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Assessing Coping Strategies in Response to Drought: A Micro Level Study in the North-West Region of Bangladesh

Trisna Mardy [1], Mohammed Nasir Uddin [1,*], Md. Asaduzzaman Sarker [1], Debashis Roy [1] and Emily Shea Dunn [2]

1 Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh; trisnamardy11@gmail.com (T.M.); masarker@bau.edu.bd (M.A.S.); droyagext@bau.edu.bd (D.R.)

2 Department of Agribusiness, College of Food and Agriculture, United Arab Emirates University, Al Ain 15551, United Arab Emirates; emishea@uaeu.ac.ae

* Correspondence: nasirbau@gmail.com; Tel.: +880-171-602-6164

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Abstract: Drought is an extreme and frequent event in the north-west region of Bangladesh and it adversely affects the livelihood of the farming community. Identifying the coping strategies that farmers use in the face of drought is crucial in order to understand how farmers minimize the effects of drought on their production, especially in the face of climatic changes that may impact the occurrence of extreme weather events. The purpose of this study was to assess farmers' coping strategies for droughts by identifying which strategies are used and the influencing factors. A mixed methods approach using qualitative and quantitative data was employed. Preliminary data were collected using structured interviews and focus group discussions in which the findings were triangulated in order to design a questionnaire. The study respondents were 100 farmers operating in north-west Bangladesh. The findings were analyzed using descriptive statistics, coefficient of correlation, multiple linear and step-wise regressions. The results reveal that the respondents have limited drought coping strategies, even though the region is prone to frequent droughts. Among the fourteen identified drought coping strategies, the use of deep tube wells for irrigation water was the most widely reported and the farmers perceived it as the most important coping strategy. Shallow tube wells closely followed as the second most commonly used coping strategy reported by the respondents. Among the identified coping strategies, the least practiced was the use of treadle pumps. The findings from the study showed that age, education, farm size, annual family income, extension media contact, and organization participation were significantly associated with the choice of coping strategy that the farmers employed. Additionally, farm size, age, and education were identified as influential factors that affected the farmers' choice of which drought coping strategies to use. The study identified important issues for policy makers engaged with governmental programs that aim to enhance the farmers' drought coping mechanisms. The methods employed and the results of this study could be usefully applied in other districts of Bangladesh, or other areas of the world suffering from the negative effects of drought on agricultural production.

Keywords: climate change; drought; coping strategies; north-west Bangladesh

1. Introduction

Climate change (CC) is continuous and it is an issue of great concern for scientists around the world [1]. Increases in greenhouse gas (GHG) emissions [2] have been attributed to rising temperatures resulting in increased variability of precipitation and extreme climatic events such as droughts, floods, and shifting of seasons [3]. The Intergovernmental Panel on Climate Change (IPCC) reports that if high GHG emissions continue, average temperatures will rise by more than 2 °C in the South Asian region and will increase by 3 to 6 °C by the mid to end of the 21st century [4].

According to the IPCC [2], developing countries are more likely to be affected by climate variability [5] and CC affects developing countries disproportionately when compared with developed countries [6]. The agricultural sector in developing countries is a significant source of income to a vulnerable population segment. The agricultural sector is particularly negatively affected through disasters brought about by CC, including droughts, floods, irregular precipitation, and salinity intrusion [7,8]. These changes are expected to continue to affect vulnerable countries with uneven rainfall, water scarcity and extreme temperatures [9].

Bangladesh is a developing country [10] that experiences extreme weather variability attributed to CC [11]. Its' geographical location, flat deltaic topography, very low elevation, and high population density are some of the characteristics that make it one of the most vulnerable countries in the world to CC [12,13]. The country is situated in the delta of the Ganges, Brahmaputra and Meghna (GBM) rivers. It is exposed to a range of rivers and two-thirds of the land mass is less than five meters above the sea level [14]. In the north-west regions of Bangladesh, the elevation is 30 m above sea level [15].

CC affects the yield of crops, livestock, fisheries, hydrologic systems, and other components of the agricultural sector [8]. Agriculture is a pillar of the Bangladeshi economy [8,16], contributing a notable share (14.22 percent) to the national economy [17]. Agriculture in Bangladesh typically depends on the amount and distribution of precipitation that comes from the south-west monsoon winds [18], thus seasonal characteristics and climate variability influence the agriculture activities in Bangladesh [19]. The characteristics of Bangladesh have made the country prone to multiple CC impacts, such as floods and flash floods (almost 80 percent of the country is prone to flooding), cyclones and storm surges (in the south and south-eastern parts of the country), salinity intrusion (the whole coastal belt along the Bay of Bengal), extreme temperatures, and droughts (especially in the north-west and to some extent the south-west parts of the country) [15,19]. The agricultural sector of Bangladesh faces many challenges and this is exacerbated by climate extremes [20].

Drought is a critical problem for Bangladeshi agriculture, especially in the north-west region of Bangladesh [16]. The National Drought Mitigation Center (NDMC) [21] reported that CC is one of the drivers behind the frequency of droughts in Bangladesh. The north-west region of the country is vulnerable to drought due to high rainfall variability [13,22] and consequently, farming communities regularly exploit groundwater resources [23,24]. Climate variability and scarcity of surface water, together with rainfall variability and high temperatures, expose the region to frequent occurrences of drought [25]. Moreover, a diverse landscape, semi-arid climate and decreased rainfall contribute to droughts [23]. Drought adversely affects the yield of different agricultural crops such as HYV B*oro* rice, A*us* rice, wheat, sugarcane, and potatoes grown in the R*abi* (mid-November to mid-March) and *Pre-Kharif* season (mid-March to mid-May) [12,25]. In addition, drought has long-term impacts on the environment, socio-economy and human health [23].

The north-west regions have been experiencing insufficient rainfall, resulting in a low groundwater table and, consequently, water shortages for agricultural and other uses [23]. Severe droughts occurred in 1951, 1961, 1975, 1979, 1981, 1982, 1984, 1989, 1994, 1995, and 2000 in Bangladesh, and about 53 percent of the total population have been negatively affected [26]. The most severe outbreak of drought occurred in 1994 and had accumulated effects on the vulnerable population.

