How do crop adaptation reduce impact of drought and mitigate food insecurity in Bangladesh? A case study on adoption of BUdhan1 rice variety

Abstract

Adaptation to climate change impacts in agriculture sector is a particular challenge in the coming decades. Erratic rainfall causes prolonged drought period in the north-western part of Bangladesh which hampers crop production and causes uncertainty of food security. Adoption of drought-tolerant crop variety could be an important strategy to overcome the challenges of food insecurity. This study examines the transferability of BUdhan1 (a high yielding staple cereal rice variety) and its effect on food insecurity status among the farmers of Gaibandha district where the case study is performed. Primary data were collected through a questionnaire survey of randomly selected 60 households' heads. Adoption quotient was measured to reveal the status of extension whereas the perceived benefit of BUdhan1 was analyzed to measure the technological factors of BUdhan1 adoption. Moreover, a contingency coefficient value was calculated through a chi-square test to determines the effect of adoption on food insecurity status. Results reveal that BUdhan1 has been moderately transferred to the northern farmers although found economically profitable (BCR= 1.42) and technologically sound. The study found that a 1% level of adoption of BUdhan1 by the respondents can lead to a 0.45% reduction of food insecurity status. It is suggested that GO and NGOs should take immediate steps to accelerate diffusion of BUdhan1 for bringing the uncultivated areas under intensive cultivation as well as to ensure sustainable food and livelihood security of the northern Bangladeshi people.

Key words: drought, adoption, rice variety, food security, climate change, Bangladesh.

1. Introduction

World population is projected to reach 9.8 billion in 2050, and 11.2 billion in 2100 [1]. That is a lot more hungry mouths to feed with limited farming land. Given that smallholder farmers are frequently food insecure and rely significantly on rain-fed agriculture, it is critical to examine climate variability and food insecurity [2]. A projected consequence of climate change is the decrease of farmland and crop production [3,4,5] in established agricultural regions due to more irregular and extreme weather throughout the cropping season [6,7]. There is ongoing research to maximize the land use to adapt the need to ensure food security. Climate change is reducing the land out of farming. Tropical and sub-tropical regions may suffer different levels of lost arable land [8]. Reduced agricultural land will be impacted heavily in the areas where GDP is poor, and people live their life with a limited alternative such as Bangladesh.

Despite Bangladesh's progress in food grain production, agricultural land is decreasing (about 1.1% per annum) [9]. Hence, to feed the increasing population (1.38% per annum), the country will have to produce an additional 0.6 million tons (Mt) of food grain per annum [10] which implies that the production of staple cereals will have to be increased in the future. Among the cereals consumed in Bangladesh, rice is a staple to 95% of the population and shares more than 80% of the total cereal food supply [11]. Rice covers about 81% of the total cropped area contributing to about 9.5% of the country's GDP [9]. However, this share of the cropping section is predicted to be at stake because of increasing climate variability and stressors like drought.

In Bangladesh, there are mainly three growing seasons for rice, i.e that is., *Aus, Aman,* and *Boro* season. Most of the production of paddy takes place during the *Boro* and *Aman* seasons. In the northern part of the country, *aman* is a major staple crop for the farming community. However, variable climate and recurrent rainfall-induced drought pose an imminent and direct threat towards achieving the food security hampering the production. Among the various options available, short durational drought tolerant rice variety is the most feasible and readily adaptable way to mitigate food insecurity in this region. In front of this menace towards crop productivity, Bangladesh is moving towards introducing short durational rice varieties. Meanwhile, several rice varieties have been developed and promoted for the northern regions. However, farmers' adoption decision is influenced by their perception of new varieties [12]. Furthermore, the perception of the farmers on specific attributes of innovation is vital in determining the extent and intensity of adoption [13]. Therefore, there is a need for adoption studies to provide the policymakers and technology inventors with farmers' feedback information regarding the attributes of newly generated rice varieties for widespread extension and better adaptation.

