EFFECTIVENESS OF CLIMATE-RESILIENT ADAPTATION STRATEGIES IN SALINE-PRONE AREAS OF BANGLADESH

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MS Thesis

Department of Agricultural Extension Education
Bangladesh Agricultural University
Mymensingh

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A Thesis

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ABBREVIATIONS AND ACRONYMS

AAS	:	Agriculture Advisory Society
BARI	:	Bangladesh Agricultural Research Institute
BDT	:	Bangladeshi taka
BCAS	:	Bangladesh Centre for Advance Studies
BBS:	:	Bangladesh Bureau of Statistics
BINA	:	Bangladesh Institute of Nuclear Agriculture
BRRI	:	Bangladesh Rice Research Institute
CCDB	:	Christian Commission for Development in Bangladesh
GDP	:	Gross Domestic Product
GO	:	Government Organization
IPCC	:	Intergovernmental Panel on Climate Change
MoA	:	Ministry of Agriculture
MoP	:	Ministry of Planning
NGO	:	Non-Government Organization
NOAA	:	National Oceanic and Atmospheric Administration
SD	:	Standard Deviation
SPSS	:	Statistical Package for Social Sciences
WAPDA	:	Water and Power Development Authority

EFFECTIVENESS OF CLIMATE-RESILIENT ADAPTATION STRATEGIES IN SALINE-PRONE AREAS OF BANGLADESH

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ABSTRACT

Adaptation is required to reduce climate-induced vulnerability and it can successfully reduce negative effects by enhancing crop production outcomes. The main purpose of this research study was to determine the effectiveness of climate-resilient adaptation strategies. The study was conducted at Patharghata Upazila of Barguna district and Morrelganj Upazila of Bagerhat district in Bangladesh. The population size was 167 and sample size was 83 respondents in Patharghata and the population size was 134 and sample size was 67 respondents in Morrelganj. A structured interview schedule was used for data collection using a face to face survey method. The data were collected during 22nd March to 1st April 2022 in Patharghata and 9th May to 15th May in Morrelganj. Findings showed that majority 67.47% of the respondents in Patharghata and and 55.22% of the respondents in Morrelganj mentioned that all climate-resilient adaptation strategies including salt tolerant rice seed, homestead gardening, training on coping with climate change, vermi-compost, and irrigation effectiveness were less than average effective. From the regression analysis it was found that level of education, extension media contact, support received from GO and NGOs had positive significant contribution and some positive reasons had positive significant contribution on the effectiveness of climate-resilient adaptation strategies. The findings emphasize the importance of having a thorough understanding of the consequences of an adaptation strategy before implementing it.

CHAPTER I

INTRODUCTION

1.1 Background of the Study

Bangladesh is a deltaic country situated between the Himalayan Mountains in the north and the Bay of Bengal in the South. Because of its geographical position, there is little doubt that Bangladesh is likely to be one of the worst affected nations in the world due to climate change (Eckstein et al., 2014). The country has been facing prolonged and repeated floods in the northern and central regions, severe cyclones, salinity increase in coastal areas, erratic rainfall, and drought in the northwest region (BCAS, 2018). The country has faced devastating Sidr in November 2007, Nargis in May 2008, Aila in April 2009, and Mahasen in May 2013, a series of floods in 2004, 2007 and 2009 (Sutradhar et al., 2015).

Bangladesh is very susceptible to the effects of climate change, in part because it is a low-lying and relatively flat country. Among the consequences: riverine flooding and sea-level rise are quite common. In addition, the confluence of the Ganges, the Brahmaputra, and the Meghna creates a vast amount of soil erosion in the country resulting in the permanent loss of currently productive agricultural land (Sikder & Xiaoying, 2014). On the other hand, recent research has shown that salt intrusion is rapidly increasing in the coastal region of Bangladesh. It is reported that salt-water intrusion has increased up to 15 km north of the coast because of sea-level rise from 2000 to 2009. However, in the dry season, it reaches up to 160 km inland on account of reduced upstream river flows (Hossain et al., 2018). Climate change affects all aspects of agriculture including production, distribution, access to food and food prices (IPCC, 2014). The overall climate change continues to pose a global food security risk (Tai et al., 2014). Bangladesh agriculture is also experiencing the same, which is really a big threat for attaining food security for the growing population of the country at

present and in upcoming days because Bangladesh agriculture plays a vital role in maintaining the livelihoods of its population (Hossain et al., 2019).

The sub-sectors of agriculture are susceptible to the effects of climate change, which will have an enormous impact on harvest and efficiency of the agricultural system (IPCC, 2014; Arshad et al., 2018). Moreover, extreme climatic events like soil salinity in coastal areas and incidence of pests and diseases may result in additional adverse effects on the agriculture sector (Hossain et al., 2018). Despite technological advancement, the climate is still a fundamental determinant of agricultural productivity where temperature and rainfall function as primary drivers of crop production (Wheeler & Von Braun, 2013).

The rural communities of Bangladesh are completely dependent on nature, and specifically those that are geographically, socially, and economically disadvantaged and face great risk of climate change (Islam & Nursey, 2017). Adaptation is essential to reduce this climate induced vulnerability (Stern, 2007) and adaptation can successfully reduce the negative impacts by enhancing positive outcomes in crop production (Wheeler et al., 2013). Under these circumstances, adaptation is one of the best possible choices to manage the climate change impacts for a country like Bangladesh (Saha et al., 2016).

The major adaptation strategies for the coastal region of Bangladesh are like salt tolerant crop variety, salt tolerant rice varieties, vermi-compost and so on. For example, one of the salt tolerant rice cultivars is Binadhan-8 which can resist salinity levels of 8–12 dS/m (Sinha et al., 2014). BRRI has developed 10 more salt-tolerant rice varieties in the last 15 years. Two new salinity tolerant varieties BRRI Dhan-97 and BRRI Dhan-99 have been developed for the latest Boro season. These two varieties can tolerate salt 14 dS/m in seeding time and full life circle it can tolerate from 8-10 dS/m which has been a pleasant surprise for the farmers of Bangladesh (Rabbani et al., 2015).

