulting in low demand and price.

Table 30. Coverage of land area under different land elevation category in Sylhet

Land elevation	**Total land area (ha)**		
	Sylhet Sadar	**Gowainghat**	**Sylhet district**
High	8219 (33)	3841 (10)	60714 (18)
Mid-High	5465 (22)	1110 (3)	86916 (26)

Land elevation	Total land area (ha)		
	Sylhet Sadar	Gowainghat	Sylhet district
Mid-Low	6022 (24)	13040 (34)	95637 (29)
Low	4059 (16)	15715 (41)	64393 (20)
Very Low	1403 (5)	4571 (12)	23110 (7)
Total	25168 (100)	38277 (100)	330770 (100)

N.B.: Figures in parenthesis denote percentage of total

Characteristics of major rice varieties according to the respondents are as follows

BRRI dhan49: This variety is known for its high yield, resistance to insect pests and diseases, and its ability to avoid lodging due to its shorter length. Additionally, it enjoys high demand in the market. However, it is not tolerant to drought during the Ashwin-Kartik month.

BR22: BR22 can be cultivated later after the water recedes from the field. It exhibits good tolerance to medium stagnant water, and the number of unfilled grains is significantly reduced. However, its yield is lower compared to BRRI dhan49.

BR11: BR11 is characterized by its high yield and paddy with good weight. However, it is highly susceptible to attacks from pests like the majra (rice stem borer), Gandhi (rice bug), and leaf roller insects.

BRRI dhan51: This variety is well-suited for areas with stagnant water conditions and can produce fine rice with a high yield.

Ranjit: Ranjit is known for its high yield and its resistance to insect pests and diseases. It offers good eating quality with fine rice and can also tolerate drought during the Ashwin-Kartik month.

BRRI dhan32: This variety performs well in less fertile land, particularly sandy soil. It also experiences fewer insect pest attacks**.**

BRRI dhan87: Unfortunately, BRRI dhan87 is highly susceptible to tungro disease in the Sylhet region, making it a challenging choice for cultivation in the area.

Table 31. Scenario of farmers' practices on BRRI dhan87 cultivation in the study areas

Specific cultivating particulars	Time, dose and amount
Seed sowing date	June 25- July 15
Seedling age	22-35 days
Date of transplanting	July 20- Aug 15
Date of harvesting	November 25- December 15
Fertilizer Dose per bigha (33dc)	Urea: 12, TSP: 10, MOP: 6
Weeding	Usually don't weeding
Use of insecticides and pesticides	2-3 times a season and 250-450 taka per bigha

Source: Field survey, 2023

In 2021, BRRI dhan87 was cultivated by first-time farmers in the Sylhet region, and it yielded exceptionally well. However, in 2022, despite utilizing the previous years' experience from the field, many farmers did not get any yield from BRRI dhan87 due to severe tungro disease. As a result, in

2023, farmers have refrained from cultivating BRRI dhan87, mainly due to their apprehensions about the variety's performance.

Conclusion

Most of the farmers sowed seed timely and also transplanted in the prescribed timeframe.But 40-50 days after transplanting and before the flowering the plant's upper leaves became reddish and continued to reach in the bottom of the plant. Then the plant had no growth and became dwarf and had no flowering at all which resulted zero yield.

Due to use aged seedling(40-45 days) ,after 10-15 days of transplanting it started to flowering .

Additional Director, Deputy Director and Upazila Agriculture Officer of the Department of Agricultural Extension visited the farmers field and they were confused about the cause and suspected that BLB or Nematode or tungro might be the reason. Farmers taken measures accordingly prescribed by SAAO but it didn't work. Farmers also told that BADC seed farm for BRRI dhan87 also faced the same situation like theirs.

This fallout of BRRI dhan87 will have negative impact on other newly released BRRI varieties. SAAO reported that farmers already showing reluctance for another new variety, BRRI dhan95. Adoption of BRRI dhan49 and BRRI dhan51 , Ranjit, BRRI dhan32 etc. will likely to increase.

It is worth mentioning that after visiting Sylhet and consulting with specialists at BRRI, we identified that Tungro disease was responsible for the significant damage to BRRI dhan87 in the Sylhet area last year. As a result, it is now a concerning fact that both BRRI dhan75 and BRRI dhan87 could be marked as highly susceptible to tungro, making them unsuitable for regions like Sylhet and Cumilla.

Recommendations

Given its promising potential, BRRI dhan87 should be closely monitored for tungro disease to prevent any potential havoc.

According to the specialists and respective extension personnel, some areas of Sylhet region are becoming hot spot for Tungro disease while it was only concerning for Cumilla before. Besides, BRRI dhan87 as well as BRRI dhan75 are being considered as highly susceptible to Tungro disease according to some experts and farmers which need to be investigated further.

To avoid late flowering, it is essential to transplant BRRI dhan87 within the recommended timeframe. If the seedling age exceeds 40-45 days, flowering may occur after 15-20 days of transplanting.

Location: Kushtia district

In Kushtia region three FGD and two KII were conducted to assess the prospect of BRRI dhan87. Head of the BRRI Kushtia regional office and the Deputy Director of DAE, Kushtia were interviewed to understand the overall scenario of rice cultivation and agricultural practices in the region. FGDs were conducted in Taltola, Bittipara and Swastipur blocks of Mirpur and Sadar upazila of Kushtia where 30 Aman rice farmers and four Sub-assistant agricultural officers exchanged their views (Table 32). Mirpur and Kushtia Sadar were chosen purposively as the adoption rate of BRRI dhan87 was lower in these Upazilas compared to the remaining Upazilas of the region (Table 33).

Table 32. Location and composition of FGDs in Kushtia

Sl. No.	Block name	Upazila	District	No. of Participant
1	Taltola	Mirpur	Kustia	10
2	Bittipara	Sadar	Kustia	10
3	Swastipur	Sadar	Kustia	10
Total				30

Overall scenario of Aman rice cultivation and varietal adoption in Kushtia

In 2022-23, Aman rice was cultivated in about 88,919 ha of area where about 85% was covered by (75810 ha) high yielding varieties (Table 33). The coverage of hybrid and local variety was about 12374 ha and 735 ha respectively. The top HYV as adopted by the farmers of Kushtia are BRRI dhan87, BRRI dhan75, Swarna, BRRI dhan49, Binadhan-17 and Dhanigold.

BRRI dhan87 is the most popular variety of Kushtia region. The overall adoption of BRRI dhan87 in Kushtia region was 16%. Upazila-wise statistics showed that, this variety covered more than 10% Aman area in all the Upazilas of Kushtia. The adoption was higher in Bheramara (31%) and Doulatput upazila (21%). DAE personnel opined that, with its higher yield and environmental adaptability, BRRI dhan87 has replaced Indian rice varieties like Motababu in this region.

Table 33. Adoption status of Aman rice in different upazila of Kushtia district in 2022-23

Area in ha.

Sl. No.	Variety	Sadar	Khoksa	Kumarkhali	Mirpur	Bheramara	Doulatpur	Total
1.	BRRI dhan87	2,110 **(10)**	940 **(14)**	2,720 **(19)**	2,080 **(10)**	2,010 **(31)**	4,120 **(21)**	13,980 **(16)**
2.	BRRI dhan75	3,645	655	3,420	1,120	605	2,287	11,732 (13)
3.	Swarna	4,450	125	835	2,590	450	2,038	10,488 (12)
4.	BRRI dhan49	1,193	145	865	4,110	605	630	7,548 (8)
5.	Binadhan-17	1,380	705	2510	690	320	1,210	6,815 (8)
	All HYV	19,210	5,035	12,635	16,530	5,955	16,445	**75,810 (85)**
6.	Dhanigold	575	635	634	2,375	260	1,965	6,444 (7)
	All hybrid	1,840	1,570	1,075	3,934	540	3,415	12,374
	All local	92	120	305	168	40	10	735
	Total	**21,142**	**6,725**	**14,015**	**20.632**	**6,535**	**19,870**	**88,919**

Source: DAE, Kushtia. Note: The figures in the parentheses indicate the percent

In FGDs, farmers reported that 75-90% areas in different blocks were under Aman rice cultivation. Major crops cultivated in the remaining highland areas were jute and vegetables like spotted gourd, snake bean, bitter gourd, spinach, chili, arum, okra, brinjal, bottle gourd and maize.

Adoption status of BRRI dhan87 in the study areas

According to the FGD respondents of Sadar upazila, BRRI dhan87 was the top variety in Aman season last year, covering more than 50% rice area. Similarly, given the environmental suitability of this mega variety, its popularity watched a considerable rise in current year. Last year they obtained a decent yield of 20 mound per bigha on average. The farmers reported that, its grain size is medium bold and

tastes good. The market price was around BDT 1200 per mound. The quality of straw was also preferable for the farmers as it wasn't prone to lodging and provided around BDT 5000 per bigha.

In Talpara block of Mirpur upazila, 90% of the cultivable area was under four crop cultivation a year. Most of the farmers reported that they prefer cropping patterns that allow T. Aus, late T. Aman and mustard cultivation. The popularity of BRRI dhan87 was lower in the upazila because it is an early variety. The adoption of hybrid Dhanigold and BRRI dhan75 was higher. They were used to transplant Aman rice at the end of August and harvest it at the end of December.

BRRI dhan87 found facing increased competition with increased adoption of Hybrid in Aman season in different Upazilas of Kushtia. The yield of hybrids is comparatively same but grain price of BRRI dhan87 enabled farmers to earn good profit. Table 34 listed the positive and negative traits of BRRI dhan87 mentioned by the FGD attendees in Kushtia.