BUdhan1 is such a newly introduced variety that take 110 to 115 days to harvest which is almost one month less than existing varieties of *T. aman* and offers to grow relay crops like potato, mustard, chili, and other vegetables before the next rice season. Generally, in the Bengali months of *Ashwin* and *Kartik*, the poor, particularly the farmers and day laborers become jobless after completing the transplantation of *Aman* seedlings on the field and face seasonal job crisis and poverty-like situation which force many of them to move to big cities in search of works. The new findings make a living for the farmer more sustainable because of the work cycle. In that context, cultivation of short duration BUdhan1 could make the growers economically benefited and help solve job crisis and poverty-like situation of the farmers and day laborers during the lean period through employment generation to them. However, only a few numbers of studies have been conducted on BUdhan1 so far. Among them, the performance of BUdhan1 in multiple cropping systems resulted in increased yield of 8.4% due to the incorporation of short duration early planting high yielding rice variety (BUdhan1) in the improved cropping system (citation). Moreover, harvesting of BUdhan1 in October allowed timely planting of potato and wheat that increased potato yield by 19.2% and wheat yield by 13% over the existing cropping system [14]. A comparative study on BUdhan1 and BRRI dhan39 with different treatment based on physical and cooking properties showed that both varieties were long grain and milling outturn was maintaining satisfactory level [15]. BUdhan1 is a suitable variety for *monga* mitigation, and farmers can cultivate potato, wheat, and other winter crops in an advanced cropping pattern under the changed climatic conditions to increase crop production through crop intensification [16]. Farmers are getting an average yield of 4 tons per hectare from BUdhan1 paddy like the other short duration anti-*monga* paddies BRRIdhan33 and BINAdhan7 at peak *monga* period [17].

It is evident from the previous studies that adoption rate and subsequent impact of adoption on food security have not been explored yet, particularly, in the drought-prone region of Bangladesh. This study, therefore, conducted to minimize this research gap. That said, the study was conducted with following objectives: i) to analyze the adoption rate and the factors influencing the adoption of BUdhan1, and ii) to measure the impact of adoption of BUdhan1 on the food insecurity status of the rice farmers.

2. Methodology

2.1 Study area and sampling technique

The study was conducted in Sadullapur and Gabindaganj upazila of Gaibandha district in the northern part of Bangladesh. The study area was selected in consultation with the RDRS personnel who are being involved with the dissemination of BUdhan1 in the northern region through different projects. In this study, BUdhan1 beneficiaries of the selected two upazila were treated as the unit of analysis. All the BUdhan1 cultivators of the selected two upazila constituted the population of this study. From that, 60 household heads, i.e., 30 from each upazila were chosen as sample respondents following a simple random sampling technique.

Figure 1. Study area map

2.2 Measurement of knowledge on BUdhan1

Knowledge of the respondents on BUdhan1 cultivation technologies and related issues was measured by administering a knowledge test containing 15 test items on different areas of knowledge viz. awareness knowledge, how to knowledge, and principle knowledge following Rogers (1995) [18]. All the questions included in the scale for measurement of knowledge level were relevant to improve BUdhan1 cultivation technologies. Each item was assigned '2' marks. For a correct answer, a respondent was given full marks and for partial answer half mark (i.e., 1). In case of an incorrect answer, a score of 'zero' (0) was assigned. Hence, the knowledge score of a respondent could range from 0 to 30.

2.3 Measurement of adoption quotient

According to Rogers (1983) [19], "adoption is a decision to make full use of an innovation as the best course of action available." When an individual takes up a new idea as the best course of action and practices the phenomenon is known as adoption [20]. The extent of adoption of BUdhan1 is calculated by adoption quotient (AQ) [21].

$$AQ = \frac{\{T_3 - (T_3 - T_2)\}}{T_3} \times \frac{\{T_3 - (T_3 - T_1)\}}{T3} \times \frac{A_1}{A_2} \times 100 \quad (1)$$

Where,
AQ= Adoption Quotient
T_1 = Year of introduction
T_2 = Year of awareness
T_3 = Year of adoption
A_1 = Actual area under practice (hectare)
A_2 = Potential area under practice (hectare)