1.2 Statement of the Research Problem

Bangladesh is one of the most exposed nations in the world, which is prone to natural disaster and climate change is making them more severe (Sikder &

Xiaoying, 2014). Climate-related extreme events such as floods, droughts, cyclones, sea-level rise, salinity, and soil erosion are all signs of climate change in Bangladesh (Hossain and Deb, 2011). Increasing temperatures, unpredictable precipitation, drought, and cyclones are negatively impacting all the agricultural sectors in our country (Alauddin & Sarker, 2013). Agriculture is fundamental for Bangladesh to sustain its population's livelihoods (Alam et al., 2017). The agricultural sector constitutes 19.29% of its GDP and 47.5% of all employment in Bangladesh (MoA, 2014). However, small-scale farmers in developing countries like Bangladesh are most likely to be affected by climate change because they depend so much on farming to make a living (Huq et al., 2015)

To assuring multigenerational balance and sustainable development, farmers must take efforts to reduce and manage climate change risks (Islam & Nursey, 2017). Climate change has forced farmers to shift from conventional agricultural practices to modern climate-resilient agricultural practices including diversifying crops, sowing drought, and heat tolerant varieties, taking care of the soil and harvesting rainwater for food security (Altieri & Nicholls, 2017). Adaptation measures are essential in enabling crop production to continue providing high yields, thereby enhancing food security (Dow et al., 2013). Adaptation is a process of adjustment to actual or expected climate and its effects (IPCC 2014).

The Christian Commission for Development in Bangladesh (CCDB) is a National NGO established in 1973 and they set up a dedicated Climate Change Program in 2009. The program aims to create a climate-sensitive and resilient society. CCDB emphasizes knowledge generation and sharing, climate learning and education, innovation of climate solutions, technology demonstration and dissemination, capacity development, and community resilient building. The program is working in five districts Satkhira, Bagerhat, Barguna, Naogaon, and Gazipur.

They introduced several climate-resilient adaptation strategies to the people of their working areas. Among them, we select five adaptation strategies, including salt tolerant rice seed, homestead gardening, training on coping with climate change, vermi-compost, and irrigation. Against flood, drought, and salinity, agriculture has developed several effective adaptation strategies. In Bangladesh,

more than one million farmers produce salt-tolerant rice cultivars such as Binadhan-8, Binadhan-10, BRRI dhan47, and BRRI dhan55.

In the *Boro* season, farmers in the Satkhira, Khulna and Bagerhat districts of the southwest coastal region have cultivated Binadhan-8 and Binadhan-10. These types have the capacity to survive up to 10-12ds/m of salt (Rahman et al., 2020).

Homestead gardening is a widely accepted activity in Bangladesh that is primarily managed by women which ensures food security and increased revenue by improving the living conditions of the poor (Sutradhar et al., 2015). Vermi-compost is also a good adaptation practice which enhances soil fertility and reduces the salinity of the soil (Sutradhar et al., 2015).Most studies of adaptation strategies have either focused on a small number of technical or economic goals or looked at adaptation approaches or designs instead of the larger social effects of strategies on the reasons that make people vulnerable (Kuhl et al., 2020).

However, we want to know the effectiveness of these climate-resilient adaptation strategies and the reasons that influence their effectiveness. Therefore, the overarching research question of this study was what is the effectiveness of CCDB-based climate strategies in the study area? Moreover, through this study I explored what are the major reasons, which influence the success of CCDB-based climate strategies in the research region. To achieve the overarching research question, the following specific research questions were formulated as:

a. What about the socio-economic profile of the farmers of the study areas?
b. What is the level of effectiveness of climate-resilient adaptation strategies in the study areas?
c. What are the reasons and to what extent do they explain the effectiveness of these sorts of climate-resilient adaptation strategies in the saline prone areas?
d. What are the reasons responsible for non-adoption of the selected climate-resilient adaptation strategies?

1.3 Objectives of the Study

The aim of this study was to determine the effectiveness of selected climate-resilient adaptation strategies. To attain the goal of this study, the following specific objectives were formulated:

a. to determine the socio-economic characteristics of the farmers of the saline prone areas,
b. to measure the effectiveness of climate-resilient adaptation strategies in the study areas,
c. to explore the reasons along with their level of contribution in explaining the effectiveness of climate-resilient adaptation strategies, and
d. to identify the reasons responsible for non-adoption of climate-resilient adaptation strategies by the farmers of the saline prone areas.

1.4 Scope and Significance of the Study

The warm and humid temperature conditions are favorable to the growth of numerous agricultural pests (Hossain et al., 2018). Evidence suggests that in coastal regions, farmers cannot use the land year-round due to rising salinity and sea-level rise, the cropping pattern in these regions is changing (Miah et al., 2020). Due to the rising frequency of natural disasters people in the coastal region cannot be steady because they lack potable water, a safe place to live, and a means of subsistence (Hallegatte et al., 2020).

The government and other non-governmental organizations take the required steps to assist the coastal peoples to provide agricultural solutions for adaptation. Agricultural solutions include technologies and training among many other things, to assist the population in adapting to these adverse circumstances. Since certain adaptation strategies are highly beneficial while others are not, it is necessary to evaluate their efficacy (Billah et al., 2015). This research deals with the climate change affected areas of Bangladesh. There by this research will help the policymakers to understand the best effective adaptation strategies. The research will assist us and farmers in determining the efficacy of adaptation measures.

This will assist policymakers in developing strategies to boost the income, food security, and well-being of respondents in response to climate change. It will also encourage concerned individuals to consider alternate solutions to adapt to the issues created by climate change.

1.5 Assumptions of the Study

The following assumptions were taken into consideration:

- The respondents answered all questions of the interview schedule appropriately.
- The researcher collected all data accurately.
- The CCDB office personnel including Upazila coordinator and field officer helped the researcher to collect the data effectively.
- The interviewers were able to rate the responses of the respondent farmers with adequate precision and the data were normally and independently being distributed.

