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Vulnerability Assessment of Crop Husbandry due to Drought in North-Western Region of Bangladesh

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Abstract
Drought is a natural phenomenon linked to reduced rainfall, affecting crop husbandry in Mediterranean semi-arid conditions like the northwestern region of Bangladesh. A study was conducted in three upazilas, Chapainawabganj Sadar, Lalpur, and Godagari, involving 180 farmers. The results showed that most farmers had a vulnerability level ranging from slightly to moderately vulnerable to crops. However, a small number of people were in low vulnerability, indicating they practiced coping strategies during drought severity. The vulnerability of crops increased with exposure and sensitivity index and lower adaptive capacity. The study found that farmers experienced high severity of drought, with 78.9% experiencing medium effects, crop damage, high irrigation costs, and low income. To reduce crop vulnerability, the government and development agencies should provide technical support, such as re excavation of ponds and canals, rainwater storage facilities, new irrigation projects, extension services, education, income-generating opportunities, and water conservation measures. This will help reduce the vulnerability of crops to drought and improve crop management.

Keywords: Adaptive capacity, Drought, Exposure sensitivity, Vulnerability level

Introduction

Increases in global warming can impact climate in many ways and may influence the type and severity of natural events (and associated hazards) that occur in many parts of the world (Khan et al., 2019; Payab and Türker, 2018). Among these naturally occurring events, drought is considered one of the most devastating and has caused millions of deaths throughout human history (Hao et al., 2018). Anthropogenic modification to the global climate has increased severe drought events in the recent past (Herrera-Estrada & Sheffield, 2017). Changes in climatic parameters are expected to escalate the severity of these events. Bangladesh is considered one of the most vulnerable countries to climate change (Vinke et al., 2017). Due to its unique geographic location, the dominance of floodplains, low elevation from the sea, high population density, high levels of poverty, and overwhelming dependence on nature, its resources, and services. The country has a history of extreme climatic events claiming millions of lives and destroying past development gains.

Variability in rainfall patterns, combined with increased snowmelt from the Himalayas and temperature extremes, result in crop damage and failure, preventing farmers and those dependent on meaningful earning opportunities. Extreme climatic hazards such as floods, sea level increase, cyclonic storm surges, riverbank erosion, saline intrusion, and drought present significant risks to the life, livelihoods, and food safety of 64 percent of the farm-dependent rural population (Alam, 2016). Bangladesh ranks 160 out of 181 climate vulnerability nations and the 33rd most susceptible nation to climate change (ND-GAIN, 2022). Bangladesh's topography and geographical location make it especially vulnerable to extreme weather occurrences such as hurricanes, floods, droughts, and storm surges (MFAN, 2018). Its vulnerability is triggered not only by its biophysical variables (being a flat, small, delta nation subjected to floods and cyclones) (Ayers et al., 2014) but also by its socioeconomic variables (such as elevated agricultural reliance, population density, and poverty) (Thomas et al., 2013).

Bangladesh has in the past been negatively impacted by events such as flooding, but in future years could potentially suffer from more droughts (Ahammed et al., 2020; Shahid, 2011). Despite the country gradually moving to an industry-based economy, the agricultural sector's contribution to gross domestic product (GDP) is still around 15%. Approximately 41% of its workforce is still associated with this sector (Ahammed et al., 2020). Since the country is heavily reliant on water resources, especially on rainfall for agricultural production, any change in climatic parameters could lead to a shift in drought patterns which may have wide-ranging impacts on the population and economy (Khan et al., 2019; Mohsenipour et al., 2018; Mortuza et al., 2019). However, little is currently known about the risks posed by the changing climate on seasonal patterns of drought and the implications for the future. Due to its geophysical position and socioeconomic context, Bangladesh is prone to natural disasters. Especially the Northwest regions are drought-prone (Sammonds et al., 2021).