Table 34. Traits of BRRI dhan87

Positive traits	**Negative traits**
Good yield	Doesn't suit four crop cultivation and cropping patterns that include T. Aus
Good price	Doesn't provide good yield if cultivated late
Strong plant, lodging-proof	Doesn't allow mustard cultivation if cultivated late
Suits the environment	
Profitable	
Good grain quality: Good in taste, medium-bold	

Conclusion

In 2022-23, Aman rice was cultivated in about 88,919 ha of area where about 85% was covered by (75810 ha) high yielding varieties. The coverage of hybrid and local variety was about 12374 ha and 735 ha respectively. The top HYV as adopted by the farmers of Kushtia are BRRI dhan87, BRRI dhan75, Swarna, BRRI dhan49, Binadhan-17 and Dhanigold. BRRI dhan87 is the most popular variety of Kushtia region. The overall adoption of BRRI dhan87 in Kushtia region was 16%. Upazila-wise statistics showed that, this variety covered more than 10% Aman area in all the Upazilas of Kushtia. The adoption was higher in Bheramara (31%) and Doulatput upazila (21%). DAE personnel opined that, with its higher yield and environmental adaptability, BRRI dhan87 has replaced Indian rice varieties like Motababu in this region. BRRI dhan87 was the top variety in Aman season last year, covering more than 50% rice area. Last year they obtained a decent yield of 20 mound per bigha on average. The farmers reported that, its grain size is medium bold and tastes good. The market price was around BDT 1200 per mound. The quality of straw was also preferable for the farmers as it wasn't prone to lodging and provided around BDT 5000 per bigha. BRRI dhan87 found facing increased competition with increased adoption of Hybrid in Aman season in different Upazilas of Kushtia. The yield of hybrids is comparatively same but grain price of BRRI dhan87 enabled farmers to earn good profit.

PROGRAM AREA II: PRODUCTION ECONOMICS

STUDY 1: ESTIMATION OF COSTS AND RETURN OF MV RICE CULTIVATION AT THE FARM LEVEL

MS Islam, MA Islam, MC Rahman, A Chowdhury, MS Rahaman, L Deb, SMMH Noman and SA Jui

Economic decisions are primarily concerned with the most profitable level of input use in the production process. The viability of technology mostly depends on its cost and return. Therefore, it is indispensable to know the cost and return of rice cultivation, where farmers used different types of technologies. Moreover, through the cost and return analysis, researchers and planners can get an indication in developing a technology which will help the farmers in increasing return and reducing cost. Thus, the present study has been undertaken to assess the profitability of rice cultivation in the country with the following specific objectives.

- determine the level of inputs used in MV Aus, MV T. Aman and MV Boro rice cultivation.
- estimate the cost of MV rice cultivation at farm level in different seasons; and
- evaluate the profitability of MV Aus, MV T. Aman and MV Boro rice cultivation at the farm level.

Methodology

Multistage random sampling technique was adopted to select farmers from all the 14 agricultural regions of Bangladesh. Farm-level data on input use pattern, prices of inputs and outputs and yields were collected from 210, 280 and 280 farmers for the Aus, T. Aman and Boro season, respectively. Thus, the number of total respondents were 770 rice-growing farmers. Data were collected through face-to-face interview using a structured questionnaire. Mainly, the descriptive statistical technique was applied to analyze the data, and tabular technique was used to present the results.

Results and discussion

Input use pattern

Farmers mainly hired contractual labors for the three major labor-intensive intercultural operations such as transplanting, harvesting and carrying. They also hired labor on a daily wage basis for other intercultural operations such as land preparation, weeding and post-harvest processing. Besides, most farmers rely on power thresher for threshing rice on a custom hired basis. The highest number of human labor (130 man-days/ha) was used for MV Boro cultivation, followed by MV Aman (115 man-days/ha) and MV T. Aus (110 man-days/ha). (Table 35)

The seed rates for Aus, Aman and Boro were 34, 32 and 34 kg/ha, respectively, indicating that the farmers substantially used a higher amount of seed than BRRI recommended rate (25 to 30 kg/ha). In most of the cases farmers used higher amount of fertilizer than BRRI recommended dose.

Table 35. Per hectare input used for MV rice cultivation in different seasons of Bangladesh, 2022-23.

Input Items	Season		
	Aus	**T. Aman**	**Boro**
Human Labor (man-day/ha)	110	115	130
Hired	37	39	43
Family	17	18	20
Hired contract (transplanting, weeding and harvesting)	56	58	67
Seed (kg/ha)	34	32	34
Fertilizer (kg/ha):			
Urea	150 (125)	167 (150)	216 (250)
TSP	63 (44)	62 (56)	75 (94)
MoP	66 (67)	93 (75)	91 (123)
DAP	56 (44)	71 (56)	91 (94)
Gypsum	15 (33)	39 (50)	58 (62)
ZnSO4	3 (7)	4 (7)	8 (10)
Mg	2	4	5
Theovit	2	5	5

Note: Data in parentheses indicate average BRRI recommended fertilizer doses (Adhunik Dhaner Chas book, 2022). Source: Field Survey, 2022-23

Cultivation costs

Per hectare human labor costs were Tk. 52503, Tk. 56564 and Tk. 70560 for MV Aus, MV T. Aman and MV Boro rice cultivation, respectively. Fertilizer cost of Boro (Tk. 17559/ha) and T. Aman rice (Tk 9750/ha) were higher than that of Aus (Tk 7845/ha) rice cultivation. Fertilizer cost was a little bit higher due to increase in fertilizer price. Irrigation cost was higher (Tk. 25778/ha) for MV Boro rice cultivation than that of MV Aman (Tk. 2982/ha) and T. Aus (Tk. 2721/ha) (Table 36). Due to lack of rainfall this year farmers had to provide irrigation during Aus season. Irrigation cost has increased due to increase in fuel price. Per hectare total variable cost of Boro rice and T. Aman rice cultivation were higher than in T. Aus season. (Table 36).

Table 36. Per hectare cost of MV rice cultivation in different season of Bangladesh, 2022-23.

Items	Season		
	Aus	**T. Aman**	**Boro**
Seed	2056	2391	3044
Seedling Development	2858	3175	3043
Land preparation (ploughing and laddering)	7262	6992	8443
Human labor	52503	56564	70560
Hired	16830	18216	21478
Family	7425	7084	9526
Contract labor cost	28248	31264	39556
Fertilizer cost	7845	9750	17559

Irrigation	2721	2982	25778
Pesticide	5089	5758	5902
Herbicide	563	1125	1138
Insecticide and Fungicide	4526	4633	4764
Power thresher	4351	4364	4464
Total variable cost	77260	84892	129267
Interest on operating capital	1449	1592	2424
Land rent	25930	27903	28737
Total fixed cost	34804	36579	40687
Total cost	112064	121471	169954

Source: Field Survey, 2022-23

Profitability

Per hectare yield of Boro paddy (6603 kg) was higher, followed by T. Aman (4775 kg) and T. Aus (4364 kg). Due to the favorable climate, low pest and disease infestation and a considerable amount of irrigation facilities, Boro season rice yield was higher compared to last year. Similarly, per hectare gross margin of rice cultivation in Boro season (Tk. 71648) was higher followed by Aman (Tk. 71335) and Aus season (Tk. 48987) (Table 37). BCR based on cash cost was the highest (1.29) in Aman season, followed by 1.18 and 1.13 in Boro and Aus, respectively (Table 37). Gross profit ratios are 39, 46 and 36 for Aus, Aman and Boro, respectively. A high-profit ratio is an indication that the farmers are selling their produce at a high profit level.

Table 37. Per hectare profitability of MV rice cultivation in different seasons in Bangladesh, 2022-23.

Items		Aus	T. Aman	Boro
1	Total costs (Tk./ha) (2+3)	112064	121471	169954
2	Total variable cost (Tk./ha)	77260	84892	129267
3	Total fixed cost (Tk./ha)	34804	36579	40687
4	Yield (Kg/ha)	4364	4775	6603
5	Market value of paddy (Tk./ha) (4*12)	109100	133700	184884
6	Market value of straw (Tk./ha)	17147	22527	16031
7	Gross benefit (GB) (Tk./ha) (5+6)	126247	156227	200915
8	Gross margin (GM) (Tk./ha) (7-2)	48987	71335	71648
9	Gross profit ratio ((GM*100)/GB)	39	46	36
10	Net return (Tk./ha) (7-1)	14183	34756	30961
11	Cost of production (Tk./kg)	26	25	26
12	Selling price of grain (Tk./kg)	25	28	28
13	BCR (full cost basis) (7/1)	1.13	1.29	1.18
14	BCR (cash cost basis) (7/2)	1.63	1.84	1.55

Source: Field Survey, 2022-23

Conclusion

Per hectare total variable cost of Boro rice and T. Aman rice cultivation were higher than in T. Aus season. Per hectare gross margin of rice cultivation in Boro season (Tk. 71648) was higher followed by Aman (Tk. 71335) and Aus season (Tk. 48987). BCR based on cash cost was the highest (1.29) in Aman season, followed by 1.18 and 1.13 in Boro and Aus, respectively. Gross profit ratios are 39, 46 and 36 for Aus, Aman and Boro, respectively. A high-profit ratio is an indication that the farmers are selling their produce at a high profit level.

STUDY 2: EFFECT OF SUBSIDY ON MECHANIZATION IN RICE CULTIVATION: AN EVIDENCE FROM COMBINE HARVESTER IN *HAOR* AREAS

L Deb, SMMH Noman and MS Islam

Introduction

Harvesting of paddy has always been considered as the most challenging operations in *haor* areas due to shortage of labor and acuteness of flash flood. By realizing the fact Government has taken up a project at a cost of Tk 3020 crore titled 'Mechanization of Agriculture Work through Integrated Management' which has targeted to distribute 51,300 units of agro-machinery of 12 categories between 2020-2025. Twelve categories of machinery are being distributed with 70% subsidies in *haor* and coastal areas and 50% subsidy in plains through the project. So far, 25,165 agricultural machineries have been distributed through subsidies under the project, of which 7,256 are combined harvesters. But the ultimate success of this mission is dependent on the economic profitability of user farmers as well as owners of these combine harvesters. Therefore, this study was undertaken to evaluate the economic performance of combined harvester in *haor* areas both from user's and owner's perspective .

