LIVELIHOOD AND ADOPTION DETERMINANTS OF DROUGHT TOLERANCE RICE VARIETIES IN NORTHWESTERN AREAS OF BANGLADESH

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CERTIFICATE

This is to certify that the thesis entitled **"LIVELIHOOD AND ADOPTION DETERMINANTS OF DROUGHT TOLERANCE RICE VARIETIES IN NORTHWESTERN AREA (RAJSHAHI & NATORE DISTRICT) 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 in Management and Finance,** embodies the result of a piece of bona fide research work carried out by **JULIA SULTANA MIM,** Registration Number: 20-11090 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information received during the course of this investigation has duly been acknowledged.

Dated:

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Dedicated To My Beloved and Respectable Parents

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“LIVELIHOOD AND ADOPTION DETERMINANTS OF DROUGHT TOLERANCE RICE VARIETIES IN NORTHWESTERN AREAS OF BANGLADESH”

ABSTRACT

Food insecurity in Bangladesh is exacerbated by the vulnerability of the country's rice industry to climate-related risks like drought. Adoption of rice types resistant to drought can significantly boost output, the availability of food grains, and income. The objective of this study was to identify the adoption determinants of drought tolerance rice variety and to compare the livelihood status between drought tolerance rice variety adopter and non-adopter. I received data from SAURES where 120 rice farmers from Rajshahi and Natore district were chosen randomly to achieve these goals were questioned. The total sample was separated into two groups: adopters, and non-adopters. Binary Logistic Regression Model identifies factors affecting the adoption of drought tolerance rice varieties, where experience, training on drought tolerance rice variety, extension contact, and knowledge of drought tolerance rice variety have a positive impact and significant at 1%, 5% and 10% level, while age has a negative impact on adoption. Finally, the study compares the livelihood components of adopter and non-adopter farmers and finds that natural, physical, and financial capital are higher for adopters, while human and social capital are higher for non-adopters. The overall livelihood index for drought tolerance rice varieties growers (0.62) was higher for non-adopter compared to adopter (0.61). The adoption of drought-tolerant rice varieties was impacted by four key variables had positive impact, while age had a negative impact. Adopters had higher natural, physical, and financial capital whereas non-adopters had higher human and social capital.

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SOME COMMONLY USED ABBREVIATIONS

SAU = Sher-e-Bangla Agricultural University

SAURES=Sher-e-Bangla Agricultural University Research System

% = Percent

DAE = Department of Agriculture Extension

FAO = Food and Agriculture Organization

MS = Master of Science

NGO = Non-Government Organization

No. = Number

UAO = Upazila Agricultural Office

EE = Economic Efficiency

MLE = Maximum Livelihood Estimation

BLRM= Binary Logistic Regression Model

AC = Adoption Capacity

WHO = World Health Organization

CHAPTER 1

INTRODUCTION

1.1Background

Bangladesh's growing season, rice contributes to both food security and livelihoods. However, there is still a need for increased productivity and climate change risk adaptation. Increased use of climate-resistant and high-yield rice varieties can be helpful in achieving this (Nayak *et al*.,2022).

The northwestern districts will experience severe moisture stress, which will result in drought conditions. According to an earlier assessment, a catastrophic climate change scenario might result in an increase from 4000 to 12,000 km^2 in the area severely hit by drought during the Boro season (Hoque *et al*.,2010). Extreme drought episodes may occur more frequently in the Barind region of northwest Bangladesh as a result of climate change (Selvaraj and Nagarajan 2010). Water scarcity is gradually becoming a major concern in the drought-prone Barind region, owing to insufficient rainfall and excessive extraction of groundwater for irrigation, as well as the negative effects of climate change (Islam *et al* ;2011). Furthermore, increased climatic variability may put additional strain on drought-prone environments and is regarded as a major crop production risk factor . As a result of climate change, it is crucial to take some adaptative actions to deal with the challenges given by climatic anomalies in the upper Barind tract of western Bangladesh (Hossain *et al*.,2016).

More than half of the world's population relies on rice as a staple diet, and 20% of people depend on it as their main source of income (Mot-taleb *et al*., 2014; Dar *et al*., 2020). Global per capita consumption of rice increased over the three years ending in 2018 from 40.70 kg to 52.69 kg (Samal *et al*., 2021). As a result, by 2050, there would be 584 million tons of rice consumed globally (Samal *et al*., 2021). The demand for rice has surged recently in Asian nations as well (Mattaleb *et al.*, 2014). However, the production of rice is significantly impacted by climate change worldwide, putting food supply in danger. The most detrimental effects on rice production are caused by drought, a hazard related to climate. Both vegetative growth and rice grain production are severely reduced by drought (Dar *et al*., 2020). It has affected around half of the land used for rice cultivation worldwide, thus jeopardizing food security (Bouman et al.,2005; Dar et al., 2020). Flash floods that result in the submersion of rice fields are one of the most important recurrent threats to rice productivity in the rainfed lowlands of Southeast and South Asia over a period longer than ten days. Abiotic stressors as flooding (50%), drought (20%), and salinity (30%) in Bangladesh provide significant obstacles to the attainment of potential yield(Habiba *et al*,2013). Abiotic stressors like flooding (50%), drought (20%), and salinity (30%) are the main obstacles in Bangladesh to the fulfillment of potential yield . The main cause of drought is irregular and poor rainfall. the westernmost region thought to be prone to drought in Bangladesh. Roughly 5.7 million acres of rice are produced in rainfed circumstances, which significantly reduce yields. Rice crops can be affected by

drought in more than one growth stage, such as the post-transplantation and establishing stages (early-phase drought) or the reproductive stage (terminal drought) in transplanted Aman (T. Aman: rainfed lowland rice), which results in a significant production loss(Hossain *et al* ,2016).

Drought is a significant impediment to sustainable crop production and food security in Bangladesh. Drought mostly impacts Bangladesh's northwestern region, where 1.2 million hectares of land are used to farm rice during the dry season (Islam *et al*., 2011). Bangladesh faced severe drought in this area in 1999, 2000, 2006, 2009, and 2012. Bangladesh suffered the longest drought in 50 years in 1999, going more than four months without rain. Crop production decreased by 25%–30% as a result of the prolonged drought, posing a serious threat to food grain supply. Bangladesh's Ministry of Agriculture reported that moderate to extreme drought had affected approximately 57% of the country's total net cultivated land. Nonetheless, owing to the increasing severity of drought and crop production losses, adaptation to drought problems through the use of climate-smart agricultural practices has been emphasized in recent years (Islam *et al*., 2011). The Bangladeshi government has implemented drought management initiatives to mitigate the impact of droughts. Farmers in Bangladesh's drought-prone areas can now look forward to a more plentiful rice harvest with the release of many drought tolerant rice varieties (BRRI dhan56, BRRI dhan-66, BRRI dhan-71) by the Bangladesh Rice Research Institute (BRRI). Drought-tolerant rice varieties are those that can pro-duce a reasonable yield even when soil moisture is less than 20% and the perch water table depth is more than 70–80 cm from the surface level (Kader *et al*.,2019). All of these varieties can reach maturity in 105–115days. Drought tolerant varieties can produce at least 3.5–5 t/ha without watering throughout the productive period (Kader *et al*., 2019). Traditional rice varieties in Bangladesh wither and die within 10–12 day's water is not available, while drought tolerant cultivars may survive without rain up to 27 days (Islam *et al.*, 2011). Drought tolerant varieties also out perform traditional varieties in terms of yield. Drought-tolerant varieties were tested in the northwestern part of Bangladesh and demonstrated better performance in adverse situations (Ahmed *et al*., 2009). As a result, rice farmers in those areas began to adopt these drought-tolerant rice varieties. Adoption of drought-tolerant rice varieties can play an important role in agriculture sector development, maintaining food grain supply and improving the well-being of a substantial number of people. The decision to adopt, on the other hand, is complicated. Several factors may affect the decision, and identifying these factors is critical for the sector's future growth. (Mottaleb *et al*2014), land characteristics, access to credit, infrastructure, and irrigation facilities have a significant affection the adoption of modern rice varieties. Adoption of stress-tolerant rice varieties is influenced substantially by education (Ahmed *et al*., 2009).Cho and Kim (2019) find that household assets, credit, and involvement in farmers field school show a positive impact on the adoption of drought-tolerant rice varieties in the Philippines. A few studies (Arouna *et al;*2019) have assessed the production effect of drought-tolerant rice varieties worldwide and conclude that the varieties provide a higher yield than traditional varieties Islam (2018) indicate that adoption of improved rice varieties increases household income and food grain availability.

The expected increases in global population are 8.6 billion in 2030 and 11.2 billion in 2100 The growing population will result in a huge number of There are many hungry people and few resources. Given that smallholder farmers make up a sizable section of the world's population that experiences food insecurity due to their excessive reliance on natural resource-based agriculture, such as rain-fed agriculture. Furthermore, due to climatic instability and natural disasters that occur throughout the cropping season, global climate change is endangering the smallholder agriculture. In regions with low GDP and where people rely primarily on agriculture for their livelihood, less agricultural land will have a significant impact restricted options, such an agro-based nation like Bangladesh (Nasim *et al* ,2019). The food and livelihood security of smallholder farmers depends on the development of sustainable adaptation pathways that can better tolerate climatic unpredictability and extreme weather. The main food source in Bangladesh is rice.

1.2 Research Question

In line with the problem setting outlined above, a number of questions were specified as a guide for the investigation in the study area.

i. What are the characteristics of the rice producing farmers?

ii. What are the various sources of income of the farmer in the study area?

iii. What types of new technology are adopted to tolerate drought in the study area?

iv. How farmers known about the training on drought tolerant rice cultivation?

v. What are the determinates of livelihood status of farmers in cultivating rice?

1.3 Research Objective

This study's particular objectives are as follows:

1) To identify the socio-economic characteristics of farmer;

2) To determine the factor affecting adoption of drought tolerance rice varieties; and

3) To compare the livelihood status adopter and non-adopter of drought tolerance rice varieties growers.

1.4 Justification of the study

Rajshahi and Natore two district, are more likely to benefit from rice harvesting as drought prone areas are base for indigenous rice cultivation and where most of the drought area of riverine Bangladesh is in Northwestern area. This research seeks to study the existing status of rice production system and technical skills of farmers in some areas drought tolerant region. The drought area is somewhat neglected and the traditional agricultural livelihood of the people

of this area is very low. They cannot meet their daily needs properly for their low-income and larger families. In rural life men engage in crop weaving on the other hand women and children have consecutively been active in producing seedlings as the greatest acceptable source of income for impoverished and miserable women and kids. Starting a farm with a small quantity of rice may reduce the production per seed , but it will play a significant role in improving their quality of life when the distribution of benefits is more even and it will have a huge impact on human development in the country as a whole. Rice cultivation can be used extensively to alleviate poverty by raising it because the cost of raising rice production is relatively low, even less skilled people can do it, as well as its productivity is high and it may be integrated into home chores as well.

Rajshahi and Nator have vital role to producing new drought tolerence rice varieties on agricultural production. So far there have been various studies on different agricultural products in the drought enclosed areas of the division where emphasis has been laid on other topics such as identification of adaptability. However, little research has been done on the socio-economic status of rice farmers in the region and their livelihood status in rice production. Therefore, the importance of this study is to analyze the adoption capacity of the rice farmers in the drought field of Rajshahi and Nator by identifying their perceived problems and future prospects in rice producing. During the monsoons, the drought area is submerged where there is ample opportunity for getting soil moisture. On the other hand, people in these drought prone areas are trapped in water when they try to improve their livelihood. They can concentrate on raising seedlings which gives them extra income where there is no need to worry about raising seedbed. Small and landless farmers can use the drought for regular rice nutrition at low cost during this time. As a result, if people are engaged in rice cultivating in a short period of time, their income will increase and their nutritional needs will be met. The bare minimum of subsistent conditions will be developed. This isolated approach will help them become self-contained and manage hazardous environment. The present socio-economic condition can also be viewed here. It will also evaluate the present socio-economic condition which affecting the rice farmers of drought areas. The outcomes of the study will be applied to raise rice industries' outputs, as well as family's nutrition and economic security, by carrying out the proper actions in the correct manner.