The farming communities in the north-west region experience frequent droughts affecting their livelihoods through reduced crop harvests, and livestock and fisheries production, resulting in food and nutrition insecurity [20]. Reduced and uneven rainfall lead to the drying up of surface water bodies such as ponds, canals, *beels*, and rivers. Extensive groundwater exploitation has damaged the irrigation system and caused severe threats to crop production and other health-related illnesses [23]. Figure 1 shows the drought-prone areas in Bangladesh.

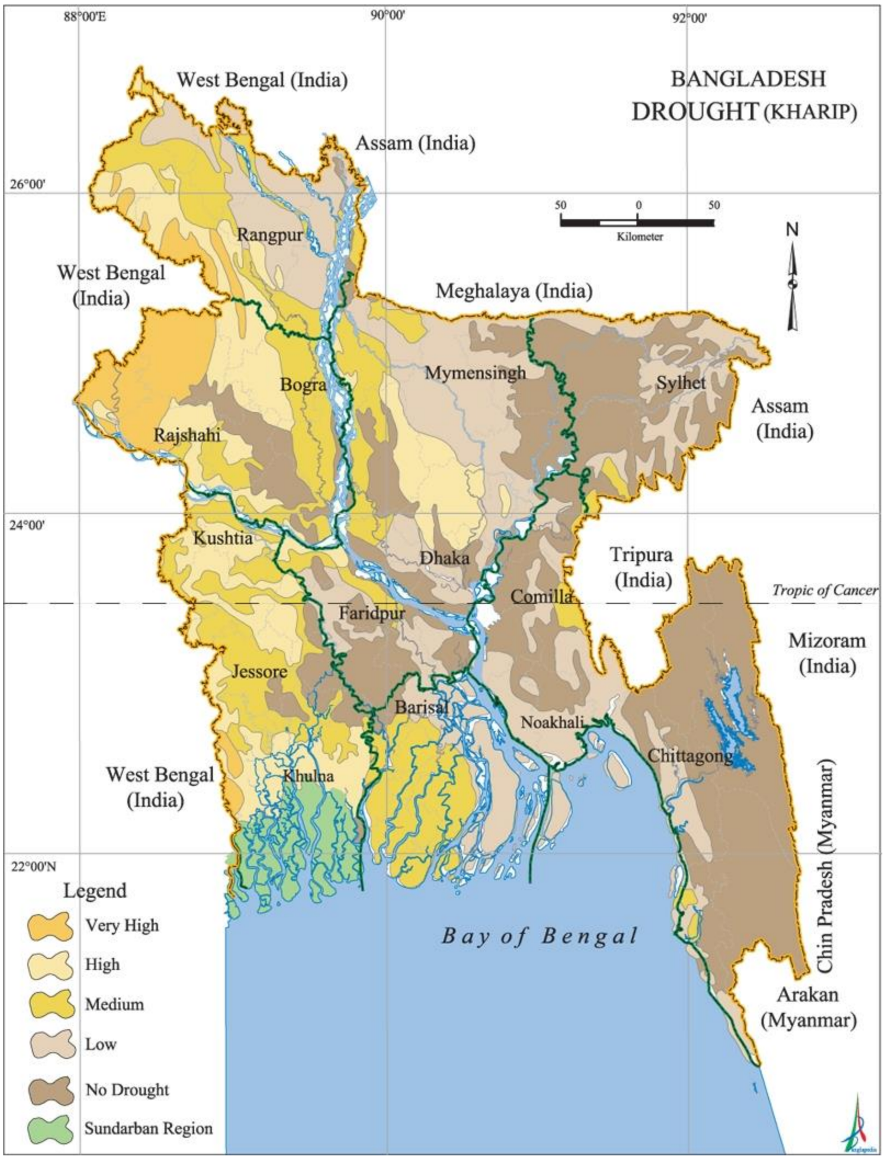

Figure 1. Map of Bangladesh showing drought-prone areas [27].

Adaptation and coping strategies for CC and related events have been a main concern over the past few decades, within the global discussions of the impacts of CC [28,29]. In Bangladesh, several coping strategies from local communities have been diffused to other communities throughout the region, such as shifting the planting time, irrigation, rainwater harvesting, and use of drought/salinity tolerant varieties [30]. Drought mitigation is time consuming and requires substantial investment. Therefore, some recommended farming practices are suggested for adaptation [31]. The farming communities in the north-west region are struggling with drought adaptation in order to manage their livelihoods [20]. To cope with droughts, farmers in this region have been adapting some measures through their own efforts, which should be acknowledged and enhanced through necessary research and extension. This study aims to assess the coping strategies of the farmers in the north-west region of Bangladesh.

The effects of drought on agriculture, and other sectors within the region, have attracted a number of studies [20,31,32]. One study [30] evaluated the existing adaptation practices and their economic sustainability for the agriculture sector of Bangladesh in the face of CC impacts and vulnerability. It was found that adaptation practices differ depending on the region and based on the technical and financial capacity of the farmers. Another study [32] modeled climate-induced droughts in the north-west region of Bangladesh using quantitative trend analysis based on the collection of secondary data (i.e., temperature, rainfall, relative humidity, and ground and surface water). The study looked at climatic indicators and geo-statistical analyses of ground and surface water levels with major findings revealing that changing climatic indicators and surface water availability affected the groundwater level and, subsequently, triggered droughts.

The aforementioned studies did not considerthe coping strategies used by the affected farmers. There are gaps in the literature regarding the assessment of the farmers' perspectives on holistic adaptation strategies in the face of extreme CC events [33,34]. Several studies focusing on farmers' adaptive options have been conducted, but most pointed out the perceived or predicted adaptation behaviors of farmers, with few studies focused on actual and existing adaptation measures and their decisive factors at the household level [31].

