FARMERS ADAPTATION STRATEGIES TO DROUGHT AND THEIR DETERMINANTS IN NORTHWESTERN PARTS OF BANGLADESH

SOMAIYA RAHMAN

DEPARTMENT OF AGRICULTURAL ECONOMICS
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
SHER-E-BANGLA NAGAR, DHAKA -1207

JUNE 2022

FARMERS ADAPTATION STRATEGIES TO DROUGHT AND THEIR DETERMINANTS IN NORTHWESTERN PARTS OF BANGLADESH

BY

SOMAIYA RAHMAN

Registration No.: 15-06805

A Thesis

Submitted to the Department of Agricultural Economics
Sher-e-Bangla Agricultural University, Dhaka-1207
In partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (MS)
IN
AGRICULTURAL ECONOMICS
SEMESTER: JANUARY-JUNE, 2022
APPROVED BY:

(Prof. Dr. Md. Sadique Rahman)
Supervisor
Dept. of Management & Finance
Sher-e-Bangla Agricultural University

(Prof. Gazi M. A. Jalil)
Co-Supervisor
Dept. of Agricultural Economics
Sher-e-Bangla Agricultural University

(Dr. Monoj Kumar Majumder)
Chairman
Department of Agricultural Economics
Sher-e-Bangla Agricultural University, Dhaka-1207

DEPARTMENT OF
AGRICULTURAL ECONOMICS
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
Website: www.sau.edu.bd

CERTIFICATE

This is to certify that the thesis entitled **"FARMERS ADAPTATION STRATEGIES TO DROUGHT AND THEIR DETERMINANTS IN NORTHWESTERN PARTS OF BANGLADESH"** submitted to the Faculty of Agribusiness Management, Sher-e- Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **AGRICULTURAL ECONOMICS**, embodies the result of a piece of bona fide research work carried out by **SOMAIYA RAHMAN**, bearing the registration No. **15-06805** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged.

Prof. Dr. Md. Sadique Rahman

Supervisor

Department of Management and Finance

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

DEDICATED TO MY BELOVED PARENTS AND SUPERVISOR

ACKNOWLEDGEMENT

Firstly, all praises are due to Almighty Allah, the Great, Gracious and Merciful, whose blessings enabled the author to complete the research work and this thesis successfully for the degree of Master of Science in Agricultural Economics. Guidance, help and co-operation have been received from several persons or authority during the tenure of the study. Although it is not possible to mention all by names, it will be an act of ungratefulness if some names are not mentioned here for their immense contribution to the accomplishment of this study.

In particular, the author takes the opportunity to express her deepest sense of gratitude to her honorable ***Supervisor Dr. Md. Sadique Rahman,*** *Professor, Department of Management & Finance, Sher-e-Bangla Agricultural University, Dhaka for his continuous inspiration, thought-provoking comments, constant guidance and supervision through the period of the study. The author would like to express her boundless appreciations to her* ***Co-supervisor Prof. Gazi M.A. Jalil****, Department of Agricultural Economics, Sher-e-Bangla Agricultural University, Dhaka for his productive and valuable advice to complete this thesis.*

The author also expresses her deepest respect and boundless gratitude to all the respected teachers of the ***Department of Agricultural Economics,*** *Sher-e-Bangla Agricultural University, Dhaka, for their valuable teaching, sympathetic cooperation, and inspirations throughout the course of this study and research work. The author would like to disclose her boundless gratitude to Ministry of "National Science & Technology" for its funding.*

The author deeply acknowledges the cooperation and sincere help of Upazila Agricultural Officers of Tanore Upazila and Nachole Upazila during selection of study areas and data collection. The author's wholehearted thanks go to the respondents of the study area who actively participated and patiently provided their efficient information during the interview period.

Last but not least, the author expresses her deepest sense of respect to her beloved parents, husband, brothers, friends and other relatives for their blessings and moral support in all phases of this academic pursuit from beginning to the end.

The author is solely responsible for errors and omissions in this study, if any.

The Author

FARMERS ADAPTATION STRATEGIES TO DROUGHT AND THEIR DETERMINANTS IN NORTHWESTERN PARTS OF BANGLADESH

ABSTRACT

The study was conducted to identify the farmers' current adaptation strategies to drought and their determinants in northwestern parts of Bangladesh. The locale of the study was Tanore and Nachole Upazila under Rajshahi and Chapainawabgonj districts in Bangladesh. A total of 150 farmers were selected through simple random sampling. Face-to-face interviews were performed to gather data. The descriptive statistics and econometric model (Poisson Regression Model) were applied to achieve the objectives of the study. The number of strategies adoption constituted the dependent variable, and the selected ten farmer characteristics were regarded as the independent variables. Statistical analysis shows that gender, education, agricultural training received and agriculture related credit received had positive and significant relationship with the adoption of adaptation strategies in drought. Credit was found as the most significant positive factor on adopting a set of adaptation strategies, holding the co-efficient of 0.28. Some barriers to adoption were mentioned by farmers such as; lack of irrigation water, lack of knowledge concerning appropriate adaptation, low credit facilities, and lack of adequate extension services. Therefore, provision of necessary measures (re-excavation of canal, installation of more deep tube-wells, motivating farmers to adopt drought tolerant varieties, affordable access to credit, community-based education and training programs) by the concerned authorities are preferable for improvement of the northwestern farmers' adaptation status.

TABLE OF CONTENTS

LIST OF THE TABLES

LIST OF THE FIGURES

ABBREVIATION AND ACRONYMS

BER	=	Bangladesh Economic Review
DAE	=	Department of Agricultural Extension
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food & Agriculture Organization
BADC	=	Bangladesh Agricultural Development Corporation
AIC	=	Agricultural Information Centre
SAAO	=	Sub-Assistant Agricultural Officer
FGD	=	Focus Group Discussion
IPCC	=	Intergovernmental Panel on Climate Change
UNDP	=	United Nations Development Program
NGOs	=	Non-Government Organizations
WB	=	World Bank
PR	=	Poisson Regression
VIF	=	Variance Inflation Factor
%	=	Percentage
et al.	=	and others (at elli)
Tk.	=	Taka

CHAPTER I

INTRODUCTION

1.1 Background

Climate change now-a-days is recognized as a continuous global phenomenon with sweeping implications and it is one of the most challenging and complex problem facing the agricultural development globally (IPCC, 2007). Increasing temperatures that cause more variability in precipitation and extreme weather events like seasonal changes, floods and droughts have been linked to a rise in greenhouse gas (GHG) emissions (IPCC, 2014). Within the next two decades, the world is close to reach the 1.5°C level. So, the most drastic cuts in carbon dioxide emissions from now will be helpful to prevent an environmental disaster (IPCC, 2022).

Although developing countries only contribute to 10% of the world's annual carbon dioxide emissions, they are the most vulnerable to climate change and have lower capacities for adaptation than developed countries (McCarthy et al. 2001). Bangladesh is one of the most vulnerable countries in the world due to its geographical location, flat deltaic topography, extremely low elevation, and dense population. As a developing nation, it also faces extreme weather variability linked to climate change (MoEF, 2009; Ahmed, 2006). Among all the natural hazards, drought is one of the major threats to human well-being and socio-economic growth. The first and most significant effect of the drought is on agriculture, endangering both the industry and those who depend on it (Hamidi, 2017). For example, Bangladesh endured more than 20 droughts in the past 50 years (IPCC, 2007; Habiba et al. 2012). As a result, agriculture which is the pillar of Bangladesh economy through contributing a large share, faces many critical problems. The north-western part of the country is more vulnerable to drought due to high rainfall variability, high temperature and consequently, farming communities regularly exploit groundwater resources (Dey et al. 2011).

In the north-western part, farmers are particularly impacted by the drought as they find it difficult to irrigate their crops because of the shortage of water resulted from drought (Shahid and Behrawan, 2010). Although the distress brought on by drought cannot be controlled, it can be lessened by taking adaptation measures. Farmers in the northwest are struggling to implement various adaptation strategies in order to mitigate the negative effects of the drought (Habiba et al. 2012; Hossain et al. 2016; Alam, 2015). Therefore, investigating the currently

practicing adaptation measures adopted by farmers and examining the influence of determinants on adaptation methods considering various socio-demographic, economic and agricultural factors are the subjects of intense research.

1.2 Drought in Bangladesh

In Bangladesh, drought and its impact on agriculture is not the recent occurrence due to high temperature and low rainfall. According to various records, droughts occurred in Bangladesh 24 times between 1949 and 1991. From 1973 to 1998, seven of the ten most extreme climatic events in the northwest were droughts (BBS, 2016). In this region, Bangladesh experienced severe drought in 1999, 2000, 2006, 2009, and 2012. In 1999, Bangladesh witnessed its worst drought in 50 years, enduring more than four months without any precipitation (Islam et al. 2017). By 2050, a potential 2°C temperature rise and a 10% decrease in rainfall are expected to place the Barind Tract (a northwest upland region with hard red clay soil) at higher risk of drought periods (FAO, 2007; FAO, 2006). Compared to other regions of the country, this region experiences less rainfall. In many areas of the region, groundwater is also unavailable due to complicated geological structures. Water scarcity thus results in a soil moisture deficit that impacts crop productivity.

The loss of crop production is a direct result of drought, impacting the daily activities of people as well as the GDP, local labor market, and overall economic growth indirectly. Drought affects approximately 0.40, 0.34, and 0.45 million hectares of agricultural land in Bangladesh during each of the three cropping seasons namely Kharif-1, Kharif-2, and Rabi (Habiba et al. 2011). Drought not only affects all three seasons of rice varieties (Aman, Aus, and Boro), but also causes damage to jute and other crops such as pulses, oilseeds, minor grains, potatoes, winter vegetables, and sugarcane (Uddin et al. 2018). In 2006, drought reduced Aman production by about 25-30% in the northwest region of Bangladesh (UNDP, 2007).