Droughts are related to either the late appearance or an early withdrawal of rainstorm downpours. Bangladesh appreciates sub-tropical rainstorm atmospheres with three conspicuous seasons, winter (November-February), summer (March-June), and monsoon (July-October) (BBS, 2018). In the severe climate change scenario, the drought situation will become even worse. While slight to direct power dry spell will beat the vast majority of the nation, the western parts of the country and the three Barind Tract AEZ clusters (i.e., AEZ 25, 26, and 27) will become susceptible to severe intensity drought. Drought has negative outcomes on agriculture, environments, livelihood, and food security in Bangladesh (Sovacool, 2018). Drought is a "Creeping Phenomenon." The effect of drought accumulates slowly over a considerable period and may linger for years after the termination of the event. Drought impacts spread over a larger geographical area than are damages that result from other natural hazards (Alam et al., 2014). Like floods, Bangladesh is vulnerable to recurrent droughts. Bangladesh has experienced droughts of major magnitude in 1951, 1961, 1975, 1979, 1981, 1982, 1984, 1989, 1994, 1995, and 2000 and about 53 percent of the total population have been negatively affected (Mardy et al., 2018).

Two critical dry periods are distinguished. Rabi and pre-Kharif droughts occur due to the cumulative effect of dry days, higher temperatures during pre-Kharif, and low soil moisture availability (Rana & Moniruzzaman, 2023). People in the northern part of the country are suffering from drought currently. They don't get rainfall often. People suffer from heatstroke, high temperature, lack of usable water, dehydration, and a lot more. In the Barind tracts of Bangladesh, terminal droughts are more frequent and coincide with the most important growth phases of the rice crop. The occurrence of drought may be related to the following physical observations such as repeatedly broken cracks developing on dried up topsoil, loosening of soil structure, ending up in the topsoil, transforming into a dusty layer, burnt-out yellowish foliage in the vegetation covers particularly observed in betel nut trees and bamboo groves, drought-stressed plants lose their turgidity and they wilt, young mustard or soybeans plants initiate flowering and reproductive growth sooner than is normally expected (Aryal et al., 2023).

Rajshahi, Chapai Nawabganj, and Natore district are huge drought-affected in the North-Western Region of Bangladesh (Sammonds et al., 2021). Almost every socioeconomic and environmental aspect is hampered by drought; agricultural sides are affected too. The north-eastern part is prone to drought mainly because of rainfall variability in the pre-monsoon and the post-monsoon periods. Inadequate pre-monsoon showers, a delay in the onset of the rainy season, or early departure of the monsoon may create drought conditions in Bangladesh and adversely affect crop output. Since it puts severe strain on the land potential, increased soil erosion, the decline in soil organic contents, and overexploitation of sparse vegetation (Begum & Kader, 2018). Most parts of Bangladesh depend on rain-fed agriculture (Moniruzzaman, 2015). But the amounts of rainfall and their duration time throughout the year are decreasing day by day. So, drought has become a curse in many regions nowadays. It is thus important to carry out drought studies so that when the disaster (drought) strikes, the area's occupants are not caught unaware. The north-eastern region (Rajshahi, Chapai Nawabganj, and Natore district) of Bangladesh is taken as a case study area in this observation because it is considered the most drought-prone area of Bangladesh.

A drought is an extended period when a region notes a deficiency in its water supply. Generally, this occurs when an area receives consistently below-average precipitation. It can have a substantial impact on the ecosystem and agriculture of the affected regions. Although droughts can persist for several years, even a short, intense drought can cause significant damage (Afrin et al., 2019). This drought affects all the Rabi crops, such as Boro and Aus rice, wheat, pulses, and potatoes, especially where irrigation possibilities are limited. Kharif droughts in the period June/July to October are created by sub-humid and dry conditions in the country's highland and medium highland areas. Shortage of rainfall affects the critical reproductive stages of transplanted Aman crops in December, reducing its yield, particularly in those areas with low soil moisture-holding capacity (Rana and Moniruzzaman, 2023).