Therefore, my study identifies the factors that influence the intensity of adoption and welfare impacts of drought-tolerant rice varieties in Bangladesh. To accomplish these 120 rice growers from three drought-prone districts of Bangladesh were surveyed. To analyze the impacts, the entire sample was divided into two groups depending on their share of land under drought-tolerant rice variety cultivation: adopters and non-adopters. The descriptive statistics BLRM (Binary Logistic Regression Model) was used to analyze the data. Therefore my opinion is added here to modifying the extension method with modern communication technologies will aid in widespread adoption of new technologies. Drought-tolerant rice varieties can help to mitigate the harmful

effects of drought and alleviate poverty in drought-prone areas.Overall, it will add some valuable information to drought region based research. The study will also help the government

and various NGO organizations to take valuable policies in the marketing channel of drought prone areas.

1.5 Scope of the study

The adoption capacity of the rice farmers of Rajshahi and Natore have been explored for research. Significant features that affect the livelihood index are accurately represented by the existing socio-economic status of the farmers and the overall condition and characteristics of the land to achieve maximum cultivation of the farmers through minimum input usage. This study is special in Rajshahi and Natore district were confined to areas where farmers, with the support of various institutions and the government, engaged themselves in large-scale rice cultivation projects. The drought prone areas of the Rajshahi and Natore rely heavily on rice cultivation because it is a high-volume operation needed minimal ground, flooded terrain and a variety of low-lying regions. A standardized questionnaire was exercised to interview a sample sized of 120 farmers.

1.6 Structure of the Thesis

Structure of the thesis contains six basic chapters; introduction, review of literature, research methodology, socioeconomic characteristics of the samples farmers, results and discussion, summary and conclusion. The first chapter discusses about the study's background, study questions and objectives, justification for the investigation, and overall framework. The review of literature will be submitted in the second chapter. The research methodology as well as the linked study's analytical procedures of the relevant study will be presented in the third chapter. The fourth chapter will explain socioeconomic characteristics of the samples farmers. The fifth chapter will organize by results and discussion of the study. Finally, chapter six will conclude with study summary.

1.7 Chapter Summary

The backdrop of the study, research questions, aims, and organization of the entire document are described in this chapter in an attempt to provide a first glance at the work.

CHAPTER 2

REVIEW OF LITERATURE

The purpose of this section is to offer an elaborate discussion on the relevant literature related to socioeconomic status of farmer, adoption and livelihood determinants of drought prone rice. Besides this, the chapter provided a summary and research gap based on the literature. The primary goal of this chapter is to review the several related studies in relation with objectives. On the following discussion provides a review of several recent research studies those are added in the current study.

2.1 Literature reviews on socio economic status of farmers

Al-Amin *et al; (*2019) investigated the agricultural sector is highly vulnerable to climate change, particularly in drought-prone environments. An understanding of perceptions, adaptation strategies, and their determinants including a gender analysis can benefit vulnerable farmers and policy makers. Using a survey of farming household heads and their spouses, this study identified the intra-household perceptions and their determinants, the major strategies adopted by the farmers to adapt to climate change, and the factors that affect their adaptation decision and choice of strategies including the role of intra-household decision making in a drought prone environment of Bangladesh.

Alauddin *et al; (*2014) recognized the vulnerability of Bangladesh's agriculture to climate change, the existing literature pays limited attention to a rigorous, quantitative analysis of farm-level data to investigate rice farmers' preferred adaptation strategies, perceived barriers, and policy implications. By employing data from 1800 Bangladeshi farm-households in eight drought-prone and groundwater-depleted districts of three climatic zones and logit models, this study breaks new ground in investigating farm-level adaptation to climate change.Results showed that farmers' perceptions of climatic variability supported macro-level evidence. Science-driven (e.g., drought tolerant rice), environmental resource-depleting (e.g., groundwater), and crop-switching (e.g., non-rice crops) typified preferred farm-level adaptation strategies to alleviate adverse effects of climate change. Drought severity, extent of groundwater depletion, education level, farm-size, access to climate information, and electricity for irrigation, and agricultural subsidies were significant factors underpinning farmers' decision to adapt. Inadequate access to climate information and scientific research outcomes, limited irrigation facility and resource-base represented major adaptation barriers.

Alam *et al; (*2015)stated the strengthening agricultural research and support services including information accessibility, community-focussed farming education and training for improved crop culture practices, and expanded and efficient surface-water irrigation infrastructure are 1critically important for creating an effective adaptation process to climate change. Scientific research-driven adaptation measures with stronger support systems appear more sustainable.

Pouliotte *et al;* (2009) explored the relationship between environmental change and development through a vulnerability study of a rural village in southwest Bangladesh. Villagers deal with a variety of pressing stresses, and climate change is not considered separately, if at all. Environmental, political and economic conditions and adjustments in resource use systems,

particularly shrimp farming, have changed livelihood opportunities and increased the vulnerabilities of poor villagers to future environmental changes, including climate change. Practical adaptation strategies to reduce vulnerabilities to climate-related stresses reflect the dynamics of people's livelihoods and address the conditions they currently face. In this case, planned adaptations were mainstreamed in the sense that they contributed to the livelihoods of people and made some improvement in their capacity to deal with changes in climate, and they were undertaken via established non-government institutions.

Alam *et al;* (2015) stated the water scarcity and droughts pose serious threats to the livelihood of farming communities and the economy in many parts of the world. Using a survey of 546 farming households and employing multinomial logit regression, this study investigates rice farmers' adaptation to water scarcity in a semi-arid climate in Bangladesh. It identified factors determining farmers' adaptation responses to addressing water scarcity. The analysis shows that farmers with more experience of farming, better schooling, more secure tenure rights, better access to electricity and institutional facilities and an awareness of climatic effects are more likely to adopt alternative adaptation strategies. Farmers' alternative adaptation choices are examined in comparison to the traditional approach of groundwater irrigation. This study raises issues of sustainability of agricultural adaptation practices in the context of an increasing dependence on groundwater irrigation. The results provide an insight to sustainable irrigation practices and an understanding of the characteristics of farms and farming households to frame better strategies to cope with water-stressed regimes in drought-prone environments.

2.2 Literature reviews on Adoption and livelihood on drought tolerant rice varieties

Several research were being conducted how farmers adopt those rice varities and examined of various important factors that affect adoption and livelihood determination related review:

Arouna *et al;* (2019) stated the adaptation methods identified include short-duration and drought-tolerant rice varieties, supplementary irrigation for crop production, non-rice winter and horticultural crops, and improved channels for irrigation and water harvesting. Discrete choice model results indicate that age, household size, membership in any organization, access to credit, drought severity, amount of cultivated land, and agricultural subsidy significantly influence farmers' adaptation decision and choices. Results reveal that climate change perceptions of husbands and spouses within the same households differ significantly and intra-household decision making plays a significant role in adaptation decision and selection of alternative adaptation strategies. The results would improve our understanding of farms and farming households and their climate change perceptions and adaptation choices by location and gender, thereby enabling us to outline better strategies to adapt to the changing climate.

Delaporte *et al;* (2018) measured the climate change is expected to disproportionately affect agriculture in Bangladesh; however, there is limited information on smallholder farmers' overall vulnerability and adaptation needs. This article estimates the impact of climatic shocks on the household agricultural income and, subsequently, on farmers' adaptation strategies. Relying on data from a survey conducted in several communities in Bangladesh in 2011 and based on an IV probit approach, the results show that a 1 percentage point (pp) climate-induced decline in agricultural income pushes Bangladeshi households to adapt by almost 3 pp.

Moreover, Bangladeshi farmers undertake a variety of adaptation options. However, several barriers to adaptation were identified, noticeably access to electricity and wealth. In this respect, policies can be implemented in order to assist the Bangladeshi farming community to adapt to climate change.This study contributes to the literature of adaptation to climate change by providing evidence of existing risk-coping strategies and by showing how a household's ability to adapt to weather-related risk can be limited. This study helps to inform the design of policy in the context of increasing climatic stress on the smallholder farmers in Bangladesh.

Habiba et al; (2013) said droughts are very frequent in Bangladesh due to its geo-physical position and varying rainfall pattern. Drought is considered as devastating and causing substantial damage and loss to agriculture and allied sectors. Particularly the northwestern livelihood experiences its noteworthy impact on their daily because of the consequence of drought impacts. More specifically, agriculture, health and social life are badly affected by drought. Despite drought vulnerabilities, a large number of actors have been involved in developing and implementing adaptation strategies to reduce the vulnerabilities. However, to adapt with drought, livelihoods in this region have been developing and using various practices mainly through agronomic management, crop intensification, water resource exploitation, etc. Although, livelihood based adaptation is person centric solution based on both local-knowledge with scientific facilitation and it is dual-way process that builds on the adaptive capacity through a systematic process. Moreover, livelihood adaptations actions may not sufficient enough for reducing drought risk that caused by climatic variability and climate change considerably. It requires greater institutional capacity at all levels of government and more efficient coordination between different levels of government. With this regards, her findings served as a basis for understanding drought impacts and to scale up viable adaptation options in the drought-prone areas of Northwest Bangladesh. In conclusion, her evaluation emphasized on the development of successful drought adaptation actions that would be performed through national to local level and helps livelihoods to build resilience against drought in future.

Rashid *et al; (*2013) stated 111to examine rice farmers' selection of adaptation strategies to cope with and offset the effects of climate change and the determinants of those selections in Rajshahi, a severely drought-prone district of Bangladesh.Farm-level micro data were obtained from 550 rice growers in the 2010-2011 farming season. A multinomial logit (MNL) model was utilised to assess the determinants of adaptation strategies practised by farmers in response to climate change.Results from the MNL model indicate that gender, age, education of household heads, household assets, annual farm income, farm size, tenure status, farmer-to-farmer extension, access to credit, access to subsidy, and access to electricity, all affect farmers' selection of adaptation strategies for climate change.This is the first study of its kind to analyse the determinants of adaptation strategies for climate change by farmers in drought-prone areas of Bangladesh. This study provides direction for policy makers in order to strengthen the adaptation strategies of farmers and guide policies accordingly. These strategies have the potential to minimise the adverse effects of climate change.

Hoque *et al; (*2010) conducted to determine the nature of adaptation strategies of the farmers in a drought-prone area of Rajshahi district. The locale of the study was drought-prone area of Tanore Upazila under Rajshahi district of Bangladesh. Data were collected from 200

households selected through a proportionate stratified random sampling technique from four villages namely Talopara and Jumerpara of Bhadair union and Kandopur and Dhebostoly of Kalma union under Tanore Upazila and analyzed with help of Microsoft Excel, SPPSS and Brasica program. The specific objectives of the study were to determine the adaptation strategies practiced by the farmers in drought period, to find out the relationship between some characteristics of the farmers and their adaptation strategies in drought prone area, to ascertain the contribution of selected characteristics of the farmers to their adaptation strategies in drought period, to explore factors that influences the farmer's characteristics in applying adaptation strategies and to explore problems faced by farmers in a drought prone area. Both primary and secondary sources of data were used in the study. Questionnaire and checklists were used in conducting survey and Key Informants Interviews. The selected 19 characteristics of the farmers were considered as the independent variables and their adapted adaptation strategies constituted the dependent variable. Adaptation strategies of the farmers in drought prone area ranged from 20 to 50 against a possible range 16 to 64, with an average of 38.65 and standard deviation 4.391. The highest proportion of the respondents (74 percent) had adapted strategies moderately, 17 percent had adapted strategies strongly, 7 percent had adapted strategies slightly and only 2 percent had not adapted strategies. Education, farm size, drought affected area, household asset, annual family income, savings, water and sanitation, communication exposure, agricultural training received, cosmopoliteness, aspiration, planning orientation, environmental awareness were positive and significant relationship with their adaptation strategies in drought period. Path analysis indicates that the variation on farmers' adaptation strategies was mainly due to the contributions of five predictors viz. that age, household asset, credit received, agricultural training received, and environmental awareness. Adaptation strategies of the farmers' model indicate that 38.99 percent of total variation in farmers' adaptation strategies status has been explained by these predictors. The five relevant characteristics having significant effects improvise their contribution to adaptation status and among those, household assets activities alone contribution explaining 25.1 percent of the variation in practice adaptation strategies during in drought period followed by environmental awareness 3.9 percent, agricultural training received 2.8 percent, credit received 3.7 percent and age 1.6 percent. The major root causes of low adaptation strategies of the farmers in drought prone area were lack of rainfall, rising temperature, lack of moisture, lack of awareness and lack of soil management. Hence, provision of necessary measures by the concerned authority and progressive change in socio-economic-environmental structure of the society are desirable for improvement of the farmers' adaptation strategies in drought prone area.