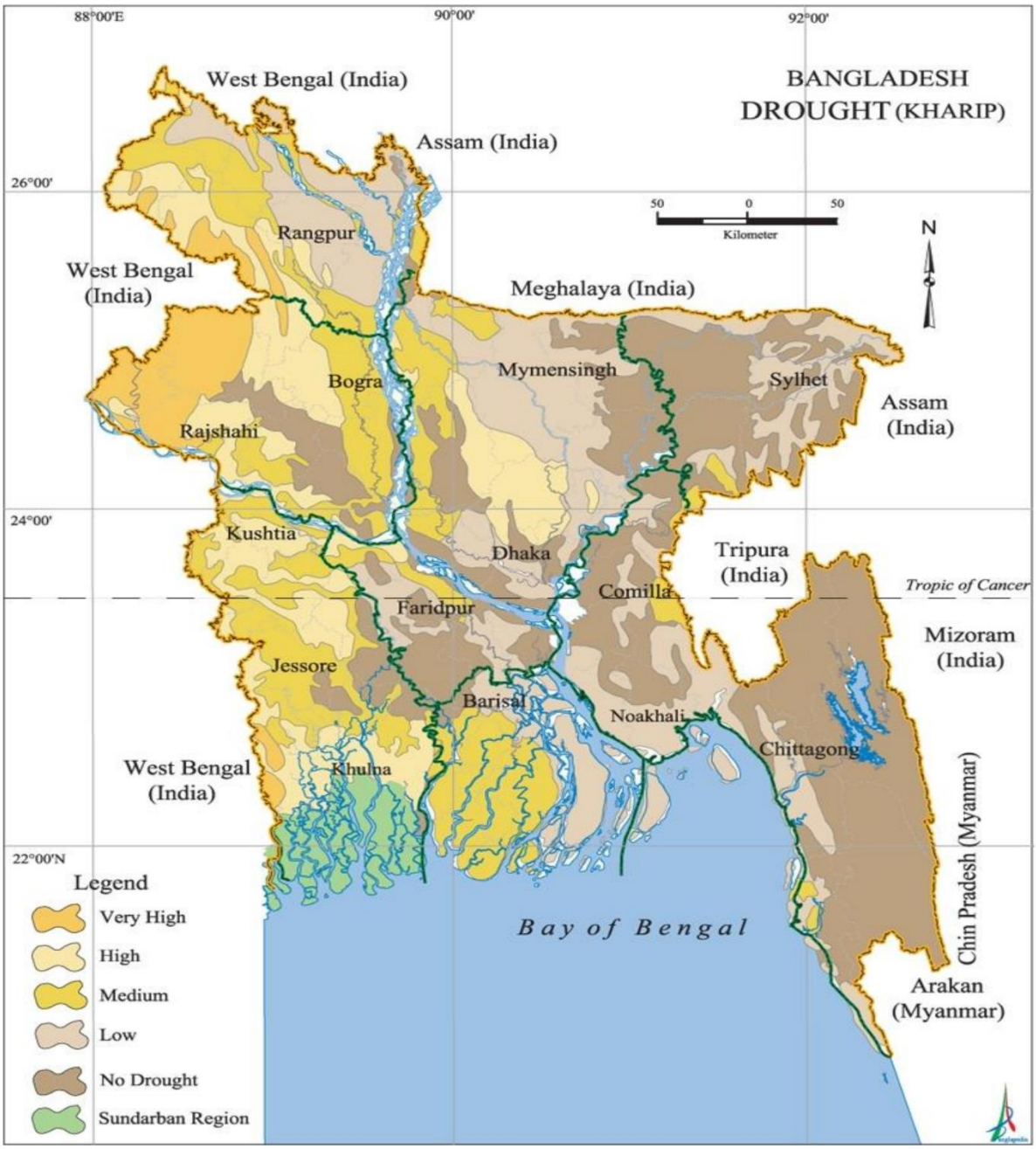

Figure 1.1 The map of drought-prone areas in Bangladesh (Source: Banglapedia, 2021)

1.3 Adaptation strategies adapted by farmers

Adaptation refers to adjustments to procedures or practices that are made to minimize possible harm or to take advantage of opportunities that arise from any event. Adaptation is a concept which derives from the word "adapt," that represents "improving things, situations, or conditions by modifying" (Ahmed, 2006). In order to lessen the negative effects of drought and improve coping mechanisms, it is possible to define adaptation to drought as the modification or adjustment of environmental, financial, and social systems.

Adaptation to drought includes stress tolerant rice varieties cultivation, crop diversification, alternative crop cultivation, mixed cultivation, early seedbed planting, organic fertilizer use, water withdrawal via pump, pond re-excavation, pond-based irrigation and alternative economic activities (Islam et al. 2019). Farmers may consider various techniques that have developed over time to reduce their overall susceptibility to drought shocks (adaptive strategies) when a drought occurs.

Since droughts frequently occur in the northwest districts. The Government of Bangladesh additionally implemented certain actions to lessen the effects of drought in this region. The Bangladesh Multipurpose Development Authority has been crucial in providing this area with irrigation and drinking water. In addition, the Ministry of Food and Disaster Management's CDMP (Comprehensive Disaster Management Program) and other NGOs, such as CARITAS, are diligently collaborating on developing various drought demonstration programs. Despite these measures, people in this region have attempted to increase their endurance either independently or with assistance from NGOs, government agencies, and other organizations (Habiba et al. 2011).

In Bangladesh, limited irrigation facility, inadequate access to climate information and resource are acted as major adaptation barriers (Alauddin and Sarker, 2014). Several factors, including education, ownership status, average household income, farming experience, availability of electricity, awareness of climatic change and access to institutional services increase the likelihood of farmers adapting (Sarker et al. 2013). Similarly, the adoption of a number of adaptation strategies relies on some socio-demographic characteristics (Paul and Routray, 2011). In order to cope with drought and minimize the risk, farmers in north-western region have already adapted various measures. So, it is essential to comprehend the factors that determine adaptive capacity for explaining the process of local autonomous adaptation.

Therefore, this study particularly concentrates on investigating the adaptation strategies that farmers are employing to mitigate the adverse effects of drought and the impact of various explanatory variables on farmers' decision regarding the number of strategies adoption while taking various socio-demographic characteristics and others factors into account. The information is essential for developing and putting into practice an effective and long-lasting adaption strategy in Bangladesh.

1.4 Objectives of the study

The major objective is to find out farmers' adaption strategies and the factors that influence them. The concrete objectives are as follows:

i. To document the socio-demographic profile of the respondents,
ii. To identify the adaptation strategies adopted by the farmers in the study areas;
iii. To identify the factors that affect farmers' choice to adopt a number of adaptation strategies and;
iv. To explore the barriers faced by farmers during adaptation.

1.5 Research questions

This study tries to address the subsequent research questions in accordance with its objectives:

i. What is the socio-demographic status of the farmers?
ii. What strategies have the farmers adopted to mitigate the effects of drought?
iii. How many strategies adopted by individual farmer in the study areas?
iv. Which factors determine the adoption of adaptation strategies?
v. What kind of barriers faced by farmers during adaptation?

1.6 Organization of the thesis

The remaining portion of this paper is divided into five chapters as an addition to this introduction:

Chapter II examines the research on drought, farmers' adaptation strategies, identifying determinants affecting adaptation and barriers, discussion the gaps in the body of literature.

Chapter III includes the selection of the study area, the description of those areas, respondent selection, the sources of collecting data, the analysis of data, the specification of model.

Chapter IV represents the results on farmers socio-demographic traits, the status of adaptation strategies, the number of strategies adoption, the Poisson regression model for evaluating the factors influencing farmers adoption, and barriers to adaptation.

Chapter V concludes the study providing the summary of overall findings and some recommendations.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The theoretical foundation for this study is presented in this chapter, which was created by synthesizing relevant literature. It provides a detailed overview of farmers' adaptation strategies against drought, identifying determinants which affect adaptation capability and barriers to adaptation both in Bangladesh and global context. Section 2.3 discusses the gaps in the body of literature that currently exists.

2.2 Farmers adaptation strategies and their determinants

Khan et al. (2022) encountered the adaptability indicators influencing the livelihood susceptibility to disasters by surveying 300 households under the three unions in Khulna district, Bangladesh. The indicators of adaptive capacity that they found to be significant were: gender; the number of dependent individuals, the educational attainment of the heads of households, the occupation of family members, the availability of family or friend support, the main source of income as agriculture, the cultivation of crops, the membership in societal groups and access to local government services. An ordered logistic regression was utilized to get these results. The study recommended that collaboration between community organizations and government agencies might result in innovative ideas for mitigating climate risk.

Aliyar et al. (2022) assessed the perceptions of farmers in Afghanistan between 1998 and 2017 regarding a rise in average temperature and a decrease in average precipitation. The study revealed that agricultural productivity was significantly lower in rainfed areas than in irrigated areas due to increased drought severity and frequency in the rainfed area. It also identified the value of local adaptation measures as a result of variations in on-farm and off-farm adaptation practices across the physical surroundings.

Dumba et al. (2021) focused on farmers' drought adaptability in Ghana. The Pearson Chi-Square test found a substantial variance across localities and utilization of drought adaption techniques. The study showed that drought monitoring, the location of farms near rivers, the development of farm-based organizations, agrochemicals application, crop diversification, altering the dates for planting, shifting crop locations, combining livestock and crop

production, generating income from non-farm activities are among the most popular drought adaptation measures. Non-Governmental Organizations (NGOs) were recommended to collaborate with the government to create small-scale irrigation infrastructure and offer drought-tolerant crops for use to strengthen the ability of Ghana's farming communities.

Mtintsilana and Akinyemi (2021) anticipated the factors that affect the farmers adaptation to climate change while assessing the effect of adaptation in Tyhume Valley communities. Crop rotation (66%), irrigation (94.8%), and crop variation (7.4%) are the adaptation strategies that the farming households in the study area adopted. The study identified the elements (gender, age, employment status, the use of mobile, heat wave, occasional exposure to severe high winds) impacting farmers' adaptability to climatic fluctuation using binary logit findings.

Quraishi (2021) explored farmers' adaptation strategies and their perception of drought impacts on their agricultural productions and livelihoods in Afghanistan. According to the information from respondents, some farmers were able to use at least one on-farm or off-farm drought strategy to cope with negative effects and some of them could not take any measure due to inadequate ability, less education, lack of capital and insufficient credit facilities.

Anik et al. (2021) evaluated farmers' adaptation strategies to mitigate the impact of climate change and identified their determinants in some selected areas of northwestern Bangladesh. The research found that around 80% of farmers adopted two or more strategies for adaptation out of six measures. The findings disclosed that education, income from poultry and livestock, the need for subsistence, extension services, the use of ICT in farming and the membership in organizations, significantly and positively influence the possibilities of adopting climate change adaptation strategies. It was recommended that encouraging the use of ICT in farming, strengthening extension services, easing the institutional access to farmers, including climatic information in education, and promoting the livestock farming could be helpful for farmers to overcome the farming challenges caused by climate change.

Savari and Amghani (2021) identified the factors affecting adoption of adaptation strategies through surveying 430 farmers in East Azerbaijan province, Iran. The findings demonstrated that the farmers under study had insufficient levels of adaptability, and all of their measures fell into the categories of integrated, active, and self-control. The study also illustrated how farmers' adaption techniques were significantly positively impacted by social, economic, infrastructural, and environmental factors.

Islam et al. (2019) investigated how farmers perceived the efficacy of adaption strategies to drought through interviewing agricultural households from three districts in Barind tract, Bangladesh. Five-point Likert scale was used to assess how farmers perceived the efficacy of adaption strategies. The Barind Multipurpose Development Authority (BMDA) and farm households employed several kinds of adaptation measures, which were divided into two categories. Farmers' adaptation strategies were mostly focused on commercial and agricultural activities, even though the majority of the farmers were in lacking of ability to implement the necessary adaptation measures by themselves. According to the opinion of farmers', the most of BMDA's adaptation practices were found to be beneficial. The study also suggested that the collection of surface water and the reduction of groundwater dependency could be a feasible solution, while identifying no correlation between the socioeconomic attributes of farmers and their judgments of the efficiency of the measures.

Ahmed et al. (2019) examined the Santal's adaptability to drought adopting regional approaches which include food, water, and people movement of people, that had an effect on livelihoods and health in the northwest of Bangladesh. They used quantitative data and qualitative data through conducting home survey and participatory rural assessment. The findings of their analysis indicated that among various drought-resistance methods, such as; altering plants, raising livestock, storing water, traveling further for water, and shifting to urban areas for additional income and decreasing the use of regional water were mostly implemented by this indigenous group.

Al-Amin et al. (2019) studied farmers' perception, their major adaptation strategies, and the factors affecting the choice and decision of farmers adoption in the northwest region of Bangladesh. It found the farmers using certain adaptation strategies including developed irrigation and water harvesting channels, drought-tolerant and short-duration rice varieties, supplemental watering for crop growth, cultivation of non-rice varieties to alleviate climate change effects in northwest Bangladesh. The results from discrete choice model revealed that the quantity of land cultivated, age, size of the family, participation in any organizations, severity of the drought, credit availability and agricultural subsidies substantially influenced the choice of farmers' adaptation strategies. Likewise, joint family decision was found to be a significant determinant for choosing and implementing various adaption techniques.