1.6 Limitations of the Study

This study is for the fulfillment of the requirement of the MS in Agricultural Extension Education. It is explanatory in nature and the study covered two Upazila (Patharghata and Morrelganj) due to limited resources, time, and financial constraints. The findings will show the effectiveness of climate-resilient adaptation strategies and reasons those affect the effectiveness of the adaptation strategies in response to climate change in Patharghata and Morrelganj Upazila. Other limitations are as follows:

- Several data collecting methods, scales and statistical tests have been utilized in order to measure the effectiveness of the adaptation strategies over a relatively short period of time.
- The study was confined to the respondents of four villages namely Charlathimara and Padma villages under Patharghata Upazila in Barguna district and Sannyasi and Poshurbonia villages under Morrelganj Upazila in Bagerhat district.

- For information about the study, the researcher depended on the data furnished by the selected respondents during the interview with them. Therefore, the data of this study were self-reported and were not further validated.

1.7 Definitions of Important Terms

Certain key terms related to the investigation are defined below for clarity of understanding.

Adaptation: Adaptation is the physical or behavioral characteristic of an individual that helps that individual to survive better in the surrounding environment. In another way, adaptation is the act of changing something or changing one's behavior to make it suitable for a new purpose or situation (Owen, 2020)

Climate-resilient: Climate-resilient is defined as the "capacity of social, economic and ecosystems to cope with a hazardous event or trend or disturbance". This is done by "responding or reorganizing in ways that maintain their essential function, identity and structure (as well as biodiversity in case of ecosystems) while also maintaining the capacity for adaptation, learning, and transformation (Wikipedia, 2020).

Adaptation strategies: A strategy is a process of creating and implementing a service, or event that is specifically designed to bring about the desired change. Strategies related to agriculture can be termed adaptation strategies. Such as irrigation, watershed development, land reforms, agricultural extension, food processing, storage, etc. (Kuang et al., 2019).

Saline prone: Salinity is the degree of saltiness; the relative proportion of salt in a solution. The areas which are suspected of and in danger of salinity are called saline-prone areas. The saline-prone areas of Bangladesh are Khulna, Barisal, Patuakhali, Noakhali, Chittagong, Laxmipur, Feni, Satkhira, Pirajpur, Barguna, Bagerhat, Bhola, Cox's Bazar, Jessore, Magura, Narail, Faridpur, Gopalganj, and Jhalkati districts of the coastal and offshore lands (Jahan et al., 2022).

CHAPTER II

REVIEW OF LITERATURE

An attempt was made in this Chapter to represent a brief review of related research information to evaluate the perceived effectiveness of the climate-resilient adaptation strategies and reasons that affect the efficacy of those strategies in response to climate change under the district of Barguna and Bagerhat in Bangladesh. Since the review of literature forms a linkage between past and present research works related to problems that help an investigator to draw a satisfactory conclusion. A few research works on the climate-resilient adaptation strategies effectiveness in response to climate change have been reviewed according to the following sequences:

2.1 Impacts of Climate Change

NASA's definition of climate change says it is "a broad range of global phenomena created predominantly by burning fossil fuels, which add heat-trapping gasses to earth's atmosphere. These phenomena include not only the increased temperature trends described by global warming, but also encompass changes such as sea-level rise, ice mass loss in Greenland, Antarctica, the Arctic, and mountain glaciers worldwide causing extreme weather events." Bangladesh ranked fifth in the Ecumenical Climate Risk Index, a ranking of 170 countries that are most vulnerable to climate change (Kreft et al., 2013).

Climate change is the greatest danger that our Earth faces today with a warming planet that impacts various aspects which include the weather system, hydrology, ecology, and environment (Dike & Dike, 2018). Climate change refers to a fluctuation in the state of the climate that can be identified (e.g., utilizing statistical tests) by vicissitudes in the mean or the variability of its properties, which persists for an elongated period, typically decades or longer (Rahman & Lateh, 2017). In 2018, the US National Climate Assessment concluded that the "earth's climate is now transmuting quicker than at any point in the history of modern civilization, primarily as a result of human activities" (Jay et al., 2018).

The global warming due to the incrimination in greenhouse gas concentrations in the earth's atmosphere and the consequent sea level rise (SLR) are going to integrate fuel to the fire and virtually every socio economic sector in Bangladesh is liable to be affected by climate change (Selvaraju and Baas, 2007). Recent decades indicate that increased human activities that affected the composition of the global atmosphere led to significant changes in the global climate (IPCC, 2007). The amount of greenhouse gasses, such as methane, in the atmosphere (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) have grown by 150%, 40%, and 20%, respectively, since 1750 (IPCC, 2014). In 2014, the proportion of greenhouse gases increased to 36.14 billion metric tons from 22.15 billion tons kg in 1990 (Abeydeera et al., 2019). As illustrated in Figure 2.1 in 1959 CO_2 comprises the majority of greenhouse gasses (NOAA, 2020).