Specific objectives:

- evaluate the profitability of MV Boro rice cultivation using combine harvester and human labour at the farm level.
- assess economic viability of combine harvester from owners' perspective.

Methodology

Sunamganj and Netrokona districts were selected purposively for the study as there are considerable combine harvester operated areas. Data were collected from 120 farmers equally distributed between the two districts, 60 of them harvested their paddy by combine harvester while rest 60 did it by conventional method. Moreover, 10 combine harvester owners were interviewed through structured questionnaire. Survey method was employed to collect the data both from users and owners which was done during June 2023. Collected data were subjected to conventional tabular analysis to work out costs and returns of Paddy with manual and Combine Harvester type of harvesting. Discounted cash flow techniques namely, Net Present Worth, Benefit-Cost ratio, Internal Rate of Return were used to analyze the capital productivity of combine harvester.

Net present worth (NPW)

It is sometimes referred to as net present value. It is the present worth of the incremental net benefits or incremental cash flow stream. The selection criterion of the project depends on the positive value of the net present worth when discounted at the opportunity cost of the capital. Net present worth of the project (NPW) is estimated using the following formula

$$\text{Net Present Worth} = \sum_{j=1}^{n} \frac{(B_j - C_j)}{(1+i)^j}$$

B_j = Benefits in Tk in j^{th} year
C_j= Costs incurred in Tk in j^{th} year
i= Discount Rate
n= Number of Years

Benefit-cost ratio (BCR)

This ratio compares the present worth of costs with present worth of benefits. The common procedure of selecting the project is to choose the projects having the BCR of more than one, when discounted at opportunity cost of capital.

$$BCR = \frac{\sum_{j=1}^{n} B_j/(1+i)^j}{\sum_{j=1}^{n} C_j/(1+i)^j}$$

Where
B_j = Benefits in Tk in j^{th} year
C_j = Costs in Tk in j^{th} year
i = Discount rate
n= Number of years

Internal rate of return (IRR)

It represents the average earning capacity of an investment over the economic life period of the project. It is that discount rate which just makes the net present worth of cash flow equal to zero. In other words, the benefit cost ratio calculated at IRR is unity. IRR is the maximum interest that a project could pay for the resources used if the project is to recover its investment and operating costs and still break even. The IRR is arrived through interpolation technique by using different discount rates so as to see that the net present worth is equal to zero. Therefore, the project costs and benefits are discounted at a certain rate to find out the present worth of the project. Again, by selecting a higher discount rate, the costs and returns are discounted throughout the project period to get a negative net present worth. The higher value of IRR indicates the first, while lowest value being the last choice of preference. However, the IRR should be more than the discount rate being considered for economic feasibility and financial soundness.

$$IRR = r_a + (r_b - r_a)\ (NPVa\ /(NPV_a - NPV_b))$$

Where,
r_a = lower discount rate
r_b = higher discount rate
NPV_a = Net present value (NPV) using the lower discount rate
NPV_b = NPV using the higher discount rate
When the calculated IRR is greater than the market rate of interest, then the investment is considered viable.

Results and discussion

Profitability from user's and non-user's perspective

Data on the economics of paddy cultivation of farmers using combine harvester and conventional method of harvesting have been presented in Table 38. All the input costs were same in both

conventional and combined harvester method of harvesting except harvesting, carrying and threshing which were higher in case of conventional method. Farmers in *haor* areas had to carry less bulk (without straw) due to using combine harvester, so farmers incurred less carrying cost (Tk 5426.52/ha) with lower harvesting (Tk 11601.52/acre) and zero threshing cost. On the other hand, farmers who harvested their paddy by conventional method expensed Tk 21908.16/ha for harvesting, Tk 6706.42/ha for carrying and Tk 3929.55/ha for threshing purpose in the study areas. Farmers incurred highest proportion of their cost in human labor which were 28.83 % and 32.62% of total cost for conventional method and combine harvester users, respectively.

Table 38. Economics of rice cultivation by the farmers using conventional and Combine harvester

Particulars	**Conventional method**		**Combine Harvester**	
	Cost (Tk/ha)	**Percent of total cost**	**Cost (Tk/ha)**	**Percent of total cost**
Seed	1946.06	1.43	1946.06	1.62
Seedling development	4416.06	3.25	4416.06	3.67
Land preparation (ploughing and laddering)	8652.48	6.36	8652.48	7.19
Human labour: (without harvesting)	39228.61	28.83	39228.61	32.62
Hired	18332.71	13.47	18332.71	15.24
Family	13455.97	9.89	13455.97	11.19
Hired contract	7439.94	5.47	7439.94	6.19
Fertilizer cost	8762.89	6.44	8762.89	7.29
Irrigation	8046.22	5.91	8046.22	6.69
Pesticide	4625.64	3.40	4625.64	3.85
Herbicide	973.03	0.72	973.03	0.81
Insecticide and fungicide	3652.61	2.68	3652.61	3.04
Harvesting	21908.16	16.10	11601.52	9.65
Carrying	6706.42	4.93	5426.52	4.51
Power thresher	3929.55	2.89	0.00	0.00
Total variable cost	94766.12	69.64	79250.02	65.90
Interest on operating capital	2029.15	1.49	1738.24	1.45
Land rent	25822.74	18.98	25822.74	21.47
Total fixed cost	41307.86	30.36	41016.94	34.10
Total cost	136073.98	100	120266.94	100

Source: Field Survey, 2023 and authors' calculation

Total cost varied mainly due to total variable cost which were Tk 94766.12/ha and Tk 79250.02/ha with manual and combine harvester methods of harvesting respectively. Total fixed cost were Tk 41307.86/ha and Tk 41016.94/ha with conventional and combine harvester method respectively, which varied a bit by interest on operating capital only. Total cost for paddy cultivation in the study areas were Tk 136073.98/ha and Tk 120266.94/ha for farmers using conventional method and

combined harvester, respectively. It is to be noted that about 70-75% of total paddy area were harvested by combine harvester this year as reported by the respondents of study areas.

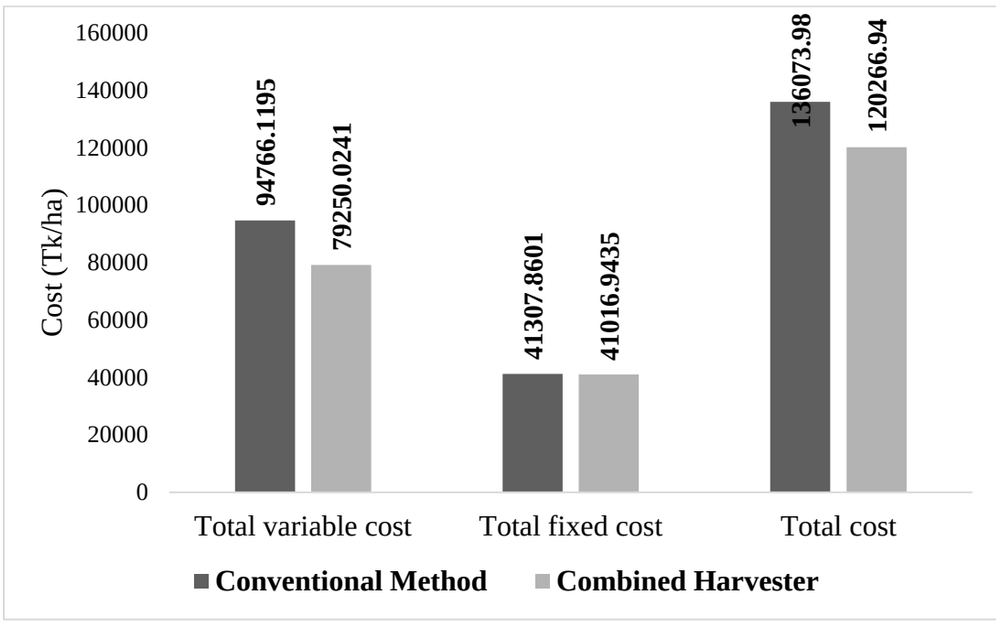


Figure 13. Cost structure of paddy cultivation: Conventional method Vs. Combine Harvester

Results from profitability analysis of paddy cultivation using conventional and combine harvester method are presented in Table 39. In case of conventional method, the gross return was Tk 147760.34/ha but it was even lower in case of combine harvester users which was Tk 143877.50/ha exactly. This is because those who harvested their paddy with combine harvester didn't receive any return from straw.

Table 39. Profitability of paddy cultivation using Conventional Vs. Combine harvester method

Particulars	**Conventional methods**	**Combine Harvester**
Total costs (Tk/ha)	136073.98	120266.94
Total variable costs (Tk/ha)	94766.12	79250.02
Total fixed cost (Tk/ha)	41307.86	41016.94
Yield (Kg/ha)	5755.10	5755.10
Market value of paddy (Tk/ha)	143877.50	143877.50
Market value of straw (Tk/ha)	3882.84	0.00
Gross return (GR) (Tk/ha)	147760.34	143877.50
Gross margin (GM) (Tk/ha)	52994.22	64627.48
Gross profit ratio ((GM*100)/GR)	26.76	35.57
Net return (Tk/ha)	11686.36	23610.53
Cost of production (Tk/kg)	23.64	20.90
Selling price of grain (Tk/kg)	25.00	25.00
BCR (full cost basis)	1.09	1.20

Source: Field Survey, 2023 and authors' calculation

However, because of lower variable cost, farmers who use combine harvester earned higher gross margin (Tk 64627.48/ha) as compare to those with conventional method (Tk 52994.22/ha). Therefore, the cost of production went down to Tk 20.90/kg with combine harvester while it became Tk 23.64/kg in case of manual harvesting. The returns per taka invested were higher in combine harvester (1.20) compared to conventional method (1.09).