Iqbal et al. (2018) examined farmers' perception and adaptations regarding drought by completing a questionnaire from 147 farming households in Heart Province, Afganistan. Even though the respondents' perception was based on their religious beliefs, they also saw drought as the result of climatic and environmental factors, such as rising temperatures and less precipitation, as well as other factors like war, financial hardship, deforestation, excessive groundwater use, lack of electricity, etc. The results demonstrated significant negative economic effects (job losses and decreases in crop and livestock production), social effects (Migration, a sense of helplessness and loss, disputes over water, health issues, effects on children's education, starvation, and a lack of food options), environmental effects (an increase in temperature, loss of pastures and forests, decline in water quality, and harm to fish and wildlife habitats, and groundwater depletion). The study found the farmers using local methods to adapt to drought and minimize its impacts while a major source of conflict was irrigation water.

Islam and Bray (2017) concentrated on the opinions of farmers and institutional practice-based communities to assess the efficiency of formal institutions in terms of agricultural climate response within two drought prone regions of Bangladesh. They discovered that the improvement of area-oriented capacity for farming alleviation as well as adaptation methods was significantly supported by formal institutions through their practice-based communities. Barriers still exist because of absence of regard for societal elements, the overemphasis on technology, the inability of managing connections across practice-based communities of both formal institutions and informal institutions. They stated that formal institutions must embrace cultural elements and develop collaborations with more informal community-based organizations.

Kabir et al. (2017) evaluated the dynamics, financial viability, and inherent risks of farmers' adaptability while exploring climatic changes in a drought-prone region, western Bangladesh. Adaptation measures for farmers include enhanced livestock farming, improvement of the production of crops, the type of crops, farming schedules, crop diversification and agricultural strategies. The main barriers to adaptation are the shortage of stress-resistant cultivars, extension services, cost-effective agricultural loans, high manufacturing costs, crop yield fluctuation and output pricing. The study suggested that easily available loans; more agricultural research and support facilities; and community-focused farming education and training are required for effective climate change adaptation.

Arfanuzzaman et al. (2016) identified Bangladeshi agricultural adaptation alternatives for the country's various ecosystems. The study found that the adoption of early maturing and saline-tolerant rice varieties, rice prawn aquaculture and rice replanting resulted in significantly bigger economic gains than the other adaptation choices. The study recommended for more research, illustration, and farmer capacity development for reducing susceptibility and increasing adaptability, while lack of affordability and accessibility acted as barriers to the advancement of some viable adaptation choices, requiring closer consideration from policy makers.

Hossain et al. (2016) explored the adaptation strategies that the farmers employed for coping with agricultural drought and climate change in two villages in northwest Bangladesh that are vulnerable to drought. It demonstrated that respondents used a variety of coping methods to deal with the negative effects of the drought, including harvesting rainwater, minimizing water loss, constructing water control structures, irrigation, the adoption of crop varieties resistant to the drought, intercropping rice with mango and jujube, kitchen gardening, controlling weeds and the cultivation of fish species with rapid growth. To assure the continued sustainable growth of agriculture in the study areas, the study also recommended the implementation of an appropriate system for early warning of droughts, the management of supplemental irrigation, surface water storage, re-excavation of traditional ponds and canals, planting of trees, assistance with credit and raising consciousness.

Alam (2015) applied multinomial logit regression to examine how rice farmers in Bangladesh had adjusted to water constraint in a semi-arid climate. The study revealed that farmers were more likely to use alternative adaptation measures if they had secured ownership rights, higher levels of education, greater agricultural experience, improved institutional infrastructure and electricity availability and understanding of climate effects. Adaptation options of farmers were compared to conventional method of groundwater irrigation. The findings offer insight into water-efficient irrigation techniques and a knowledge of the traits of farmers and farms for coping with water-stressed regimes.

Alauddin and Sarker (2014) investigated on farmers' perceptions about climate variability, and the determinants of adaptation decisions on adaptation strategies in eight drought-prone and groundwater-depleted districts of Bangladesh's three climatic zones. Strategies to lessen the negative effects of climate change were categorized as crop variation (e.g., non-rice plants), environmental resource-depletion (e.g., ground water) and science-driven (e.g., drought-tolerant rice). The findings also demonstrated that macro-level data was supported by

farmers' views of climate fluctuation. The results from Binary Logit Model and Multinominal Logit Model found some factors, such as the severity of the drought, the degree of groundwater depletion, the level of education, the size of the farm, access to climate related information, irrigation energy, and agricultural subsidies, influencing farmers decision and choice of adaptation strategies significantly.

Tessema (2013) conducted a study in Eastern Hararghe Zone in Ethiopia to explore small-holder farmers' level of perception of climate change, information sources, various adaptation options, factors impacting their decisions, constraints to their adjustment. The study found that farm households had perceptions of a minimum of one side of climate change mostly based on personal experience. The main adaptation strategy was planting trees, while the others were harvesting water, irrigation, terracing, and early planting. The outcomes of a multinomial logit model revealed that the choice of adaption strategies was affected by income, local market distance, availability of financial services, the extension among farmers and non-farm activities. The survey also determined that the major challenge to climate change adaptation was a lack of information.

Habiba et al. (2012) conducted a study by surveying 718 farmers from irrigated and non-irrigated villages in 14 upazilas in two severe drought-prone districts of northwest Bangladesh. The study found that, in addition to rainfall and temperature variations, the depletion of groundwater, enlarged population, lack of canals and rivers and deforestation stimulated drought. Farmers' health and social lives along with agriculture, were most at risk as a result of the drought. The study also found the farmers modifying their techniques to cope with the drought, mostly through maximization of crop yield, agronomic management, exploitation of water resources etc.

Paul and Routray (2011) pinpointed basic socio-economic, demographic, and other related factors influencing the strategies to cope while investigating local coping strategies in three different cyclone-prone coastal regions, Bangladesh. It was found that the adoption of a particular group of coping mechanisms depended upon a number of factors such as time period, socioeconomic status, gender, societal security, prior warning system, local exposure, outside assistance, societal security, and unofficial social networks for risk-exchanging, in addition to the size, intensity, and potential effects of the cyclone.

Deressa et al. (2009) identified the farmers adoption of adaptation strategies, the variables influencing their strategies adoption, and the obstacles to adaptation in the Nile Basin of

Ethiopia. The strategies included irrigation, changing planting date, planting trees, the use of several crop varieties and conserving soil. The results of the discrete choice model showed that farmers' decisions were influenced by a variety of factors, including the head of the household's wealth, age, gender, educational attainment, access to extension, and knowledge of the local climate. Financial limitations and a lack of knowledge about adaption techniques were identified as main obstacles.

Bryan et al. (2009) conducted a survey of 1800 South African and Ethiopian farm households to identify the factors that influenced the decision to adapt. The study found that the use of various crops, altering planting dates, conserving soil, planting trees and irrigation were the most widely used adaptation measures. A significant portion of farmers did not alter their farming operations, despite seeing variations in the temperature and rainfall. The results from the analysis of probit model revealed greater tendency of adaptation among the farmers of both countries when they had enough land, access to extension and credit. South African farmers mentioned a lack of credit, and Ethiopian farmers found the lack of access to information, loans and land as their key obstacles to adaptation. Providing food assistance, extension services, and climate change information can help the poorest farmers to adapt.

Ahmed (2006) investigated the opinions of the locals in Northwest Nawabganj and Naogaon districts of Bangladesh, regarding historical and contemporary environmental change and its consequences on rural life. The study stated that the average summer temperature had increased while the length of the winter had dropped but with an increased frequency of cold spells. Farmers main adaptive strategies were such as; the creation of ponds and reservation of rainwater in canals, the cultivation of mangoes, and the raising of birds for livestock and poultry.

2.3. Gaps in the existing literature

The aforesaid reviews reveal in the following;

i. Some of the studies generally focused on Bangladeshi farmers' perceptions of entire climate change, adaptation tactics, and obstacles to adaptation (such as, Islam and Bray 2017; Arfanuzzaman et al. 2014; Alauddin and Sarker 2014; Ahmed 2006).
ii. Additionally, numerous studies conducted across various regions in worldwide, including Bangladesh, have highlighted farmers' perspectives on drought, their methods for coping with it, and the challenges they faced during adoption (such as, Aliyar et al.

2022; Dumba et al. 2021; Quraishi 2021; Anik et al. 2021; Islam et al. 2019; Ahmed et al. 2019; Al-Amin et al. 2019; Iqbal et al. 2018; Kabir et al. 2017; Hossain et al. 2016; Alam 2015; Habiba et al. 2012).

iii. However, very limited studies were conducted in Bangladesh identifying the determinants influencing farmers' decision and choice of adaptation strategies (Al-Amin et al. 2019). More particularly, there was no study exploring the number of strategies adoption (intensity of strategies adoption) against drought in Bangladesh. Therefore, it becomes essential to estimate the number of strategies adoption among farmers along with identifying the determinants affecting farmers' choice of current adaptation strategies and the barriers to adaptation in northwestern drought prone areas of Bangladesh. Therefore, the present research was undertaken to fill this gap.

CHAPTER III

METHODOLOGY

3.1 Introduction

In order to address the research objectives, this chapter describes the methodology in depth. This includes the selection of the study area, description of the study area, respondent selection, interview schedule preparation, the sources of collecting data, and the analysis of data through using tabular framework and the specified econometric model.

3.2 Selection of the study area

Selection of study area is an important step. The study area for this research includes northwestern areas of Bangladesh where drought is the continuous and more prominent problem compared to other regions. Two northwestern districts, Rajshahi and Chapainawabgonj, were selected based on previous literature. Keeping in mind the objectives of this study, one upazila was deliberately chosen from each district (Tanore upazila of Rajshahi district and Nachole upazila of Chapainawabgonj district). Three villages were selected randomly from each upazila for data collection.

The following factors were considered when choosing the study areas:

i. Farmers are afflicted by drought and are growing various crops on their own or rented property, in addition to adopting one or more adaptation strategies on their own to combat drought.
i. This region is appropriate for the investigation from the perspective of time and available resources.
ii. Anticipating the respondents to cooperate well in order to collect accurate data.

3.3 Description of the study areas

Tanore is an upazila located in the division of Rajshahi, Bangladesh, inside the Rajshahi district. It is bordered to the north by Niamatpur and Manda upazilas in the Noagaon district; to the south by Paba and Godagari upazilas; to the east by Manda upazila in the Naogaon district; and to the west by Nachole and Nawabganj sadar upazilas in the Nawabganj district.

This upazila is situated between latitudes 24°29' and 24°43' north; and longitudes 88°24' and 88°38' east (Figure 3.1).

With 47425 households, it covers an area of 295.40 square kilometers. There are 191330 people living in the upazila, where males constitute 49.2% and females 50.85%. There are 648 people per square kilometer. The upazila consists of seven unions, 157 mauzas, and 169 villages. 48.8% of the population in the upazila is literate on average for both sexes (51.1% for men and 46.7% for women). In most part of the year, the temperature remains above 30°C while experiencing the lowest amount of rainfall during winter season (December and January). Around 78.35% peoples are engaged in agricultural activities. Paddy, wheat, sugarcane, oil seed, potato, onion, garlic, betel leaf, and mulberry plant are the principal crops. Mango, jackfruit, banana, papaya, lichi, coconut and palm are the most common fruits produced by the farmers. (BBS, 2021; Wikipedia, 2021).