Islam *et al;* (2011) investigated geographically, Bangladesh is highly vulnerable to climate change. In particular, impacts of climate variability on agriculture and consequences on other sectors are already evident in the drought prone High Barind Tract and coastal regions. The agriculture and fisheries sectors in the High Barind Tract (HBT) and southern coastal region are very likely to face significant yield reduction in the future due to climate change. Global circulation model results revealed that higher temperature and water stress due to heat results an in decline in vegetation and agricultural production, especially in the drought affected HBT. While the coastal region would suffer from increased degradation of land, salinity intrusion, river bank erosion, siltation, water logging, tidal surge and floods. Drought delays the timely planting of T.Aman rice, the main crop of HBT, while drought in September and October

drastically reduces the yield of said crop, and the chance of sowing/planting of different rainfed rabi crops markedly decreases. Nationwide rice production losses due to drought in 1982 were about 50% more than losses due to flood in the same year, particularly in the HBT, >80% T.Aman rice production was lost. Moreover, the ground water table of HBT is continuously going down in the dry season due to over exploitation by deep-tube well. The 1997 drought caused a reduction of around1 million tons of food grain, of which about 0.6 million tons was T.Aman rice, entailing a loss of around $ 500 million. A cyclone in 1970 resulted in 300,000 deaths, and another in 1991 led to the loss of 138,000 lives. These effects are likely to be exacerbated by climate change as peak intensity of cyclones is projected to increase by 5–10%, and precipitation rates may increase by 20–30%. The strength of SIDR and economic losses was caused by the major hurricane in 2007 fit into this trend. Even before the new impacts of SIDR, about 1.2 million hectares of arable land were already affected by varying degrees of soil salinity, tidal flooding during wet season, direct inundation by saline water and upward and lateral movement of saline ground water during the dry season. Inundation of brackish water for shrimp farming is a key cause for secondary salinization of coastal lands. The severity of salinity problem has increased over the years and is expected to increase in the future due to rise of sea level. Even in non-cyclonic situations, higher mean sea-levels are going to increase the problem of coastal flooding and salinization, causing significant pressure on livelihood activities. Thus, climate change effect has a large negative impact on the farming systems and livelihoods of rural people of HBT and coastal area and on the overall economy of Bangladesh.

Ahmad *et al;* (2022) conducted the increasing impacts of recurrent droughts on dryland smallholders, causing extensive damage to agriculture that impedes sustainable livelihoods and adaptation pathways. This paper presents findings from research focusing upon five asset categories of livelihood approach, namely economic, social, natural, physical, and human capital, that are repeatedly exacerbated by the dynamics of repeated droughts. Focus group discussions were performed in four villages of Gorinabari union, Panchagarh district, northwest Bangladesh. This study explores the severe effects of drought on agronomic and livestock production, causing huge economic losses and unanticipated uncertainty to smallholders' livelihood activities. The findings infer several challenges that remain for undermining adaptive capacity associated with scarce modern techniques and knowledge, lacking agro-information, inadequate credit, capital inadequacy, agronomic damages, economic losses, and persistent drought episodes. The findings also suggest that smallholders' inability to adapt to changing situations causes much suffering during drought events. The results suggest that effective policy implementation, institutional arrangements, drought-resistant yields, poultry farming, livestock rearing, and small trading can expedite the smallholders' adaptive capacity to a given adverse condition in northern Bangladesh.

Kabir *et al;* (2017) stated the using long-term district-level climate data and a case study from a drought-prone village in western Bangladesh, this research explored trends in climate change, and analysed farmers' adaptation dynamics and livelihood status. This is the first study of its kind for drought-prone areas in Bangladesh.

Farmers perceived climate changes included increases in temperature and decreases in rainfall which were as consistent with the trends of Chuadanga climate records. Farmers' adaptation measures included changes in cropping systems, cropping calendars, crop varieties, agronomic practices, crop diversification and improved animal husbandry. Reducing environmental stress, ensuring self-sufficiency in staple crops (mainly rice) and other crop production practices, and

enhancing economic viability of farm enterprises have underpinned these adaptations. Off-farm and non-farm wage employment, temporary migration, self-employment and educating children, constituted the core non-farm adaptation strategies.Emerging cropping systems like maize/cucumber and maize/stem amaranth/rice were economically more viable than the traditional rice/rice and rice/maize systems. Despite some uncertainties, farming was preferred to off-farm work, generating higher returns to labour for all cropping systems. Limited access to stress-tolerant varieties, extension services and affordable agricultural credit, combined with high production costs, variability in crop yields and output prices, are the main barriers to adaptation. Stronger agricultural research and support services, affordable credit, community-focussed farming education and training are critically important for effective livelihood index determination to climate change.

Hossain et al; (2012) investigated Bangladesh is globally considered one of the most vulnerable and exposed countries to climate change (Climate change and Bangladesh Department of Environment, Government of People' Republic of Bangladesh. Climate Change Cell, Dhaka, 2007). There is evidence of prominent increases in the intensity or frequency of many extreme events such as flood, land erosion, heat waves, tropical cyclones, intense rainfall, tornadoes, drought, storm surges, salinity intrusion, etc. which cause loss of livestock, damage to pasturelands, increase fodder scarcity, destroyed shelters, decreased production, increased management costs to incidence of diseases, etc. in Bangladesh. This paper therefore intends to do three things: (1) it shall identify the extreme climatic hazards, vulnerabilities and risks; (2) it shall find out the impacts of climatic hazards on the livelihood of the vulnerable people; and (3) it shall propose some possible strategies for reducing the vulnerability to the climatic hazards. The present paper is intended as a concept paper to deal with the impact level assessment on livelihoods due to climate change. The method has followed both qualitative and quantitative approaches in the southwestern coastal zone in Bangladesh and used secondary data and information. The livelihood and income of a large population depends on the natural resource base and most of the poor people often live in marginalized lands and areas more prone to natural disasters. Climate change means that many natural disaster-prone areas will become more prone due to increased frequency and intensity of disasters. Drought-prone areas will become hotter and drier, with less predictable rainfall; flood frequency and intensity along onset and recession will be changed in future; the nature of cyclone and storm surges will be different from the historical trend. All of these together will change crop yields and affect many poor people's livelihoods. Agriculture yields have been decreased and cropping pattern has been changed in recent years. Adverse impacts of climate change are likely to reduce availability and deteriorate quality of water for domestic use. Moreover, climate change is likely to increase the prevalence and infection of vector- and water-borne diseases such as malaria and dengue fever, cholera and dysentery, etc. Degradation of biodiversity will reduce the availability of many traditional medicines which may affect poor and rural people who depend more on natural resources for medicine as well as income and food. Sea level rise (SLR) will drastically affect the poor people who are in coastal area and flood plain zone in Bangladesh. However, many actions undertaken to address the baseline or contextual risks in Bangladesh are also synergistic with the so-called adaptations that might be required as climate change impacts manifest themselves.

2.3 Summary and Research Gap

From several literature reviews, most of the studies evaluates that the farmers get appropriate facilities and they use their resources efficiently as maximizing output through a given level of inputs. Marital status, religion, farming status, years production and cultivation experience etc in drought area measures all have a significant impact on farmers' livelihood. Additionally, Literature explained different factors that affect farmer efficiency of production. However, most studies considered only socio-economic status of different agricultural commodities such as cereal crop, livestock, fisheries, poultry; and very few studies considered to analyzing only adaptability of rice on the drought areas not to discuss about resistance adaptability. Moreover, researcher consider crop sectors on drought areas as to examine the livelihood status of farmers in Bangladesh; whereas an important improving sector, rice production are founded less considerable in several drought based research in Bangladesh. From the above literature, it implies that this is a crucial sector which affect adoption of rice varieties and overall economy of Bangladesh.

The aforesaid review reveals that most of the study was undertaken exclusively on the adaptability of rice cultivation in low lying drought fields and in inland rice cultivation. Other researchers were not found on impacts of adoption new rice varieties which could be harvested on drought land and so that farmers not to make their livelihood. So the research was undertaken to fill up the knowledge gap in the drought prone field.

CHAPTER 3

METHODOLOGY OF THIS STUDY

3.1 Chapter overview

This section's main goal is to list all of the methodologies which is undertaken on this study to reach the objectives of this study. A simple description of research methodology for both qualitative and quantitative research is included initially in this part. The paper's methodology is then described in depth including research design, data sources, designing of questionnaire, selection of population and sample of the study, techniques of data analysis are given gradually. Finally, in order to rationalize the different methods used in different stages of the study, a justification of study methodology is also provided.

3.2 Selection of the Study Area

In every research project, choosing the right study area is crucial. In any research, a study area is selected where all the objectives was fulfilled. For this study the drought prone areas was selected which is under two specific District namely, Rajshahi and Natore.

The objectives of the study is fulfilled by selected this area. Specifically rice production at drought prone areas is common, however adequate study were not being conducted in this areas. Therefore drought areas of Rajshahi and Nator are being selected to analysis adoption rice varieties by the farmers from the project data whose are gained by SAURES. Inside these two district, the information was gathered from numerous communities. The people of the area have diversified earning sources. There have many drought affected land whose were the main component in the study. A large number of populations of the area depend upon cultivating rice in conveniently on open land. Besides they are also work on livestock and poultry sector, catching fish and doing many non-farm activities. The two selected areas are just about 40-50 km from division headquarters. Thus, the area was also convenient to collect necessary data.

3.3 Selection of the Sample and Sampling Technique

Partially reviewing my study data, it is not possible to collect data from all the populations because of, budget and labor limitations. Thus, a sampling technique has been done in the used project questionnaire to conduct the study. On the sampling questionnaire was used to pick 60 samples in each group because rice cultivation is a key encroachment in the research region due to the high densities of population; this necessitates a multifaceted strategy to bolstering household economic well-being. The research was add to the scant literature on rice producer adoptability. From the study area, 60 sample respondents have been selected from Rajshahi and 60 sample respondents have been selected from Natore District from SAURES data..

Table-1 Sample area and Sample size

Sample number	Study area	Sample size
1.	Rajshahi	60
2.	Natore	60
Total		120

3.4 Method of Data Collection

The researcher conducted whole survey. Primary data has been collected by the researcher after going to the respondent with the prepared interview schedule information gained by SAURES. Most of the farmers are illiterate and ignorant about the research system. As a result, a quick summary of the study's goals and objectives was provided. There was no recorded information with the farmers. Thus, the farmer's memories are primarily relied upon by the researcher. The data were collected at the leisure times of the farmers. After summerizing all the study data, a brief overlook upon the questions was given to identify any misses. If there was any missing or misunderstanding, requisitioned has been done. The local criteria were used to determine the unit. It was transformed to an international standard unit during the tabulation process. Lastly best effort was given to find as correct information as possible.

3.5 Summarization, Tabulation and Analysis of Data

The information was thoroughly examined. All interview schedules were reviewed further to see whether there is any inconsistency or not. Irrelevant information was deleted and appropriate coding was done. Then all the information was transferred to excel master sheet.

3.6 Analytical Technique

Quantitative analysis is used to analysis data which helps in assessing performance and evaluating financial instruments. It encompasses regression analysis as a main techniques of measuring data. This statistical methods as an analysis technique is a set includes Binary Logistic Regression Model (BLRM) for evaluating connections between a dependent variable and one or more independent variables. Analyses in tabular format was mostly used in the process because it is easy to use and understand. Descriptive statistics like mean, mode, variance, standard deviation, standard error, marginal effects have been used for analyzing socio-economic condition of rice farmers, their livelihood and adoption of rice varieties will be analyzed by using logistic function.