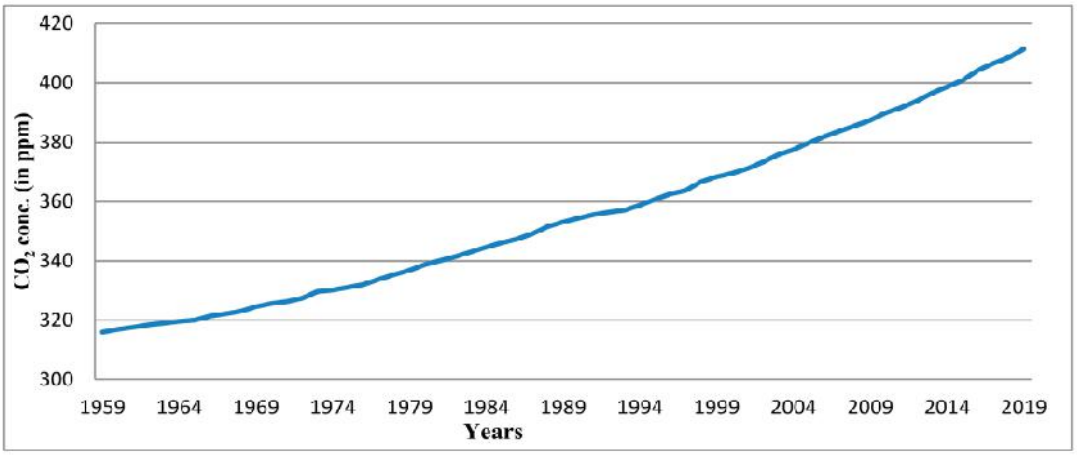

Figure 2.1 The increase in CO_2 concentration in the atmosphere (NOAA, 2020)

Over the last two decades, it has experienced multiple terrible climatic events, including droughts, river erosion, increasingly intense cyclonic activity, storm surges, saltwater inundation, hotter, drier summers, and escalating challenges to food production cycles and water security (Alam & Rahman, 2017). This geology, combined with river water from the melting Himalayan glaciers in the north and an encroaching Bay of Bengal in the south makes the region prone to severe flooding (Dastagir, 2015).

Some consequences of climate change in temperature and rainfall are that the average pace of global temperature increase has been ordinary since 1975, it has increased by 0.15–0.20 ^{0}C every decade, and it is anticipated to rise by 1.4–5.8 ^{0}C by 2021 (Malhi et al., 2021). The rainfall variability rises, water supply is a major concern in semi-arid and arid regions, and water harvesting, storage, and utilization strategies have the potential to mitigate some of the dangers associated with extended periods of little rainfall (Anderson et al., 2020).

2.2 Climate Change Adaptation

Adaptation refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. The main goals of climate change adaptation are to reduce vulnerability and build resilience to the impacts brought by climate change (IPCC, 2007). Adaptation is the process of adjustment to climate effects to moderate the negative impacts and (or) enhance the positive impacts of climate change (Fankhauser, 2016). Adaptation of land, crop, and livestock management practices to climate change involves a vast range of activities, including soil nutrient management, tillage intensity, crop selection, and rotation, water management, livestock selection, breeding outcomes, and agricultural diversification and intensification (Anderson et al., 2020).

Adaptation in the context of climate change developed its own definitions over time. Several types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (Haddad, 2005).

The causes of climate change are to be addressed through a drastic reduction in greenhouse gas emissions, and its consequences will be addressed through an equal emphasis on investment in climate adaptation (Fankhauser, 2016). The nomenclature around adaptation can be confusing and is worth clarifying up front. Literature in related disciplines, particularly the risk management field, often uses the term mitigation rather than adaptation to describe actions that reduce climatic risks.

The Intergovernmental Panel on Climate Change (IPCC) defines resilient as the ability of a system to anticipate, absorb, accommodate, or recover from a hazardous event (Field et al., 2012). Micro-economists who study climate change adaptation attempt to quantify the harm that climate change will inflict (and, consequently, its influence on the quality of life) on persons whose income, demography, and assets vary (e.g., those who own coastal real estate) and this strategy for exploring climate change adaptation adopts Gary Becker's research methodology 1993 (Kahn, 2020). In 1992 Gary Becker stated in his Nobel Prize speech that "The analysis assumes that individuals maximize welfare as they conceive it, whether they be selfish, altruistic, loyal, spiteful, or masochistic.

Their behavior is forward-looking, and it is also consistent over time. They try as best they can to anticipate the uncertain consequences of their actions. Forward-looking behavior, however, may still be rooted in the past, for the past can exert a long shadow on attitudes and values" (Kahn, 2020). In agriculture, a number of solutions are being investigated as a means of climate change adaptation. Agricultural diversification, livestock farming systems with diversified crops, utilizing various crop kinds, adjusting the planting, and harvesting schedules, types that are drought-resistant and high-yielding, water-stressed crops are examples of some adaptation strategies (Harun & Islam, 2007).

2.3 Climate Change Adaptation in Agricultural Sector

Numerous research works have found a multitude of adaptation practices on different developing world continents (Shaffril et al., 2018). These include on-farm practices– such as changing planting and/or harvesting times, cultivating resistant varieties, crop diversification, adopting agro-forestry, adjusting agrochemical use, adopting new soil and/or water management practices, and purchasing insurance and off or non-farm practices such as engaging in off-farm jobs or businesses, migration, and even reducing or exiting farming (Islam et al., 2021). Significant fears to farmers' agricultural productivity and incomes are posed by the recent increase in the frequency and severity of extreme climate events, as well as increases in the frequency and intensity of climate in the future (Bouwer, 2019).

Farmers can manage climate-related risk by purchasing insurance and redistributing income to maintain a predetermined level of income in risky states (Pascual et al., 2015). When crops are susceptible to such weather extremes, heavy rain or drought can result in significant production losses. To prevent these losses, farmers may adapt to changes in the climate by introducing fewer sensitive crops, investing in more robust agro-ecological management, or taking land out of production (Anderson et al., 2020).

The development of adaptation policies requires a better understanding of climate change perceptions, existing adaptation patterns and its key drivers despite a vast body of research from both developed and least-developed countries (Habtemariam et al., 2016). The net cereal production in South Asia is projected to decline between 4% and 10% by the end of the 21st century under the most conservative climate change scenario (Abid et al., 2019).

In 2009, agriculture directly accounted for 14% of global GHG emissions in CO_2 equivalents and indirectly accounted for an additional 17% of emissions when land use and conversion for crops and pasture were included in the calculations (IPCC, 2014). Climate change is expected to affect agricultural practices through changes in precipitation, temperature, carbon dioxide fertilization, climate variability and surface water runoff (Karimi et al., 2018).