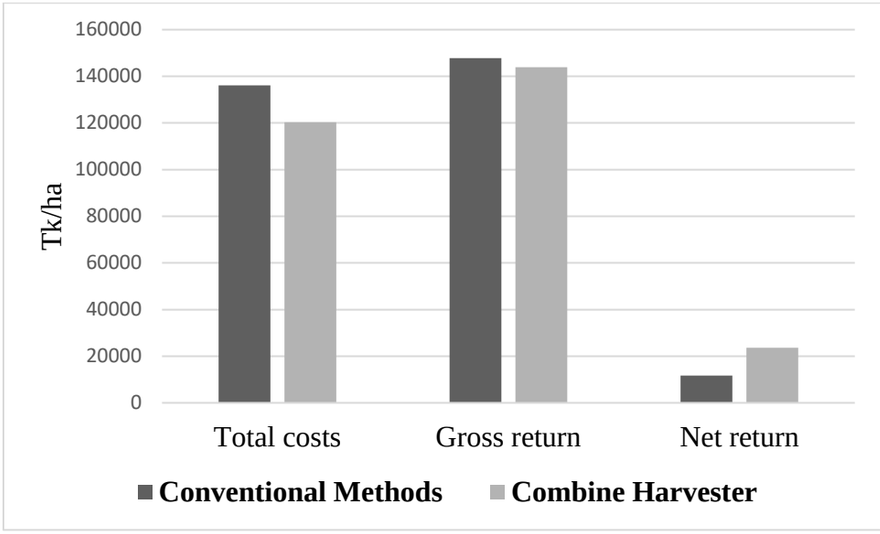


Figure 14. Returns from paddy with Conventional Methods Vs Combine Harvester

Financial Analysis of Combine Harvester from owner's perspective

Before making a choice on any enterprise, it becomes necessary to examine the economic feasibility of that enterprise. Several techniques are available for evaluating the economic viability of paddy combine harvester. For this study project evaluation techniques like discounted measures namely net present value (NPV), benefit cost ratio (BCR) and internal rate of returns (IRR) were employed to examine the economic feasibility of investment on Paddy combine harvester. Table 40 portraits the economic feasibility of investment on combine harvester at 12 percent discount rate. The basic data were collected from the combine harvester owners. Economic life span of new combine harvester was assumed to be 5 years based on several expert opinions. The price of combine harvesters varies from Tk 25,00,000 to 38,00,000 but for our study the average price of combine harvester was observed as Tk 36,00,000. Thus, the average initial investment (down payment) for a combine harvester was Tk 500000. It is to be noted that the 70% of the machine's worth was paid by Government but there is a ceiling amount for this subsidy which is about Tk 23,00,000. Apart from the initial down payment, owner farmers had to pay back the rest of the money mostly in 3 installments i.e. by the second year of their initial investment. Therefore, cash outflow started to diminish after second year as there were no installment payment involved but as long as the machine get older the maintenance costs assumed to be higher. It is evident from the Table 40 that the net present value was positive and high enough (Tk 822663.50) at 12% interest rate. This high positive net present worth even at higher interest rate indicated the soundness of the investment made in maintaining the combine harvester as entrepreneur. Again, the internal rate of return was found to be 58.39% which was much higher than the existing bank rate of interest on long term loans and hence the combine harvester as an enterprise is economically well feasible.

Table 40. Economic feasibility of investment on combine harvester at 12 percent interest rate

Year	Costs	Gross Returns	Net Returns	Discount Factor	**NPW**
0	500000	0	-500000	1.000	-500000.000
1	1225000	1500000	275000	0.893	245535.714
2	1350000	1500000	150000	0.797	119579.082
3	980000	1600000	620000	0.712	441303.754
4	1025000	1440000	415000	0.636	263740.003
5	995000	1440000	445000	0.567	252504.951
				NPW	**822663.50**
				IRR	**58.39%**

Source: Field Survey, 2023 and authors' calculation

Table 41. Estimation of BCR at 12 percent interest rate

Year	Costs	Gross Return	Discount Factor	Present worth of Costs	Present worth of Gross Returns
0	500000	0	1.000	-500000	0
1	1225000	1500000	0.893	1093750	1339285.714
2	1350000	1500000	0.797	1076211.735	1195790.816
3	980000	1600000	0.712	697544.6429	1138848.397
4	1025000	1440000	0.636	651406.0304	915146.0329
5	995000	1440000	0.567	564589.7214	817094.6722
			Total	3583502.129	5406165.632
				BCR	**1.51**

Source: Field Survey, 2023 and authors' calculation

From the Table 41 it is also observed that the benefit cost ratio was 1.51 for the owners of combined harvester which is quite higher. It is apparent that the returns per taka invested were much higher in case of combined harvester owners than that of user farmers. All of these project evaluation metrics show that the investment in the combine harvester business is highly profitable. Attention is needed to make the combined harvesters more profitable for user farmers by setting up a reasonable fixed rental price for them. More intensive studies are inevitable to get better insights into the facts.

Problems encountered in farm mechanization in rice cultivation

Table 42 presents the challenges encountered in mechanizing paddy cultivation. The ranking of these issues was determined using the Garrett ranking technique. The foremost problem identified was the high rental charges especially at the peak time, securing the top position with a mean score of 79.70. Following closely was the issue of substantial investment in farm machinery which is often difficult for the farmers, ranked second with a mean score of 77.20. Combined harvesters were reported as not

suitable for low land especially in deep of the haors, secured the third position by obtaining a mean score of 71.50, while lack of roads emerged as the fourth-ranked issue with a mean score of 65.63. Additional concerns, albeit of lesser significance, included lack of synchronized cultivation (Rank V), fodder loss due to use of combine harvester (Rank VI), non-availability of skilled labours (Rank VII), and delay in repairing the machines (Rank VIII).

Table 42. Problems encountered in farm mechanization in rice cultivation

Problems	Mean Score	Rank
High rental charges	79.70	I
Lack of substantial capital for investment in farm machineries	77.20	II
Not suitable for low land especially in deep of the haor	71.50	III
Lack of roads	65.63	IV
Lack of synchronized cultivation	62.56	V
Fodder loss due to use of combine harvester	60.32	VI
Non-availability of skilled labour	55.25	VII
Require a substantial amount of time for repairs	41.32	VIII

Source: Field Survey, 2023 and authors' calculation

Conclusion

Paddy cultivation still involves huge number of human labor especially in operations like transplanting and harvesting, while mechanization is considered to be the best solution in this regard. The cost of cultivation is less if farmers use combine harvester so as the return go higher. Again, despite certain limitations and abundant of risk factors, investment in combine harvester is still very much profitable endeavor as an entrepreneur which results higher return than many other current ventures. It is worth mentioning that there is a lack of thorough research into setting a impartial rental rate for combine harvesters in order to distribute the economic gain among many user farmers and improve community welfare.

PROGRAM AREA III: AGRICULTURAL POLICY AND DEVELOPMENT

STUDY 1: IMPACT OF POVERTY REDUCTION ON NUTRITION SECURITY IN BANGLADESH

MA Islam, MC Rahman, MS Rahaman, and MS Islam

Introduction

Bangladesh made significant progress in reducing poverty and malnutrition over the past two decades, yet many indicators of food insecurity and malnutrition remain high (HIES, 2016). The nature of malnutrition has significant long-term implications for the country's economic development. It is presumed that Bangladesh would face enormous challenges in achieving nutrition security and ensuring food security for all individuals and groups in the country if the country can not implement a sustainable development goal (SDG) by 2030. Although Bangladesh has achieved remarkable progress in food security in terms of access, nutrition security is still a central problem for heterogeneous farm households. However, this study aims to:

- investigate whether the reduction of poverty can increase the nutrition security status of rural farmers in Bangladesh using panel data and;
- to draw some policy recommendations from the findings.

Methodology

For this study, two-period panel data were obtained from the International Food Policy ResearchInstitute (IFPRI). IFPRI conducted two nationwide Bangladesh Integrated Household surveys covering 6,500 nationally representative sample rural households in Bangladesh in 2011 and 2015. Out of 6,500 rural householdsin each period, we selected 3,180 rural households in the 2011 (base) and 2015 (follow-up) periods for achieving the goal of the study. Balanced panel data were updated to March 2023 using the consumer price index (CPI).

In this study we used Household Dietary Diversity Score (HDDS) as a indicator of nutrition security. The HDDS is constructed based on the number of food groups consumed by the household during a given reference period. Food items were categorized into 12 different food groups as proposed by the Food and Agriculture Organization of the United Nations (FAO, 2011). The 12 food groups are Cereals; White tubers and roots; Legumes, nuts and seeds; Vegetables; Meat; Eggs; Fish and other seafood; Fruits; Milk and milk products; Oils and fats; Sweets; and Spices, condiments and beverages. Each food group adds one score point toward the HDDS if any member of the household consumed a food item from that group in the given seven-day period. Thus, an HDDS ranges from 0 to 12. The use of dietary diversity scores is considered superior to calorie intake totals or an HDRS because the HDDS also reflects the quality of foods available to households (Ruel, 2003).

In the context of measuring poverty in a population, the indices in Foster *et al.* (1984) are commonly used which is expressed as:

$$P_{\propto} = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{Z-y_i}{Z}\right]^{\propto} (\alpha > 0) \ and \ (y_i < Z) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where Z is the agreed-upon poverty line (US$ 1.90/capita/day) converted to Bangladeshi Taka, N is the total household population, y_i is household expenditure per capita for the i^{th} person and $\propto$ is a poverty aversion (sensitivity) parameter. When $\propto = 1$, it is a measure of the poverty gap (Islam 2018). The study used the international poverty line of US$ 1.90/capita/day for 2011-12 and 2015 (2011-12: base period). Real per capita household expenditure was used for measuring poverty.