Holistic adaptation measures [26,35] to CC and variability have been investigated, but limited studies [16,20] have managed to draw out farmers' adaptation responses to drought and influential factors to adaptation strategies. Hence, there is a great need to understand the specific coping strategies that farmers employ in the face of increased drought at the household level, as well as the factors affecting the farmers' choice of coping strategies. The purpose of the study was to assess the farmers' coping strategies to drought and the factors influencing their strategic measures. Specifically, the studysought to understand how the farmers perceived the effect of drought on their agricultural production, to identify the coping strategies that the famers' employed in times of drought, to determine the extent that farmers' are practicing the coping strategies identified in the study, and thefactors that influenced the farmers' use of drought coping strategies.

2. Materials and Methods

2.1. Study Area

This study was conducted in Ghoraghat Sub-District (Upazila) in theDinajpur District of north-west Bangladesh. Three unions (the lowermost unit of the local government of Bangladesh) were selected for this study after consultation with experts—i.e., the Upazila Agriculture Officer (UAO) and the Upazila Rural Development Officer (URDO)—from the same sub-district. The UAO is the mainstream agricultural extension service provider at the field level and works with farmers. The URDO works for rural development and one of the main activities carried out is to provide irrigation facilities (installation of deep tube wells) to the farmers for agricultural production. These organizations were selected as the relevant experts for consultation for the study. The three selected unions were Ghoraghat, Ghoraghat Paurashava and Shingra (see Figure 2).

Dinajpur district is surrounded by Thakurgaon and Panchagarh districts in the north, Gaibandha and Joypurhat districts in the south, Nilphamari and Rangpur districts in the east, and West Bengal, India, in the west. The area of Dinajpur district is 3437.98 km^2 and it is located in the Barind Tract along with Rangpur, Pabna, Rajshahi, Bogra, Joypurhat and Naogaon districts of north-west Bangladesh. This region is a drought-prone area within Bangladesh. Dinajpur district has a distinct monsoon season and is typically characterized by a hot, wet and humid tropical climate. The annual average rainfall is comparatively lower (1979 mm) than in other parts of Bangladesh. The annual average temperature is 25 °C with a monthly variation of 18 °C in January and 29 °C in August. The *Dhepa*, the *Punarbhaba* and the *Atrai* are the main rivers in this district [36,37].

The economy of this district relies mainly on agriculture-related products and activities—rice, wheat, some vegetables and fruits such as litchi and mangoes are the widely cultivated crops [37]. Agriculture is the main source of income (63.90 percent) [38] and this district is in a predominantly drought-prone area, but is also affected by other CC events [39]. The farmers rely mainly on groundwater sources for agricultural and domestic uses. Moreover, the area is deprived of water availability due to river bed siltation, low water flow and a dam for India [40]. Consequently, the farming activities in this area are extremely affected in terms of water availability for farming and domestic use.

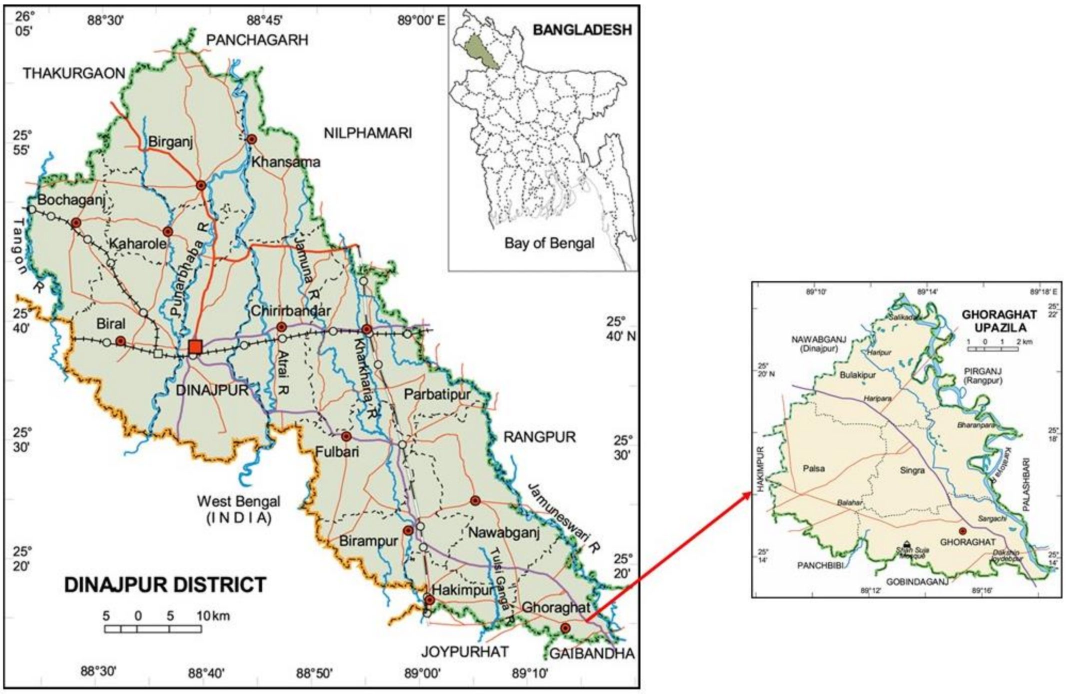

Figure 2. The study area.

2.2. Sampling, Data Collection and Analysis

The subjects of this study were agricultural households that farm within the three unions listed above. These farms were vulnerable to drought and the farmers utilize drought coping strategies. Drought coping strategies are the measures taken by the farmers to reduce the adverse impacts of drought on crop production. This includes how the farms are managed during the drought period as well as in the non-drought periods. These strategies are aimed at reducing the possible effects of drought.

A list of households using drought coping strategies was collected from the office of the Upazila Agriculture Officer (UAO) for each respective sub-district. A total of 1001 farmers were identified. A 10 percent sample size was determined for the study based on IFAS Agricultural Extension Services [41] reporting that the ideal sample size fora population of 1000—with 95 percent confidence level and 10 percent level of precision (sampling error)—is 91. A total of 100 households from the list were randomly selected so that each respondent would get an equal chance of being selected to be part of the study sample. The sample characteristics were reflective of the population demographics.