The evidence about the impacts of climate change on natural and human systems is accumulating fast. This information comes from a wide number of sources, including farmers themselves. Farmers in many locations are experiencing quick changes in phenomena such as the customary start of the rainy season, planting dates, rainfall levels and patterns, and the frequency of extreme weather events (Kumar et al., 2018).

Until now, the majority of focus on adaptation in agriculture has been given on only improvements or development of adaptation practices that may enable better management of climate-related risks. The topic of transformational adaptation in agriculture has combined a large body of literature over the past decade (Mapfumo et al., 2017). Despite this, the term transformation in relation to adaptation remains unclear and has plural definitions (Vermeulen et al., 2018).

Bangladesh is more vulnerable to common and catastrophic climatic events, such as large variations in rainfall levels, harsh weather, droughts, and strong cyclones. These extreme climate-related challenges threaten agricultural production and occur every year in Bangladesh (Delaporte & Maurel, 2018). It is also causing havoc on the crop agriculture sector, notably rice production. In fact, if the exchange reduces agricultural GDP by 3.1% annually, a total of $36 billion in lost revenue will be incurred between 2005 and 2050 (MoEF, 2015). Climate change has already had an influence on people's lives and livelihoods in Bangladesh's coastal areas, as well as the drought and semi-arid regions (MoP, 2011). The effects of climate change on agriculture and other industries are already visible. In the agriculture sector, major yield reductions are most anticipated in future because of climate change (Sikder & Xiaoying, 2014).

Adaptation can successfully reduce negative consequences by improving positive outcomes in crop production, among other responses (Islam & Nursey, 2017). Since climate change has been visible in this country, the coastal agriculture industry has been undergoing a variety of adaptations. People have been adopting independent actions to defend their agricultural activities from natural and anthropogenic hazards. Furthermore, public knowledge of climate change and the necessity for adaptation measures has risen in recent years. The community knows what adaptation providers are doing and reacts to it (Saha et al., 2016). Coastal Bangladesh has focused on agricultural management, infrastructure development, disaster preparedness, recovery, and other ways to adapt (Saha et al., 2016). Some examples of agricultural adaptation in coastal areas are permanent raised beds which are both an innovative and common technique in Nashipur and Rajshahi. Watermelon, okra, and BARI Tamato-3 produced better in raised beds with mulching in the coastal zone of Noakhali and Shatkhira (Sutradhar et al., 2015). Farmers are adopting high-value cash cropping systems in chars of the Teesta River in Lalmonirhat district, chars of the Ganges River in Rajshai district, and chars of Chapinawabganj districts, such as cabbage (Atlas 70), cauliflower (Snow Star), onion (Taherpuri), groundnut (Dac-1) in Asriadah char in Rajshai, Pakachar in Chapainawabganj (AAS, 2012).

2.4 Agricultural Adaptation in the Coastal Areas of Bangladesh

Several effective adaptation techniques related to flood, drought, and salinity have been developed by different research organizations in agriculture. More than one million farmers in Bangladesh cultivate saline-tolerant rice varieties including Binadhan-8, Binadhan-10, BRRI dhan47, and BRRI dhan55. The Binadhan types Binadhan-8 and Binadhan-10 are distinct (Alam et al., 2013).

The analysis of climate change adaptation practices in thirty Agro-Ecological Zones of Bangladesh and certain agriculture adaptation practices in selected publications revealed that vegetables grown on floating beds have the potential to alleviate flood-related problems in the southwestern regions of Bangladesh (Oxfam, 2009).

The Sorjan method with shallow depths are suitable for the year-round cultivation of vegetables and monsoon rice, but sorjan method with deeper depths are suitable for rice-fish and rice-duck farming in addition to the year-round cultivation of vegetables on raised beds are especially popular among farmers in the Patuakhali coastal region, and the annual net return on investment in Sorjan systems is exceptionally high (Sattar & Abedin, 2012).

Homestead gardening is a widely accepted practice in Bangladesh and is managed by women. It ensures food security and additional income by enhancing the livelihoods of poor people. Homestead gardening is adapted to low soil moisture and high temperature (FAO, 2008).

In the coastal region, salinity is a major problem to cultivate agricultural crops. Farmers are using zero tillage potato cultivation using straw as mulch and zero tillage potato without straw. Zero tillage cultivation is better to produce potatoes in Nazirpur Upzila as a livelihood adaptation to climate change (Sutradhar et al., 2015). Sunflower of the variety Hi-Sun-33 is adopted as a Rabi crop in the coastal region of Jhalokathi for meeting edible oil requirements as well as higher income and saving of foreign currency. BRAC has undertaken a pilot study to popularize sunflower in the coastal belt and develop a local market for this crop and has established a mill for oil extraction (Rahman, 2012).

Coastal green belt is one of the most effective methods of adaptation for protecting local, coastal, and regional areas from storms, cyclones, and tidal surges. It is necessary to minimize wind speed by planting trees that can survive high wind speeds and break them up. Naturally occurring halophytic plants are specially adapted to thrive in littoral zones with clayey alluvial soil, severe salinity, and fierce winds. Several palm species and swamp grasses can bind soil and prevent erosion. They also decrease the velocity of tidal surges (Alauddin & Rahman, 2013).

Crab fattening is increasingly accepted as a livelihood practice for many families in the south-west coastal districts of Shatkhira, Bagerhat and Khulna. Such adaptation became favorable among coastal communities due to natural phenomena like tidal inundation, water logging, saline water, available feed for crab, very profitable livelihood option, low investment, and high demand in Dhaka market and abroad (Alam et al., 2013).

2.5 Effectiveness of Climate-resilient Adaptation Strategies in the Coastal Areas of Bangladesh

Most of the resources are important to our existence on earth. Ecological systems, water resources, food sources, coastal systems, health, and human settlements are sensitive to changes in the climate (Islam & Amstel, 2018). Bangladesh is currently ranked as one of the world's most disaster-prone countries, with 97.1% of its total area and 97.7% of the total population remain at risk of multiple hazards, including cyclones (Saha et al., 2016).