Hoque et al. (2020) reported a study, and presents a spatial multi-criterion integrated approach for mapping comprehensive drought vulnerability using geospatial techniques and an analytical hierarchy process (AHP). The developed approach was applied in the northwestern region of Bangladesh to justify its applicability. So, drought has become a curse in many regions nowadays. It is thus important to carry out drought studies so that when the disaster (drought) strikes, the area's occupants are not caught unaware. The northern region of Bangladesh is taken as a case study area in this observation because it is considered the most drought-prone area of Bangladesh (Sammonds et al., 2021). Therefore, the following specific objectives were formulated for giving proper direction to the study-

i. To measure the vulnerability situation of crop husbandry due to drought disasters in the north-western region of Bangladesh;
ii. To assess the extent of drought disasters' impact on crop husbandry;
iii. To explore the factors associated with the vulnerability of crop husbandry due to drought.

Materials and Methods

Study Area

North-Western Regions of Bangladesh are vulnerable to drought in various aspects. Most of the farmers in these areas are smallholders whose livelihood depends on various farming activities. Their farming activities are being changed and affected due to drought disasters and climate change. The study areas are mainly affected by drought disasters. Low rainfall is a common phenomenon in these affected areas. Irreplaceable Crop losses due to drought occurred in the North-Western Regions of Bangladesh. Agriculture is the primary activity in these areas. The farmers' farming activities are largely depending on the water sources.

Lack of water hampers their crop production and livelihood as well. Though the scarcity of water the farmers are trying their level best in conducting various farm practices through adopting various technologies (Hussain, 2017). Vulnerability of crop husbandry is required to measures of these areas. Thus, the study was conducted in the North-Western Region of Bangladesh. Three purposively selected Upazila namely

Chapainawabganj *Sadar* of Chapainawabganj district, and Lalpur of Natore district, Godagari of Rajshahi district (**Fig. 1**). Thus, the researcher selected these three upazila to conduct research emphasizing agriculture.

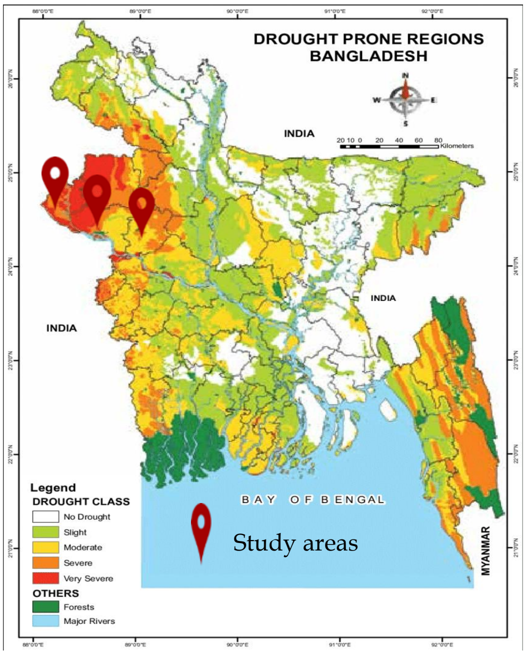

Fig. 1. Drought Prone Regions of Bangladesh (Hussain, 2017)

Sampling, Data Collection and Analysis

The survey schedule was prepared according to the objectives to collect the expected data. A draft schedule was first prepared following the study objectives. The draft schedule was then pre-tested to verify the relevance of the questions and the nature of the response of the sampling procedure. A final survey schedule was developed after pretesting and necessary adjustment. The survey was conducted from 6th March to 5th April 2021. Data was collected from farmers who were engaged with crop husbandry. Data were collected by researcher from 180 farmers (60 farmers from each area) through a structured questionnaire.

A total of three FGDs were carried out in the study areas by the researchers. One session was conducted in each village, each group comprising seven participants. A semi-structured questionnaire was used to conduct FGDs. Different adaptation practices and constraints faced by the farmers in adapting farming practices due to climate change were identified through this method. To develop the conceptual basis of the study, the information from different relevant sources, such as books, journals, thesis, abstracts, reports, and websites. The researcher also collected documents from various organizations like the Upazila Agricultural office, rainfall and temperature data from Bangladesh Metrological Department (BMD).