2.4 Measurement of the appropriateness of attributes

To calculate attributes appropriateness index (AAI), we adopted the technique of measuring severity index of climate change [22, 23,24]. The perceived appropriateness of BUdhan1 cultivation was measured by asking on fourteen (14) selected attribute mentioning statements. A five-point Likert scale was used for taking the agreement of the respondents. The agreements were Strongly Agree (SA), Agree (A), No Opinion (NO), Disagree (DA) and Strongly Disagree (SDA), and a weight of 4, 3, 2, 1 and 0 was assigned respectively. A simple percentage, frequency, and AAI were calculated using statistical tools. The AAI was computed employing equation 2 [25]:

$$\boldsymbol{Attributes'Appropriateness\ Index\ (AAI)} = \frac{\sum_{i=0}^{4} p_i q_i}{\sum_{i=0}^{4} q_i} \quad (2)$$

Where p_i denotes the index of a class, the constant denotes the weight assigned to the class, while q_i denotes the frequency of response, i.e., i= 0,1,2,3,4 as shown below. The valuation arrangement of the class was considered as similar to Majid and McCaffer (1997) [23].

2.5 **Profitability of *BUdhan1* cultivation**

Profitability of crop production was measured by computing BCR (Benefit Cost Ratio) [26].

$$BCR = \frac{\text{Gross return}}{\text{Total cost}} \quad (3)$$

Where, total cost represents the total of inputs, cultural and intercultural operation, post-harvest operation and related other costs. Gross return was measured by the market price of agricultural products and sub-products, e.g., grain and straw for rice.

2.6 Impact on food security

The chi-square test was used to determine whether any relationships exist between the adoption of BUdhan1 and food insecurity status of farmers in the study area. The result of the chi-square test was converted into the contingency coefficient to examine the extent to which the adoption of BUdhan1 reduced the incidence of food insecurity in the study area [27]. The $\chi 2$ distribution is given as:

$$\chi^2 = \sum \frac{(F_0 - F_e)^2}{F_e} \qquad (4)$$

Where,
F_0 = observed frequency
F_e = expected frequency
$\sum$ = summation sign

The contingency coefficient (C) was calculated as:

$$\mathrm{C} = \sqrt{\frac{\chi^2}{\chi^2 + N}} \qquad (5)$$

Where N= sample size

Adoption quotient value of the respondents were categorized as 'low,' 'medium' and 'high' whereas food insecurity was categorized as 'not at all to slightly insecure,' 'moderately insecure' and 'extremely insecure.' This study categorized the food insecurity status of a household as 'not at all to slightly insecure' when that household had no rice shortage or a rice shortage of up to two months until the next harvest. It was regarded as the 'moderately insecure' when that household has a rice shortage of three to four months before the next harvest. Finally, a household was considered as 'extremely insecure' when it had rice shortage of five months or more before the next harvest. On the other hand, categorization of adoption quotient value was done based on the observed range and mean value.

2.7 Data collection

A questionnaire was carefully designed to collect relevant information from the respondents keeping the objectives of the study in view. The questionnaire contained both open and closed form of questions. The questions were arranged systematically for easy understanding. The final version of the interview schedule was revised by pre-test experience from five farm households in each study site. Primary data were collected from January to April 2016. While starting an interview, the researcher took utmost care to establish rapport with the respondents, so that they do not feel hesitates or hostile to furnish proper responses to the questions of the interview schedule. The questions were explained and clarified whenever any respondent feel difficulty in understanding them correctly.

2.8 Statistical analysis

Collected data were coded for processing and analysis. The SPSS PC+ was used to perform the data analysis. Statistics like frequency counts and percentages as well as mean and standard deviation were calculated. Coefficients of correlation (r), chi-square, 't' test, 'F' test and contingency coefficient was computed to test the hypothesis.