Salinity is a key issue that climate change and sea-level rise are anticipated to intensify, particularly in the southwest region of the United States (Mondal et al., 2019). Approximately one million Bangladeshis' livelihoods have been impacted by water logging during the previous two decades. Due to its susceptible geographical situation and climate change, southwest Bangladesh is subject to flooding (Sarker et al., 2013). Loss of livelihoods due to land submersion frequently compels men to migrate for searching for alternative employment (Rahim et al., 2018).

Patharghata and Morrelganj Upazilas are located in coastal areas that are susceptible to a variety of natural disasters. Annually, the inhabitants of the region are exposed to a variety of dangers, including flood, cyclone, and storm surge, salinity, and riverbank erosion, among others. These have caused a significant disturbance in human life, damage to settlements and infrastructure, economic issues, population displacement, and a shift in the pattern of subsistence in this region. Due to the presence of natural hazards in the region, life and livelihood, economy, household and infrastructure, and human health are at danger. According to the literature review, many researchers have studied specific natural hazards in different regions of Bangladesh, but in the context of Patharghata and Morrelganj, little research has been conducted to investigate the different natural hazards, their adverse effects on livelihood, and adaptation strategies to cope with these adverse effects and disasters on livelihood.

This study will focus on the effectiveness of climate-resilient adaptation strategies those are practiced by the respondents in Patharghata and Morrelganj (Rahim et al., 2018). By monitoring the efficacy of adaptation strategies such as saline-tolerant variants, homestead gardening, training, vermi-compost and irrigation, we can determine which intervention provides the best adaptation for that region.

2.6 Conceptual Framework of the Study

Conceptual frameworks (theoretical frameworks) are a type of intermediate theory that attempts to connect to all aspects of inquiry (e.g., problem, definition, purpose literature review, methodology, data collection and analysis). Conceptual frameworks can act like maps that give coherence to empirical inquiry. Because conceptual frameworks are potentially so close to empirical inquiry, they take different depending upon the research question or problem (Wikipedia, 2014). A conceptual model is a representation of a system, made of the composition of concepts which are used to help people know, understand, or simulate a subject the model represents. The conceptual framework is kept in mind while framing the structural arrangement for dependent and independent variables. This study was concerned with the effectiveness of climate-resilient

agricultural adaptation strategies which was considered as the dependent variable and focus of the study. The selected characteristics of the respondents, including age, education, family size, farm size, annual family income, credit availability, disaster impact, extension media contact, and support from GOs/NGOs were considered as the independent variables. The effectiveness of climate-resilient adaptation strategies might be influenced by the personal, social, economic, and psychological characteristics of the respondent's surroundings.

However, it is not possible to deal with all the characteristics of the respondents in a single study. It was, therefore, necessary to limit the characteristics into nine. It is assumed that selected characteristics of the respondents (Independent variables) might have influence on the effectiveness of climate-resilient adaptation strategies (Dependent variable). However, for clear understanding a conceptual framework of the study based on this discussion and review of literature, has been formulated as shown in the Figure 2.1