The majority of the previous studies have employed household dietary diversity score (HDDS) as an indicator of nutrition security. In this study, we also used it for addressing nutrition security in developing countries like rural Bangladesh.

In this study, Poisson two-way fixed effect regression was used:

$$HDDS_{it} = \beta X'_{it} + C_i + \gamma_t + u_{it}, t = 1 \ldots\ldots T \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where HDDS is the respective outcome variable (household dietary diversity score). X_i is a vector of explanatory variables that influences the outcome variable, and it includes the poverty gap index (PGI), household socioeconomic, farm and contextual characteristics, and crop diversity score. β as the respective vectors of parameters to be estimated. C_i and γ_t represent unobserved individual and time-specific effects respectively, and u_{it} is the error term. For addressing unobserved heterogeneity problems, we used the Mundlak approach. Our dependent variable is a count variable, so the Poisson two-way fixed effect model is a natural starting point. The log-linear model form of the Poisson regression model can be depicted as:

$$ln\lambda_{it} = \beta X'_{it} + C_i + \gamma_t + u_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Results and discussion

Figure 15 shows the nutrition security changed over the years from 2011 to 2015 using the indicator of household dietary diversity score (HDDS). HDDS increased in 2015 compared to 2011 in different divisions of Bangladesh.

Figure 15. Household diatery diversity score (HDDS) changes in rural farm households during 2011 to 2015 in different divisions of Bangladesh

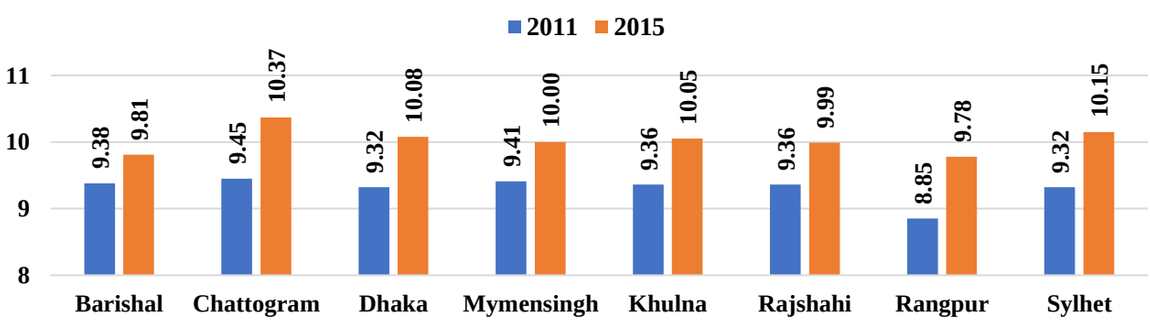


Figure 16 shows the agriculture production diversity changed over the years from 2011 to 2015 using the indicator of agriculture diversity score (ADS). ADS increased in 2015

compared to 2011 in different divisions of Bangladesh. Chattogram and Sylhet divisions' ADS increased at a sluggish rate compared to other divisions. It might be due to less production of different food groups.

Figure 16. Agriculture diversity score (ADS) changes in rural farm households during 2011 to 2015 in different divisions of Bangladesh

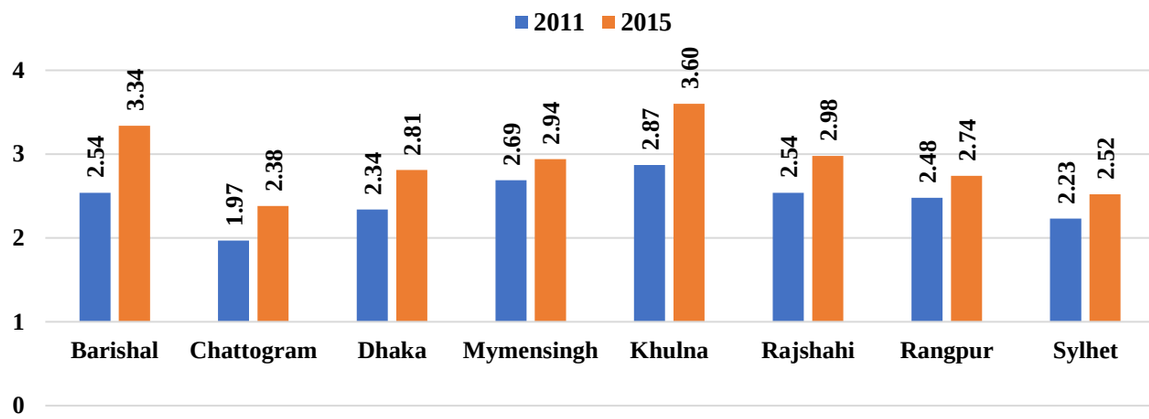


Figure 17 shows the poverty status changed over the years from 2011 to 2015 using the indicator of headcount ratio (HCR). HCR decreased in 2015 compared to 2011 in different divisions of Bangladesh. Rangpur division HCR decreased at a faster rate compared to other divisions. It might be due to more income-oriented activities being involved over the year in their district and other districts.

Figure 17. Head count ratio (HCR) (%) changes of rural farm households during 2011 to 2015 in different divisions of Bangladesh

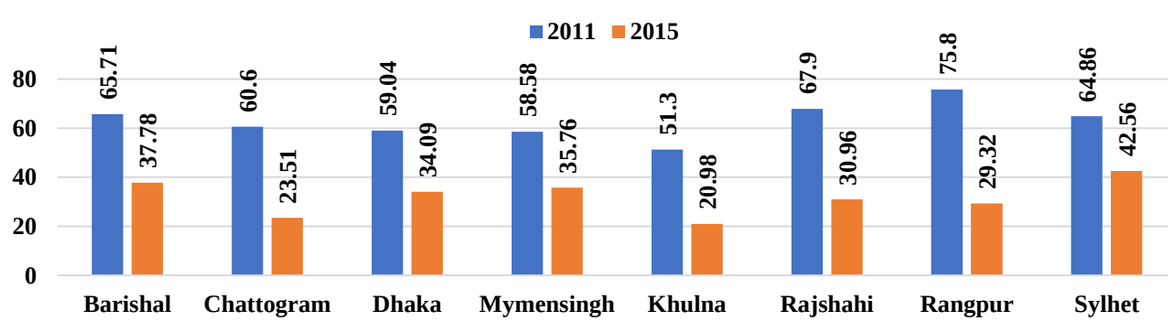


Figure 18 and 19 show the poverty status changed over the years from 2011 to 2015 using the indicator of the Poverty gap index (PGI) and square poverty gap index (SPGI). PGI and SPGI decreased in 2015 compared to 2011 in different divisions of Bangladesh. Rangpur division of PGI and SPGI decreased at a faster rate compared to other divisions. It might be due to more income-oriented activities being involved over the year in their district and other districts.

Figure 18. Poverty gap index (PGI) (%) changes of rural farm households during 2011 to 2015 in different divisions of Bangladesh

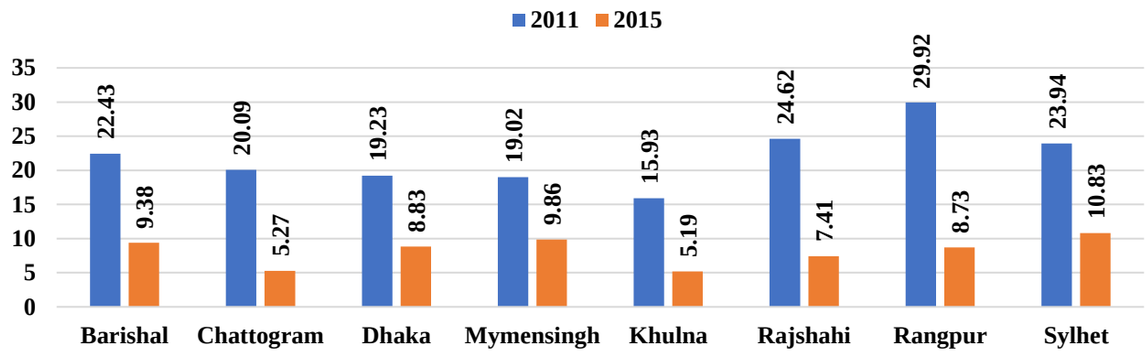
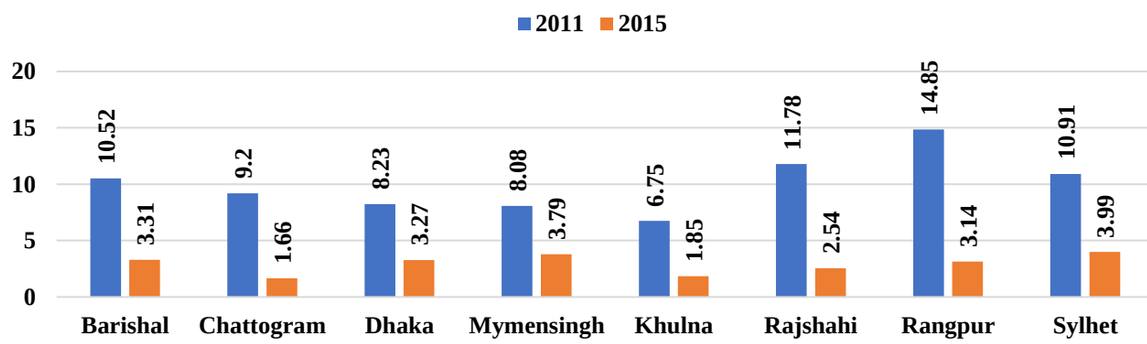


Figure 19. Square poverty gap index (SPGI) (%) changes in rural farm households during 2011 to 2015 in different divisions of Bangladesh



Data in Table 43 show that the agricultural diversity score (ADS) significantly increased the household dietary diversity score (HDDS). The magnitude of this variable was between 5.0 % to 12.1% higher in 2015 compared to the base period (2011) in different divisions in Bangladesh. It might be due to crop diversification projects implemented by the government. Similarly, if the poverty gap decreases, then nutrition security (HDDS) increases substantially from the base period (2011) to the follow-up period (2015). However, the magnitude of the increase was between 15.8% to 33.20% higher than the base period in different divisions in Bangladesh. Private Public Partnership (PPP) has been tried for the last two decades to reduce poverty among Bangladeshi people due to exploring different income-generating/earning works in different divisions as well as different districts of Bangladesh.