In descriptive social research, selection, and measurement of the variable is an important task. A variable is any characteristic that can assume varying or different values in successive individual cases (Ghanad, 2023). Organized research usually contains at least two identical elements viz. Independent and dependent variable. The independent variables of this study were seven selected characteristics of the farmers. These were age, education, family size, farm size, annual family income, extension media contact and credit availability. Vulnerability assessment of crop husbandry was the dependent variable of this study. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (Gumel, 2022). Thus, as per this definition, vulnerability has four components: hazard, exposure, sensitivity, and adaptive capacity. The first three components together represent the potential impact and adaptive capacity is the extent to which these impacts can be averted. Thus, vulnerability is the potential impact minus adaptive capacity AC. This leads to the following mathematical equation for vulnerability: V= f(I-AC). For the vulnerability assessment, the three components of vulnerability such as exposure, sensitivity, and adaptive capacity consist of a total of 43 indicators. Thus, indicators are measured by the scoring methods (Hoque et al., 2019).

The extent of exposure, sensitivity and adaptive capacity of the drought was measured based on opinions provided by farmers according to their extent of drought in agriculture. The 43 indicators in this study reflect socio-economic, agro-ecological, and biophysical variables. After computing the scores, it transforms to a special scale. Therefore, the data is applied in the formula of the vulnerability index. However, the integrated vulnerability index (VI) will be measured using the following formula. The following formula was used by Jha & Gundimeda (2019) and (Hoque et al., 2019).

$$VI = (EI + SI) – ACI$$

where,

VI = Vulnerability Index
EI = Exposure Index
SI = Sensitivity Index
ACI = Adaptive Capacity Index

For measurement of Exposure Index (EI), Sensitivity Index (SI), and Adaptive Capacity Index (ACI) was measured with the indicator's extent level following four-point scale score such as great extent, moderate extent, slight extent and not at all assigned as 3, 2, 1 and 0 respectively. In the exposure subgroup, we considered 7 exposure indicators. In the subgroup of sensitivity, there are 21 sensitivity indicators which are distributed by four sectors (Population, Health, Land resources, and Agricultural practices). To measure adaptive capacity index, it combined 10 adaptive capacity indicators 5 coping strategies indicators. Extent the components of the vulnerability of crop due to drought was measured based on opinion provided by farmers according to their extent level. A total of 43 indicators developed the possible score range 0-129 (for one respondent).

Normalization of indicators scores to special score

A special score technique is used for the development of a vulnerability index. The sum of total indicators scores is divided by the indicators numbers for normalized the data into the special score technique (Jha & Gundimeda, 2019). After completion, the value will insert in the following formula to estimate the vulnerability index. The value of the VI range from -1 to +1. The value under zero (0) will be considered as adaptive capacity of the farmers and above zero (0) value will be considered as vulnerable situation of the respondents.

Results and Discussion

Socio-Economic Characteristics of the Respondents

The respondents' age ranged from 21 to 80 years. The mean and standard deviation were 46.71 and 12.51 respectively. The majority (56.7 percent) of the respondents were middle-aged while 21.1 percent and 22.2 percent were of young and old aged respectively. The education score of the farmers ranged from 0 to 16. The mean and standard deviation were 4.36 and 4.88, respectively. A good number (23.3 percent) of the respondents after a high number of illiterate (32.8 percent) fell under the categories of 'secondary education' and 19.4 percent under 'primary education. Where 13.9 percent of farmers can sign only, 4.4 percent had 'higher secondary' and 6.1 percent under the category of a bachelor degree. The family size of the farmers ranged from 2 to 12 members. The average was members' 45.23 members with a standard deviation of 1.74 members. The findings indicated that about 51.1 percent of the respondent belongs to the medium family, about 38.3 percent of the respondent belongs to the small family size and about 10.6 percent belongs to the large family. The farm size of the farmers varied from 0.02 to 7.50 ha. The average farm size was 0.96 ha with a standard deviation of 1.00 ha. The highest proportion of the farmers 68.3 percent had a small farm size, 26.7 percent had a medium farm size and 5 percent had a large farm size. There were no marginal or landless farmers. The annual family income of the farmers ranged from 15 to 350 thousand taka. The mean was 110.85 thousand takas and a standard deviation of 65.32 thousand. The findings indicated that about 54.4 percent of the respondents had low income, about 35.6 percent had medium income and 10 percent of the farmers had a high income. The extension media contact score of the farmers ranged from 3 to 37 against the possible range of 0 to 42. The mean and standard deviation were 17.11 and 7.00 scale scores respectively. The findings indicated that about 53.9 percent of respondents had medium extension media contact, 41.1 percent had low extension media contact and only 5 percent had high extension media contact. The access to credit of the farmers ranged from 0 to 350 thousand takas with an average of 32.31 and a standard deviation of 61.47 thousand takas. The findings indicated that the majority (55.6 percent) of the respondents could not get any credit while about 27.8 percent of the respondents had low access to credit and about 10 percent and 6.7 percent had medium and high access to credit respectively (**Table 1**).