This study employed a mixed methods approach, collecting qualitative and quantitative data in two stages. The design of the study was based on an exploratory sequential mixed-methods design that aimed to collect qualitative data in the first stage to assist in building the second stage quantitative data collection instrument [42]. The first stage employed interviews and focus groups to prepare the data collection instrument. The second stage employed a questionnaire survey that was conducted by the researchers to collect the final data from the farmers.

One-on-one interviews and two focus group discussions (FGDs) were conducted during the first stage to collect preliminary information about the farming districts and the drought-related issues from the farmers' group. A total of 12 male farmers and eight female farmers participated in the FGDs. The FGDs were facilitated by using a checklist of information on climate change, drought effects, irrigation water management, and drought coping strategies that the researchers developed with the help of the experts. The second stage of data collection employed a questionnaire that was developed based on the information the researchers obtained from the FGDs and interviews conducted in the first stage. The questionnaire was piloted by 10 farmers. Then the necessary corrections and modifications were made accordingly. The questionnaire was deployed during the months of April to May, 2017. The questionnaire was comprised of four sections that included demographics and relevant farm/farmer characteristics such the farmers' participation in organizations, social mobility and extension contacts in one section, and knowledge of drought coping strategies, the effects of drought on crop production, and the extent of practicing drought coping strategies in the other three sections.

The categorization of farmers' participation in different organizations was made based on the observed score. For no participation, the score 0 was used, and for participation as a general member, executive member and president/secretary, a corresponding score of 1, 2, and 3, respectively, was used. Examples of organizations listed in the questionnaire are farmers' co-operative societies, school committees, and a community information center. If the farmer declared participation, then the duration of that position was also asked.

In the case of the social mobility of the farmers, a scale was used and the categorization was made based on a possible scale score based on the frequency of visits. Frequency was determined as frequent (more than five times per month), occasionally (three to four times per month), rarely (one to two times per month) or not at all. Examples of places that the farmer could have reported visiting were outside of their village, their own district headquarters, or the capital city of Bangladesh.

Extension media are the sources of information from which the farmers collect relevant information regarding their farm-related problems. A four-point rating scale was used to assess the accessibility of extension media. Different extension media (19) were listed in the scale against four possible responses such as frequently, occasionally, rarely, and not at all with their corresponding score of 3, 2, 1, and 0, respectively.

In order to assess the knowledge of the farmers regarding coping strategies to drought, questions were asked within five knowledge categories, namely remembering, understanding, applying, analyzing and evaluating droughts and coping with drought. Each question was assigned a mark (2 or 3) and based on the response from the farmer, the marks were given. If the answer was correct then a full mark was given, half a mark was given for a partial answer and zero was given for the wrong answer.

A four-point rating scale was used to determine the farmers' perceived effects of drought on agriculture. Thirteen effects such as scarcity of soil water, increased fallow land, and increased cost of production were identified from the first stage of the study. The farmers were asked to rate the effects of drought on crop production using high, medium, low, or none with a corresponding score of 3, 2, 1, and 0, respectively. Hence, the scale score ranged from 0 to 39, where 0 indicated no effect and 39 indicated a high effect. The ranking of the statements was carried out to prioritize the statements where the effects of drought are high. A weighted average index (WAI) [43] for an individual coping strategy was computed to find out the important strategies in the study area (Equation (1)).

$$\frac{F_h \times 3 + F_m \times 2 + F_l \times 1 + F_n \times 0}{N} \quad (1)$$

where WAI = weighted average index, F_h = frequency of responses with high effect, F_m = frequency of responses with moderate effect, F_1 = frequency of responses with low effect, F_n = frequency of responses with no effect, and N = total number of responses.

The extent of practice of different drought coping strategies by the farmers was assessed by asking them about the frequency with which they practice the coping strategies. The responses obtained from the farmers were scaled as regularly, occasionally, seldom, and not at all, with a corresponding score of 3, 2, 1, and 0, respectively. The score ranged from 0 to 42, where 0 indicated no practice and 42 indicated widely practiced. Based on the score, the respondents were categorized into three drought coping strategy segments—low, moderate, and high practicing. An adaptation strategy index (ASI) [5] for individual coping strategies was computed to find out how many farmers' responded as using the drought coping strategies (Equation (2)).

$$ASI = AS_r \times 3 + AS_o \times 2 + AS_s \times 1 + AS_n \times 0 \quad (2)$$

where ASI = adaptation strategy index, AS_r = number of responses with regular practice of drought coping strategies, AS_o = number of responses with occasional practice of drought coping strategies, AS_s = number of responses with rare practice of drought coping strategies, AS_n = number of responses with no practice of drought coping strategies.

The survey data was coded and analyzed using the Statistical Package for Social Science (SPSS) Version 16 using descriptive and inferential statistics. Microsoft Excel 13 was used to create various graphs based on the data analysis from SPSS. Pearson's product moment coefficient of correlation was used to check for association between the explanatory and focus variables. Multiple linear regression and step-wise multiple regression were employed to identify the factors affecting the focus variable. In order to test the formulated hypotheses of the study, Pearson's product moment correlation co-efficient (r) was used. Through this statistical treatment, the nature of the relationship between the explanatory and focus variables was determined. It was performed to explore the relationship between the farmers' socio-economic characteristics and thefarmers'practiced drought coping strategies. The formula of Pearson's product moment correlation coefficient (r) is given below.

$$r_{xy} = \frac{\sum(x_i - \overline{x})(yi - \overline{y})}{\sqrt{\sum(xi - \overline{x})^2 \sum(y_i - \overline{y})^2}}$$

where,

r_{xy} = Pearson's product moment correlation coefficient
$\overline{x}$ and $\overline{y}$ = means of the variables x and y, respectively