3. Results and Discussion

3.1 Socio-economic characteristics of the respondents

It is very much clear that socio-economic profile of the studied respondents showed mark individual differences among themselves (Table 1) where highest proportions of the respondents (45%) were in the old aged category while 36.7 percent were in the young aged category and 18.3 percent middle-aged category. Respondents under ‘primary education’ category constitute the highest proportion (35.0 %) compared to 25 percent ‘secondary’ category and 11.67 percent higher secondary level category. On the other hand, 28.33 percent of the respondents had no institutional education. About 55 percent of the respondents had medium family size while 30 percent had small family size and only 15 percent of the respondents had a large family size. The highest proportion (46.7%) of the respondents had a medium size farm while 41.7 percent and 11.6 percent of them had small and large size farm respectively. The majority (56.7%) of the respondents fell under medium income category followed by 30 percent low-income category and 13.3 percent high-income category. The majority (81.67%) of the respondents had access to NGOs for getting information related to BU dhan1 followed by the neighbor farmer (60%), relatives (41.67%), mass media (38.33%), research institute (26.67%) and Agricultural extension personnel (13.33%). The majority (65%) of the respondents had below 1.0 ha of land under rice cultivation followed by 25 percent between 1.0 to 3.0 ha, and only 10 percent of them had above 3.0 ha of land under rice cultivation.

Table 1. Socio-demographic profile of the respondents

Parameter	Category	Percentage	Mean	SD
Age	Young (<30 years)	36.7		
	Middle (30-45 years)	18.3	43.91	15.45
	Old (>45 years)	45.0		
Level of education	No institutional education	28.33		
	Primary education (1-5 years)	35.0	5.63	6.42
	Secondary education (6-10 years)	25.0		
	Higher secondary education (above 10 years)	11.67		
Family size	Small (up to 4)	30.0		
	Medium (4-7)	55.0	5.56	1.97
	Large (above 7)	15.0		
Farm Size	Small (Up to 1.01 ha)	41.7		
	Medium (Between 1.01 to 3.03 ha)	46.7	1.43	1.14
	Large (Above 3.03 ha)	11.7		
Annual Income	Low (up to tk. 10000)	30.0		
	Medium (tk.100000- tk. 300000)	56.7	192130	152692
	High (above tk. 300000)	13.3		
Access to information sources	Neighbor farmer	60.0		
	Agricultural extension personnel	13.33		
	Relatives	41.67		
	Research institute	26.67		
	NGOs	81.67		
	Mass media (Radio ,TV, Newspaper, Internet)	38.33		
Area under Rice Cultivation	Up to 1.0 ha	65.0		
	Between 1.0 to 3.0 ha	25.0	1.32	1.41
	Above 3.0 ha	10.0		

3.2 Knowledge on BUdhan1 cultivation

Observed knowledge scores of the farmers ranged from 10 to 29 against a possible range from 0 to 30 with mean and standard deviation were 21.68 and 5.91, respectively. Data presented in Table 2 showed that most of the respondents were correctly answer correctly answered the questions related to the time of planting, the name of the variety, seed rate, fertilizer application rate, suitable soil, and major insects. On the other hand, the majority of the respondents correctly answered the questions related to diseases, pesticides, spacing, a method of fertilizer application and seed quality. However, the majority of the respondents were found unaware about the optimum level of moisture for storing seed, temperature, and relative humidity.

Table 2. Distribution of the respondents according to their knowledge on BUdhan1 cultivation

Sl	Questions on BUdhan1 cultivation technologies	Responses of the respondents (%)			Mean score
		Correct	Partially Correct	Incorrect	
1	Could you mention the name of two drought-tolerant varieties of rice?	86.7	8.3	5.0	1.82
2	What is the seed rate (kg/acre) of BUdhan1?	78.3	16.7	5.0	1.73
3	What kind of soil is suitable for BUdhan-1 cultivation?	75.0	21.7	3.3	1.72
4	Could you mention the minimum number of seedling required per hill for BUdhan1?	25.0	75.0	0	1.25
5	What is optimum planting time of BUdhan1?	90.0	5.0	5.0	1.85
6	What is the standard spacing of BUdhan1?	53.3	41.0	5.0	1.48
7	What is the optimum rate of fertilizer application for BUdhan1 cultivation?	76.7	20.0	3.3	1.73
8	Could you mention the name of two diseases that cause damage to BUdhan1 cultivation?	67.0	16.7	16.7	1.51
9	Could you mention the name of two insects that cause damage to BUdhan1 cultivation?	80.0	10.0	10.0	1.70
10	Could you mention the name of two pesticides & two insecticides?	65.0	20.0	15.0	1.50
11	What is meant shattering of rice?	63.3	21.7	15.0	1.48
12	What is meant quality seed?	53.3	25	21.7	1.32
13	How many splits do you maintain in urea application?	58.3	16.7	25.0	1.33
14	What is optimum temperature & RH for storing BUdhan1?	31.7	11.2	56.7	0.75
15	What is the optimum level of moisture for storing BUdhan1?	33.3	16.7	50.0	0.83
Overall mean		62.47	21.72	15.81	1.47