Vulnerability Assessment of Crop Husbandry

Vulnerability is constituted by three components such as exposure, sensitivity, and adaptive capacity of the farmers. This dependent variable consists of a total of 43 indicators. We incorporated indicators in the subgroup of exposure, sensitivity, and adaptive capacity in the line. The biophysical aspects consider agricultural systems' exposure to climate change and variability by incorporating indicators like precipitation variability, the occurrence of flood, drought, and environmental degradation. The agro-ecological dimensions are represented by the sensitivity of farmland and production to climate shocks. Drought causes a great loss to farmers but farmers took some strategies to adapt and cope with drought impact. These are indicated adaptive capacity. **Table 2** presents the vulnerability level of the farmers of three specific regions of Bangladesh. These are Amnura village of Chapainawabganj *Sadar* upazila, Balitita village of Lalpur upazila and Narayanpur village of Godagari upazila. The vulnerability level is categorized into four levels according to their vulnerability index which range starts from -1 to 1. The farmers are not vulnerable if the value remain below zero (0), slightly vulnerable (0.01-0.25), moderately vulnerable (0.26-0.50), and finally highly vulnerable (above 0.50).

Vulnerability level of Chapainawabganj Sadar

Fig. 2 shows the vulnerability level of Chapainawabganj. It is observed from **Table 2** and **Fig. 2** that a large number of the farmers (65 percent) are in a moderately vulnerable condition. Not vulnerable and slightly vulnerable present 8.3 and 26.7 percent respectively in this study area. A high value is 0.50 while the lower value is -0.16. The negative value indicates that the farmers had the adaptive capacity with the coping strategy against drought impact.

Vulnerability level of Natore (*Lalpur*)

Observation of vulnerability level of Lalpure upazila from **Table 2** is a major number (51.7 percent) of farmers are in slightly vulnerable. Highly vulnerable are not present in this study area. Rather than we found the negative value that means farmers had the adaptive capacity for drought by taking different adaptive strategies (**Fig. 3**). **Fig. 3** shows the high value and lower value of the vulnerability index. Relatively high percentages (28.3) of farmers are in a not vulnerable condition.

Vulnerability level of Rajshahi (Godagari)

A major number of the farmers are in a moderately vulnerable condition in the Godagari upazila of Rajshahi district. **Table 2** shows 50 percent of respondents are moderately vulnerable while not vulnerable is 16.7 percent, slightly vulnerable is 31.7

percent, and high vulnerable is 1 percent. From **Fig. 4** it is observed that the high vulnerability value is 0.51 and the lower value is -0.39. The negative value presents the adaptive capacity level against drought impact.

Effect of Drought on Crops and Livelihoods

Observed effects of drought on crop production and livelihoods scores ranged from 3 to 22 against possible range from 0 to 30. The average and standard deviation of the data distribution were found at 13.17 and 3.62, respectively. Based on the scores, the effects were classified into three categories: low (below 10), medium (10 to 19), high (above 19) as shown in **Table 3.** Data presented in **Table 3** indicate that the majority (78.9 percent) of the farmers had medium effects compared to 15.6 percent having low effects, 5.6 percent having high effects. It reveals that the majority of the farmers in the study area were having medium effects of drought on agriculture and livelihoods. Similar results were found by Mardy et al (2018).