Multiple regression analysis (both the enter and step-wise method) was used to determine the farmers' practiced drought coping strategies. The multiple regression analysis equation is as follows:

$$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + €_i$$

where,

$$y_i = \text{Coping strategies of drought}$$

$$\beta_0 = \text{Constant}$$

$$X_1 = \text{Age}$$

$$X_2 = \text{Education}$$

$$X_3 = \text{Household size}$$

$$X_4 = \text{Farm size}$$

$$X_5 = \text{Annual family income}$$

$$X_6 = \text{Farming experiences}$$

$$X_7 = \text{Organizational participation}$$

$$X_8 = \text{Social Mobility}$$

$$X_9 = \text{Extension contact}$$

$$X_{10} = \text{Knowledge}$$

$$€_i = \text{Error term}$$

3. Results and Discussion

3.1. Socio-Economic Characteristics of the Respondents

The socio-economic characteristics of the respondents are shown in Table 1. The table shows that the majority of the respondents were middle aged (45 percent) and older farmers (29 percent). The age of the farmers was found to be positively correlated with utilizing more drought coping strategies This confirmed the findings of [44], where the age of the farmer was a significant and positive determinant towards adaptation decisions to CC effects. Middle-aged and older farmers were identified as more experienced and aware about CC and its' effects on the variability of weather [45]. Middle-aged farmers were more capable of managing their farms and stated diversified strategies to improve farm outcomes [16]. The data showed that 26 percent of the respondents had a secondary education, while 36 percent of the farmers reported being only literate enough to sign their name. Half (50 percent) of the respondents stated being a member of a small households (two to four family members). Education has been found, in other studies, to help the farmers' access more diversified information sources and was positively correlated with the extent of adoption of new technology [20,44–46].

Table 1. Socio-economic characteristics of the respondents (n = 100).

Category	Respondents (%)	Mean	SD *
Age (year)			
Young (18–35)	26		
Middle (36–50)	45	44.05	11.59
Old (Above 50)	29		
Education (year of schooling)			
Illiterate (0)	2		
Can sign only(0.5)	36		
Primary (1–5)	23	5.00	4.52
Secondary (6–10)	26		
Above secondary (Above 10)	13		
Household Size (number)			
Small (2–4)	50		
Medium (5–6)	31	4.95	1.83
Large (above 6)	19		
Farm Size (ha)			
Landless (0.002–0.02)	1		
Marginal (0.021–0.2)	6		
Small (0.21–0.99)	71	0.78	0.67
Medium (1.0–3)	21		
Large (above 3)	1		
Annual Income ('000' BDT *)			
Up to 100	28		
101–200	51	155.99	102.5
Above 200	21		
Farming Experience (year)			
Low (up to 10)	34		
Medium (11–20)	26	20.33	12.68
High (above 20)	40		
Organizational Participation (observed score: 0–33)			
No participation (0)	12		
Low (up to 11)	69	7.24	7.30
Medium(12–22)	16		
High (above 22)	3		

Table 1. *Cont.*

Category	Respondents (%)	Mean	SD *
Social Mobility (possible scale score: 0–21)			
Low (up to 7)	35		
Medium(8–14)	50	9.15	3.99
High (above 14)	15		
Extension Media Contact (possible scale score: 0–51)			
Low (up to 17)	95		
Medium(18–34)	4	7.35	5.94
High (above 34)	1		
Knowledge on Coping Strategies (possible scale score: 0–32)			
Low (up to 11)	33		
Medium (12–21)	67	14.15	2.88
High (above 22)	0		

* SD = Standard deviation; * BDT = Bangladeshi Taka (1 BDT= 0.0121$).

The majority of the respondents (71 percent) reported having small farm holdings (0.21–0.99 ha), whereas 21 percent reported medium-sized farms (1.0–3.0 ha). Farm size influences both access to information and technology adoption [46,47]. The data reported that the annual family income of about half of the respondents (51 percent) was 101,000 BDT to 200,000 BDT (US $1232 to $2440). Family income has been determined as a key factor in farm decision-making regarding the adoption of new technologies and as important regarding decisions to cope with the effects of CC [20]. It was found that the majority of the respondents (40 percent) had farming experience of more than 20 years. More experienced farmers may have a better understanding of drought and other CC effects, and hence are more able to employ drought coping strategies [44].

More than half of the respondents (69 percent) reported low participation in farm-related organizations and half of them (50 percent) reported medium social mobility. Organizational participation and social mobility can help facilitate farmers to explore and access helpful information sources which can boost their capability of adopting more adaptive coping strategies and decisions that benefit their farm. It was found that 95 percent of the respondents reported low contact with extension media. Access to extension media was positively and significantly related with adaptation measures [44]. These results identified a gap where necessary inputs in terms of information and training could enhance farmers' coping strategies. Knowledge of coping strategies to CC and drought is important to practice suitable and potential adaptation measures. Sixty-seven percent of the respondents reported medium knowledge of drought coping strategies in the study area. The farmers with more knowledge of coping strategies could make better-informed adaptation decisions [44].

3.2. Perceived Effects of Drought on Agriculture

The farmers' ranked order of the perceived effects of drought on their agricultural production is displayed in Table 2. Agriculture is a vitally important sector for livelihoods and is highly impacted by drought [16,31]. The list of statements of the possible effects of drought were determined by stage one of the preliminary data collection used in the questionnaire, and the responses were analyzed using the WAI method, as mentioned in the previous section. The farmers identified the scarcity of soil water as having the highest effect on drought with a WAI of 2.93. Almost all the farmers reported using groundwater for rice cultivation (a crop requiring high amounts of water) and, subsequently, during the peak growing season water shortages arise. "*Because of less and irregular rainfall canal and river remains dry all the year and therefore, we need to pull groundwater for irrigation and other usage and eventually during the peak cropping season we experience water shortage*", as stated by one of the FGD participants.

This finding confirms what other studies have found. A study conducted in Kenya [48] reported that 74 percent of the respondents (n = 120) perceived water scarcity as the most serious problem of drought. A study conducted [49] in Maharashtra State, India, revealed that the drying up of water sources was identified by farmers as the perceived main impact of drought.

Table 2. Rank order of the farmers' perceived effects of drought on agriculture (n = 100).