The analysis further showed that the level of household old age-dependent family members' food consumption significantly decreased, and the magnitude was about 9.8%% lower in the follow-up period than in the base period in the Barishal division. The family size of the households significantly increased nutrition security in Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet divisions over the years. The magnitude was between 0.09% to 2.80% higher in the follow-up period compared to the base period. HDDS increased significantly when minimizing the gender parity gap among rural farmers (both husband and wife), and the magnitude was 15.30% higher in the follow-up period than in the base period in the Sylhet division. The time lag also increased nutrition security over the years from 2011 to 2015.

Table 43. Estimated two-way fixed effect Poisson regression with Mundlak approach results of poverty impact on nutrition security in different divisions of Bangladesh (2011 to 2015)

Variable name	Barishal	Chattogram	Dhaka	Mymensingh	Khulna	Rajshahi	Rangpur	Sylhet
Dependent variable:	**HDDS**	**HDDS**	**HDDS**	**HDDS**	**HDDS**	**HDDS**	**HDDS**	**HDDS**
Agricultural diversity score	0.121***	0.050***	0.091***	0.106***	0.093***	0.096***	0.093***	0.091***
Market access (Access=1)	0.000*	0.000ns	0.000ns	0.000ns	0.000ns	0.000ns	-0.000ns	-0.000ns
Poverty gap index	**-0.159*** **	**-0.332*** **	**0.224*** **	**-0.157*** **	**-0.158*** **	**-0.216*** **	**-0.268*** **	**-0.313*** **
Head age (year)	-0.000ns	-0.000ns	-0.000ns	0.001ns	0.002ns	-0.000ns	0.000ns	0.000ns
Young dependency	0.006ns	-0.022ns	-0.003ns	-0.004ns	0.001ns	0.018ns	0.027ns	-0.009ns
Old age dependency	-0.098***	-0.026ns	-0.025ns	-0.005ns	-0.003ns	0.011ns	0.013ns	0.035ns
Farm size (ha)	0.000ns	0.000ns	0-.000ns	0.000ns	0.000ns	-0.000*	-0.000ns	-0.000ns
Number of houses owned	-0.083ns	0.027ns	0.013ns	0.074ns	0.019ns	-0.005ns	-0.002ns	-0.005ns
Family size	0.018ns	0.014ns	0.015**	0.006ns	0.016*	0.009*	0.028*	0.024***
Gender parity gap	-0.014ns	0.029ns	0.0123ns	0.029ns	-0.019ns	-0.027ns	0.011ns	-0.153***
Time dummy (base:2011)	-0.014ns	0.028*	0.036***	0.036**	0.023**	0018ns	0.011ns	0.016ns
Diagnostic statistics:								
Log pseudolikelihood	-550.910	-541.427	-1793.010	-573.839	-1156.764	-618.570	-496.251	-526.724
Wald Chi2(11)	78.06	168.17	413.18	96.74	193.58	115.33	117.83	184.94
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sample size	620	600	2004	640	1294	694	556	592

Note: Bootstrapped standard error with 1000 replication was considered. Data were updated to March 2023 using the consumer price index.

Conclusion

Nnutrition security was significantly increased due to the reduction of the poverty gap among households over the periods in different divisions. Agricultural diversity score was also significantly influenced to increase nutrition security. In Bangladesh, at present one of the top policy priorities is to improve food and nutrition security. The poverty gap (increased consumption among poor people up to the poverty line) reduction highly contributed to increasing nutrition security. Apart from poverty gap reduction, higher agricultural diversity is frequently theorized to contribute to better food and nutrition results, including increased dietary diversity (Islam *et al.* 2018). Other factors like family size, time lag, and closing the gender parity gap among farm households can improve dietary diversity in Bangladesh. Policy actions are required to increase income-generating activities that can help to purchase nutritious foods at any time. Reduce transaction costs and encourage increased agricultural commercialization. The policy is needed to lower the cost of accessing credit, quality inputs, and research and development (R&D) to support intensification and diversification in low-productivity agricultural systems. To modernize agricultural systems, it is also necessary to correct rice, wheat, and maize subsidies to create a crop-neutral agricultural policy that encourages farm-level diversification. Women's empowerment might continue to play an essential role in resolving gender-specific access issues, especially in deciding agricultural production, use of resources, income, take leadership, and effective time allocation.

STUDY 2: LIVELIHOOD VULNERABILITY TO FLOOD HAZARD IN BANGLADESH

MC Rahman, MS Rahaman, MA Islam, MS Islam, JC Biswas, M Maniruzzaman

Introduction

Climate change is a fact, and Bangladesh is one of the world's most susceptible nations. Extreme events connected to climate change are becoming more frequent and intense every day. Bangladesh counts as a low-lying country given its location at the base of the Himalayas. Numerous factors, such as heavy rainfall, the melting of Himalayan snow, hydrographic changes within the Brahmaputra basin, and declining river carrying capacity, make it susceptible to flooding. The most common natural disaster that the country experiences is flooding. Therefore, this study estimated the livelihood vulnerability index (LVI) based on the impact of flood vulnerability on rural livelihoods in the northern areas of Bangladesh, where floods affect almost every year.

Specific Objective:

- estimate the households' socio-economic vulnerability in the flood-prone areas of Bangladesh.

Methodology

A multistage sampling technique was employed for selecting the sample households from the flood-prone Kurigram and Jamalpur districts of Bangladesh. A well-structured questionnaire was used to conduct face-to-face interviews among the 200 selected households. The well-known LVI-IPCC approach was used to analyze the collected data for vulnerability assessment.

Results and discussion

The estimated results show that the study areas are highly vulnerable to floods (LVI: 0.402). Whereas, Kurigram is more vulnerable (LVI: 0.415) than Jamalpur (0.390). Considering the IPCC contributing factors, Kurigram has higher sensitivity and exposure than Jamalpur. However, the adaptive capacity of Jamalpur is less than Kurigram. Therefore, the LVI-IPCC index shows that Jamalpur is more vulnerable than Kurigram (Table 44).

Table 44. IPCC contributing factors to the LVI.

IPCC contributing factor	IPCC contributing factor value		
	Jamalpur	Kurigram	Overall
Adaptive capacity	0.333	0.369	0.351
Sensitivity	0.362	0.374	0.368
Exposure	0.587	0.606	0.596
LVI	0.390	0.415	0.402
LVI-IPCC	0.092	0.089	0.090

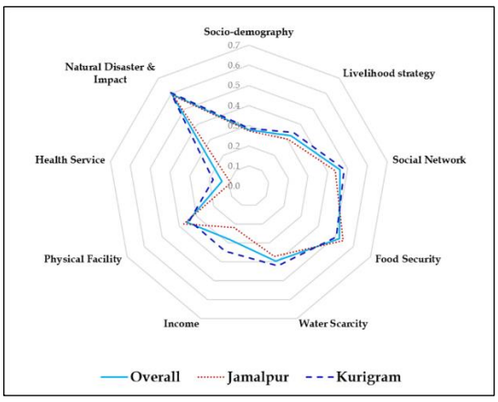


Figure 20. Spider diagram of the major components of the livelihood vulnerability index (LVI) for the households in the selected flood-prone areas.

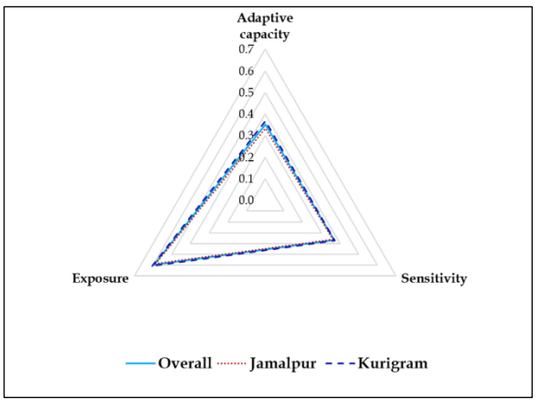


Figure 21. Tringle diagram of the vulnerability of the flood-affected areas based on LVI-IPCC scores.

Conclusion

The LVI values show that Kurigram is more vulnerable than Jamalpur. However, considering the adaptive capacity, LVI-IPCC values show that Jamalpur is more vulnerable than Kurigram. The findings of this study would help to identify the causes of household vulnerability in the study areas and plan for drawing policy options for suitable adaptation to reduce vulnerability.

STUDY 3: ASSESSMENT OF FOOD SECURITY OF *GARO* TRIBE IN SELECTED AREAS OF MYMENSINGH DIVISION

SMMH Noman, L Deb, SA Jui, MA Islam, and MS Islam

Introduction

It is increasingly recognized that indigenous populations may experience food insecurity differently than non-indigenous peoples do. Food insecurity is defined as "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways" (Hamilton et al., 1997). Power (2008) has argued, "Given the centrality of traditional food practices to cultural health and survival, cultural food security is an additional level of food security beyond individual, household and community levels". From the standpoint of cultural food security, an aspect of food sovereignty, the right to food is dependent on the right to produce food (Wittman, Desmarais, & Wiebe, 2011; Patel, Balakrishnan, & Narayan, 2007), which has significant implications for indigenous women. Along with Shiva (2000) and Barndt (2008), Desmarais (2003) argues that indigenous women must have "greater access over land, seeds, water, credit and markets", as "connections to the land" and "access to resources", are imperative for Indigenous food security (Kuhnlein, Erasmus, & Spigelski, 2009).