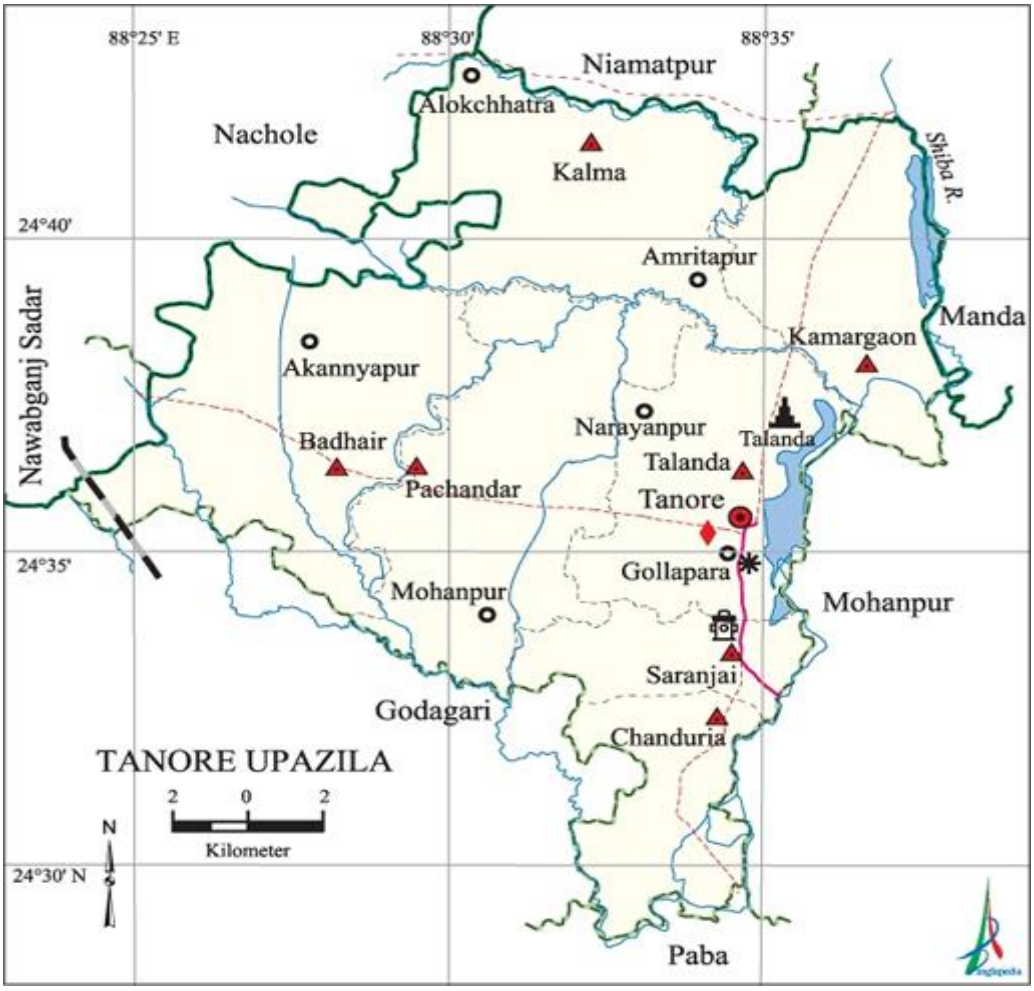

Figure 3.1 The map of Tanore upazila (Source: Banglapedia, 2021)

Nachole, which occupies 283.67 square kilometers, is a region of Rajshahi division. The upazila is bordered to the west by Gomastapur, Nawabganj Sadar and Shibganj Upazilas; to the north by the upazilas (Gomastapur, Niamatpur) of Naogaon district and Tanore upazila in Rajshahi district; to the south by Tanore upazila in Rajshahi district and Nawabganj Sadar upazila. Its latitude and longitude are 24°38' to 24°51' north and 88°15' to 88°21' east, respectively (Figure 3.2).

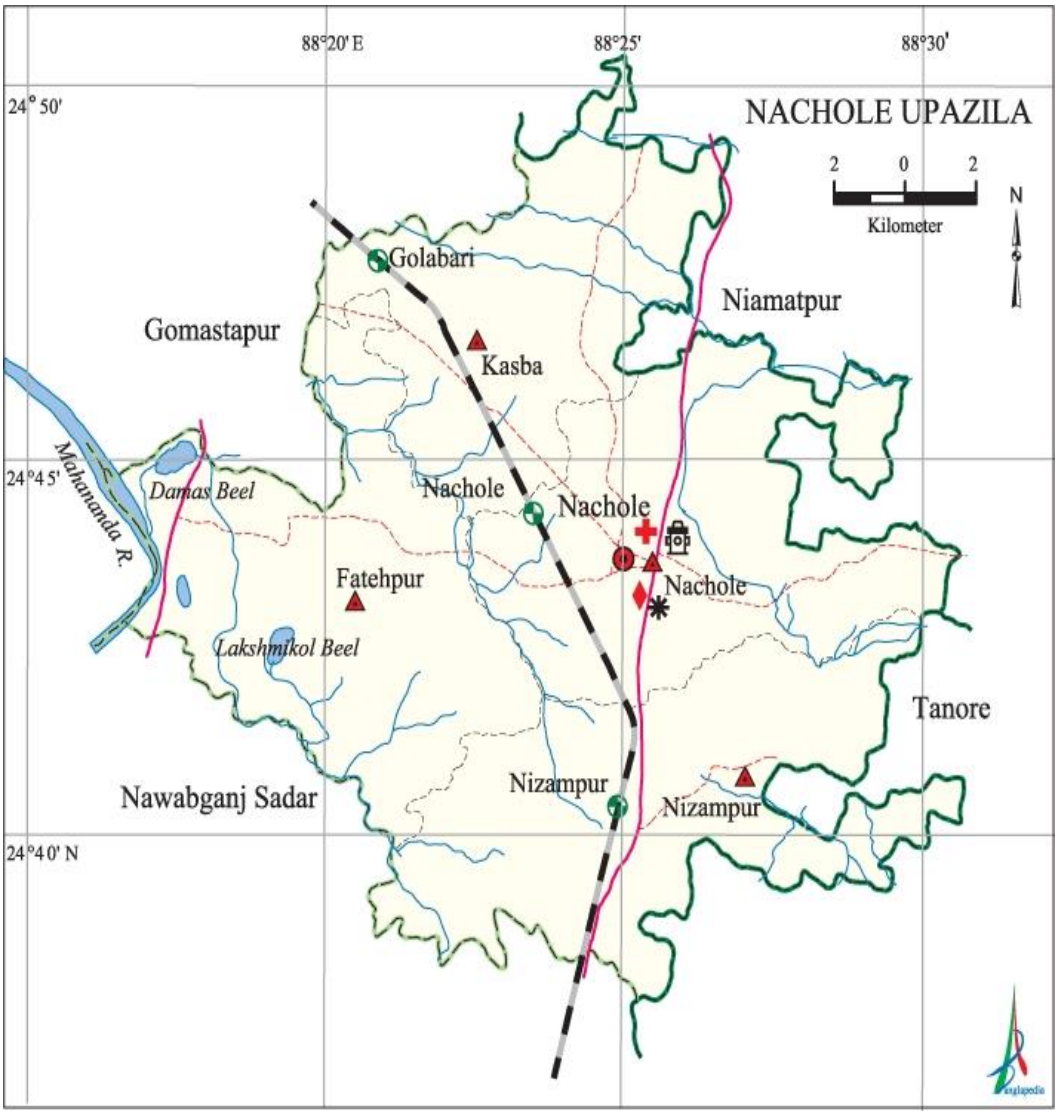

Figure 3.2 The map of Nachole upazila (Source: Banglapedia, 2021)

The upazila has a total population of 1,46,627, of whom males are about 49.7% and the rest 50.3% are female. There are 32,922 total households, with an average household size of 4.45. Agriculture (73.27%) is the main profession of this upazila. Paddy, jute, sugarcane, wheat, betel leaf, oil seeds, and pulses are the region's principal crops. Crops that are extinct or almost extinct: china (common millet), indigo, koda, and maara (one type of pulse). Mango, jackfruit,

litchi, blackberries, palm, coconut, watermelon, and boroi are the region's main fruits. 45.5% of people are literate, of which 44.9% are male and 46% are female. (BBS, 2021). Rainfall is comparatively low in this region. The long-term average rainfall is around 1,250 mm in the west and 2,000 mm in the northeast, mostly from late April to October. The region is regarded as semiarid and drought-prone due to its fluctuating rainfall patterns and temperatures, which may reach up to 35°C during the monsoon season and even reach 40°C (Ali et al. 2018).

3.4 Sampling procedure and sample size

The study's population consisted of farmers from the selected areas. Although, the standard statistical formula estimates a large sample-size to represent the whole population of selected areas, it is often not practicable or worthwhile to conduct a survey of all farmers due to the additional time and money required. Since all the farmers in the area directly or indirectly engage in farming activities under similar socio-economic, environmental and climate conditions, they form a relatively homogenous group, which supports the use of a small sample size (Alam et al. 2016; Gilbert, 2008). As a result, rather than utilizing a statistical formula, sample size is set by the context. The Upazila Agricultural Offices provided a list of farmers in the individual villages under each upazila. Finally, 150 farming households (75 respondents from each upazila) were randomly selected by using a random number table. The desired sample size distribution is shown in table 3.1:

Table 3.1 Sample size distribution

Districts	Upazilas	Selected Villages	Number of Respondents from each upazila
Rajshahi	Tanore	Debipur Lalpur Narayanpur	75
Chapainawabgonj	Nachole	Shibpur Shiala Maktapur Verendi	75

3.5 Preparation of interview schedule

The most crucial stage for a researcher is to prepare an interview schedule in order to obtain trustworthy and authentic information from farmers. As a result, a preliminary interview schedule in English was created as per the study's objectives. The following factors were included in this schedule:

- **i.** Identification of farm households and general information about them.
- **ii.** Socio-demographic profile (Gender, age, marital status, education, spousal education, highest education in the family, main source of income, monthly household income, family type, family member).
- **iii.** Detailed information about agricultural farming experience, farm ownership, the estimation of farm size from the farmers own-cultivable land, rented in land, rented out land, shared in land, shared out land.
- **iv.** Others information concerning extension contacts, training received, farmer to farmer extension, access to essential facilities such as; agricultural credit, electricity, drinking water, pucca road, local market, highway.
- **v.** Severity of drought, soil type.
- **vi.** Barriers to adaptation.
- **vii.** Solutions suggested by farmers.

3.6 Pre-testing of the draft schedule

Pre-testing, which is more of an information gathering technique than a formal process, allows a researcher to identify problems with the draft schedule and determine the range of likely responses for each question before conducting the final survey (Williams, 2003). The draft schedule had been tested by the researcher herself on ten farmers in the study area. This process evaluated the suitability of the design, the clarity and interpretation of various questions, and the length of an interview in order to make the schedule clear, suitable, and acceptable to the final respondents.

3.7 Preparation of final interview schedule

Based on actual and practical experiences gathered from pretesting, the interview schedule (Appendix-I) was finalized. The final schedule was prepared to identify the farmers socio-

demographic profile, their adaptation strategies to drought and find out problems regarding adaptation in the study areas.

3.8 Data collection

The survey data was gathered by the researcher, who conducted in-person interviews with every respondent and considered both close-ended and open-ended questions. Before starting the survey, the respondents were offered an informal overview of the scope and objectives of the research to guarantee that the privacy of their information would be maintained and be used only for the study purpose. The questions were posed in an easy way and also provided them an explanation considering the necessity. Respondents' responses were promptly noted on the schedules. Significant data discovered throughout the study was also documented as notes. In this way, Primary data were collected from July 2022 to August 2022 through conducting interviews in respondents' house or at the farm site. Secondary data were gathered from several established reports (Food and Agriculture Organization and Bangladesh Bureau of Statistics), books, journals, and websites.