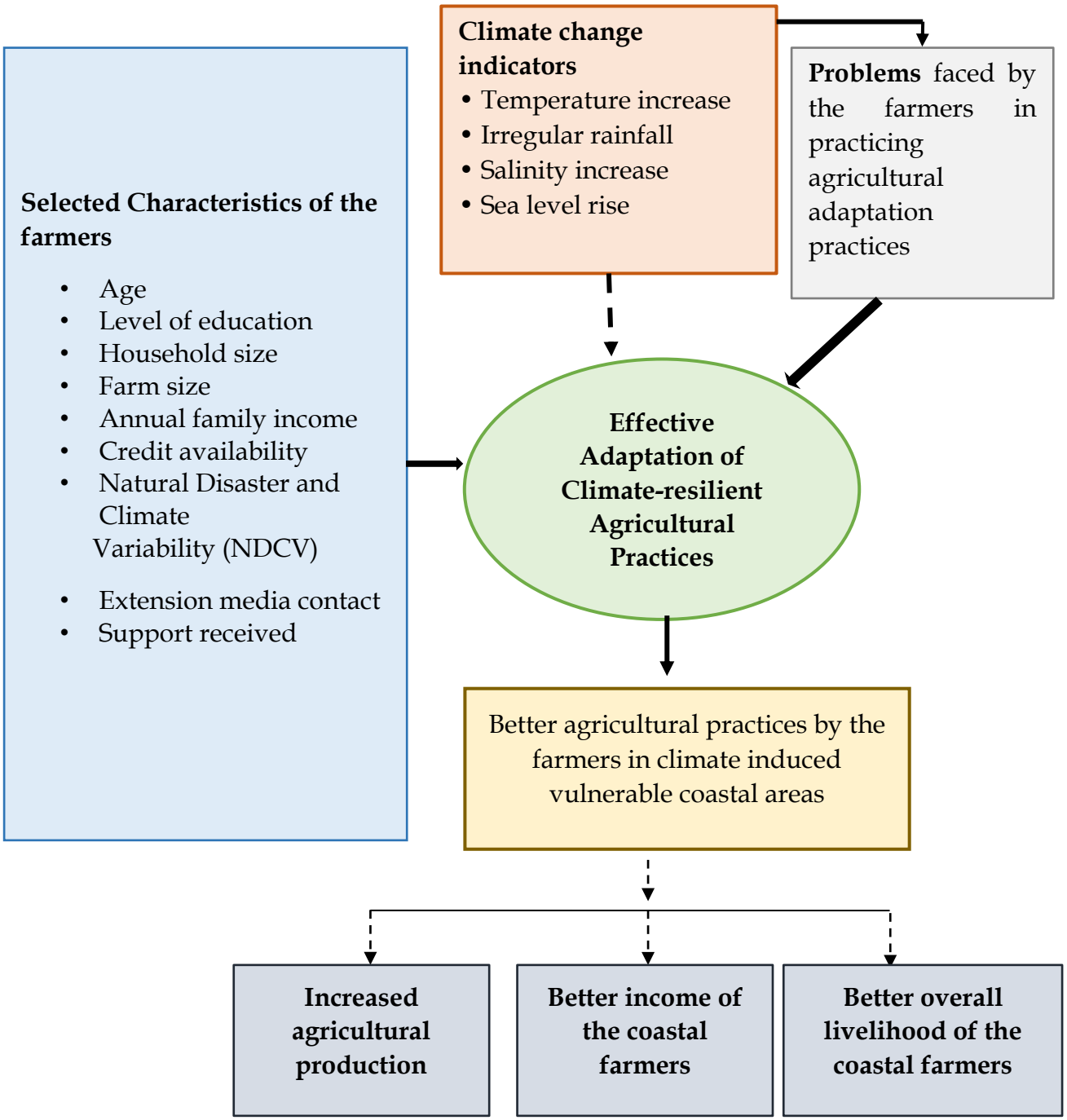

Figure 2.2 Conceptual Framework of the Study

CHAPTER III

METHODOLOGY

This Chapter explains the methodological approach and design of the study, the study area, sampling design, methods and procedures used for data collection of the study and different variables and their measurement procedures used for data analysis.

3.1 Research Approach

To answer the research questions, we collected data from respondents using quantitative methods. Several government departments and local administration have been visited and their relevant people were questioned in order to conduct a thorough evaluation of existing adaptation efforts. To acquire quantitative data, we administered interview schedules to residents of the research regions. Several Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) to understand the climate vulnerability scenarios of the study areas and subsequently, identified top five climate-resilient adaptation strategies as provided by CCDB. Afterwards, I developed a structured interview schedule and conducted a survey.

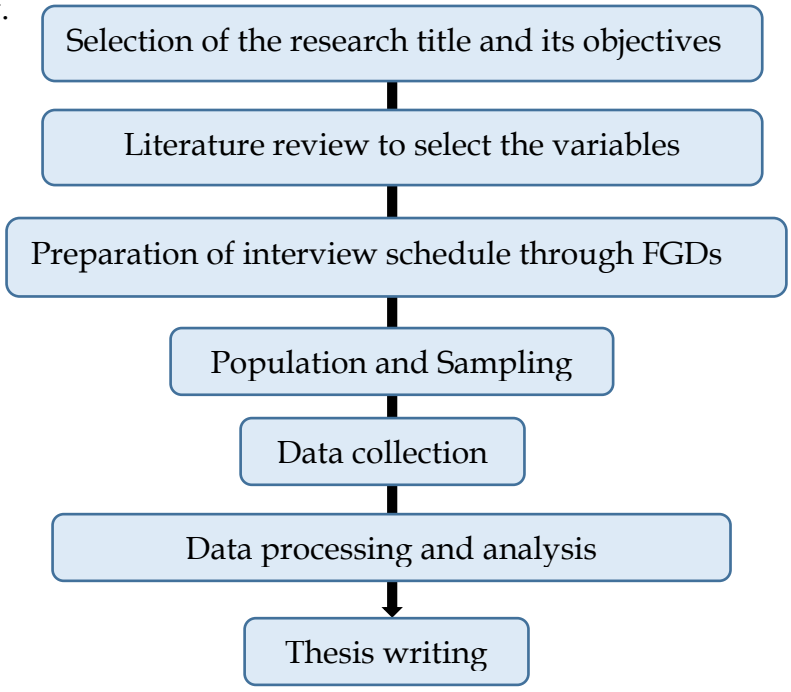

Figure 3.1 The research design of the study

3.2 Study Area

The study has been conducted in four villages of two Upazilas under two coastal districts in Bangladesh, namely Barguna and Bagerhat. These four villages have been selected purposely where CCDB has been continuing their works with climate vulnerable farmers since 2009. A detailed description of the study areas in terms of justifying the research objectives is given below.

3.2.1 Patharghata

In Barguna district, the investigation has been performed in Patharghata Upazila. Padma and Charlatimara village were selected from Patharghata Upazila. The total population of the Patharghata Upazila is 163927 of which 80544 are male and 83383 are female (BBS, 2018). These villages are vulnerable to different natural disasters because of their proximity to the Bay of Bengal and are surrounded by Bishkhali and Boleswar River.

The common hazards of these areas are flood, storm surge, cyclone, salinity intrusion, riverbank erosion, water logging, heavy rainfall, late rainy season, excessive mist, and rapid temperature change. Of these natural hazards cyclones, storm surge, salinity intrusion, are the most frequent ones and happen almost every year. The vulnerability of the people to these disasters has intensified due to dense population and poverty (Rahim et al., 2018). People in these two villages are protected from the tidal surge of the Bay of Bengal by an approximately 12.5 km long embankment (i.e., polder number 42) made by the Water and Power Development Authority (WAPDA).

However, over 40% of the total population lives outside of the embankment. Although a population with a mix of occupations e.g., farmer, fisherman, day labor, small businessman, shopkeeper, housewife, teacher, NGO worker, etc. are living in these two villages, most of them are mainly farmer and fisherman (Rahim et al., 2018). Padma village is beside one of the incursive rivers Boleswar. Concrete and semi concrete housing are very rare in the village and most of the people live in iron sheet and wood made houses, therefore every year the household falls in damage due to seasonal cyclones.

Rice, Mung bean, Sunflower, Brinjal are the crops grown in the limited amount of land in the villages. Charlathimara is a village larger than the Padma and the area of the village is 6.4 square kilometers. Around 5,752 people live in the village and most of them are fishermen. The other characteristics are same as the Padma village and similarly vulnerable to climate change.