Statements	Effects				WAI	Rank Order
	High	Moderate	Low	No		
Scarcity of soil water	97	1	0	2	2.93	1
Increase cost of production	82	9	2	7	2.66	2
Decrease of crop production	67	24	6	3	2.55	3
Lower income	57	17	15	11	2.2	4
Stunted crop growth	52	22	6	20	2.06	5
Food shortage	20	38	18	24	1.54	6
Transformation to off-farm activities	30	24	15	31	1.53	7
Wilting of crops/stunted crop growth	12	27	22	39	1.12	8
Changes planting time	14	13	25	48	0.93	9
Increase fallow land	9	20	22	49	0.89	10
Loss of livestock	8	19	13	60	0.75	11
Changes in livestock composition	2	19	7	72	0.51	12
Crop failure	9	6	10	75	0.49	13

Code: High effect = 3, Moderate effect = 2, Low effect = 1, No effect = 0.

Increased production costs (WAI = 2.66) was perceived as the second highest impact of drought. The majority of the farmers in the study reported having small farms (0.21 to 0.99 ha) that have a shortage of irrigation water during the drought period and this requires a significant amount of money to support, therefore increasing the cost of production. The respondents stated that they needed to sacrifice other needs in order to pay for those costs (see the next paragraph).

Decreased crop production was perceived as the third most important effect of drought with a WAI of 2.55. Drought is a cause of pest and insect outbreaks and was found to be responsible for decreased crop production, as reported by the farmers. "*We need to expend notable amount of money for irrigation water because most of the irrigation sources (DTWs, STWs) are owned by only few farmers and on the other hand, pest infestations become high during drought period which also costs some money*". This statement was confirmed by the majority of the FGD participants and, thus, the installation of and access to irrigation water sources are of great need to improve their crop production. Decreased production of rice in the north-west Bangladesh has been a severe impact of drought, because rice production is highly dependent on water availability [31]. However, these perceived effects of drought on crop failure were among the lowest reported by the respondents, with a WAI of 0.49. These finding differs with the study reported in [47], where the farmers reported crop failure as the most severe impact of drought.

3.3. Farmer Coping Strategies in Response to Drought

As previously mentioned, coping strategies in response to drought was the focus variable of the study. Fourteen coping strategies were obtained from FGDs, experts consultations and the available literature for the development of the questionnaire. A score was obtained on a scale ranging from 0 to 42. Based on the total score, the farmers were categorized into low, medium and high levels of practicing of the coping strategies—see Figure 3, which shows the reported extent of practice of the drought coping strategies.

From Figure 3 it is evident that the practice of the drought coping strategies was mainly low (94 percent). A few of the farmers stated a medium level of practice (six percent) and no farmers reported a high level of drought coping strategies. Farmers' coping strategies to CC can be influenced by several factors such as climatic, social and economic factors [50,51]. Rural populations are the most vulnerable to CC, as they usually lack the necessary resources to cope with the changing climatic conditions. The findings clearly indicate that a low knowledge of drought coping strategies, along with small and fragmented land holdings and low income are related to low and late adaptive measures to drought. Therefore, an enormous opportunity for an intervention by development practitioners to improve the drought coping mechanisms of the farmers exists.

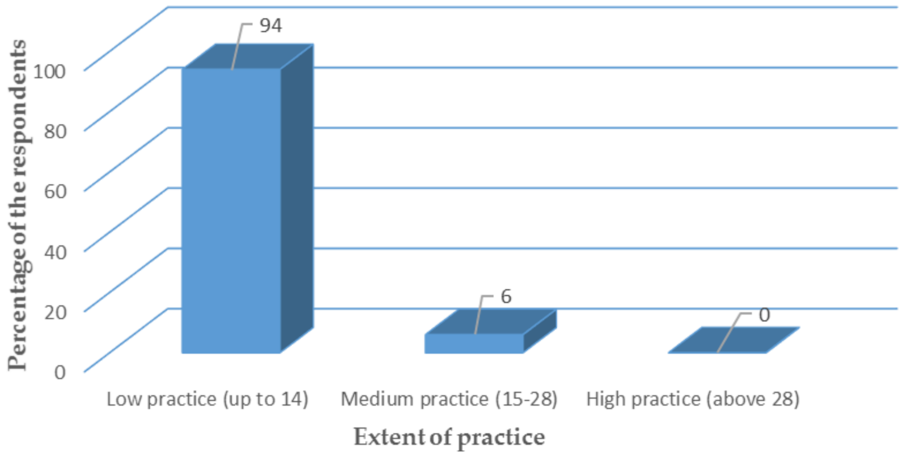

Figure 3. Extent of practice of the drought coping strategies by the farmers.

Several coping strategies were found to be practiced by the farmers in order to minimize the adverse effects of drought such as using irrigation, planting drought tolerant plants and others. The main crop produced in the study area is rice, however occasionally farmers plant maize and/or wheat as an alternative. Cultivating drought-tolerant crop varieties, especially maize, was the third most important drought coping strategy (ASI = 175).

The findings point to the use of irrigation pumps such as deep tube wells (DTWs), shallow tube wells (STWs), low lift pumps (LLPs), treadle pumps (TRAD), forced motion tube wells (FMTWs) and hand tube wells. Irrigation pumps are power operated (electricity or diesel), or human operated, and bring up surface and groundwater during the dry season. Indigenous techniques such as the re-excavation of ponds, *Khari* and canals, rain water harvesting and tree planting are used to get water during the dry season [21]. Crop and irrigation management strategies—i.e., alternate wetting and drying (AWD), mulching practices (rice straw mulching, water hyacinth mulching—and to a lesser extent crop cultivation, secure efficient irrigation and water use management to reduce water loss from the crop fields. Some drought-tolerant crops and crops requiring less water for cultivation are used to avoid excessive yield losses that can result from droughts.