3.9 Data processing

After collecting all completed interview schedules, they were rechecked before transferring to the computer. A detail coding plan was prepared. To meet the particular goals of the study, data were entered into the Microsoft excel through categorization and tabulation. Finally, the researcher analyzed the data after completing the required processes. With the use of appropriate scoring methods, qualitative data were also provided in quantitative form for analytical purposes.

3.10 Data analyzing methods

In order to meet the study's objectives, data were evaluated. The following methods were applied in this study:

i. Descriptive analysis
ii. Statistical analysis

3.10.1 Descriptive analysis:

Tabular technique of analysis was applied to classify the data collected on different segments such as; the socio-demographic profile of farmers (gender, age, marital status, status of education, main source of income, monthly household income, farm size, family size, farm ownership, farming experience), other socio-demographic information, barriers to adaptation, adoption status of farmers. It was employed to obtain basic measurements such as averages, percentages.

3.10.2 Statistical analysis:

This analysis was performed in STATA 14. In the context of various adaptation alternatives, Poisson regression was utilized to examine the factors affecting farmer choices on implementing adaptation tactics.

3.10.3 Analysis of the factors affecting farmers adoption

In this case, The Poisson regression model (PRM) was chosen because of its advantages in estimating a farmer's expected degree of adoption among different adaption practices with his or her socio-demographic profile. It is also simple to quantify the impact of every independent factor on the adoption. The following empirical Poisson Regression model was used (King, 1989b; Ramirez and Shultz, 2000; Ewunetu et al. 2021):

$$E\ (Y_i) = \beta X_i\ + \varepsilon_i$$

The model was also specified as;

$$E(Y_i) = \ exp^{(\beta_1 X_{1i})} exp^{(\beta_2 X_{2i})} \dots\dots\dots exp^{(\beta_{10}\ X_{10i})}$$

Here,

$E\ (Y_i)$ = dependent variable's expected value for the i^{th} farmer

Y_i = the number of strategies adoption which is estimated through the summation of binary response of the adaptation measures implemented by the i^{th} farmer

exp = the exponential function

β = slope of the model's parameters or regression coefficients that measure a unit change in variables, $\beta = \ \beta_1, \beta_2, \dots\dots\dots\dots\dots \beta_{10}$

X_i = vector of independent variables, $X_i = \ X_{1i}, X_{2i}, \dots\dots\dots\dots X_{10i}$

i = the number of farmers counting from 1 to 150

ε_i = the error term in the model

Table 3.2 Description of the independent variables used in the model

Variables	Description
Age (X_1)	Farmers age in years (continuous)
Gender (X_2)	**Dummy**: 1 if the farmer is male and 0 for otherwise
Education (X_3)	Years of schooling of farmer
Family size (X_4)	Total number of family members
Farm ownership(X_5)	**Dummy**: 1 if the farmer is owner and 0 for otherwise
Training (X_6)	**Dummy**: 1 if the farmer has received training in agriculture and 0 for otherwise
Societal membership (X_7)	**Dummy**: 1 if the farmer has any societal membership and 0 for otherwise
Credit (X_8)	**Dummy**: 1 if the farmer has received any agriculture related credit and 0 for otherwise
Access to farming information (X_9)	**Dummy**: 1 if the farmer uses mobile phone for farming information and 0 for otherwise
Distance from local market(X_{10})	Distance of home from local market (km)

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Introduction

Results on socio-demographic characteristics, the status of adaptation methods, the adoption of a number of strategies, the Poisson Regression model for evaluating the factors influencing farmers' adoption of a number of strategies, and barriers to farmers' adaptation are presented in this chapter.

4.2 Farmers socio-demographic characteristics

4.2.1 Distribution of farmers by age

All interviewed farmers were divided into various ages for the purpose of the study (Khan et al. 2022). It has been determined that the farmers' ages ranged from 21 to 66, with an average of 40.44. Of the sample farmers as a whole, 15.33 percent were under 30, 82.67 percent were between 31 and 60 years old, and only 2 percent were above 60. The majority of the sample farmers were in the age category of 31 to 60 years old, which is considered to be the most active. It implies that they put in greater physical effort to improve farm outcomes.

Table 4.1 Distribution of ages

Age category	% of farmers	Average age in years
≤ 30years	15.33	**40.44**
31-60 years	82.67	
> 60 years	2.00	

Source: Field survey, 2022

4.2.2 Gender and marital status of farmers

The percentage of women employed in agriculture rose from less than 20% to 33.6% of overall workforce (BBS, 2014). However, the results illustrate that there were only 6.67% of female farmers, compared to 93.33% of male farmers. According to a comparison with national data, women's empowerment was found to be restricted due to their less involvement in agriculture

compared to men. Of the surveyed farmers, 90.67% were married, and 9.33% were unmarried (Table 4.2).

Table 4.2 Gender and marital status

Category	% of farmers
Male	93.33
Female	6.67
Married	90.67
Unmarried	9.33

Source: Field survey, 2022

4.2.3 Educational status

An education helps a man make appropriate decisions regarding adoption and increases his capacity to deal with limited resources. Farmers had an average education level of 4.97 years, ranging from 0 to 16 years. The results show that farmers with primary education comprised the largest portion (46%), followed by those who received secondary education (21.33%), and above secondary education (16%) (Table 4.3). However, 16.67% were classified as illiterate. According to the results, literacy rate of total interviewed farmers in the study areas was 83.33% which was above the national literacy rate (74.66%) in Bangladesh (BER, 2022).

Table 4.3 Educational status

Category	Years of schooling	% of farmers	Average years of schooling
Illiterate	0	16.67	**4.97**
Primary	1-5	46.00	
Secondary	6-10	21.33	
Above secondary	>10	16.00	

Source: Field survey, 2022

4.2.4 Farmers main source of income

Agriculture employs approximately 40% of total population in Bangladesh (BBS, 2021). The interviewed farmers were participated in a variety of occupations. The occupation was divided into two categories: agriculture and non-agriculture (Table 4.4). Table 4.4 shows the proportion of farmers based on their main source of income. The majority of farmers (87.33%) were involved in agricultural activities where crop farming constituted the main source of income of 77.33% farmers. In addition to this, about 6%, 4%, 2%, 3.34% and 7.33% of farmers main source of income came from livestock farming, fish farming, business, service, day labor and other activities (handicrafts, charity etc.) respectively.

Table 4.4 Main source of income

Category		**% of farmers**
Agriculture	Crop farming	77.33
	Livestock farming	6.00
	Fish farming	4.00
Non-Agriculture	Business	2.00
	Service	3.34
	Day labor and others	7.33

Source: Field survey, 2022

4.2.5 Monthly household income of farmers

Extreme poverty is defined as falling below the $2.15/person/day Purchasing Power Parity (PPP) line (World Bank, 2022). During the study period, monthly household income was estimated from the earnings of farmers including other active family members from various income-generating activities. Based on monthly income, they were also arbitrarily categorized with concerning about the extreme poverty line. Table 4.5 shows that 14% of farmers was under the extreme poverty line. A large number of farmers (34.67%) had monthly household incomes ranging from Tk.11894 to Tk.16894.

Table 4.5 Monthly income status

Category	% of farmers
Less than Tk.6892	14.00
Tk.6893- Tk.11893	30.00
Tk.11894- Tk.16894	34.67
Tk.16895- Tk.21895	16.00
More than Tk.21895	5.33

Source: Field survey, 2022

4.2.6 Family size of farmers

The amount of people living together and eating in the same kitchen under the supervision of the same family head was used to determine the size of the farmer's family, which ranged from 2 to 14 members. Based on this number, the farmers were divided into three categories: "small," "medium," and "large" families (Islam et al. 2019). Of the total studied farmers, 13.33% fell into the small family category, 80.67% to the medium family category, and 6% to the large family category. The average family size of the evaluated farmers was greater than the 4.00 national average (BBS, 2022).

Table 4.6 Family size distribution

Category	Number of family members	% of farmers	Average family size
Small	≤ 3	13.33	**4.79**
Medium	4-6	80.67	
Large	≥ 7	6.00	

Source: Field survey, 2022

4.2.7 Agricultural experience

The study found that farmers' average experience in agriculture was 23.77 years, with a range of 5 to 52 years. Table 4.7 represents the classification of farmers based on their overall farming experience. The majority of farmers (85.33%) had between 10-39 years of experience whereas only 8% belonged to the category of more than 39 years of experience and 6.67% fell in the range of ≤ 9 years of experience category of farmers.

Table 4.7 Agricultural experience distribution

Category	% of farmers	Average years of experience
≤ 9 years	6.67	**23.77**
10-39 years	85.33	
>39 years	8.00	

Source: Field survey, 2022

4.2.8 Farm ownership

Farmers were split into owner, tenant and owner + tenant in the table 4.8. The results indicate that about 36.67 % of farmers had their own farm for farming while 42% had only rented or shared in farmland because of having no cultivable land on their own. In contrast, 21.33% of farmers rented or shared in farmland in spite of having their own farmland where they cultivated crops with other farmers or by themselves.

Table 4.8 Farm ownership status

Category	% of farmers
Owner	36.67
Tenant	42.00
Owner + Tenant	21.33

Source: Field survey, 2022

4.2.9 Farm size

The farmers were divided into four categories: landless farmers, small farmers, medium farmers and large farmers (GOB and UNDP (2009). Most (91%) of the farmers owned small to medium sized farms where 78% were small farmers, 12.67% were medium farmers and 7.33% of farmers were found as landless. Only 2% of farmers belonged to the category of large farmers. Farm size was estimated using the following formula:

Farm size = Own cultivable land + Rented in land + Shared in land -Rented out land - Shared out land.

Table 4.9 Farm size distribution

Type of farmers	% of farmers
Land less (<49 decimal)	7.33
Small Farmer (50-249 decimal)	78.00
Medium Farmer (250-749 decimal)	12.67
Large Farmer (>750 decimal)	2.00

Source: Field survey, 2022

4.2.10 Other socio-demographic information of farmers

Other socio-demographic information indicates farmers' societal membership**,** training received in agriculture, credit received from any government agencies, access to farming information using mobile phone. The Table 4.10 exhibits that only 27.33% of farmers had a membership of the social organizations which helps them to improve knowledge through maintaining connections with others. An efficient training helps to perform activities more successfully through providing deep knowledge. However, out of the 150 farmers, only 28.67% of farmers had received agriculture related training in the study areas. Access to credit is crucial specially for small and landless farmers for farming, increasing productivity and income. The results represent that 24.67% of farmers received agricultural related credit from government agencies, NGOs and remaining 75.33% didn't receive credit due to various complexities. The Table 4.10 also shows that only 25.33% of the farmers were found using mobile phone for farming information while the rest of the farmers (74.67%) did not use mobile phone for agriculture related information.

Table 4.10 Other socio-demographic information of farmers

Particulars	Yes (%)	No (%)
Membership of social organizations	27.33	72.67
Training received in agriculture	28.67	71.33
Agriculture related credit received	24.67	75.33
Access to farming information using mobile phone	25.33	74.67

Source: Field survey, 2022

The obtained results show that there was a predominance (82.67%) of the interviewed farmers from the (31-60 years) age category, which highlights that they provided more physical efforts to improve farm outcomes. Out of 150 farmers, the highest proportion of them was male (93.33%) as against female of (6.67%). It indicates that the women empowerment was comparatively low because of inability and traditional situation in the study areas. Around 17% of the farmers had not any formal education while 67.33% of them had received education between primary and secondary level. Besides, 16% had above secondary level of education. From this result, it can be said that the literacy rate was high, which may have a significant impact on the degree to which strategies were adopted (Habiba et al. 2014). More than half of the sample farmers were from medium-sized families. It is found that majority of farmers had 10-39 years of agricultural farming experience and about 28.67% of the farmers received training facilities. 27.33% of the farmers had a membership of the social organizations which can help them to improve knowledge about new strategies through maintaining connections with others. Although, small proportion of farmers received agricultural related credit. Previous studies suggested that access to credit and training facilities significantly influence farmers' decision and choices of strategies (Kabir et al. 2017). So, arranging more training and affordable capital supply from government agencies may improve the adoption decision of farmers.