Data Analysis Method

The logit model is used to address the objective, which is the factor influencing adoption of drought tolerance rice varieties, because its likelihood function is well behaved and consistently produces maximum likelihood estimate (MLE) coefficients and standard error of the estimate . After adjusting the pertinent model variables, the logit model calculates the likelihood that drought-tolerant rice cultivars will be adopted. The first step's dependent variable is described as a dichotomous variable with values of 1 for adopter and 0 for non- adopter.

$Ui^* = Xi'\gamma + u_i$ ..... (1)

with $U_i = \begin{cases} 1 & \text{if } U_i^* > 0 \\ 0 & \text{otherwise} \end{cases}$

where, U_i^* is the latent variable which represents the probability of the household's decision to adopt of drought tolerance rice varieties, and takes the value '1' if the farmer adopt of drought tolerance rice varieties '0' otherwise. The term X_i' represents explanatory variables explaining the adoption decision, γ is a vector of parameters to be estimated, and u_i is the error term assumed to be independent and normally distributes as $u_i \sim N(0, 1)$.

We employed a logit model (STATA 14.2) to determine the probability of adopting farm mechanization using plot-level data. The logit model is the most suitable tool to determine the probability of whether or not to choose adoption, particularly at the plot-level data analysis (Gauchan et al, 2012). We, further, are interested in assessing the influence of each of the independent variables on the decision of the farm household to adopt farm mechanization. For that, we estimated the marginal effect of independent variables in the logit model which can be obtained by differentiating the first and second order conditions as follows (Greene, 2012):

$\partial E[U_i^*|X_i] / \partial X_i = \Phi(X_i'\gamma)\,\gamma$

Based on the above mentioned theoretical model and previous study experiences (Gao et al, 1995; Newman et al, 2003; Feleke and Zegeye, 2006; Langyintuo and Mungoma, 2008; Gauchan et al, 2012; Noltze et al, 2012; Kohansal and Firoozzare, 2013), we selected our explanatory variables and specified a logit model as follows:

$$\text{Log}\,[P/1\text{-}P] = \beta_0+\beta_1X_1+ \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + e$$

Where,

P = Probability of Outcome (Adoption of Drought Tolerance Rice Variety)

X_1 = Age (Years)

X_2 = Education of the Farmer (Yes/No)

X_3 = Farm Size (Hectare)

X_4 = Experience (Years)

X_5 = Training (Yes/No)

X_6 = Training on Drought Tolerance Rice Variety (Yes/No)

X_7 = Extension Contact (Yes/No)

X_8 = Knowledge of Drought Tolerance Rice Variety (Yes/No)

β_0 = Intercept

β_1,....., β_8 = Co-efficient of respectively independent variables;

e = Random Error.

STATA software was used to analysis the data. A probability of 10% (0.10) was utilized to reject the null hypothesis. Asterisks (***) indicate the significance of coefficient values at the 0.01 level, while two asterisks (**) indicate the significance of coefficient values at the 0.05 level and one asterisks (*) indicate the significance of coefficient values at the 0.10 level

The above model was developed to establish the components that contribute to the examination of adopted rice and to evaluate the influence of socioeconomic variables on rice farmers and their livelihood.

Livelihood Status

To compare the livelihood status of the shrimp farmers in the two situations, a livelihood assessment index (LAI) was constructed following the DFID's sustainable

livelihood framework (SLF) (DFID, 2000). The SLF provides a way of breaking down the complexity of people's lives and livelihood strategies by addressing their access to a range of assets (human, social, financial, physical and natural). In the context of stress, shock, and seasonality, SLF primarily focuses on livelihood as an integrated function of livelihood capitals (Sarker et al., 2020). It provides a more realistic framework for analyzing the direct and indirect effects on people's living conditions than, say, one-dimensional productivity or income metrics (Chuong et al., 2015). According to DFID, livelihood is a function of following five types of capital:

Livelihood = f (Human, Natural, Social, Physical, and Financial Capital)

To measure and compare the livelihood status, major livelihood components were translated into a composite index based on the five types of capital mentioned above. The subcomponents of the five capital types were estimated by equal weighting to obtain a full picture of the livelihood status of shrimp farmers in the two time periods (Sarker et al., 2020). The selection of subcomponents and their weights was subjective (Eriksen and Kelly, 2007; Alam et al., 2018; Sarker et al., 2020). In this study, the subcomponents were selected based on previously-published studies and field experiences (Table 3.1). Though the five major capital types comprise various subcomponents, each of them contributed equally to the index. Since a specific scale was used for each specific component, standardization was performed using flowing formula:

$$Index_{SV} = \frac{S_V - S_{min}}{S_{max} - S_{min}}$$

where S_V is the original subcomponent value of situation V, S_{min} is the minimum value of subcomponents, and Smax is the maximum value of the subcomponents.

After finding an index value for each subcomponent, the index value of each component was calculated using the following equation:

$$M_{VJ} = \frac{\sum_{i=1}^{n} Index_{SVi}}{n}$$

where M_{VJ} is the value of major component J for situation V, $Index_{SVi}$ denotes the value of subcomponents, indexed by *i*, of major component M_J; and n represents the number of subcomponents in major component M_J.

Once values for each of the five major capital types for a particular situation were calculated, they were averaged following Eq. (4) to obtain the LAI for situation V:

$$LAI_V = \frac{W_H H_V + W_N N_V + W_S S_V + W_P P_V + W_F F_V}{W_H + W_N + W_S + W_P + W_F}$$

where LAI_V is the livelihood assessment index of situation V; W_{MJ} is the weight of component J; and W_H, W_N, W_S, W_P, and W_F are weight values of human, natural, social, physical, and financial capital, respectively. H_V, N_V, S_V, P_V, and F_V are the index values of human, natural, social, physical, and financial capital in situation V.

The human capital index includes access to health (H_A), skill development (H_{SD}), and child schooling (H_{CS}), and was calculated as follows:

$$Human\ Capital\ Index\ (H_V) = \frac{W_A H_A + W_{SD} H_{SD} + W_{CS} H_{CS}}{W_A + W_{SD} + W_{CS}}$$

Where W_A, W_{SD}, and W_{CS}, represent weight for access to health (H_A), skill development (H_{SD}), and child schooling (H_{CS}), respectively.

The natural capital index includes safe drinking sources (N_{SDS}), and cropland ownership (N_{CL}) and was calculated as follows:

$$Natural\ Capital\ Index\ (N_V) = \frac{W_{SDS} N_{SDS} + W_{CL} N_{CL}}{W_{SDS} + W_{CL}}$$

Where W_{SDS}, and W_{CL} represent weight for safe drinking sources (N_{SDS}), and cropland ownership (N_{CL}), respectively.

The social capital index includes taking seeking help from leader (S_{HL}), and allow women working outside (S_{WO}) and was calculated as follows:

$$Social\ Capital\ Index\ (S_V) = \frac{W_{HL} S_{HL} + W_{WO} S_{WO}}{W_{HL} + W_{WO}}$$

Where W_{HL}, and W_{WO}, represent weight for seeking help from leader (S_{HL}), and allow women working outside (S_{WO}), respectively.

The physical capital index includes ownership of house (P_{HO}), and transportation ownership (P_{TW}) and was calculated as follows:

$$Physical\ Capital\ Index\ (P_V) = \frac{W_{HO} P_{HO} + W_{TW} P_{TW}}{W_{HO} + W_{TW}}$$

Where W_{HO}, and WTW represent weight for ownership of house (P_{HO}), and transportation ownership (P_{TW}), respectively.

The financial capital index includes service income (F_{SI}), savings continued (F_{SC}), and business income (F_{BI}) and was calculated as follows:

$$Financial\ Capital\ Index\ (F_V) = \frac{W_{SI}F_{SI} + W_{SC}F_{SC} + W_{BI}F_{BI}}{W_H + W_N + W_S + W_P + W_F}$$

Where W_{SI}, W_{SC} and W_{BI} represent weight for service income (FSI), savings continued (FSC), and business income (FBI), respectively. Details of the methodology are available in Hahn et al. (2009) and Sarker et al. (2020).

Table 3.1: Description of Livelihood Components

Livelihood capital types	Subcomponents	Justification	Value
1. Human Capital	Access to health	Access to health services can contribute to a healthy life.	Yes = 1 No = 0
	Skill development	A high number of skill development programme attendant can increase income and livelihood status	Number
	Child Schooling	Education can aid in diversifying livelihood.	Yes = 1 No = 0
2. Natural Capital	Safe drinking sources	Unsafe drinking water can be a source of many diseases and illnesses which can hamper	Yes = 1 No = 0
	Cropland ownership	Possession of land can increase income and livelihood status	Yes = 1 No = 0
3. Social Capital	Seek help from leader	Help from leader may increase the possibilities to diversify income.	Yes = 1 No = 0

	Allow women working outside	Allowing women working outside may increase income and livelihood status	Yes = 1 No = 0
4. Physical Capital	House ownership	Housing can be a significant factor in livelihood assessment	Yes = 1 No = 0
	Transportation ownership	Owning a means of transportation can enable the pursuit of diversified livelihood strategies	Yes = 1 No = 0
5. Financial Capital	Service income	Availability of service income can help increases livelihood status	Yes = 1 No = 0
	Savings	Savings can be used to overcome difficult situations.	Yes = 1 No = 0
	Business income	Income from business can further improve income diversification.	Yes = 1 No = 0

3.7 Variables and their Measurement

A variable in the field of research is an object, idea, or any other characteristic which can take any value that you are trying to measure. In analytical research there are generally two types of variables. Independent variables are what we expect will influence dependent variables. A dependent variable is what happens as a result of the independent variable. For example, if we want to explore whether high concentrations of vehicle exhaust impact incidence of asthma in children, vehicle exhaust is the independent variable while asthma is the dependent variable. A confounding variable, or confounder, affects the relationship between the independent and dependent variables.

The researcher carefully studied thoroughly and reviewed literature to widen the spectrum of utmost understanding about the natures and scopes of the possible dependent and independent variables pertinent and selected for this research. After a huge examining and sorting the

possibilities and relevance eight independent variables and one dependent variable are selected purposively.

Age, education, farm size, experience, training, training on drought tolerance rice variety, extension contact and knowledge of drought tolerance rice variety are taken as the independent variables selected for using in the study. The dependent variable of this study was the adoption of drought tolerance rice variety. The methods and procedures in measuring the variables of this study is presented below:

3.8 Measurement of dependent variable

Adoption of drought tolerance rice variety by the farmers was selected as the dependent variable for the study. Among some varieties like BRRI Dhan 33, BRRI Dhan 48, BRRI Dhan 56, BRRI Dhan 71 and BINA 7 etc. the farmers who adopted at least one of these varieties was given a score of 1 and the farmers who didn't adopt drought tolerance variety was given a score of 0. Thus, the range of adoption of drought tolerance variety in rice farming score was 0 to 1.

3.9 Measurement of independent variable

Age

Actual years from their birth to the time of the interview was measured as age which was found on the basis of the verbal response of the rural rice cultivating people (Rashid, 2014). A score of one (1) was assigned for each year of one's age. This variable appears in item number 1 in the interview schedule.

Education

Level of education was measured in terms of class (year of schooling) passed by rice cultivators of those areas. If a rice cultivator received education from any educational institute or recognized school or college or university, their education was expressed in terms of year of schooling, i.e. one (1) score was given for one year of schooling. Each illiterate person was given a score of zero.

Farm Size

Farm size of a farmer referred to the total area of land on which his/her family carried out the farming operation, the area being in terms of full benefit to the family. The term refers to the cultivated area either owned by the farmer or cultivated on sharecropping, lease or taking from other including homestead area and measured using the following formula (Rashid, 2014):

FS = A + C + D + F + G – B – E

Where, FS = Farm size,

A = Own land under own cultivation,

B = Land share out

C = Land share in

D = Land taken from others on lease,

E = Land given to others on lease,

F = Homestead land

G = Pond

The data was first recorded in terms of local measurement unit i.e. hectare.

Based on their total farm size, the farmers were classified into five categories as follow:

Category	Area (Hectare)
Landless	≤ 0.020
Marginal Farmer	0.021 to 0.20
Small Farmer	0.21 to 1.00
Medium Farmer	1.01 to 3
Large Farmer	> 3

Farming experience

Farming experience of rice cultivators was determined by the total number of years involved in farming activities. A score of one (1) was assigned for each year farming experiences of his own in this sector.