To show the perceived importance of the individual coping strategies, an ASI was computed. Table 3 represents the rank order of different drought coping strategies reported by the farmers in the study area. The findings indicate that the use of DTWs for irrigation water was the most important drought coping strategy, with an ASI of 235, followed by STWs, with an ASI of 189. The Barind irrigation project supported by the Barind Multipurpose Development Authority (BMDA) was the main stakeholder in the irrigation water supply through the installation of DTWs and STWs during the study period [52]. The findings indicate that DTWs were widely used due to their availability. A study by [53] stated that groundwater was the main source of irrigation in the north-west region of Bangladesh. A study conducted by [20] found that the majority of the farmers producing in the irrigated areas of the Rajshahi district utilized irrigation water through DTWs. Farmers in areas where irrigation was not used (in the Rajshahi district) use LLPs and STWs to utilize groundwater sources for crop production [20]. Another study by [54] found that deepening irrigation wells was widely practiced by the technical drought management (TDM) group in Iran. However, a study by [20] reported different adaptation practices and stated that water resource exploitation through DTWs, STWs, and LLPs was significant in irrigated areas, where the use of agronomic practices was higher in non-irrigated areas, as investigated within the Rajshahi district of north-west Bangladesh. A study by [55] in Kenya noted that the excavation of water reservoirs was the most effective drought coping strategy as perceived by the farmers, followed by water and soil conservation.

Use of the TRAD pump (ASI = 1) had the lowest importance for irrigation water in this study. A treadle pump is a human powered pump that is labor intensive and less water efficient than DTWs or STWs. In addition, easy access to DTWs and STWs could be the reason for less use of TRAD pumps in the study area. *"We do not use TRAD pump for rice cultivation because rice requires more water and therefore, we use DTWs or STWs for irrigation"*, stated a FGD participant. They also pointed out that the main source of irrigation water for agriculture is groundwater and they almost completely rely on DTWs or STWs to access the water.

Table 3. Rank order of the coping strategies based on the extent of practice (*n* = 100).

Coping Strategies	Extent of Practice				ASI	Rank Order
	Regularly	Occasionally	Seldom	Not at All		
Deep tube well (DTW)	222	10	3	0	235	1
Shallow tube well (STW)	147	42	0	0	189	2
Drought-tolerant crop cultivation (rice, wheat, maize)	129	44	2	0	175	3
Lower extent crop cultivation	48	40	19	0	107	4
Tree plantation (mango, litchi orchard)	21	46	15	0	82	5
Less water required crop cultivation	27	32	17	0	76	6
Alternate wetting and drying (AWD)	3	44	18	0	65	7
Hand tube well	14	24	1	0	39	8
Re-excavation of pond, *khari* and canal	12	8	7	0	27	9
Rain water harvesting	0	10	3	0	13	10
Force motion tube well (FMTW)	6	2	0	0	8	11
Mulching practice	3	4	0	0	7	12
Low lift pump (LLP)	3	0	0	0	3	13
Treadle pump (TRAD)	0	0	1	0	1	14

Code: Regularly = 3, Occasionally = 2, Seldom = 1, Not at all = 0.

3.3.1. Correlation between the Socioeconomic Characteristics of the Farmers and Their Coping Strategies

To determine the association between the socioeconomic characteristics of the farmers, which are the explanatory variables of the study, and the focus variable of the farmers' drought coping strategies, a null hypothesis (H_0) was formulated. H_0 indicated that there is no association between the explanatory and focus variables. Pearson's product moment coefficient of correlation (r) was used to test the H_0. To reject the H_0, a five percent level of probability was used. Table 4 represents a summary of the correlation test between the variables.

Table 4. Correlation between socioeconomic characteristics and coping strategies (*n* = 100).

Socioeconomic Characteristics	Correlation Co-Efficient (r)
Age	0.263 **
Education	0.274 **
Household size	0.037
Farm size	0.402 **
Annual family income	0.354 **
Organizational participation	0.192
Social mobility	−0.130
Farming experience	0.187
Extension contact	−0.119
Knowledge on coping strategies to drought	0.123

Degrees of Freedom (df) = 98; ** Significant at the 1 percent level of significance (two-tailed); Tabulated value (r) = 0.197 (5 percent level) and 0.257 (1 percent level).

The results found that out of ten characteristics reported by the farmers, only four—age, education, farm size, and annual family income—had a positive and significant association with the drought coping strategies. There has been varying information in previous studies regarding the farmers' socio-economic characteristics and the relationship with drought coping strategies [56]. For example, variables such as age, household size, experience, nonfarm income, and livestock showed significant association with drought coping strategies [57]. Another study revealed that education, household size, gender, livestock ownership, access to information sources, and credit availability were associated with CC adaptation [58]. It was also found that farm type and literacy level had significant influence on farmers' choice of coping strategies [56]. According to [59], farm size, farming experience, extension media contact, membership of a farmer field school (FFS), and risk orientation were significantly associated with the practice of soil and crop management technologies.

3.3.2. Econometric Estimation of the Factors Affecting Farmers' Drought Coping Strategies

Multiple linear regression analysis was employed to determine the factors and their relevance in predicting the focus variable farmers' drought coping strategies. Table 5 represents the output of the analysis.

Table 5. Summary of multiple linear regression explaining the focus variable (n = 100).

Explanatory Variable	Unstandardized Co-Efficient		Standardized Co-Efficient	t	Sig. B
	B	Std. Error	Beta		
(Constant)	3.399	2.008		1.692	0.094
Age	0.074	0.038	0.257	1.921	0.050
Education	0.206	0.061	0.282	3.383	0.001
Household size	−0.071	0.160	−0.039	−0.442	0.660
Farm size	1.337	0.434	0.272	3.080	0.003
Annual family income	0.000	0.000	0.323	3.490	0.001
Farming experience	0.012	0.037	0.046	0.3623	0.747
Organizational participation	0.097	0.037	0.214	2.650	0.010
Social mobility	−0.088	0.078	−0.106	−1.130	0.261
Extension contact	−0.173	0.053	−0.311	−3.257	0.002
Knowledge	0.098	0.091	0.085	1.076	0.285

Adjusted R^2 = 0.420; F-value = 8.157; Significant if $p < 0.05$, Level of significance = 95%.