4.3 The state of farmers adaptation strategies

The Table 4.11 represents the percentage of farmers adopting various adaptation measures in the study areas. The adaptation strategies include using of organic fertilizer, drought-tolerant varieties of rice, increasing irrigation frequency, crop diversification, mixed cultivation, alternate wetting and drying, practicing fruit gardening, change in planting date and non-farm activities.

More than half of the farmers (57.30%) were found using organic fertilizer that helps the soil to hold water and consequently promotes crop growth during drought.

Most farmers (74%) had increased irrigation frequency to mitigate water shortage caused by drought, through re-excavation of ponds to preserve rainwater for irrigation purpose, using shallow and deep-water pumps to draw water from the ground. The results show that 24.70% of the farmers preferred to use of drought-tolerant rice varieties (e.g., Swarna, BRRI dhan-32 etc.) as a strategy.

A further innovative strategy used by farmers to cultivate crops other than rice is called crop diversification (Islam et al. 2019). Crop diversification was chosen by about 38.70% of the farmers in the studied areas as a means of reducing the negative effects of the drought. They were found growing wheat, maize, potatoes, onions, and other crops rather than rice because rice farming requires extra water. For making the most effective use of water, the "mixed cultivation/intercropping" is an incredibly creative approach. The study identifies that a small number of respondents (28%) were cultivating more than one crop (rice + mango, rice + guava, wheat + mango etc.) at the same time on the same land due to lack of awareness, shortage of inputs, high price of chemical fertilizers and pesticides etc.

‘Practicing fruit gardening’ is another strategy which is mostly followed by farmers to deal with water scarcity and maximize farming profits. The study found only 6% of total farmers practicing fruit gardening in the surveyed area. On the other side, nearly half of the farmers (40%) changed the crop calendar or the planting date.

The effects of drought have a multiplicity of negative effects on both the local and the national economies. Seasonal unemployment is one of the important effects which reduce farmers' ability to secure their livelihood. The study primarily focuses on drought-related measures for the agricultural sector, which is the most vulnerable. But 49.30% farmers had turned to ‘non-farm activities’ in addition to farming in order to supplement their income and help them

overcome challenging situations. Petty business, van or auto rickshaw driving, day labor, services were the most prevalent non-farm economic activities observed in the study areas.

Table 4.11 Adaptation strategies adopted by farmers

SI No.	Adaptation Strategies	Respondents in percent (%)
a.	Organic fertilizer use	57.30
b.	Drought tolerant varieties (rice)	24.70
c.	Increase in irrigation frequency	74.00
d.	Crop Diversification	38.70
e.	Mixed cultivation/ Intercropping	28.00
f.	Practicing fruit gardening	6.00
g.	Alternate wetting and drying	20.70
h.	Change in planting date (crop calendar)	40.00
i.	Non-farm activities	49.30

Source: Field survey, 2022

4.4 The number of strategies adoption among farmers (The intensity of strategies adoption)

The result identified that, as a result of their ignorance and indigenous beliefs, about 3.30% of the farmers did not adopt any type of adaptation strategy. About 38% of farmers used three adaptation measures to combat drought situation. Highest adoption (44%) of three adaptation strategies was found in Nachole from chapainawabgonj district. Very small number of interviewed farmers about (2.70%) and (1.3%) used eight and nine adaptation strategies at Tanore upazila in Rajshahi district. The results show that the intensity of the strategies adoption rate was almost similar across the two upazilas.

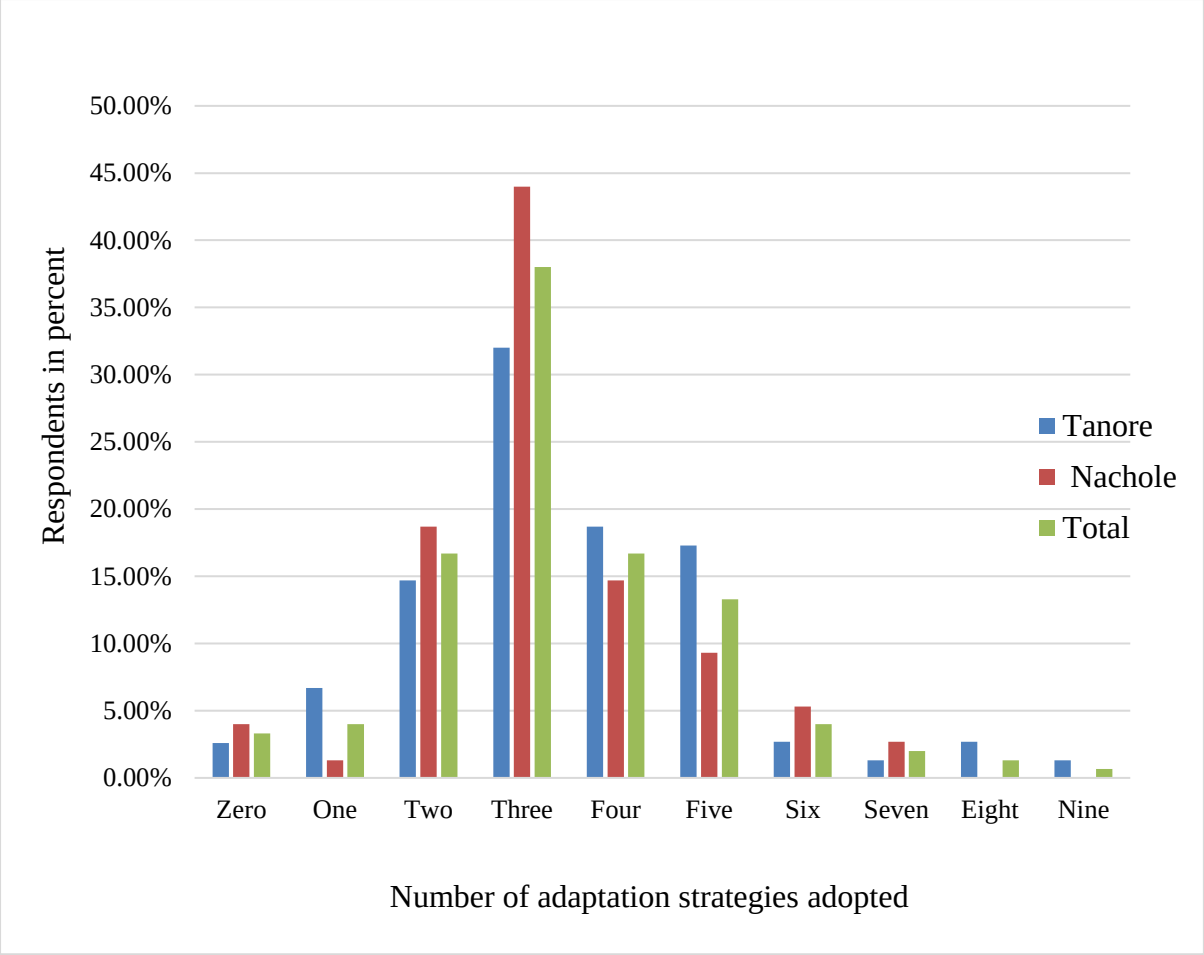

Figure 4.1: The number of strategies adoption among farmers (Source: Field survey, 2022)

4.5 Determinants of farmers' adaptation strategies

To run the Poisson regression model, continuous, discrete and dummy variables were used as independent variable. Sometimes, the variables chosen for analysis may correlate with one another by some extent. From this concern, the study also tested multicollinearity among independent variables through VIF (range of VIF is 1.05 – 2.60) and did not find any multicollinearity issue (Appendix-II). The Poisson regression results of the estimated parameters is shown in Table 4.12. Overall, the regression provides a decent fit with parameters indicating the adoption status of the farmers under study. Each independent variable's mathematical relationship to the dependent variable is explained by the coefficients. Whether or not these relationships are statistically significant is shown by the p-values for the coefficients. The chi-square statistics demonstrate the model's potent explanatory ability. Furthermore, it was discovered that a few of the model's explanatory variables were statistically significant with an expected sign.

Table 4.12 Estimated values and co-efficient of Poisson regression

Explanatory variable	**Coefficient**	**Standard Error**	**z statistic**	**P-value**
Intercept	-0.505	0.511	-0.99	0.323
Age (X_1)	-0.001	0.006	-0.16	0.872
Gender (X_2)	**1.36*****	**0.421**	**3.24**	**0.001**
Education (X_3)	**0.03****	**0.015**	**2.03**	**0.043**
Family size (X_4)	0.028	0.028	1.02	0.305
Farm ownership(X_5)	0.015	0.010	0.15	0.877
Training (X_6)	**0.21****	**0.105**	**1.99**	**0.046**
Societal membership (X_7)	0.110	0.106	1.03	0.302
Credit (X_8)	**0.28****	**0.137**	**2.07**	**0.038**
Access to farming information (X_9)	0.127	0.126	1.01	0.313
Distance from local market (X_{10})	-0.034	0.047	-0.73	0.465
LR chi-squared	**96.80**			
Pseudo R^2	**0.17**			

Source: Author's estimation based on field Survey, 2022.

Note: ***, ** denote significance at the 1% and 5% levels, respectively.

4.5.1 Interpretation of the variables based on co-efficient

Gender (X_2):

The co-efficient of gender represents significant relationship at 1% level of significance. From the above results, it can be said that the difference in the logs of expected counts is 1.36 unit higher for male farmers compared to others.

Education (X_3):

The co-efficient of education is found positive and significant at 5% level of significance. This implies that for one unit (year of schooling) increase in a farmers' education, the difference in the logs of expected counts is expected to increase by 0.03 unit.

Training (X_6):

The co-efficient of training also represents significant and positive relationship at 5% level of significance. In terms of training, the difference in the logs of expected counts is 0.21 unit higher for the farmers who have received agriculture related training compared to those who have not received training in agriculture.

Credit (X_8):

Credit is found as the most significant positive factor influencing adaptation decisions. The results depict that the difference in the logs of expected counts is 0.28 unit higher for farmers who have received agricultural credit in comparison to those farmers not receiving any kind of agricultural credit at 5% level of significance.

According to the findings, farmers gender, education, training and credit were identified as the most influential factors in farmer's adoption. Therefore, more community-based education, training and awareness building programs may be arranged frequently. The findings also indicate that affordable credit facilities can be provided by targeting farmers whose livelihood mainly based on agriculture.

4.6 The barriers to adaptation

Farmers may encounter a number of difficulties in attempting to mitigate the negative effects of the drought, which sometimes discourages them from trying new strategies. The focus of this section is to investigate and find out the extent of barriers faced by farmers in the study area. Open ended questions regarding the barriers to adaptation were asked to the respondents. The respondents were free to mention all the problems they faced during adaptation.

Table 4.13 represents that the majority of respondents (73.33%) faced severe problem with irrigation water scarcity, while 47.33% reported having low credit facilities because of high interest rates, collateral requirements, and complicated paperwork documentation. About 13.33% of farmers stated ignorance about suitable adaptation. Another significant obstacle to adaptation was inadequate agricultural extension services.