Table 3.2: Explanatory variables used in the models

Variable	**Notation**	**Type**	**Description**
Age (years)	X_1	Continuous	Age of the farmer
Education (years)	X_2	Continuous	Total number of years the farmer attended school
Farm size (ha.)	X_3	Continuous	Total amount of cultivable land by the farmers
Experience (years)	X_4	Continuous	Total number of years involved in farming by the farmer
Training (yes/no)	X_5	Binary	1 if the farmer received training, otherwise 0
Training on Drought Tolerance rice variety (yes/no)	X_6	Binary	1 if the farmer received training on drought tolerance rice variety, otherwise 0

Extension contact (yes/no)	X_7	Binary	1 if the farmer had extension contact, otherwise 0
Knowledge of Drought Tolerance rice variety (yes/no)	X_8	Binary	1 if the farmer had knowledge of drought tolerance rice variety, otherwise 0

Training Received

Training was measured based on their response to participate any training program organized by the local agricultural extension office and the duration of the training they attended. Those who was attended any training program was given score 1 otherwise 0.

Training on Drought Tolerance Rice Variety Received

Training on drought tolerance rice variety was measured based on their response to participate any training program organized by the local agricultural extension office and the duration of the training they attended. Those who was attended any training program was given score 1 otherwise 0.

Extension Contact

Field Visit was measured based on the visits and communication and discussion with the local agricultural officer or block supervisors. Those whose fields were visited by the agricultural officers was given score 1otherwise 0.

Knowledge of Drought Tolerance Rice Variety

Knowledge of drought tolerance rice variety was measured based on their response to have knowledge of availability of drought tolerance rice varieties in the study area. Those who had knowledge was given score 1 otherwise 0.

3.10 Statement of the Hypotheses

In order to guide relevant data collection, analysis and interpretation of data, a set of hypothesis would be formulated for empirical testing. As defined by Good and Hatt (1952), "Hypothesis is a proposition which can be put to test to determine its validity. It may seem contrary to, in accord with common sense. It may prove to be correct or incorrect. In any event, however, it leads to an empirical test." In broad sense, hypothesis may be divided into two categories, namely, research hypothesis (H_1) and null hypothesis (H_0). In studying relationships between variables an investigator first formulates research hypothesis which states anticipated relationships between the variables. On the other hand, for statistical test, it becomes necessary to formulate null hypothesis. A null hypothesis states that there is no contribution with the concerned variables. The following null hypothesis would be formulated to explore the relationship of the selected characteristics of the growers with their adoption of drought

tolerance rice variety. There is no significant contribution with the selected characteristics of the growers and their adoption of drought tolerance rice variety.

H_0 : There is no influence of independent variable on the adoption of drought tolerance rice variety.

H_1 : There is an influence of independent variable on the adoption of drought tolerance rice variety.

3.11 Ethical Issue of the Study

This study maintained and followed all the ethical issues relevant of the study. Before data collection farmer's appointment were ensured. Before beginning the interviews, the farmers were informed of the study's goal. The farmer had complete discretion over whether or not to participate in the interviews and avoided misleading questions were asked which might violate the confidentiality or privacy aspects. Somewhere a little chaotic situation had to be encountered but the researcher managed it very tactfully. Additionally, all information were collected for the Master's thesis and other than the research, I haven't used it for anything else.

3.12 Limitations of the Study

The biggest limitation of this investigation was most of the respondent were not well-educated and they did not agree to give data easily. Due to pandemic situations, the targeted sample size was difficult to achieve. Additionally, during face-to-face interviews, the respondent had to take extra precautions when interviewing at home or at work. While collect data from respondents it was necessary to using extra friendly behavior to maintain their privacy. In addition, it was no longer possible to wait owing to the research project's deadline.

3.13 Chapter Summary

A clear conception of what and why of the methodology taken for the study was provided in this chapter. More specifically, a detailed description of techniques used and why they are used in each and every step of the study is provided in this chapter.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Chapter overview

The work's research findings are presented in this section. Farmers vary with respect to different socioeconomic variables which help to know the insight profile of the farmer. The behavior aspect of an individual largely depends upon his or her socio-economic situations. It also influences the decision making capacity and to choose between the positive and the negative ones. The purpose of this chapter is to give an in-depth review of the adoption results and the sources that influence rice farmers livelihood in the research region.

4.2 Socio-Economic Characteristics of the Rice Farmers

Introduction

The purpose of this chapter is to provide a quick overview of the socio-economic features of the rice producers. Socio-economic characteristics of farmers may be interpreted in a variety of ways, depending on aspects such as their standard of living, the financial situation in which they live, and the kind and extent to which growers support national progress efforts. Due to time and asset constraints, it was difficult to collect full data on the financial characteristics of the sample farmers. The financial situation of the example farmers is critical in the event of study planning, as there are several connected and component aspects that identify a person and have a substantial influence on the development of his/her behavior and character. Individuals differ in their financial viewpoints. Nonetheless, for the sake of this study, a few of the financial characteristics have been considered for exchange.

Age

In the study, all categories of farmers of the study area were classified into different age groups as presented in table 4.1. It is evident from the table that most of the adopter and non-adopter farmers were under older group.

Table 4.1: Age Distribution of the Farmers

Age	Drought Tolerance Rice Variety Adopter		Drought Tolerance Rice Variety Non-adopter	
	Number(n)	Percentage (%)	Number(n)	Percentage (%)
Up to 35 years old	20	29.85	15	28.30
36-50 years old	18	26.87	17	32.08
Above 50 years old	29	43.28	21	39.62
Total	67	100.00	53	100.00

(Source: Field Study 2022)

Out of the 67 adopters, 29.85% belongs to the up to 35 years old age group 26.87% belonged to the age group 36-50 years and 43.28% were under the age group of above 50 years old, For non-adopter of drought tolerance rice variety 28.30% belonged to the age group of up to 35 years old, 32.08% belonged to the group of 36-50 years and 39.62% were under the age group of above 50 years .This finding imply that majority of the sample farmers were in the most active age group of above 50 years indicating that they may provide more physical efforts for farming (Table 4.1).

Educational Status

Education increases the efficiency of the nation. Bangladesh it has, an adult literacy rate of 74.66% (MoF, 2022). Table 4.2 shows for drought tolerance rice variety adopter 28.36% farmers were illiterate, 25.37% farmers had primary education, 31.34% farmers had completed secondary level education, 14.93% farmers had completed their college level and above education. On the otherhand, non-adaptor 28.30% farmers were illiterate, 28.30% farmers had primary education, 22.64% farmers had completed secondary level education and 20.76% farmers had completed their higher secondary level and above education which indicates that their education made them more efficient in farming.

Table 4.2: Educational Status of the Farmers

Education Level	Drought Tolerance Rice Variety Adopter		Drought Tolerance Rice Variety Non-adopter	
	n	%	n	%
Illiterate	19	28.36	15	28.30
Primary	17	25.37	15	28.30
High School	21	31.34	12	22.64
College and Above	10	14.93	11	20.76
Total	67	100.00	53	100.00

(Source: Field Study 2022)

Family Size

In the study, all categories of farmers of the study area were classified into different family size groups as presented in table 4.3. It is evident from the table that most of the farmers were small family in the study area. Out of the 67 drought tolerance rice variety adopters 47.76% belonged to the group of small family, 46.27% belonged to the group of Medium family and 5.97% fell into the group of large family. And out of total 38 drought tolerance rice variety non-adopters 50.94% belonged to the group of small family, 41.51% belonged to the group of medium family and 7.55% fell into the age group of large family. This finding imply that majority of the sample farmers were small family which indicates that larger family size farmers are not interested to take risk adopting new technique.

Table 4.3: Family Size of the Farmers

Family Size	Drought Tolerance Rice Variety Adopter		Drought Tolerance Rice Variety Non-adopter	
	n	%	n	%
Small (up to 4 members)	32	47.76	27	50.94
Medium (5-7 members)	31	46.27	22	41.51
Large (more than 7 members)	4	5.97	4	7.55
Total	67	100.00	53	100.00

(Source: Field Study 2022)

Farm Size

Table 4.4 indicates that for drought tolerance rice variety adopters the small farm holder constitutes the highest proportion 67.16% followed by medium farm holder was 32.26%, large farm holder was 11.29%, marginal farm holder was 7.46% and landless was 1.49%. Again for drought tolerance rice variety adopters the small farm holder constitute the highest proportion 64.15% followed by marginal farm holder was 24.53%, medium farm holder was 9.43%, larger farm holder was 1.89% and no landless. The findings of the study reveal that majority of the drought tolerance rice variety adopters were small to medium sized farm holder (drought tolerant cultivers at 1222-1473 kg more per hectre). This findings also indicates the farmer with landless and marginal farm size has very little scope to experiment about new technologies as their earnings depend on mainly in agriculture.

Table 4.4: Farm Size of the Farmers

Farm Size	Drought Tolerance Rice Variety Adopter		Drought Tolerance Rice Variety Non-adopter	
	n	%	n	%
Landless (<=0.02 ha)	1	1.49	-	0.00
Marginal (0.021-0.20 ha)	5	7.46	13	24.53
Small (0.21-1.00 ha)	45	67.16	34	64.15
Medium (1.01-3.00 ha)	14	20.90	5	9.43
Large (>3.00 ha)	2	2.99	1	1.89
Total	67	100.00	53	100.00

(Source: Field Study 2022)

Access to Agricultural Credit

Table 4.5 shows that out of the total sample, for drought tolerance rice variety adopters only 44.78% farmers hold agricultural related credit and remaining 55.22% farmer didn't receive any kind of agricultural credit from any organization. This findings refers most of the farmers were self-sufficient and didn't depends on agricultural credit or loan. Again for drought tolerance rice variety non-adopters only 45.28 % of farmers received agricultural related loan where remaining 54.72% farmers didn't received any kind of agricultural related credit.

Table 4.5: Access to Agricultural Credit by the Farmers

Access to Agricultural Credit	Drought Tolerance Rice Variety Adopter		Drought Tolerance Rice Variety Non-adopter	
	n	%	n	%
Yes	30	44.78	24	45.28
No	37	55.22	29	54.72
Total	67	100.00	53	100.00

(Source: Field Study 2022)

Membership of Social Organization

Table 4.6 shows that out of the total sample, for drought tolerance rice variety adopters 56.72% farmers hold membership of social organization and remaining 43.28% farmer didn't hold any social organization. This findings refers most of the farmers were members of social organizations. Again for drought tolerance rice variety non-adopters 62.26% of farmers hold membership of social organization and remaining 37.74% farmer didn't hold any social organization.

Table 4.6: Membership of Social Organization by the Farmers

Membership of Social Organization	Drought Tolerance Rice Variety Adopter		Drought Tolerance Rice Variety Non-adopter	
	n	%	n	%
Yes	38	56.72	33	62.26
No	29	43.28	20	37.74
Total	67	100.00	53	100.00

(Source: Field Study 2022)

Farmers Training Received on Drought Tolerance Rice Variety

Table 4.7 indicates that for drought tolerance rice variety adopter most of the farmer low range that means 83.58% of farmer received training for less than 4 days, followed by 4.48% received training on medium range, and 11.94% received training on high range. And for drought tolerance rice variety adopter most of the farmer low range that means 79.25% of farmer received training for less than 4 days, followed by 3.77% received training on medium range, and 16.98% received training on high range. The findings of the study reveal that majority of the drought tolerance rice variety adopters were low training holder which indicates that if they get more training facilities the adoption will also increase.

Table 4.7: Farmers Training Received on Drought Tolerance Rice Variety by the Farmers

Training	Drought Tolerance Rice Variety Adopter		Drought Tolerance Rice Variety Non-adopter	
	n	%	n	%
Low (less than 4 days)	56	83.58	42	79.25
Medium (4-7 days)	3	4.48	2	3.77
High (above 7 days)	8	11.94	9	16.98
Total	67	100.00	53	100.00

(Source: Field Study 2022

Farming Experience

In the study, all categories of farmers of the study area were classified into different experience groups as presented in table 4.8. Out of the 67 drought tolerance rice variety adopters 28.36% belonged to the group of lower experienced, 29.85% belonged to the group of medium experienced and 41.79% fell into the group of high experienced. And out of total 38 drought tolerance rice variety adopters 49.06% belonged to the group of lower experienced, 15.09% belonged to the group of medium experienced and 35.85% fell into the group of high experience. It is evident from the table that most of the farmers were high experienced for drought tolerance rice variety adopter and low experienced in non-adopter in the study area.