3.3 Comparative area coverage by BUdhan1

Other than BUdhan1, farmers of the study area are were cultivating BRRI dhan28, BR11, Gotisona, Pariza and Hybrid as a popular rice variety in their field. Comparative analysis on different rice variety being adopted by the respondents was performed to find out the relative position of BUdhan1 in the study area. Data presented in Figure 2 revealed that BR11 covered the highest area (28.74%) followed by Pariza (23.49%), BRRI dhan28 (22.16%), Gotisona (10.53%), BUdhan1 (9.25%) and Hybrid (5.82%).

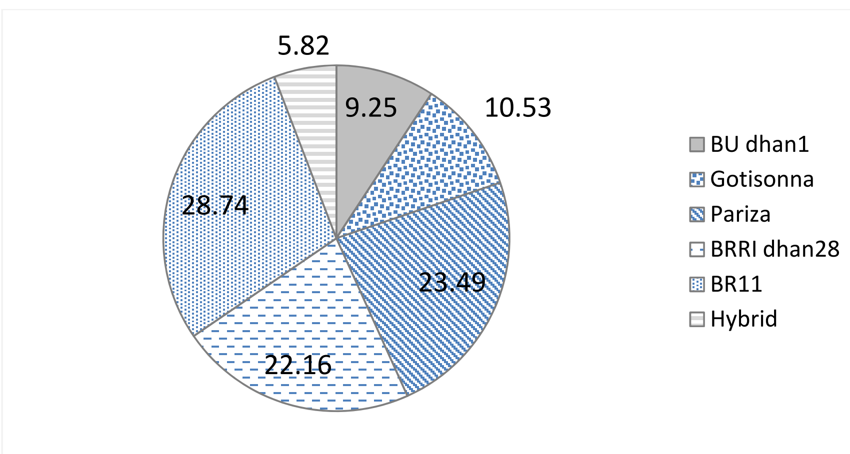

Figure 2. The comparative area covered by BUdhan1

3.4 Adoption of BUdhan1

The possible range of extent of adoption of BUdhan1 by the respondents ranged from 0 to 100, while the observed range was 2.22 to 33.28. Based on the observed range of extent of adoption, the respondents were classified into three categories as presented in Table 3.

Table 3. Distribution of the respondents according to the extent of adoption of BUdhan1

Category	Respondents		Mean	SD
	Frequency	Percent		
Up to 7% (Low)	7	11.7	14.56	7.13
Between 7% and 21 % (Medium)	48	80.0		
Above 21% (High)	5	8.3		
Total	60	100.0		

Information displayed in Table 3 revealed that majority (80%) of the respondents had medium adoption of BUdhan1 followed by low adoption (11.7%) and only small portions (8.3%) were found high adoption. The finding indicated that the farmers had low to medium adoption of BUdhan1 cultivation in the study area. This indicates that farmers are cautious in introducing the crops for a while adoption processes of the BUdhan1 were slowly progressing.

3.5 Profitability of BUdhan1 cultivation

Different factors influence the adoption of innovation. Among these factors, profitability is vital. In order for that benefit-cost ratio (BCR) of BUdhan1 was analyzed to measure the profitability. Data presented in Table 4 revealed that total cost of cultivation of BUdhan1 in the study area was 45,253.23 Tk./ha whereas sale price of paddy was 47,546.14 Tk./ha and market value of straw was 17,373.15 Tk./ha. Hence, respondents' farmers received a total of Tk. 64,919.29/ha as total income from their BUdhan1 cultivation. However, farmers received a net income of Tk. 19,666.01/ha from BUdhan1 cultivation. As a result, the BCR of BUdhan1 was found 1.43 which means that by investing 1 taka in BUdhan1 cultivation, respondents' farmers were received tk. 1.43 as output. From the results, it may be concluded that BUdhan1 cultivation in the study area was not much profitable. Previous studies found BCR of *Boro* rice as 1.53[28] and 1.66 [29] whereas 1.96, 2.12 and 1.86 were recorded for BRRIdhan28, BRRIdhan29, and hybrid rice respectively [30].