Table 4.13 The barriers faced by farmers during adaptation

No	Barriers	Percent (%)
a.	Lack of irrigation water	73.33
b.	Low credit facilities	47.33
c.	Lack of adequate extension service	42.67
d.	Inadequacy and high price of fertilizer and pesticides	34.67
e.	Labor shortage	19.33
f.	Lack of knowledge concerning appropriate adaptation	13.33

Source: Field survey, 2022

The survey depicts some barriers such as lack of knowledge concerning appropriate adaptation, lack of irrigation water, lack of agricultural extension service delivery, low credit facilities etc. were confronted by farmers. To overcome the barriers and further enhancement of adaptation status, different suggestions were preferred by the farmers. Most of the respondents recommended for increasing the supply of irrigation water, strengthening credit facilities, ensuring adequate extension services, reducing prices of fertilizer and pesticides.

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

In order to address the four research objectives, the key findings are briefly summarized in Section 5.2 of this chapter. Taking into account the results, Section 5.3 offers some recommendations for improving the situation of the farmers withdrawing the attention of the respective authority.

5.2 Summary of the findings

Drought is more frequent especially in the northwestern part of Bangladesh due to high temperature and low rainfall. The study was conducted in Tanore and Nachole upazila of Rajshahi and Chapainawabgonj districts in Bangladesh. Data were gathered from randomly selected 150 farmers using structured survey schedule in 2022. This study has documented the socio demographic profile and adaptation strategies of farmers in two upazilas. The factors determining the selection of adaptation strategies were also evaluated in the study. To achieve the objectives of the study, descriptive analysis (mean, percentage) and econometric model (Poisson regression model) were applied.

It is identified that the distribution of the farmers' age varied from 21 to 66 years. Out of 150 farmers, 82.67% were between 31 and 60 years old. Farmers' average age was 40.44 years, which indicates that the highest proportion of farmers in the age range of 31 to 60 years were mostly engaged in agriculture and other economic activities. Most of selected farmers were male which reflects the limited empowerment of female farmers. Of the surveyed farmers, 90.67% were married, and 9.33% were unmarried. Farmers had an average education level of 4.97 years, ranging from 0 to 16 years. The medium size family constituted the highest proportion (80.67%) of farmers while 13.33% fell into the small family category and 6% to the large family category. The average family size of the studied farmers was 4.79.

Crop farming constituted the main source of income of 77.33% farmers. The farmers having monthly household income Tk.11894 to Tk.16894 constituted the largest proportion 34.67%. Majority of the farmers (85.33%) were 10-39 years experienced whereas only 8% belonged to

the category of > 39 years of experience and 6.67% fell into ≤ 9 years of farming experience category.

About 36.67 % of farmers had their own farm for farming while 42% had only rented or shared in farm land. Most (91%) of the farmers owned small to medium sized farms where 78% were small farmers, 12.67% were medium farmers and 7.33% of farmers were found as landless. Only 27.33% of farmers had membership of the social organizations. Majority of the farmers (71.33%) hadn't the opportunity to take part in any training program regarding farm activities. Due to various complexities, only a small percentage of farmers (24.67%) were able to obtain agricultural credit, while the remaining 75.33% were unable to get credit from government agencies, NGOs. About 25.33% of farmers were found using mobile phone for agriculture related information.

The result indicated that almost 97% of farming households implemented various adaptation strategies to mitigate the negative impacts of drought. Out of total farmers, 38% used at least three adaptation measures. Very small number of the interviewed farmers about (2.70%) and (1.3%) used eight and nine adaptation strategies at Tanore upazila in Rajshahi district.

The adaptation strategies included use of organic fertilizer, drought tolerant varieties of rice, increasing irrigation frequency, crop diversification, mixed cultivation, alternate wetting and drying, practicing fruit gardening, change in planting date and non-farm activities. More than half of the farmers (57.30%) were found using organic fertilizer, which ultimately helps crop growing during drought period. In contrast, only 24.70% of the farmers preferred to use of drought-tolerant varieties of rice (e.g., Swarna, BRRI dhan-32 etc.) as a strategy. About 74% of the farmers had increased irrigation frequency to mitigate water shortage through re-excavation of ponds. Crop diversification as an innovative strategy was followed by 38.70% of total farmers cultivating wheat, maize, potato, onion etc. instead of rice. The study also found that a small number of respondents (28%) used mixed cultivation/intercropping strategy (rice + mango, rice + guava, wheat + mango etc.) and 6% practiced fruit gardening in their farm area. On the other side, change in planting date or adjusting crop calendar was adopted by almost half of the farmers (40%). About 49.30% farmers had turned to 'non-farm activities' (Petty business, van or auto-rickshaw driving, day laborer, working as service holders etc.) in addition to farming.

Among ten independent variables used in Poisson regression, four of them such as gender, education, training and credit availability were significantly affected adoption of adaptation

strategies. Among the different barriers mentioned by the farmers, high proportion (73.33%) of respondents faced severe problem of irrigation water scarcity and 47.33% faced low credit facilities such as; collateral requirements, interest rate, critical process of paper documentation. Lack of knowledge and inadequate agricultural extension services were also among the significant obstacles to adaptation.

5.3. Recommendations

On the basis of analysis, experience and summary of findings drawn from this study, some specific recommendations are made dedicating to the concerned authorities, planners for increasing the performance of farmers toward disaster risk reduction activities (more adoption of appropriate strategies against drought) in Bangladesh. These recommendations are as follows;

i. Most farmers in the study area have increased the irrigation frequency due to the severe drought. Sometimes, it becomes really impossible for them to extract ground water for irrigation because of lowering ground water level and other complications. It is therefore recommended that the government and concerned authorities should make efforts (re-excavation of canal, installation of more deep tube-wells) in order to reduce irrigation water deficiency.

ii. The findings reveal that a large proportion of farmers is habituated to cultivate local varieties, despite the fact that those varieties may not be able to withstand drought. They might not be particularly motivated to adopt drought-tolerant varieties. So, introduction of drought tolerant varieties should be extended through DAE (Department of Agricultural Extension), BADC (Bangladesh Agricultural Development Corporation), and NGOs (Non-Government Organizations).

iii. Low credit facility (interest rate, collateral requirements) was one of the major barriers they mentioned. It is therefore recommended that government should take more initiatives (ease of obtaining credit, document, collateral requirement for credit) to ensure an efficient means of credit and financial facilities to farmers. Bangladesh Krishi Bank (BKB) can also offer loans without any interest to small and landless farmers for buying fertilizer and pesticides.

iv. The farmers are suffering from a shortage of knowledge regarding proper adaptation, so the need for Agricultural Information Centers (AIC) is high. AIC can provide

appropriate adaptation strategy knowledge so that the farmers can implement efficient measures by their own initiative.

v. The farmers having training related to agriculture are more active toward adoption of a number of strategies compared to those farmers having no training in the study areas. But small proportion of the farmers were found receiving agricultural training due to lack of adequate extension services. It is also known that farmers' decision-making ability can be raised to some extent if proper training can be provided to them. Respective authorities should arrange frequent field days, community-based education and training programs to improve the knowledge of farmers and more extension services should be assured.

REFERENCES

Ahmed, A.U. (2006). Bangladesh: Climate Change Impacts and Vulnerability: A Synthesis, Department of Environment, Dhaka, Bangladesh.

Ahmed, B., Kelman, I., Kamruzzaman, M., Mohiuddin, H., Rahman, M.M., Das, A., Fordham, M., and Shamsudduha, M. (2019). Indigenous people's responses to drought in northwest Bangladesh. Environmental Development, 29: 55-66.

Alam, G.M.M., Alam, K., and Mushtaq, S. (2016). Influence of institutional access and social capital on adaptation decision: Empirical evidence from hazard-prone rural households in Bangladesh. Ecological Economics, 130, 243-251. Doi: 10.1016/j.ecolecon.2016.07.012.

Alam, K. (2015). Farmers' adaptation to water scarcity in drought-prone environments: a case study of Rajshahi District, Bangladesh. Agricultural Water Management, 148, 196–206.

Al-Amin, A.K.M.A., Akhter, T., Islam, A.H.M.S., Jahan, H., Hossain, M.J., Prodhan, M.M.H., Mainuddin, M., and Kirby, M. (2019). An intra-household analysis of farmers' perceptions of and adaptation to climate change impacts: empirical evidence from drought prone zones of Bangladesh. Climatic Change, 156: 545-565.

Alauddin, M., and Sarker, M.A. (2014). Climate change and farm-level adaptation decisions and strategies in drought-prone and ground water depleted areas of Bangladesh: An empirical investigation. Ecological Economics,106, 204-213. Doi: 10.1016/j.ecolecon.2014.07.025

Ali, M.S., Rahman, S.M.M., Mohammad, A., Saha, S.B., Haque, S.A.M.A., Nazma, Ms., and Ahmed, A. (2018). Land-use and Landcover changes and their GEO-Environmental impacts in Nachole Upazila under Chapai-nawabgang District of Bangladesh: A RS and GIS Approach." International Journal of Research - Granthaalayah, 6(9), 351-355. https://doi.org/10.5281/zenodo.1451859.

Aliyar, Q., Zulfiqar, F., Datta, A., Kuwornu, J.K.M., and Shrestha, S. (2022). Drought perception and field-level adaptation strategies of farming households in drought-prone areas of Afghanistan. International Journal of Disaster Risk Reduction, 72. Doi: 10.1016/j.ijdrr.2022.102862.

Anik, A.R., Rahman, S., Sarker, J.R., and Hasan, M.A. (2021). Farmers' adaptation strategies to combat climate change in drought prone areas in Bangladesh. International Journal of Disaster Risk Reduction, 65, 102562.

Arfanuzzaman, M., Mamnun, N., Islam, M.S., Dilshad, T., and Syed, M.A. (2016). Evaluation of Adaptation Practices in the Agriculture Sector of Bangladesh: An Ecosystem Based Assessment. Climate, 4, 11; doi:10.3390/cli4010011

Bangladesh Economic Review (2022). Economic Adviser's Wing, Finance Division, Ministry of Finance, Government of the People's Republic of Bangladesh.

BBS (2014). Yearbook of Agricultural Statistics. Dhaka: Bangladesh Bureau of Statistics, Statistical Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (2016). Yearbook of Agricultural Statistics. Dhaka: Bangladesh Bureau of Statistics, Statistical Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (2021). Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

BBS (2022). Population and Housing Census. Bangladesh Bureau of Statistics, Statistical Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Blaikie, N.W.H. (2010). Designing social research, UK: Polity press Cambridge.

Bryan, E., Deressa, T.T., Gbetibouo, G.A., and Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: Options and constraints. Environmental Science & Policy, 12(4), 413-426. Doi: 10.1016/j.envsci.2008.11.002

Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T., and Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environmental Change 19 (2): 248-255.

Dey, N.C., Alam M. S., Sajjan A. K., Bhuiyan M. A., Ghose L., Ibaraki Y., and Karim F. (2011). Assessing Environmental and Health Impact of Drought in the Northwest Bangladesh. Journal of Environmental Science and Natural Resources, 4(2): 89-97.

Dumba, H., Danquah, J.A., and Pappinen, A. (2021). Rural Farmers' Approach to Drought Adaptation: Lessons from Crop Farmers in Ghana. African Handbook of Climate Change Adaptation, 52: 1033-1051.

Ewunetu, A., Simane, B., Teferi, E., and Zaitchik, B. F. (2021). Relationships and the Determinants of Sustainable Land Management Technologies in North Gojjam Sub-Basin, Upper Blue Nile, Ethiopia. Sustainability. 13, 6365. Doi: 10.3390/su13116365

FAO (2006). Livelihood adaptation to climate variability and change in drought-prone areas of Bangladesh, Food and Agriculture Organization, Rome.