Table 4.8: Farming Experience by the Farmers

Farming Experience	Drought Tolerance Rice Variety Adopter		Drought Tolerance Rice Variety Non-adopter	
	n	%	n	%
Low (up to 20 years)	19	28.36	26	49.06
Medium (21-30 years)	20	29.85	8	15.09
High (above 30 years)	28	41.79	19	35.85
Total	67	100.00	53	100.00

(Source: Field Study 2022)

Average Annual Income, Expenditure and Savings

Table 4.9 shows that for drought tolerance rice variety adopter the average annual income, expenditure and savings were Tk. 258344.78, Tk. 81359.85 and 176984.93, respectively. And for drought tolerance rice variety non-adopter the average annual income, expenditure and savings were Tk. 205886.79, Tk. 78161.32 and 127725.50, respectively. It is evident from the table that drought tolerance rice variety adopter had higher income and savings than non-adopter in the study area. Here savings are calculated by substraction of income from expenditure.

Table 4.9: Average Annual Income, Expenditure and Savings by the Farmers

Particulars	Income (Tk.)	Expenditure (Tk.)	Savings (Tk.)
Drought Tolerance Rice Variety Adopter	258344.78	81359.85	176984.93
Drought Tolerance Rice Variety Non-adopter	205886.79	78161.32	127725.50

(Source: Field Study 2022)

4.3 Factor Affecting Adoption of Drought Tolerance Rice Varieties

The second objective of the thesis is "To identify the factors affecting adoption of drought tolerance rice varieties". In this chapter, findings of the data analysis explaining the second objective of the study are discussed.

4.3.1Factor Affecting Adoption of Drought Tolerance Rice Varieties

Table 4.10 presents the results of the Logistic regression of estimated parameters and marginal effect. Overall, the regression offers a good fit with factors predicting the adoption status by

the study households. The chi-square statistics indicate the strong explanatory power of the model. Moreover, most of the explanatory variables in the model were found to be statistically significant with an expected sign.

P-values and coefficients in regression analysis describe which relationships in model are statistically significant and the nature of those relationships. The coefficients discuss the mathematical relationship between each independent variable and the dependent variable. The p-values for the coefficients indicate whether these relationships are statistically significant. If the p-value for a variable is less than significance level, sample data provide enough evidence to reject the null hypothesis for the entire population Changes in the independent variable are associated with changes in the dependent variable at the population level. Marginal effects show the change in probability when the predictor or independent variable increases by one unit.

Table 4.10: Factor Affecting Adoption of Drought Tolerance Rice Varieties

Dependent Variable	Independent Variable	Co-efficient	Standard Error	Marginal Effect	Standard Error
Adoption of Drought Tolerance Rice Varieties	Constant	-0.391	0.74	-	-
	Age (X_1)	-0.051*	0.03	-0.007*	0.004
	Education (X_2)	-0.083	0.062	-0.012	0.009
	Farm Size (X_3)	0.542	0.395	0.078	0.055
	Experience (X_4)	0.053*	0.031	0.008*	0.004
	Training (X_5)	-0.543	0.535	-0.078	0.075
	Training (X_6)	2.792***	0.89	0.403***	0.107
	Extension Contact (X_7)	2.906***	0.905	0.419***	0.108
	Knowledge (X_8)	1.536**	0.607	0.221***	0.078
	LR chi^2 = 60.14 Prob > chi^2 = 0.0000 Pseudo R^2 = 0.37 Log likelihood = -52.287871				

*** p<.01, ** p<.05, * p<.1

(Source: Authors estimation from study data, 2022)

The Pseudo R^2 was 0.37. It means that the empirical model is 37% successful while predicting the respondents' adaptive responses against drought tolerance rice variety in rice production.

Besides, the LR Chi^2 (60.14) was highly significant at 1% level (Table 6.6). These findings indicate that the model is valid.

4.3.2 Significant contribution of age to the farmers' adoption of drought tolerance rice variety

From Logistic Regression, it was concluded that the contribution of age to the farmers adoption of drought tolerance rice variety was measured by the testing the following null hypothesis;

"There is no influence of age on adoption of drought tolerance rice variety"

The p-value of independent variable age for adoption of drought tolerance rice variety is 0.088 which is significant at 10% level of significance that means we will reject the null hypothesis. The co-efficient of the age was -0.051 which indicates that age had a negative significant relationship with adoption of drought tolerance rice variety at 10% level of significance ($p<0.1$). The marginal effect indicates that 1 year additional age will decrease the likelihood of adoption by 0.007%.

4.3.3 Significant contribution of experience to the farmers' adoption of drought tolerance rice variety

From Logistic Regression, it was concluded that the contribution of experience to the farmers adoption of drought tolerance rice variety was measured by the testing the following null hypothesis;

"There is no influence of experience on adoption of drought tolerance rice variety"

The p-value of independent variable experience for adoption of drought tolerance rice variety is 0.09 which is significant at 10% level of significance that means we will reject the null hypothesis. The co-efficient of the experience was 0.053 which indicates that experience had a positive significant relationship with adoption of drought tolerance rice variety at 10% level of significance ($p<0.1$). Selvaraj et al. 2010 and Meenakshi et al., 2015 found the similar result. The marginal effect indicates that 1-year additional experience will increase the likelihood of adoption by 0.008%.

4.3.4 Significant contribution of training on drought tolerance rice variety to the farmers' adoption of drought tolerance rice variety

From Logistic Regression, it was concluded that the contribution of training on drought tolerance rice variety to the farmers adoption of drought tolerance rice variety was measured by the testing the following null hypothesis;

"There is no influence of training on drought tolerance rice variety on adoption of drought tolerance rice variety"

The p-value of independent variable training on drought tolerance rice variety for adoption of drought tolerance rice variety is 0.002 which is significant at 1% level of significance that means we will reject the null hypothesis. The co-efficient of the training on drought tolerance rice variety was 2.792 which indicates that training on drought tolerance rice variety had a

positive significant relationship with adoption of drought tolerance rice variety at 1% level of significance ($p<0.1$). Rahman et al. 2022 found the similar result. The marginal effect indicates that, while maintaining all other factors equal, the projected likelihood of adoption improves by 0.403 when the training ondrought tolerance rice variety is changed from 0 to 1.

4.3.5 Significant contribution of extension contact to the farmers' adoption of drought tolerance rice variety

From Logistic Regression, it was concluded that the contribution of extension contact to the farmers adoption of drought tolerance rice variety was measured by the testing the following null hypothesis;

"There is no influence of extension contact on adoption of drought tolerance rice variety"

The p-value of independent variable extension contact for adoption of drought tolerance rice variety is 0.001 which is significant at 1% level of significance that means we will reject the null hypothesis. The co-efficient of the extension contact was 2.906 which indicates that extension contact had a positive significant relationship with adoption of drought tolerance rice variety at 1% level of significance ($p<0.1$). Meenakshi et al., 2015 and Sultana et al. 2021 found the similar result. The marginal effect indicates that, while maintaining all other factors equal, the projected likelihood of adoption improves by 0.419 when the extension contact is changed from 0 to 1.

4.3.6 Significant contribution of knowledge of drought tolerance rice variety to the farmers' adoption of drought tolerance rice variety

From Logistic Regression, it was concluded that the contribution of knowledge of drought tolerance rice variety to the farmers adoption of drought tolerance rice variety was measured by the testing the following null hypothesis;

"There is no influence of knowledge of drought tolerance rice variety on adoption of drought tolerance rice variety"

The p-value of independent variable knowledge of drought tolerance rice variety for adoption of drought tolerance rice variety is 0.011 which is significant at 5% level of significance that means we will reject the null hypothesis. The co-efficient of the knowledge of drought tolerance rice variety was 1.536 which indicates that knowledge of drought tolerance rice variety had a positive significant relationship with adoption of drought tolerance rice variety at 5% level of significance ($p<0.1$). Nasim et al. 2019 found the similar result. The marginal effect indicates that, while maintaining all other factors equal, the projected likelihood of adoption improves by 0.221 when the knowledge of drought tolerance rice variety is changed from 0 to 1.

4.4 Comparison of The Livelihood Status Adopter and Non-Adopter of Drought Tolerance Rice Varieties Growers

Table 4.11 represents the comparative livelihood status of adopter and non-adopter of drought tolerance rice varieties growers. The overall livelihood index for drought tolerance rice varieties growers (0.62) was higher for non-adopter compared to adopter (0.61).

Human Capital

The index value of human capital for non-adopter (0.85) was higher than adopter (0.71) of drought tolerance rice varieties growers. A larger difference found in skill development programme attendant. The index value of access to health and child schooling was nearly similar for both adopter and non-adopter of drought tolerance rice varieties growers (Table 4.11).

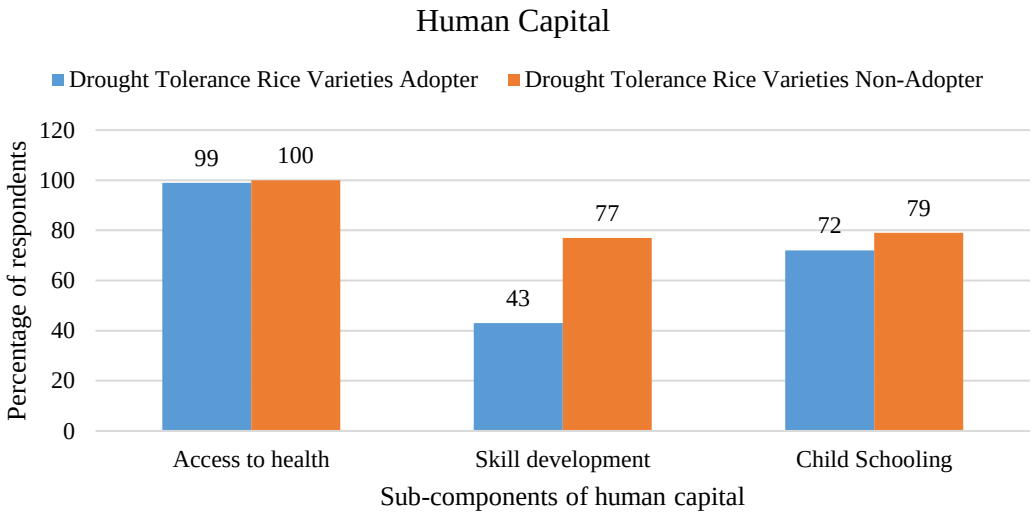

Figure 4.1: Comparison of human capital subcomponents status adopter and non-adopter of drought tolerance rice varieties

Three subcomponents were identified to compare human capital status adopter and non-adopter of drought tolerance rice varieties growers (Fig. 4.1). A higher index value denotes a relatively higher livelihood status. Among the subcomponents, access to health care showed the maximum variation, followed by child schooling and skill development. 99% of respondents had access to health and 72% had access to child schooling for drought tolerance rice varieties adopter. However, these subcomponents were higher to 100% and 79% for drought tolerance rice varieties non-adopter.

Natural Capital

The index value of natural capital for adopter (0.86) and non-adopter (0.88) of drought tolerance rice varieties growers was nearly similar. The index value of subcomponents: safe drinking sources and cropland land ownership also nearly similar for both adopter and non-adopter of drought tolerance rice varieties growers (Table 4.11).

Two subcomponents were identified to compare natural capital status adopter and non-adopter of drought tolerance rice varieties growers (Fig. 4.2). A higher index value denotes a relatively higher livelihood status. 97% of respondents had safe drinking sources and 79% had cropland ownership for drought tolerance rice varieties adopter. However, these subcomponents were lower to 96% and 77% for drought tolerance rice varieties non-adopter.