Linear multiple regression analysis of the vulnerability of crop due to drought

A multiple regression analysis was conducted to determine the factors affecting the vulnerability of crops to drought. The independent variables included age, level of education, family size, farm size, annual family income, extension media contact, and access to credit. The results showed that the determinant factors of crop vulnerability were level of education, annual family income, and extension media contact. The analysis indicated that the probability of crop vulnerability increases with the decrease in education level. Increasing education levels can help increase knowledge about drought-related information, reducing crop vulnerability. This can lead to significant development opportunities in local areas if used appropriately. The study suggests that increasing education can help individuals better understand and adapt to drought conditions, ultimately reducing crop vulnerability.

This assumption was in line with the results of similar work on climate change adaptation strategies are done by (Deressa et al., 2009). Similar results were found by Mardy et al. (2018), and Burhan (2009). The findings of the multiple regression analysis indicated that annual family income was significant and showed a negative trend. It implies that farmers with high-income levels are likely to adapt to climate change such as drought and the vulnerability of crop decreased. Farmers with lower income had a high level of vulnerability of crop. These findings agree with other studies which indicate that farmers that engage in off-farm activities can diversify their income and continue with their agricultural operations in face of climatic uncertain activities. (Kim, 2009) found out that household income positively and significantly influenced the adoption of adaptive climate change. Similar results were found by Mardy et al. (2018).

Step-wise multiple regression analysis

A step-wise multiple regression analysis had been applied to identify significant explanatory variables that have effects on the vulnerability of crops due to drought. The results of the multiple regression analysis show that among the explanatory variables, four variables had significant influences on the vulnerability of crop due to drought. These four variables were finally entered into the model and the contribution of these variables accounted for 59.2 percent of the total variation in the extent of vulnerability of crop. Hence, the hypothesis is almost true and the null hypothesis can be rejected. The results of the analysis are shown in **Table 5** The variable-wise effect is explained below:

Extension media contact significantly impacted the vulnerability of crops to drought, with a 47.4% impact. Farmers with better exposure to communication followed more adaptation practices and took risks against climatic hazards. Annual family income also had a significant negative impact on crop vulnerability, with low family income being more vulnerable to drought. The level of education of farmers also played a role, with a 2.5% contribution. Education enhances the power of observation, understanding, decision-making, and adjustment to natural disasters. Step-wise multiple regressions revealed that education had a significant and negative influence on crop vulnerability. Access to credit also had a 0.9% contribution, indicating that access to credit negatively impacts crop vulnerability. Overall, extension media contact, annual family income, and education are key factors in predicting crop vulnerability to drought.

Table 1. Salient features of the individual characteristics of the farmers

Characteristics	Scoring system	Respondent categories	Respondent (180)		Mean	SD
			No.	%		
Age	Years	Young (18 -35)	38	21.1	46.71	12.51
		Middle (36-55)	102	56.7		
		Old (Above 55)	40	22.2		
Level of Education	Years of schooling	Illiterate (0)	59	32.8	4.36	4.88
		Can sign only (0.5)	25	13.9		
		Primary (1-5)	35	19.4		
		Secondary (6-10)	42	23.3		
		Higher secondary (11-12)	8	4.4		
		Bachelor (>12)	11	6.1		
Family Size	No. of members	Small family (2-4)	69	38.3	5.23	1.74
		Medium family (5-7)	92	51.1		
		Large family (>7)	19	10.6		
Farm Size	Hectares	Small (up to 0.99 ha)	123	68.3	0.96	1.00
		Medium (1.0-3 ha)	48	26.7		
		Large (above 3 ha)	9	5		
Annual Family Income	'000' Tk	Low income (<100)	98	54.4	110.85	65.32
		Medium income (100-200)	64	35.6		
		High income (>200)	18	10		
Extension Media Contact	Scale Score	Low contact (up to 14)	74	41.1	18.11	7.00
		Medium contact (15-28)	97	53.9		
		High contact (>28)	9	5		
Access to Credit	'000' Tk	No credit (0)	100	55.6	32.31	61.47
		Low credit (up to 50)	50	27.8		
		Medium credit (51-100)	18	10		
		High credit (>101)	12	6.7		