Table 4. Benefit-Cost Ratio (BCR) of BUdhan1

Parameter	Items	Taka/ha
Cost	Seed cost	1226.82
	Seedling preparation cost	1401.30
	Land preparation cost	4644.20
	Transplanting cost	3694.09
	First top dress of Nitrogen	1242.50
	Second top dress of Nitrogen	1059.97
	Third top dress of Nitrogen	71.97
	Application of Phosphate	1216.19
	Application of Potassium	788.23
	Application of Zinc	572.52
	Application of Gypsum	512.67
	Fertilizer outspread cost	1213.19
	Application of Organic/Cow dung	12093.73
	Cost of carrying and outspread of Cow dung	2658.11
	Cost of Weeding by labors	3530.52
	Cost for herbicide	390.54
	Irrigation cost	3218.36
	Cost of harvesting	4389.29
	Cost of carrying	702.01
	Cost of threshing	627.04

	Total Cost	45253.28
Return	The sale price of rice	47546.14
	The market value of straw if sold	17373.15
	Total return	64919.29
Net profit	Net Income (total return - total cost)	19666.01
Profitability	BCR (total return/total cost)	1.43

3.6 Farmers' response to BUdhan1 cultivation decision influenced by yield and profitability

Responses of the farmers towards BUdhan1 cultivation was recorded by administering questions whether they would like to increase, continue same area, reduced area or completely reject BUdhan1 cultivation. Data contained in Table 5 reveals that majority (35%) of the respondents decided to continue cultivation of BUdhan1 for the same area whereas 25.0 percent of them decided to increase the area in compared to 23.3 and 16.7 percent those decided to reduce area and completely reject cultivation in the next season respectively. The finding implies that the farmers who have been (delete) benefited decided to increase the area of cultivation in the next season or at least continue its cultivation. However, the farmers who were benefited were not benefiting or being loosed or lost money for its cultivation compared to other varieties ultimately decided to reduce the area of cultivation or reject its cultivation.

Table 5. Distribution of the respondents according to their decision towards BUdhan1 cultivation

Decisions	Frequency	Percent	Average Yield (ton/ha)	Average BCR
Increase area in next season for BUdhan1 cultivation	15	25.0	3.70[a]	2.06[a]
Cultivate same area in the next season for BUdhan1 cultivation	21	35.0	3.81[a]	1.55[b]
Decrease area in next season for BUdhan1 cultivation	14	23.3	3.49[a]	1.10[c]
Completely reject BUdhan1 cultivation in the next season	10	16.7	2.31[b]	0.79[d]
Total	60	100.0	3.46	1.45
F -value			14.22**	45.31**

3.7 Perception of respondents on attributes of BUdhan1

Adoption of innovation is influenced by different attributes amongst them technological factors is very much important. Hence, to find out the influencing factors of BUdhan1 adoption, farmers' perceived appropriateness of the selected attributes was calculated (Table 6).

Table 6. Perceived attributes' appropriateness index (AAI)

Sl.	Attributes	Response (%)					AAI (%)
		SA (4)	A (3)	NO (2)	D (1)	SD (0)	
1.	Short duration variety	73.3	6.7	11.7	8.3	-	86.25
2.	Tolerable to high level of drought	65.0	8.3	6.7	11.7	8.3	77.50
3.	High yield than other variety	58.3	11.7	13.3	10.0	6.7	76.28
4.	Suitable for consumption after being processed	60.0	6.7	13.3	15.0	5.0	75.42
5.	Non –complexity on cultivation procedure	60.0	10.0	10.0	10.0	10.0	75.00
6.	Easy intercultural and post-harvest operation	58.3	10.0	11.7	11.7	8.3	74.58
7.	Resistant to lodging	56.7	13.3	11.7	6.7	11.7	74.17
8.	Better grain quality	56.7	20.0	3.3	3.3	16.7	74.14
9.	More profitable	56.7	11.7	11.7	10.0	10.0	73.75
10.	High market price	58.3	11.7	8.3	8.3	13.3	73.33
11.	Higher weight of rough rice	55.0	13.3	10.0	11.7	10.0	72.92
12.	Spectacular and eye-catching view of the rice field	51.7	16.7	10.0	13.3	8.3	72.50
13.	Less seed requirement	53.3	10.0	8.3	16.7	11.7	69.17
14.	Higher straw yield	53.3	8.3	11.7	8.3	18.3	67.50