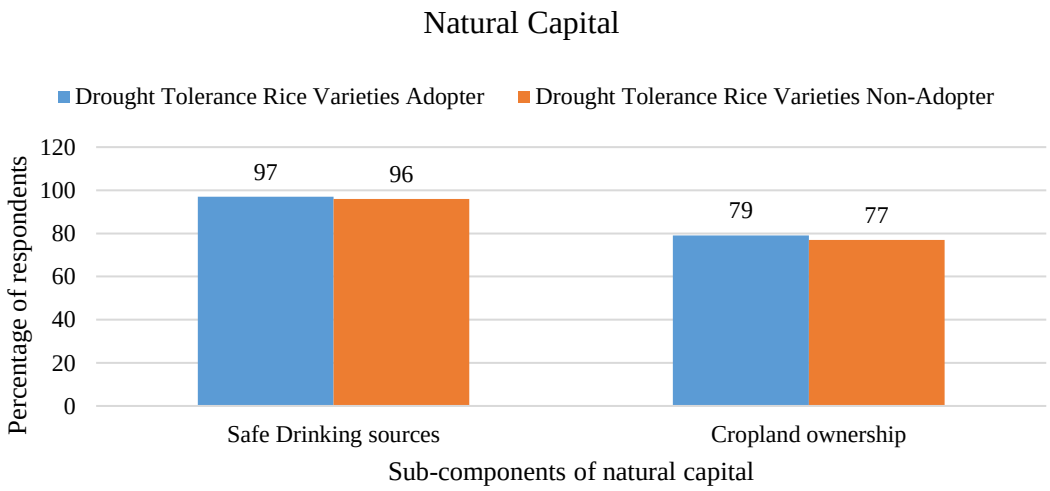

Figure 4.2: Comparison of natural capital subcomponents status adopter and non-adopter of drought tolerance rice varieties

Table 4.11: Livelihood status of drought tolerance rice verities growers

Sub-components	Values of Subcomponents		Major Capitals	Value of Major Capitals	
	Drought Tolerance Rice Varieties Adopter	Drought Tolerance Rice Varieties Non-Adopter		Drought Tolerance Rice Varieties Adopter	Drought Tolerance Rice Varieties Non-Adopter
Access to health	0.99	1	Human Capital	0.71	0.85
Skill development	0.43	0.77			
Child Schooling	0.72	0.79			
Safe drinking sources	0.97	0.96	Natural Capital	0.88	0.86
Cropland ownership	0.79	0.77			
Seek help from leader	0.36	0.50	Social Capital	0.24	0.29
Allow women working outside	0.13	0.09			
House ownership	1	1	Physical Capital	0.92	0.87
Transportation ownership	0.85	0.74			
Service income	0.25	0.26	Financial Capital	0.36	0.30
Savings	0.42	0.32			
Business income	0.42	0.32			
Overall Livelihood Index					
Drought Tolerance Rice Varieties Adopter		0.61			
Drought Tolerance Rice Varieties Non-Adopter		0.62			

Social Capital

The index value of natural capital for adopter (0.24) and non-adopter (0.29) of drought tolerance rice varieties growers was nearly similar. A larger difference found in seeking help from leader. The index value of allow women working outside was nearly similar for both adopter and non-adopter of drought tolerance rice varieties growers (Table 4.11). Two subcomponents were identified to compare social capital status adopter and non-adopter of drought tolerance rice varieties growers (Fig. 4.3). A higher index value denotes a relatively higher livelihood status. 36% of respondents seek help from leader and 13% allowed women working outside for drought tolerance rice varieties adopter. However, these subcomponents were 50% and 9% for drought tolerance rice varieties non-adopter.

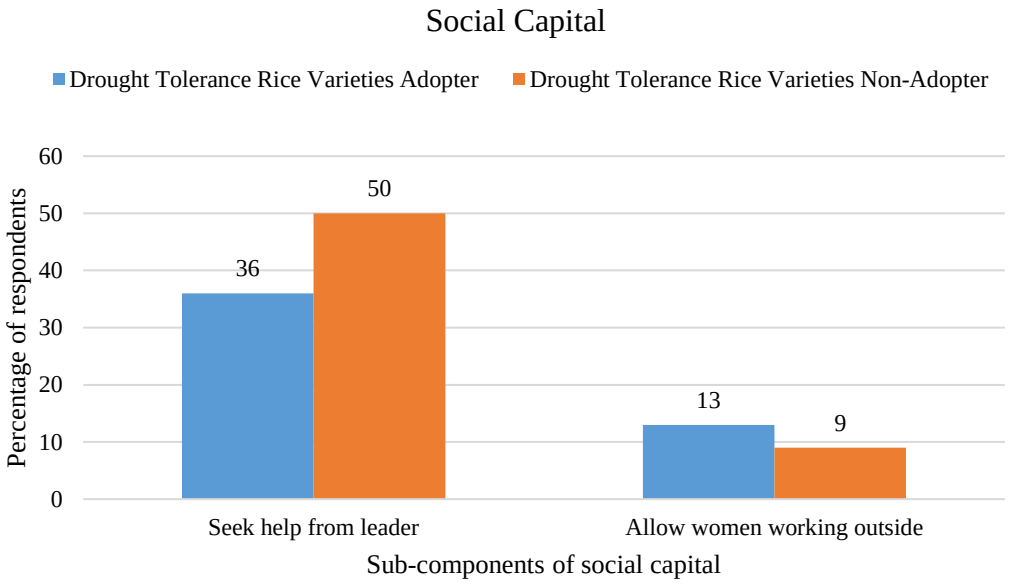

Figure 4.3: Comparison of social capital subcomponents status adopter and non-adopter of drought tolerance rice varieties.

Physical Capital

The index value of physical capital for adopter (0.92) and non-adopter (0.87) of drought tolerance rice varieties growers was nearly similar. The index value of subcomponents: house ownership and transportation ownership were nearly similar for both adopter and non-adopter of drought tolerance rice varieties growers (Table 4.11).

Two subcomponents were identified to compare physical capital status adopter and non-adopter of drought tolerance rice varieties growers (Fig. 4.4). A higher index value denotes a relatively higher livelihood status. 100% of respondents had house ownership and 85% had transportation ownership for drought tolerance rice varieties adopter.

However, these subcomponents were 100% and 74% for drought tolerance rice varieties non-adopter.

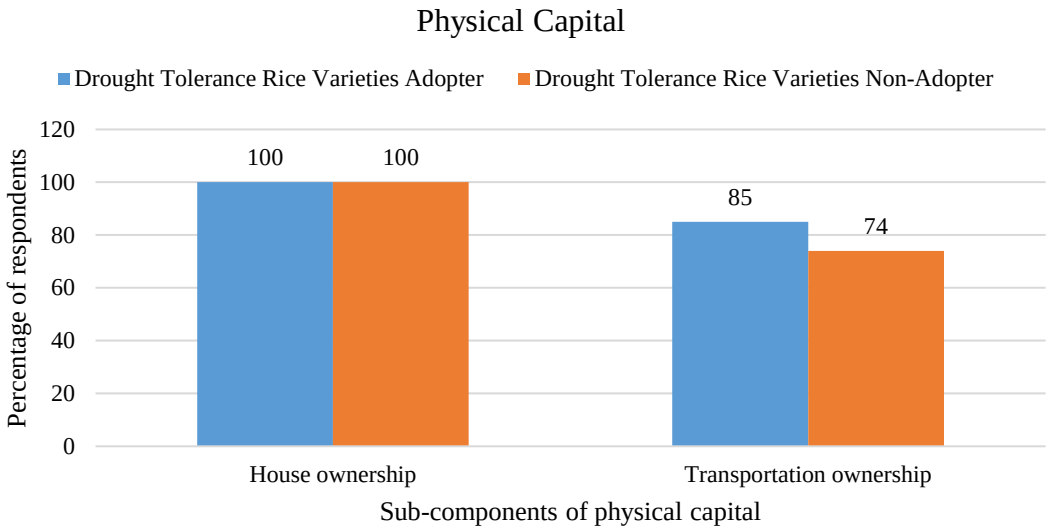

Figure 4.4: Comparison of natural physical subcomponents status adopter and non-adopter of drought tolerance rice varieties

Financial Capital

The index value of physical capital for adopter (0.36) and non-adopter (0.87) of drought tolerance rice varieties growers was nearly similar. A larger difference found in savings and business income. The index value of service income was nearly similar for both adopter and non-adopter of drought tolerance rice varieties growers (Table 4.11).

Three subcomponents were identified to compare financial capital status adopter and non-adopter of drought tolerance rice varieties growers (Fig. 4.5). A higher index value denotes a relatively higher livelihood status. Among the subcomponents, service income showed the maximum variation. 25% of respondents had service income for drought tolerance rice varieties adopter. However, this subcomponent was higher to 26% for drought tolerance rice varieties non-adopter.

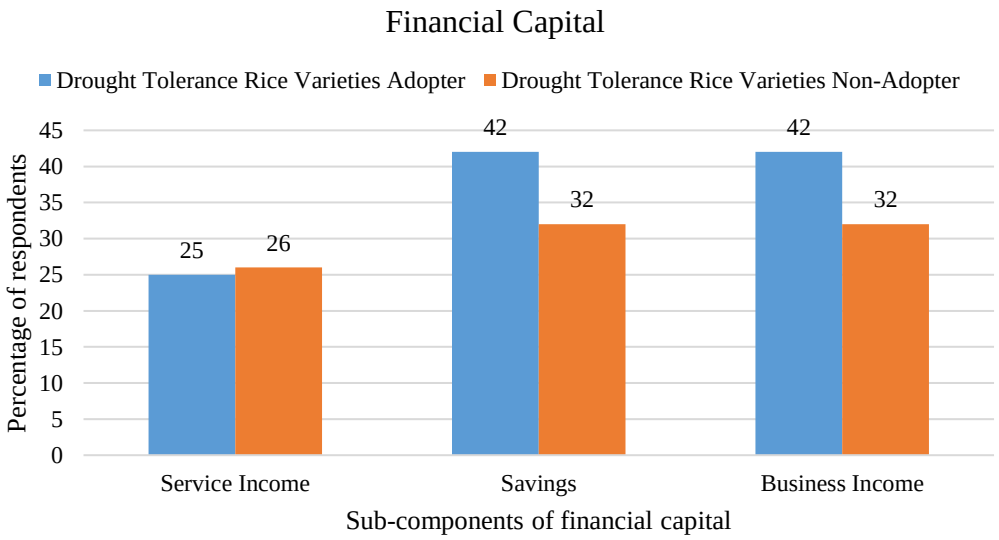

Figure 4.5: Comparison of financial capital subcomponents status adopter and non-adopter of drought tolerance rice varieties

Among the five major livelihood components, the human, and social capital was higher for non-adopter compared to adopter of drought tolerance rice varieties growers. And on the other hand, natural, physical and financial capital was higher for adopter compared to non-adopter of drought tolerance rice varieties growers (Table 4.11).

4.5 Summary

The rice farmers' socioeconomic position is depicted in this section as well as their adoption capacity and various sources which affecting AC in the study area. This study finds out five sources (age, education, farm size, rice farming experience, training, knowledge) that affects adoption and livelihood in drought areas of Rajshahi and Nator in Bangladesh.

4.6 Discussion

This section summarizes the research findings based on the study objectives: assessing the farmers' socioeconomic situation, determine the adoption of rice varieties and livelihood status between adopter and non-adopter.

Socio Economic Status of Rice Farmers

As a method of improving lives, a considerable sum of Bangladesh's rural farmers are presently active in rice production. In Rajshahi and Natore distrct rice cultivation has great prospect because there are large low-lying areas of artificial water bodies where water taken place around several of the month in the year, that remains nice potentiality in irrigation of rice through higher production and management.