The results show that six out of ten explanatory variables were significant with an F value of 8.157 and adjusted R^2 value of 0.420. Therefore, the results imply that 42 percent of the variation in the drought coping strategies practiced by the farmers could be explained by the combined effects of explanatory variables. The coefficient of age (t = 1.921 and p = 0.05), education (t = 3.383 and $p < 0.05$), farm size (t = 3.080 and $p < 0.05$), annual family income (t = 3.490 and $p < 0.05$), organizational participation (t = 2.650 and $p < 0.05$), and extension media contact (t = −3.257 and $p < 0.05$) were significant. The data analysis shows that these are the factors that influenced the farmers when practicing drought coping strategies. The results also revealed that the age of the farmers had a positive coefficient, i.e., the older the farmers, the more likely they were found to practice drought coping strategies. This result is in line with the study in south-eastern Nigeria conducted by [60].

The variable of farmers' education indicated that the practice of drought coping strategies increases with a higher educational level [61]. This may be due to the fact that education facilitates farmers to explore and adopt new technologies aimed at improving farm output [62]. This result is consistent with other research studies in the literature [5,63]. Other results on farm size indicate that a larger farm size is related to farmers practicing more drought coping strategies. This may be due to the fact that some crop-based coping strategies require a larger farm size. A study conducted by [63] found that land area has a positive and significant influence on CC adaptation.

Annual family income was positive and significant for the practice of drought coping strategies by the farmers in the study area. The result implies that increased family income augments the adaptation options to drought and reiterates that farmers avoid risks that are associated with the adoption of new technology [61]. Therefore, the result may be due to the fact that the higher the income of the farmers, the less risk averse they are and they do not need to face extra burdens when adopting coping strategies.

Organizational participation also emerged as a positive and significant factor in practicing drought coping strategies by the farmers. This factor may be related to farmers having membership in different social, cultural, and professional organizations that bring them into contact with networks of other farmers who may be applying and sharing different solutions, or with alternative insights to coping strategies. They can learn from one another with regards to farming problems and can adjust their farm accordingly. This result is in line with [61,63]. Extension media contact was also found to have a positive and significant relationship with the practice of drought coping strategies by the farmers. This implies that increased access to extension sources facilitates the farmers' practice and adjustment to drought coping strategies, within the area of study. According to [64], farmers exposed to climate information through extension media are more likely to adapt coping strategies than others.

Step-Wise Multiple Regression Analysis

To understand the contribution of each variable to the respondents' variation in the practice of drought coping strategies, a step-wise multiple regression analysis was conducted. Table 6 represents the output of the analysis. The findings indicate that of the six significant socio-economic characteristics obtained from the multiple linear regression, three variables—farm size, age, and education—comprise the model. The findings also indicate that these three variables together (R^2 = 0.287) explained 29 percent of the variation in the farmers' drought coping strategies.

Table 6. Summary of the step-wise multiple regression analysis (*n* = 100).

Model	Variables Entered	Multiple R	Multiple R^2	Variation Explained (Percent)	Significance Level
Constant + X_4	Farm size (X_4)	0.162	0.153	15	0.000
Constant + X_4 + X_1	Age (X_1)	0.241	0.226	7.3	0.000
Constant + X_4 + X_1 + X_2	Education (X_2)	0.309	0.287	6.1	0.000

The first variable entered into the model was farm size (R^2 = 0.153), which made the highest contribution (15 percent) to explaining the variation in farmers' drought coping strategies. This implies that the larger the farm size, the more likely farmers are to practice drought coping strategies. The farmers with larger farms can take more risk when adapting their farming to droughts [65]. The second variable entered into the model was the age of the farmers. It was found that 7.3 percent of the variation in drought coping strategies can be explained by the age of the farmers. The finding reveals that as farmers age, they are more likely to practice drought coping strategies. The reason behind this may be that the older farmers possess a higher level of knowledge regarding CC and drought through their own dealings and experience. Together, the variables of farm size and age of the farmers (R^2 = 0.226) contributed to a 23 percent explanation of the drought coping strategies of the farmers. The third variable entered into the model was the educational level of the farmers, which contributes6.1 percent to explaining the focus variable. Education plays a significant role in acquiring useful information. The finding implies that the higher the educational level, the more likely and able the farmers are to practice drought coping strategies. According to [5], educated farmers have greater knowledge to help them understand and develop the ability to cope with adverse changes, as they have a wider exposure to different information sources. Educational level increases the probability of adopting CC adaptation measures [66]. This study's findings concur with the literature.

4. Conclusions

While it is evident that the farmers in the study area experienced adverse effects of drought on their agricultural production, the results regarding their existing coping strategies are not satisfactory. To cope with the adverse effects of droughts, the farmers have been adapting strategies like DTWs, STWs, and cultivating drought tolerant crops, especially rice varieties such as BRRI *dhan*56 and BRRI *dhan*57. While these coping strategies are of specific importance to minimizing drought effects, the extent of their uptake and, consequently, their impact, is being limited by other socio-economic factors such as low income, the level of education, age, access to extension, and logistics. The government of Bangladesh could act to ensure logistical support such as electricity and subsidies for the installation of more DTWs and STWs. Research into and the extension of drought-tolerant crop varieties could be strengthened to cope with droughts in the future. Age, education, and farm size were identified as the more influential factors affecting the adoption of drought coping strategies. Therefore, necessary initiatives focusing on these factors could increase the coping capacity of the farmers. Annual family income, organizational participation, and extension media contact were significant factors, but individual contributions to the model were not significant in explaining the variation of the practice of drought coping strategies as identified in this study. Hence, the policies and programs aimed at enhancing and strengthening the drought coping strategies of the farmers need to consider these factors as well. Moreover, development practitioners and extension organizations could concentrate on strengthening drought coping capacities for the betterment of farming communities. Increasing the knowledge level of farmers regarding drought and drought coping strategies, as well as making extension services easily accessible to the farming community, could improve drought coping strategies within the study area and could be applicable to other regions with a similar background and context.

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