FAO (2007). Declaration of the World Food Summit on Food Security. Rome: Food and Agriculture Organization of the United Nations.

GOB and UNDP (2009). The probable impacts of climate change on poverty and economic growth and options of coping with adverse effects of climate change in Bangladesh, Dhaka.

Habiba, U., Shaw, R., and Takeuchi, Y. (2011). Drought Risk Reduction through a Socio-Economic, Institutional and Physical Approach in the Northwestern Region of Bangladesh. Environmental Hazards, 10, 121-138. Doi: 10.1080/17477891.2011. 58231

Habiba, U., Shaw, R., and Takeuchi, Y. (2012). Farmers perception and adaptation practices to cope with drought: Perspectives from Northwestern Bangladesh. International Journal of Disaster Risk Reduction,1, 72-84. Doi: 10.1016/j.ijdrr.2012.05.004

Habiba, U., Shaw, R., and Takeuchi, Y. (2014). Farmers adaptive practices for drought risk reduction in the northwest region of Bangladesh. Nat. Hazards, 72, 337-359.

Hamidi, F. (2017). Farmers Adaptation Strategies to Drought: a case study in Nong Ya Sai district in Thailand. Agrarian Studies, 1-129.

Hossain, M.N., Chowdhury, S., and Paul, S.K. (2016). Farmer-level adaptation to climate change and agricultural drought: empirical evidences from the Barind region of Bangladesh. Nat Hazards, 83, 1007–1026. Doi: 10.1007/s11069-016-2360-7

https://en.banglapedia.org/index.php/Drought

https://en.banglapedia.org/index.php/Drought#/media/File:DroughtKharip.jpg

https://en.banglapedia.org/index.php/Tanore_Upazila#/media/File:TanoreUpazila.jpg

https://en.banglapedia.org/index.php?title=Nachole_Upazila#/media/File:NacholeUpazila.jpg

https://en.wikipedia.org/wiki/Tanore_Upazila

IPCC. “Climate Change 2007: Impacts, Adaptation and Vulnerability”: contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK.

IPCC. “Climate Change 2014: Impacts, Adaptation, and Vulnerability”, Part A: Global and Sectoral Aspects. In Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: New York, NY, USA.

IPCC. “Climate Change 2022: Impacts, Adaptation and Vulnerability”: contribution of Working Group II to the sixth assessment report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK.

Iqbal, M.W., Donjadee, S., Kwanyuen, B., and Liu, S. (2018). Farmers’ perceptions of and adaptations to drought in Herat Province, Afghanistan. Journal of Mountain Science, 15: 1741-1756.

Islam, M.S., Hossain, M.Z., and Sikder, M.B. (2019). Drought adaptation measures and their effectiveness at Barind Tract in northwest Bangladesh: a perception study. Natural Hazards, 97:1253–1276. Doi: 10.1007/s11069-019-03704-2

Islam, M.S., Hossain, M.Z., and Sikder, M.B. (2019). Farmers’ adaptation strategies to drought and their determinants in barind tract, Bangladesh. SAARC J. Agric., 17(1): 161-174. Doi: 10.3329/sjav17i1.42769

Islam, M.T., and Bray, M.N. (2017). Adaptation to climate change in agriculture in Bangladesh: The role of formal institutions. J Environ Manage, 200: 347-358. Doi: 10.1016/j.jenvman.2017.05.092.

Islam, A.R.M.T., Shen, S., Hu, Z., and Rahman, M.A. (2017). "Drought Hazard Evaluation in Boro Paddy Cultivated Areas of Western Bangladesh at Current and Future Climate Change Conditions", Advances in Meteorology, vol. 2017, Article ID 3514381, 12 pages. https://doi.org/10.1155/2017/3514381

Kabir, M.J., Alauddin, M., and Crimp, S. (2017). Farm-level adaptation to climate change in Western Bangladesh: An analysis of adaptation dynamics, profitability and risks. Land Use Policy, 64, 212-224. Doi: 10.1016/j.landusepol.2017.02.026

Khan, M.A., Hasan, K., and Kabir, K.H. (2022). Determinants of households' livelihood vulnerability due to climate induced disaster in southwest coastal region of Bangladesh. Progress in Disaster Science, 15. Doi: 10.1016/j.pdisas.2022.100243.

King, G. (1989). "A seemingly unrelated Poisson regression model." Sociological Methods and Research 17(b):235-255.

McCarthy, J.J., Canziani O.F., Leary N.A, Dokken D.J., and White K.S. (eds.). (2001). Climate Change 2001: Impacts, Adaptation and Vulnerability, Inter-Governmental Panel on Climate Change (IPCC), Work Group II In put to the Third Assessment Report, Cambridge University Press, Cambridge.

MoEF (2009). Bangladesh Climate Change Strategy and Action Plan; Ministry of Environment and Forests, Government of the People’s Republic of Bangladesh: Dhaka, Bangladesh, xviii+76pp.

Mtintsilana, O., and Akinyemi, B.E. (2021). Determinants of adaptation to climate variability among farming households in Tyhume Valley communities, Eastern Cape province, South Africa. International Journal of Climate Change Strategies and Management, 13(2): 181-190.

Paul, S.L., and Routray, J.K. (2011). Household response to cyclone and induced surge in coastal Bangladesh: coping strategies and explanatory variables. Nat Hazards (2011) 57:477–499, Doi: 10.1007/s11069-010-9631-5.

Quraishi, R. (2021). Adaptation Strategies for Drought Risk Reduction in Farmers' Livelihoods Kabul, Afghanistan. GSJ, 9(8): 1323-1335.

Ramirez, O.A., and Shultz, S.D. (2000). Poisson Count Models to Explain the Adoption of Agricultural and Natural Resource Management Technologies by Small Farmers in Central American Countries. J. Agric. Appl. Econ. 32, 21–33, Doi:10.1017/s1074070800027796.

Sarker, M. A., Alam, K., and Gow, J. (2013). Assessing the determinants of rice farmers adaptation strategies to climate change in Bangladesh. International Journal of Climate Change Strategies and Management, 5(4): 382-403. Doi:10.1108/ijccsm-06-2012-0033

Savari, M., and Amghani, M.S. (2021). Factors influencing farmers' adaptation strategies in confronting the drought in Iran. Environment, Development and Sustainability, 23: 4949-4972.

Shahid, S., and Behrawan, H. (2010). Drought risk assessment in the western part of Bangladesh. Natural Hazards, 46(3): 391–413.

Tessema, Y.A., Aweke, C.S., and Endris, G.S. (2013). Understanding the Process of Adaptation to Climate Change by Small-Holder Farmers: The Case of East Hararghe Zone, Ethiopia. Agricultural and Food Economics, 1,13.Doi: 10.1186/2193-7532-1-13

Uddin, M.H., Baten, M.A., Uddin, M.Y., Alam, M.J., Haque, M.M., and Mostafa, M.G. (2018). Adaptation Strategies of Farmers in a Drought-Prone Area of Rajshahi District. International Journal of Environment and Climate Change, 8(4): 269-282.

UNDP (2007). Human development report 2007/2008: Fighting climate change: human solidarity in a divided world, Palgrave Macmillan, New York. United Nation Children's Fund (2013). Multiple Indicator Cluster Survey, Bangladesh.

Williams, A. (2003). How to write and analyze a questionnaire. Journal of Orthodontics, vol. 30, no. 3, pp. 245–52.

World Bank. Poverty and Shared Prosperity 2022: Correcting Course. Washington, DC: World Bank. Doi: 10.1596/978-1-4648-1893-6.

Appendix-I:

DEPARTMENT OF AGRICULTURAL ECONOMICS

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

An Interview Schedule for the Study Entitled

FARMERS ADAPTATION STRATEGIES TO DROUGHT AND THEIR DETERMINANTS IN NORTHWESTERN PARTS OF BANGLADESH.

Sample No: ……

Dear Respondent,

All of your information will be kept confidential and will be used for research purpose only. Please provide the following information.

A. General information

Name: ……

Village: …….. Upazila: ……...

District: …….

B. Socio-demographic profile

1. Gender: Male / Female

2.Age of the respondent: ……..... years

3.Marital status: Unmarried= 1, Married = 2

4.Education of the respondent (Year of schooling): ……..... years

4.1 Spousal education …….. years

4.2 Highest education in the family……. years

5. Main source of income (Use code): …….

Use code: Crop farming = 1, Livestock rearing = 2, Fish farming = 3, Business = 4, Service = 5, Day labor = 6, others =7

6. Monthly household income: …….. Tk.

7. Family type (Use code): ……..

(Use code: Nuclear family = 1, Joint family = 2)

8. Total no. of family member: ……...…...… No.

9. Agricultural farming experience …….. years

10. Farm ownership (Use code): ……..

(Use code: Owner = 1, Tenant = 2, Owner + Tenant = 3)

11. Amount of own cultivable land: ……. Decimal

11.1 Rented in …….decimal

11.2 Rented out ……decimal

11.3 Share in ……decimal

11.4 Share out ……..decimal

11.5 Homestead area…….decimal

C. Adaptation Measures

12. What measures have you made to mitigate the effects of the drought?

Sl. No.	Particular statement	Yes	No
a	Organic fertilizer use		
b	Drought tolerant varieties (rice)		
c	Increase in irrigation frequency		
d	Crop diversification (vegetables and others)		
e	Mixed cultivation / Intercropping		
f	Practicing fruit gardening		
g	Alternate wetting and drying		
h	Change in planting date (crop calendar)		
i	Non-farm activities		

13. Other information about respondent's (last one-year information):

Questions	Yes	No	If yes	
			times	days
a. Have you received any agriculture related training?				
b. Did you visit extension office/SAAO for advice?				
c. Have you received any training on climate smart agriculture (CSA)?				
d. Did you visit extension office/SAAO for CSA advice?				
e. Are you confident about SAAO advice?				
f. Do you think CSA practices are available in your area?				
g. Do you have any bank account?				
h. Did you receive any agriculture related credit?				
i. Are you a member in any societal organization?				
j. Is there any IPM club in your village?				
k. Is there any climate field school in your village/upazila?				
l. Are you a member of IPM club?				
m. Are you a member of climate field school?				
n. Do you have pucca road in your village?				
o. Do you have electricity in your house?				
p. Do you use mobile phone for farming information?				
q. Do you think adaptive measure increases productivity?				
r. Is crop farming your only income source?				
s. Do you have income from livestock?				
t. Distance of your home to local market (km).				
u. Distance to upazila agriculture office from home(km).				
v. Distance of your home to highway (km).				
w. Severity of extreme events like drought in your upazila.***				
x. Soil type where you adopted farming related adaptive measures.****				

Code: ***__Events__: 3 extreme severe, 2 moderate, 1 low, 0 none; ****Soil: 1 clay loam, 2 clay, 3 loam, 4 sandy loam, 5 others

14. Please mention the barriers to adaptation:

a)

b)

c)

d)

e)

15. Suggest some measures to overcome these barriers:

a)

b)

c)

d)

e)

Date: …….. Signature of the enumerator: …….

……Thank you for your nice co-operation……

Appendix-II: Variance Inflation Factor (VIF)

Variable	**VIF**
Age (X_1)	1.28
Gender (X_2)	1.23
Education (X_3)	2.37
Family size (X_4)	1.72
Farm ownership(X_5)	1.17
Training (X_6)	1.27
Societal membership (X_7)	1.26
Credit (X_8)	2.11
Access to farming information (X_9)	1.89
Distance from local market (X_{10})	1.13
Mean VIF	**1.54**

Source: Author's estimation based on field Survey, 2022.