The above study shows that most of the farmers were above 50 years aged. This age group is significantly impact on rice cultivation with drought tolerance capability. Education status shows that majority of farmers were educated in both adopter (71.64%) and non-adopter

(71.70%) of drought tolerance rice variety. From farmers family size, about half of the farmers had small family size in both adopter (47.76%) and non-adopter (50.94%) of drought tolerance rice variety. Farm size of the farmers shows that 67.16% adopters had small farm size and 64.15% non-adopters had small farm size. In terms of agricultural credit access, majority farmers had no access to agricultural access in both drought tolerance rice variety adopter (55.22%) and non-adopter (54.72%). Membership status of social organization by the respondents shows that majority households had membership of any cooperative societies in in both drought tolerance rice variety adopter (56.72%) and non-adopter (62.26%). Most of the farmers had low training om drought tolerance rice variety in both drought tolerance rice variety adopter (83.58%) and non-adopter (79.25%). Most of the farmers (41.79%) had high level experience for drought tolerance rice variety adopter and on the other hand 49.06% non-adopters had low level experienced in the study area. It is evident from the farmers income that drought tolerance rice variety adopter had higher income (Tk. 258344.78) and savings (Tk. 176984.93) than non-adopter income (Tk. 205886.79) and savings (Tk. 127725.50) in the study area.

Factor Affecting Adoption of Drought Tolerance Rice Varieties

The Binary Logistic Regression Model (BLRM) was applied to investigate the factors affecting adoption of drought tolerance rice varieties.

Eight different independent variables against adoption of drought tolerance rice varieties had shown in the empirical model, which were: age, education, farm size, experience, training, training on drought tolerance rice variety, extension contact and knowledge of drought tolerance rice variety. Among them five factors had been found after the analysis. Experience, training on drought tolerance rice variety, extension contact and knowledge of drought tolerance rice variety had a positive impact on adoption of drought tolerance rice varieties and age had a negative impact on adoption of drought tolerance rice varieties. Selvaraj et al. 2010, Meenakshi et al., 2015, Rahman et al. 2022, Sultana et al. 2021, and Nasim et al. 2019 found similar result in their study.

Comparison of the Livelihood Status Adopter And Non-Adopter of Drought Tolerance Rice Varieties Growers

Among the five major livelihood components, the human, and social capital was higher for non-adopter compared to adopter of drought tolerance rice varieties growers. And on the other hand, natural, physical and financial capital was higher for adopter compared to non-adopter of drought tolerance rice varieties growers.

4.7Chapter summary

The discussion in the preceding chapter is according to the study's empirical findings. This findings on rice farmers' socioeconomic status and this results on adoption capacity and various sources which affecting AC and comparison livelihood status between adopter and non-adopter in the study area is discusses in this chapter.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Chapter Overview

Based on the empirical findings after analysis of data in previous chapter, this section shows whole study summarization, study conclusion, and its recommendation.

5.2 SUMMARY

The economic condition of Bangladesh is steadily growing towards development at a low to medium motion where agricultural crop centered on different drought prone areas; drought areas have been neglected for a long time which can be considered as a major obstacle to national development. Drought represents a large part of the infrastructural development of Bangladesh, therefore it is difficult to expect overall progress of the country without the development of these regions. On the other hand, the drought zones of Rajshahi and Nator covers a huge population which demands special vision and development. Some long-term plans can be adopted in the context of development of this particular region, keeping in view the challenges of temperature change.

Different identities of socio-economic such as age, religion, sex, marital status, education, farming status, years and experiences of farming greatly effect on AC (Adoption Capacity) of farmers. Additionally, Literature explained different factors that affect farmer efficiency of production. However, most studies considered AC of different agricultural commodities such as crop, livestock, fisheries, poultry; and very few studies considered to AC of rice on the drought areas. Moreover, researcher consider crop sectors on drought areas as to examine AC in Bangladesh; whereas an important improving sector, rice production are founded less considerable in several drought based research in Bangladesh. From the above literature, it implies that this is a crucial sector which affect AC of farmers and overall economy of Bangladesh.

The lesson exercised on 120 selected rice farmers from two Districts of Rajshahi and Nator district. A structured questionnaires were applied to gather information. The binary logistic approach was applied to evaluate AC, on the other hand, the Logistic regression model was applied to evaluate the sources that impact AC. Socioeconomic factors with variety have been shown to have an impact on technologies to AC such as Farmers' age, degree of education, sex distribution, marital status, religion, farming status, major purpose for rice producing, years of producing, land ownership pattern, and cooperative participation are all factors to consider.The researcher aim was assessing rice farmers' AC in the Rajshahi and Nator drought zones.

The first objective was identifying the rice farmer's socio-economic status in these area. This work found that most of the farmers are belonged to 50 years age group, where 28.36% adopter and 28.30 non-adopter farmers are illiterate. Respondents had primary level of education at 25.37% to 28.30% (Adopter to Non-Adopter) on rice cultivation. All farmers of this area were

Muslim and cultivated their own land as a full time farmers. Most of the farmers producing rice for extra income and they were not a member of any cooperatives.

The second objective was calculating the farmers' AC of rice cultivating in study zones. The key productivity drivers were found to be the number of harvesting ($p<0.1$). Most of the farmers were functioning at a high degree of AC. Whereas, rice production was shown to be positively correlated with the number of varieties produced, but negatively correlated with the cost of immunization and housing. The output from rice cultivation was influenced by other related inputs. It was directly connected to the majority of these parameters. Rice productivity, for example, is directly related to labor and seed costs.

The third goal of researcher was investigating the sources of livelihood of rice farmers' comparing adopter and non-adopter in Rajshahi and Nator. Respondent age, marital status, education, experience, credit access have direct impact on how they maintain their livelihood. Among this factors marital status, education, experience, credit access of the respondents significantly effect on AC at a positive rate however increase of respondent's age cause to decrease AC. In case of rice productivity respondent marital status, education, experience, credit access have positive significant relationship with it. These factors also have positive significant relation with farm output and farmer long term efficiency. Education, experiences, and access of low cost credit increase the possibility to cope with advantage technologies and taking risk for improve production. The comparative livelihood status of adopter and non-adopter of drought tolerance rice varieties growers on livelihood index for drought tolerance rice varieties growers (0.62) was higher for non-adopter compared to adopter (0.61).

Finally this study characterized the rice farmers of drought area, calculated their adoption capacity and identified decisive variables for rice harvesting at drought zones of Rajshahi and Nator. Future improvement is on rice production in drought area so much dependent on the opinions of rural rice producing farmers. Farmer's opinions on socio economic condition on drought areas can help to improve the position of farmer's livelihood. It may suggest improving the factors which directly affects the farmer socio economic status on the drought area.

5.3 CONCLUSION

Agriculture is a key component of Bangladesh's economy, which is now developing at a slow to medium pace. However, the country's overall development is significantly hampered by the neglect of areas that are prone to drought, particularly in the Rajshahi and Nator regions, where a sizable population requires special development and attention. According to a study conducted with 120 rice farmers in the area, both those who adopted drought-tolerant rice varieties and those who didn't were equally educated and most of them were 50 years of age or older. Both groups' farms were typically small in size, and the majority of farmers lacked access to agricultural credit. While social organization participation was high, little training was provided on how to grow rice that is drought-tolerant. The adoption of drought-tolerant rice varieties was impacted by five key variables identified by binary logistic regression analysis: experience, training on drought-tolerant rice varieties, extension contacts, and knowledge of drought-tolerant rice varieties all had a positive impact, while age had a negative impact. Adopters had higher natural, physical, and financial capital whereas non-adopters1 had higher human and social capital. The results imply that training and extension programs should be strengthened, and loan access for farmers should be extended, in order to encourage the adoption of rice varieties resistant to drought in the area. Additionally, initiatives should be taken to improve the economic circumstances in the regions that are prone to drought because they are essential to the nation's overall development.

5.4 RECOMMENDATIONS

In order to enhance rice farmers' adoption capacity against various backdrop from finding of the study, the following are recommended:

1. Improve access to education for rice farmers is important. Many rice farmers argued that they cannot get adequate information at reasonable price at reasonable time. This arguement should be eliminated.

2. Provide access to low-cost credit for rice farmers because credits and loan facilities should be made available to the farmers with lowest rate of interest to overcome different problems of inadequacy of capital. This will maximize their potential of rice producing as well as enhance their secured nutrition contribution.

3. The farmer should be gained knowledge about proper care of seed and timely management of inputs and other related services. They should be encouraged to form cooperative societies so that they can jointly tackle the constraints limiting their full involvement in rice production.

4. The extension officer at Upazila level should take some steps regarding the development of the rice farmer's harvesting systems through training program and implementation of different administrative and institutional projects being significant ideas towards development of the drought area regarding the improve rice production with timely accessibility of credit.

5. The promotion of the use of sustainable agricultural practices for proper price of agricultural output produced from the rice farmers should be ensured.

5.5 Chapter Summary:

The study's overall summary, its conclusion and recommendation is included on this section.

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APPENDICES

Dept. of Management and Finance

Sher-e-Bangla Agricultural University

Interview Schedule

"Livelihood and Adoption determinants of the smallholder drought tolerant rice varieties growers in northern (Rajshahi and Natore) Bangladesh''

Sample no.: ----------

1. **General information:**

Name: …… Upazila: ……

Village: ……. District: …….

Contact No: ……..

2. **Respondents profile:**

Sl#	Relationship	Age (yrs)	Education (yrs)	Main occupation*	Family size	Working people
1	Self					
2	Spouse					

*Occupation code: 1 =Agriculture, 2= service, 3=business, 4= unemployed, 5=others

3. **Farm Size:**

Land type	Area (ha)
Own cultivated land	
Sharecrop out	
Sharecrop in	
Lease out	
Lease in	

Homestead	
Pond	
Area under rice cultivation	
Production (Kg)	
Area under drought tolerant rice cultivation	
Production (Kg)	
Name of drought tolerant rice variety	

4. **Do you ever heard (aware) about drought tolerant rice variety?** Yes (1) / No (0) If yes, from where: …….

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

Questions	YES (1)	NO (0)	If yes	
			times	Total days
a. Have you received any agriculture related training?				
b. Did you visited extension office/SAAO for advice?				
c. Have you received any training on drought tolerant rice cultivation?				
d. Did you visit extension office/SAAO for advice related with drought tolerant rice cultivation?				
e. Are you confident about SAAO advice?				
f. Do you think drought tolerant rice varieties 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. Did you experience any health-related issues which hamper your activity?				
k. Did you experience any labour crisis to work in your field?				
l. Do you receive climate related information?				
m. Are you a member of IPM club?				
n. Is there any climate field school in your village/upazila?				
n. Are you a member of climate field school?				
o. Do you have electricity in your house?				
p. Do you have pacca road in your village?				
q. Do you use mobile phone to receive rice cultivation related information?				
r. Do you watch rice/agricultural related TV show?				
s. How many months in a year you can consume from your own production? (months)				
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. Your total experience in agriculture (years).				
x. How long you are cultivation drought tolerant rice variety? yrs				
y. Housing condition of the respondent.**				
z. Severity of extreme events like drought in your upazila.***				

Code: **House condition: 1 building, 2 tin shed, 3 others; ***Events: 3 extreme severe, 2 moderate, 1 low, 0 none

6. Annual Income

	Source of income	Income (Tk.)		Source of income	Income (Tk.)
a. Agricultural	Rice		b. Non agricultural	Service	
	Wheat			Business	
	Fruits and vegetables			Remittance	
	Livestock and poultry			Others (if any)	
	Fisheries				
	others				

7. Annual expenditure:

Sources	unit	Expenditure
a. Consumption expenditure		
Food	Weekly	
b. Non consumption expenditure		
Housing	Year	
Cloths	Year	
Education	Yearly	
Medical	Yearly	
Festivals	Yearly	

Livelihood related information (Yes =1, No=0)

8. Human capital

Access to health facilities: YES / NO

How many skill development programmes you attended in last one year: …….

Do your family send children in school: YES / NO

9. Natural capital

Do your family have safe drinking water sources? YES / NO

Do you have own crop land? YES / NO

10. Social capital

Have you or someone in your family gone to your community leader for help? YES / NO

Do you allow women member work outside home? YES / NO

11. Physical capital

Do you have own house? YES / NO

Do you have own transportation (motor cycle/bicycle/boat)? YES / NO

12. Financial capital

a) Do you have income source from service? YES / NO

b) Do you have saving? YES / NO

c) Do you have any business income? YES / NO

13. Food issues

a) Does any member of your family include in social safety net programmes? YES / NO

14. Problems and suggestion regarding drought tolerant rice variety cultivation. <u>a. Problems</u>

i ……

ii…….

iii……....

<u>b. Suggestions for future development</u>

i……..……

ii……

Thanks for your kind co-operation