Data presented in Table 6 revealed that appropriateness index value ranges between 67.50 % to 86.25% which falls under agreed opinion range of $62.5 \leq AAI < 87.5$ [23]. The AAI value "short duration variety' (AAI = 86.25%) ranked first followed by "tolerable to a high level of drought" (AAI = 77.50%) and "higher yield than other variety" (AAI = 76.28%) as farmers' perception of technological appropriateness. Based on the farmers' perception, adoption decision is profoundly influenced.

3.8 Factors influencing adoption of BUdhan1

Socio-economic status of the respondents has a profound influence on the diffusion and adoption of farming technologies [31]. Hence, correlation test (Table 7) was performed to find out the relationship between socio-economic characteristics and adoption of BUdhan1.

Table 7. Relationships between socio-economic characteristics of the farmers and their adoption of BUdhan1

Independent variable	Dependent variable	The coefficient of correlation (r)
Age of farmer		-0.225
Farmers education		-0.176
Family size		0.221
Farm size	Adoption of BUdhan1	0.246*
Extension contact		0.269*
Knowledge		0.420**
Annual income		0.248*
The area under rice cultivation		0.238

** Correlation is significant at 0.01 level of probability
* Correlation is significant at 0.05 level of probability

The correlation coefficient between farm size and adoption of BUdhan1 was found positive and significant at 5 % level of probability (r = 0.246*) which indicates that farm size has a positive influence on adoption of BUdhan1. Innovation always involves some sorts of risks or uncertainty. BUdhan1 cultivation in the study area was not an exception to that. Sometimes new technology fails to cope up with new areas. Hence, there is a risk of failure (of what?). The farmers having large farm size can take this risk as a trial basis, and if they fail, they can compensate through other rice varieties. On the other hand, small farmers have no scope limited capacity of taking the risk for which they have to wait for a while in adopting new technology. Another fact is that the farmers could not always produce the quality seeds of modern rice varieties and depend on the seeds to be supplied from other sources. When the supply of seeds is limited, the farmers hardly continue its cultivation. It is a risky situation, especially for the small farmers. However, the medium and large farmers could take risk easily because of their diversified income sources which compensate for the loss. It is assumed that the farmers are having more farms land likely to adopt BUdhan1 faster in their cultivation practice. The similar findings were also observed for adopting sugarcane [31], cotton [32], potato [33, 34], mung bean [35] and BRRI Dhan47 [36]. Access to information sources also showed significant positive relations (r = 0.269*) which led to reject the null hypothesis indicating that contact with information sources have a significant relationship with the adoption of BUdhan1. Using more number of information sources means accumulating more information, empowering with a higher level of knowledge and technologies [37, 38, 39, 40]. Farmers knowledge on BUdhan1 also showed a significant positive relationship (r = 0.420**) which indicates that knowledge of rice cultivation technologies has a significant relationship with the adoption of BUdhan1. Annual income and adoption of BUdhan1 were positively correlated (r = 0.248*). It indicates that the annual family income of the farmers had an impact on the adoption decision. Cultivation of BUdhan1 requires risk bearing ability as because there is a risk of crop failure due to severe drought. Therefore, the farmers having more annual family income could able to take the risk to a considerable extent. Thus, with the increase of annual family income of the farmers, their adoption of BUdhan1 cultivation tended to be increased [37, 41, 42, 40]. On the other hand, age, level of education, family size and area under rice cultivation showed the non-significant relationship.

3.9 Impact of BUdhan1 adoption on farmers' food insecurity

It is expected that the adoption of BUdhan1 has a potential impact on changing the food insecurity status of the respondents. A cross tabulation was done between adoption category and food insecurity status of the respondents to unveil the fact (Table 8).