Despite this recognition, the broader political conditions under which Indigenous populations may access or be excluded from food security are typically underexplored in the literature. Some analyses of food insecurity among indigenous populations appear to minimize or overlook the contexts of state–Indigenous relations, colonization, settlement or land alienation, marginalization, cultural trauma, and discrimination that are typically seen as essential for understanding contemporary challenges facing indigenous peoples (Atkinson, 2002; Cannon & Sunseri, 2011). Devendra & Chantalakhana (2002), for example, examined food insecurity in Asia with no mention of cultural dislocation, forced assimilation, or other aspects of political violence experienced by indigenous populations.

Specific objectives:

- findout the calorie intake level of the sample households; and
- estimate the nutritional status using food consumption score of the Garo tribe

Overview of the Garo

At least 350 million (mill) people worldwide are classified as indigenous, and about two mill indigenous people of 45 different distinct ethnic communities live in Bangladesh (Costa & Dutta 2007, GOB 2008). The Garo are an indigenous people who live in India and Bangladesh. All the indigenous people of Bangladesh have distinctive social and cultural practices, languages and customs that are commonly referred to within the communities as 'Adivasis'. The existence of these people with their traditional way of life and culture that has been practiced for centuries, has enriched the cultural and social diversity of the region. The number of national ethnic people is 1.65 million (Population and Housing Census, BBS 2022). Among the indigenous people, the Garo population is one of the largest indigenous communities in Bangladesh, comprising approximately 0.1 to 0.13 million people (Islam 2008, Drong, 2004).

Methodology

Sampling procedure and study area

The Garo tribal population is predominantly concentrated in the northeastern districts of Bangladesh, specifically in areas such as Mymensingh, Sherpur, Netrokona, and Jamalpur. For the purpose of our study, we intentionally selected Haluaghat upazila in Mymensingh and Jhinaigati upazila in Sherpur due to their significant Garo tribal communities. To facilitate our research, we initially developed a structured survey schedule, which was subjected to a pre-test by conducting interviews with a small number of Garo households. Subsequently, based on the pre-test feedback and alignment with our research objectives, we refined and finalized the survey schedule. Data collection occurred from May to June 2023 and encompassed a comprehensive cross-sectional approach. This approach involved gathering information such as personal details, household member profiles, household food consumption patterns, income and expenditure data, and an assessment of various livelihood assets, including human, natural, financial, physical, and social capital. Our study involved interviews with a total of 105 households, comprising 45 Garo households from Haluaghat upazila in Mymensingh and 60 Garo households from Jhinaigati upazila in Sherpur. The data collection process involved face-to-face interviews with the household heads, with active participation and valuable input from other household members during the discussions.

Calculation of calorie intake level

To assess the calorie intake of the sampled households, we analyzed their food consumption data over a period of seven days. We determined the calorie intake on a per person per day basis. To achieve this, we standardized the consumption of each food item by converting it to the equivalent of 100 grams of that item. In our calculations, we established a framework for defining family members' contributions to the overall intake. Specifically, each adult male and each adult female were considered as one unit, with a 1:1 ratio. Children under the age of 5 years were accounted for as zero units, while children between the ages of 5 and 10 years were considered as half of an adult member. Individuals above the age of 10 were treated as equivalent to one adult in terms of their contribution to the overall calorie intake calculation. This approach allowed us to accurately determine the calorie intake levels within the sampled households.

Calculation of the food consumption score (FCS)

The frequency weighted diet diversity score or "food consumption score" is a score calculated using the frequency of consumption of different food groups consumed by a household/individual during the 7 days before the survey.

Calculation steps

- **i.** Using standard vulnerability analysis and mapping (VAM) 7-day food frequency data group all the food items into specific food groups.
- **ii.** Sum all the consumption frequencies of food items of the same group, and recode the value of each group above 7 as 7.
- **iii.** Multiply the value obtained for each food group by its weight (see food group weights in table below) and creates new weighted food group scores.

iv. Sum the weighed food group scores, thus creating the food consumption score (FCS)

v. Using the appropriate thresholds, recode the variable food consumption score, from a continuous variable to a categorical variable. These are the standard food groups and current standard weights used in all analyses.

Table 45. Food groups and their weight

	Food items (examples)	Food groups (definitive)	Weight (definitive)
1	Maize, maize porridge, rice, sorghum, millet pasta, bread and other cereals cassava, potatoes and sweet potatoes, other tubers, plantains	Main staple	2
2	Beans, Peas, groundnuts and cashew nuts	Pulse	3
3	Vegetables, relish and leaves	Vegetables	1
4	Fruits	Fruit	1
5	Beef, goat, poultry, pork, eggs and fish	Meat and fish	4
6	Milk yogurt and other dairy products	Milk	4
7	Sugar and sugar products	Sugar	.05
8	Oils, fats and butter	Oil	.05
9	Spices, salt, fish power, small amounts of milk for tea	Condiments	0

Source: WFP, 2009

WFP's corporate FCS thresholds

The thresholds for the FCGs should be determined based on the frequency of the scores and the knowledge of the consumption behavior in that country.

Table 46. Food thresholds

FCS	Profiles
0-21	Poor
21.5-35	Borderline
<35	Acceptable

Source: WFP, 2009

Two standard thresholds have been identified by WFP to distinguish different food consumption level.

- A score of 21 was set as the minimum food consumption composed by an expected daily consumption of staple (frequency * weight, 7 * 2 = 14) and vegetables (7 * 1 = 7). A score below 21, implies that the household is expected NOT to eat at least staple and vegetables on a daily basis and therefore considered to have "poor food consumption".
- The second threshold was set at 35, composed by daily consumption of staple and vegetables complemented by a frequent (4 day/week) consumption of oil and pulses (staple* weight + vegetables* weight oil* weight + pulses* weight = 7*2 + 7*1 + 4*0.5 + 4*3 = 35). With an FCS between 21 and 35, a household is assumed to have "borderline food consumption".
- Households that score above 35 are estimated to have "acceptable food consumption".

Bangladesh specific FCS thresholds

Given the importance of oil and fish in the diet of the Bangladeshi people, these thresholds were elevated. As a result, FCS thresholds were revised for Bangladesh and four food consumption groups were created:

- Poor consumption (≤28),
- Borderline Consumption (>28 and ≤42),
- Acceptable Consumption (>42).
- An additional threshold was introduced to distinguish the acceptable households between acceptable low (43-52) and acceptable high (>52).

Source: WFP, 2009

Results and discussion

Table 47, depicting socio-demographic characteristics, highlights several noteworthy findings. Firstly, it is evident that the average age of Garo respondents in Mymensingh was notably higher compared to Sherpur. Additionally, the family size of Garo individuals in Mymensingh stood at 4.31, surpassing the family size in Sherpur, which averaged 3.80. Notably, the survey included 68 female and 37 male Garo household heads. This composition reflects the matriarchal nature of the society, where females typically assume the role of household heads. Furthermore, when examining educational attainment, the data reveals that the average number of schooling years in Mymensingh district exceeded that in Sherpur by a margin of two years. An intriguing observation is the disparity in literacy rates between the two regions. Mymensingh exhibited a higher literacy rate, with approximately half of the population being illiterate, whereas in Sherpur, this proportion was evidently larger. Lastly, it's worth noting that while Sherpur had a larger homestead area, Mymensingh boasted a significantly larger farm size, measuring 96 decimals compared to Sherpur's 68 decimal. These distinctions provide valuable insights into the socio-economic dynamics of the two regions.

Table 47. Socio-demographic profile of Garo people in the study areas.

Particulars		**Mymensingh**	**Sherpur**
Age		49	46
Family size		4.31	3.80
Sex	Male	11	26
	Female	34	34
Education	Schooling years	8	6
	Illiterate (0)	7	13
	Up to primary (1-5)	6	21
	Up to secondary (6-10)	21	18
	Up to higher secondary (11-12)	7	5
	Graduation and above	4	3
Homestead area (decimal)		29	40
Farm size (decimal)		96	68

Source: Field Survey, 2023 and authors' calculation

Figure 22 presents a comparison between the national average food consumption and the average food consumption observed in the study among Garo households. According to the findings, the per capita consumption of rice by the Garo population stood at 390 grams per day, surpassing the national average of 329 grams. Notably, other food items such as pulses, vegetables, eggs, and milk showed considerably higher consumption levels among the Garo community in contrast to the national averages. Conversely, the consumption of wheat, meat, fruits, and fish was observed to be lower

among the Garo households compared to the national averages. This trend can be attributed to several factors. The Garo people typically possess large homestead areas, enabling them to cultivate vegetables throughout the year. Additionally, nearly every household maintains domestic poultry and animals like swine, cows, and goats, which contribute to higher consumption of eggs and milk within their community.