SD=Standard Deviation

Table 2. Vulnerability level of Chapainawabgang, Natore, and Rajshahi district

Location	Vulnerability Level	Farmers percentage (n=180)	Mean	SD
Chapainawabgang	Not vulnerable (below 0)	8.3	0.28	0.17
	Slightly vulnerable (0.01-0.25)	26.7		
	Moderately vulnerable (0.26-0.50)	65.0		
	Highly vulnerable (above 0.50)	-		
Natore	Not vulnerable (below 0)	28.3	0.10	0.23
	Slightly vulnerable (0.01-0.25)	51.7		
	Moderately vulnerable (0.26-0.50)	20.0		
	Highly vulnerable (above 0.50)	-		
Rajshahi	Not vulnerable (below 0)	16.7	0.20	0.20
	Slightly vulnerable (0.01-0.25)	31.7		
	Moderately vulnerable (0.26-0.50)	50.0		
	Highly vulnerable (above 0.50)	1.7		

Table 3. Extent of effects of drought on crops and livelihoods of the farming community

Categories	Respondents		Mean	SD
	Number	Percentage		
Low effect (below 10)	28	15.6	13.17	3.62
Medium effect (10-19)	142	78.9		
High effect (above 19)	10	5.6		
Total	180	100		

Table 4. Summary of the linear multiple regression analysis

Explanatory variable	Unstandardized Co-efficient		Standardized Co-efficient	t	Sig. β
	β	Std. Error	β		
(Constant)	0.544	0.053		10.173	0.000
Age	0.000	0.001	0.024	0.463	0.644
Level of education	-0.009	0.002	-0.190	-3.480	0.001
Family size	0.005	0.006	0.039	0.782	0.435
Farm size	0.008	0.011	0.040	0.795	0.427
Annual family income	-0.001	0.000	-0.287	-5.179	0.000
Extension media contact	-0.013	0.001	-0.513	-9.322	0.000
Access to credit	0.000	0.000	0.097	1.873	0.063
Adjusted R^2 = 0.580, F-value = 36.30					

Table 5. Summary of the step-wise multiple regression analysis

Model	Variables entered	Multiple R	Multiple R^2	Variation explained	F value	Sig. level
Constant $+X_6$	Extension media contact (X_6)	.689	0.474	47.4	160.69	.000
Constant + X_6 $+X_5$	Annual family income (X_5)	.747	0.558	8.4	111.59	.000
Constant $+X_6+X_5+X_2$	Level of education (X_2)	.763	0.583	2.5	81.87	.000
Constant $+X_6+X_5+X_2+X_7$	Access to credit (X_7)	.769	0.592	0.9	63.49	.000