Table 8. Association between adoption of BUdhan1 and food insecurity among the respondents

BUdhan1 adoption category	Food insecurity status			Total
	Extremely insecure	Moderately insecure	Not at all to slightly insecure	
Low	5 (71.4%) 35.7%	2 (28.6%) 8.3%	-	7 (100.0%) 11.7%
Medium	8 (16.7%) 57.1%	22 (45.8%) 91.7%	18 (37.5%) 81.8%	48 (100.0%) 80.0%
High	1 (20.0%) 7.1%	-	4 (80.0%) 18.2%	5 (100.0%) 8.3%
Total	14 (23.3%) 100.0%	24 (40.0%) 100.0%	22 (36.7%) 100.0%	60 (100.0%) 100.0%

Data presented in Table 8 revealed that 36.7 percent of the respondents were found not at all to slightly food insecure whereas 40 percent were moderately insecure and 23.3 percent were found extremely food insecure. Among the low adoption category, 71.4 percent of the respondents were found extremely food insecure, and 28.6 percent were moderately food insecure. In the case of medium adoption category, 45.8 percent were moderately food insecure whereas 37.5 percent were slightly insecure and only 16.7 percent were extremely food insecure. In contrary, 80 percent of the high adoption category farmers were found not at all to slightly food insecure, and 20 percent were found extremely food insecure. Hence it may be concluded that there is a trend of increasing food security with the increasing adoption rate of BUdhan1.

A chi-square test was carried out to determine whether there was any association between the adoption of the BUdhan1 by farmers and the food insecurity status of the farmers. The results in Table 9 revealed a calculated chi-square (χ^2 – cal) value of 15.65. When this value was compared with the tabulated chi-square (χ^2 – tab) value of 13.28, and given the degree of freedom of 4, it was found that the χ^2 – cal (15.53) value becomes higher than the χ^2 – tab (13.28) value. This shows that the adoption of BUdhan1 affected the food insecurity status of the respondents. The adoption of farming technologies is one of the alternative ways of increasing farming output thereby reducing the level of food insecurity among small-scale farmers. This is given the fact that yield is a direct measure of seed performance and that high-yield seeds have a high likelihood of being adopted by farmers.

Table 9. Results of chi-square test between the adoption of BUdhan1 varieties and food insecurity among the farmers

Tabulated χ^2	Calculated χ^2	DF	Level of significance	Decision	Contingency Coefficient
13.28	15.65	4	0.004	Significant	0.455

This means that there was an association between the adoption of BUdhan1 by farmers and the food insecurity status of the farmers. This is in agreement with the findings from an earlier study [27] where it was determined that DT maize adoption significantly improved the food security status among small scale farmers in Nigeria. Furthermore, the chi-square value was converted to a contingency coefficient (C) to find out the extent to which adoption of BUdhan1 was able to reduce the level of food insecurity among farmers in the study area. The result of the analysis revealed a contingency coefficient of 0.45. This suggests that a 1% level of adoption of BUdhan1 by the respondents can lead to a 0.45% reduction of food insecurity status. In other words, the introduction of BUdhan1 into the communities has enhanced food security in those communities by at least 45%.

4. Conclusion

This(delete) the outcome of very specific research and a local case study on how a change in cultivation technology can enhance food security. The outcome is to enhance the interest on the other crop cultivation partners to address the drought caused by climate change (confusing text, delete or improve it). The results of this study show/indicate that adoption of BUdhan1 would play a vital role to eradicate food insecurity from the northern region of Bangladesh. However, a considerable proportion of the farmers had low to medium adoption. It is therefore recommended that a useful step should be taken by the Department of Agricultural Extension (DAE) to accelerate the adoption process. GO, and NGOs should take necessary initiatives to conduct training and supply good quality seeds as per their demand. Most of the farmers under the study area possessed small and medium types of (delete) farm size. These farmers could give more attention to their farming operation as they generally work on their farm. Hence, the extension workers should utilize the small and medium farmers in their extension activities to introduce BUdhan1 on a significant scale. Since a considerable number of the farmers had dissatisfaction on certain technological features of BUdhan1 variety, Cconcerned authorities should give attention to solve these limiting factors as soon as possible to make the rice variety more adaptable against drought vulnerability.

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