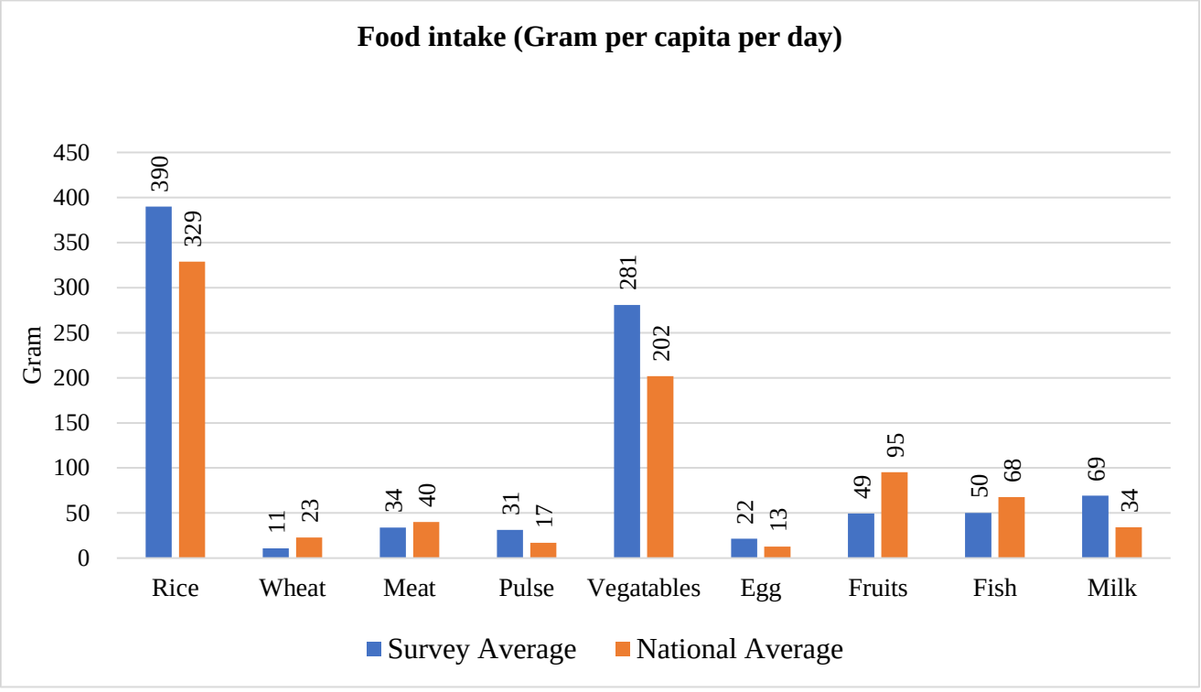


Figure 22: Intake of different food items per person per day

Source: Field survey, 2023 and HIES 2022

Table 48 categorizes respondents based on their daily calorie intake levels into four groups: "Ultra Poor" (<1600 K/Cal), comprising 4.76% of respondents with an average intake of 1515 K/Cal; "Hardcore Poor" (1600-1804 K/Cal), encompassing 15.24% of respondents with an average intake of 1705 K/Cal; "Absolute Poor" (1805-2121 K/Cal), constituting 38.10% of respondents with an average intake of 1965 K/Cal; and "Non-Poor" (>2122 K/Cal), accounting for 41.90% of respondents with an average intake of 2390 K/Cal.

Table 48. Calorie intake

Categories	Calorie (K/Cal)	Number of respondents	Average calorie intake
Ultra Poor	<1600	5 (4.76%)	1515
Hardcore Poor	1600-1804	16 (15.24%)	1705
Absolute Poor	1805-2121	40 (38.10%)	1965
Non-Poor	>2122	44 (41.90%)	2390

Garo households were categorized into four groups based on their frequency-based consumption of various foods, following the food consumption score categories established by the World Food Programme in 2009 for Bangladesh. Table 4 illustrates that 1.90% of respondents from Sherpur district had poor food consumption. In the borderline consumption category, 19.05% of Garo households were identified, with only 4 Garo households hailing from Mymensingh, while 16 were from Sherpur, indicating higher food insecurity among the latter. Within the acceptable consumption category, there

were two subcategories: acceptable low consumption score and acceptable high consumption score. In this regard, only 6 households from Mymensingh were in the acceptable low category, while 21 households from Sherpur fell into the same category.

A total of 35 Garo respondents from Mymensingh and 21 respondents from Sherpur were categorized within the "acceptable high" category, constituting 53.33% of households from both districts with an acceptable high consumption score. Among the 45 households in Haluaghat, Mymensingh, a mere 10 Garo households had a low food consumption score. Conversely, in Jhinaigati, Sherpur, among the 60 households, a substantial 39 households exhibited low food consumption scores, underscoring the notably lower dietary diversity in Sherpur district.

Table 49. Food consumption score (FCS)

Profiles	**No. of respondents**	**Mymensingh**	**Sherpur**
Poor consumption (≤28)	2 (1.90)	0	2
Borderline Consumption (>28and ≤42)	20 (19.05)	4	16
Acceptable Consumption low (>42 and ≤52)	27 (25.71)	6	21
Acceptable Consumption high (>52)	56 (53.33)	35	21
Total	105	45	60

Source: Field Survey, 2023 and authors' calculation

Table 50 provides a comprehensive overview of the annual expenditures among Garo tribal households across various categories. Notably, the largest share, comprising 56.06% of their total yearly expenditure amounting to 161,986 Taka, is directed toward food consumption, highlighting its paramount importance.

Table 50. Household expenditure of the tribe households

Items	**Average annual expenditure(Tk.)**	**Percentage**
Food	90810	56.06
Clothing	7311	4.51
Housing	1476	0.91
Education	22402	13.83
Health Care	9843	6.08
Crops	17743	10.95
Domestic Animals, Poultry	2162	1.33
Parents	2552	1.58
Relatives	1285	0.79
Children	2795	1.73
Social Activities	873	0.54
Others (Transport and Travelling)	2733	1.69
Total	**161986**	**100.00**

Source: Field Survey, 2023 and authors' calculation

Following closely, the second-highest expenditure is directed towards the education of Garo children, signifying a strong commitment to their development, with an annual spend of Taka 22,402, equivalent

to 13.83% of the budget. The agricultural sector holds a substantial position in their financial allocation, with an annual expenditure of Taka 17,743, accounting for 10.95% of their expenses. Health care ranks as the fourth significant category, totaling Taka 9,843 yearly, encompassing expenses related to medicine, doctor's visits, and, in some cases, medical procedures. Clothing for the entire family consumes a notable portion, totaling Taka 7,311, which equates to 4.51% of the total expenditure. Furthermore, other miscellaneous expenses, including support for parents, relatives, children's school allowances, participation in social activities, transportation costs, domestic animal care, and housing expenses, each represent around 1% of their annual budget.

Household income among the Garo people is multifaceted. According to the data presented in Table 51, the primary contributor to the annual income, at 30.63%, is the employment of the household head, amounting to Taka 57,771. Garo individuals engage in various occupations, including government and non-government roles such as school teaching and NGO worker. Additionally, both men and women supplement their income by working as day laborers who doesn't have either job or much of land to cultivate. Another substantial portion of their annual income, approximately 19.65% or Taka 37,062, is derived from cultivating crops throughout different seasons. Many Garo women's husband work in urban areas, often in the capital city of Dhaka or other district centers, and regularly remit money to their families in the village. This remittance constitutes a significant portion of the household income, totaling Taka 31,733 annually, or 16.82%. Furthermore, it's noteworthy that Garo children who are employed contribute to their parents' income by sending money on a monthly basis. This practice is a vital aspect of their livelihood, with an annual sum of Taka 26,095, representing approximately 14% of the total household income.

Table 51. Household income

Items	**Average annual income (Tk.)**	**Percentage**
Crops	37062	19.65
Domestic animals	23914	12.68
Poultry	4952	2.63
Job	57771	30.63
Investment	2776	1.47
Husband/Wife	31733	16.82
Children	26095	13.83
Parents	524	0.28
Relatives	3810	2.02
Total	188638	100.00

Source: Field Survey, 2023 and authors' calculation

Many of the girls in Garo families find employment as beauticians in beauty parlors in Dhaka, the capital city of Bangladesh. Livestock rearing also plays a significant role, contributing an average of Taka 23,914 per year, accounting for about 13% of the total annual income. This income source includes the rearing of pigs, goats, and cows. Finally, other sources of income, such as poultry farming,

assistance from relatives and parents, and small investments, collectively contribute around 6% to the total annual income of the Garo households (Table 51).

The ethnic Garo community encounters a multitude of challenges at both the household and community levels. Among these challenges, the most prevalent and significant issue in their daily lives is the scarcity of irrigation water for crop cultivation. This deficiency in water resources leads to food insecurity as it hinders their ability to cultivate an adequate quantity of crops and vegetables. Remarkably, approximately 20% of the Garo respondents identified this water scarcity as their foremost concern. The second most noteworthy problem faced by the Garo people is the frequent intrusion of wild elephants into their vicinity, particularly after sunset. These majestic but menacing creatures wreak havoc by consuming and damaging crops in the fields. In cases where crops are unavailable, the elephants venture into homes, devouring orchard vegetables and fruits. Unfortunately, these encounters can escalate to a perilous level, with wild elephants sometimes causing harm by breaking into houses and pilfering food. Tragically, it is not uncommon for individuals to lose their lives while attempting to resist or protect themselves during such elephant attacks. In addition to these pressing issues, the Garo community grapples with more persistent challenges, including day-to-day poverty characterized by a shortage of available funds and a recurring problem with access to clean drinking water. Furthermore, there are sensitive concerns related to land ownership disputes with the Bengali population, a matter that has been raised by a few individuals within the Garo community (Table 52).

Table 52. Problems of Garo tribal people

Problems	**Mentioned as first problem**		**Mentioned as 2nd problem**	
	No. of respondents	**(%)**	**No. of respondents**	**(%)**
Elephant attack	19	18.3	9	6.0
Irrigation water	20	19.2	17	11.3
Drinking water	9	8.7	3	2.0
Poverty	13	12.5	6	4.0
Flash flood	5	4.8	3	2.0
Lack of road	5	4.8	1	.7
Load shedding	1	0.7	4	2.6
Land ownership problem	2	1.9	2	1.3

Conclusion

The Garo tribe respondents surpassed the national average in their daily consumption of rice, vegetables, and milk. An analysis of calorie intake within households revealed that around 42% of the surveyed households were deemed non-poor, with the remaining 52% classified as ultra-poor, hardcore poor, or absolute poor. In terms of food consumption scores, 53% of respondents exhibited commendable high consumption, while others were categorized as having poor consumption, borderline consumption, or acceptable low consumption. Regarding financial aspects, a significant portion of the yearly total expenditure, equivalent to 56% (Tk 90,810 out of Tk 161,986), was allocated to food expenditures.