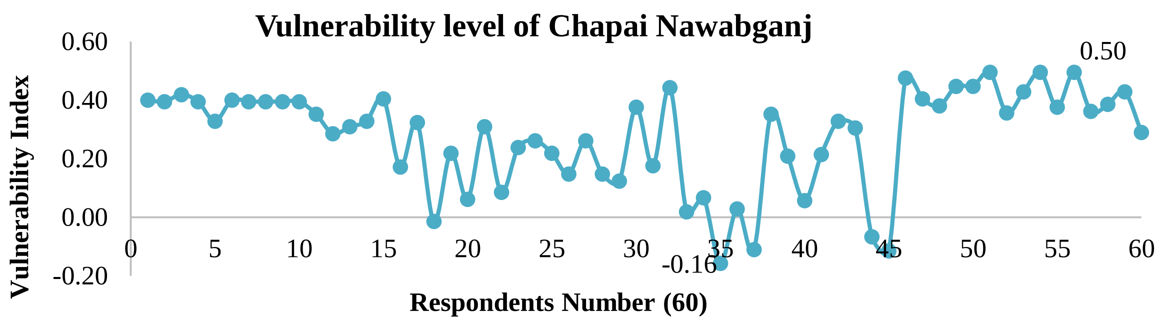

Fig 2. A linear graph of the vulnerability level of Chapainawabganj

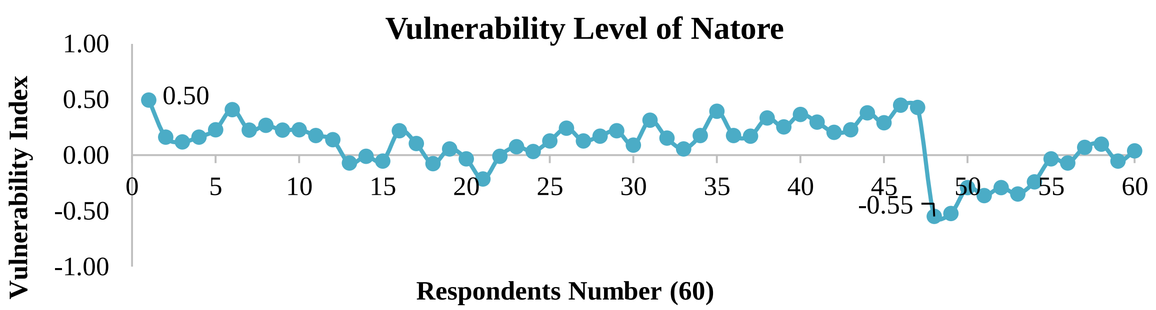

Fig 3. A linear graph of the vulnerability level of Natore

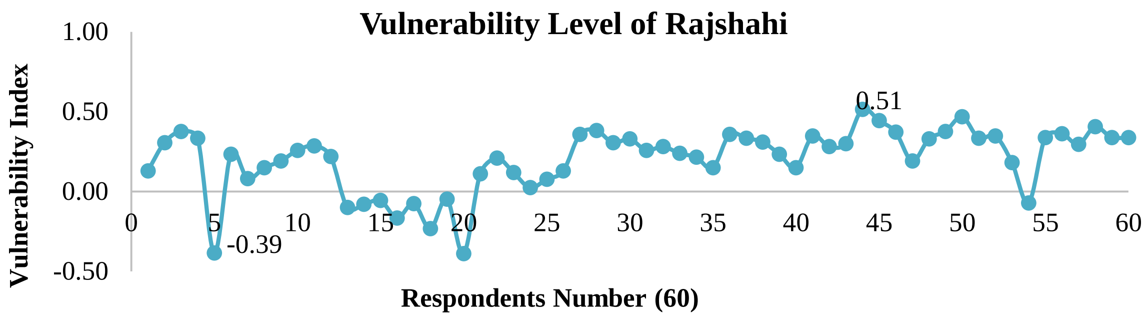

Fig 4. A linear graph of the vulnerability level of Rajshahi

Conclusions

The effect of drought on crop husbandry and livelihoods in these study areas observed that the majority of the farmers had medium effects. The findings of the study indicated that 15.6 percent had low effects of drought. Thus, it may be concluded that farmers of the study areas affected by drought with medium severity. It was found that the maximum percentage of vulnerability level ranged from slightly vulnerable to moderately vulnerable to crops in the study areas. A small number of people are in low vulnerability which means they practiced coping and adaptive strategy during the drought severity. The findings indicated that vulnerability of crop increases with the increasing of exposure and sensitivity index and lower adaptive capacity. So, it could be concluded that the vulnerability of crop husbandry is influenced by the exposure, sensitivity, and adaptive capacity indicators. The factors of vulnerability such as extension media contact, annual family income, level of education, and access to credit, had significant influences on the vulnerability of crop due to drought. The study revealed that the farmers of the study areas could not get proper adaptive care during drought. Farmers might get limited facilities from GOs and NGOs to overcome the drought impact. Results indicated that farmers could get some adaptive care with limited extent such as the adoption of drought-tolerant rice varieties (BINA7, BRRI Dhan 51/56/57/71), cultivation of less water required cereal (wheat, maize, sorghum), sugarcane cultivation, cultivation of pulses, digging of deep tube well, and doing non-agricultural work.

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