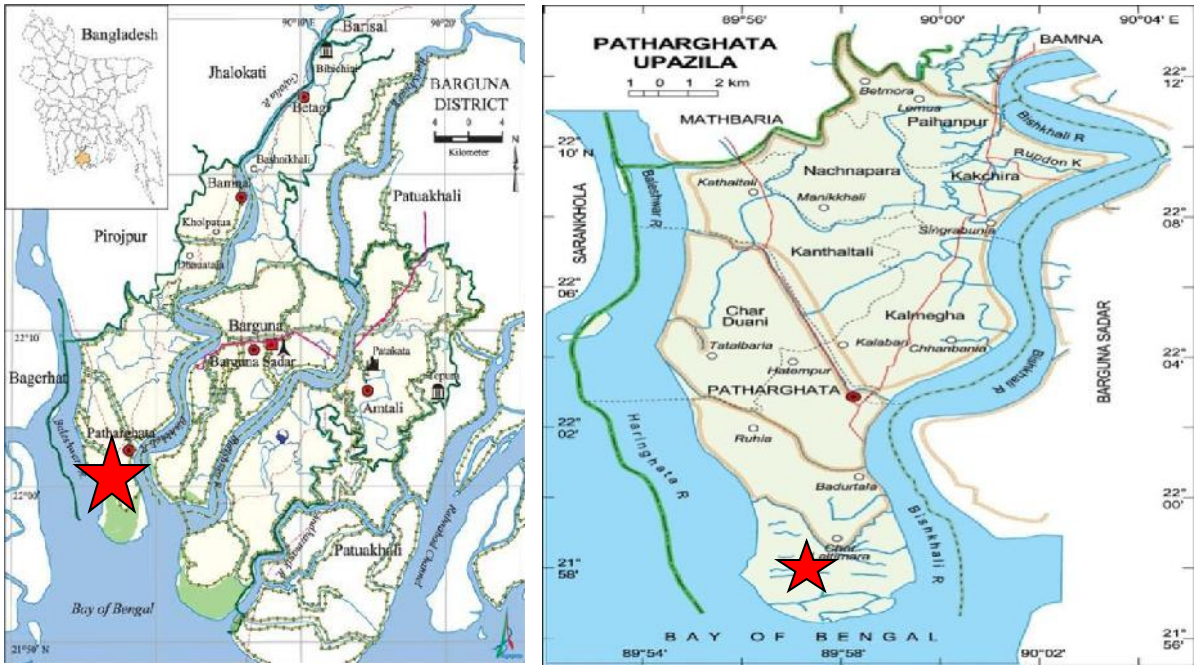

Figure 3.2 Map of Barguna District Showing Patharghata Upazila

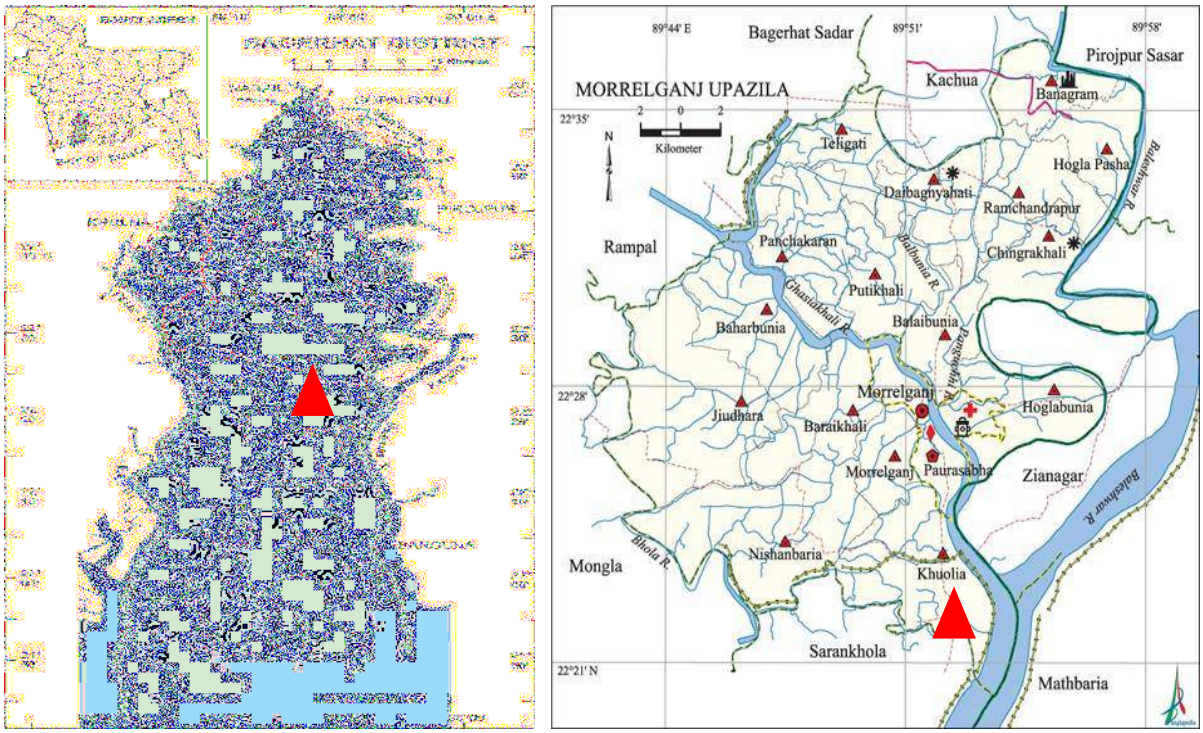

Figure 3.3 Map of Bagerhat District Showing Morrelganj Upazila

3.2.2 Morrelganj

The investigation was performed in Morrelganj Upazila under Bagerhat district. Sannyasi and Poshurbunia village were selected for this study. The total population of this upazila is 294,576 of which 143,251 are male and 151,325 are female (BBS, 2018). Approximately 1,877 people live in the village. It is a cyclone prone area and vulnerable to flood, salinity intrusion and erosion from the Panguchi river. The embankment (polder number 35/1) in the Sannyasi village is about 1.25 km long and constructed by the WAPDA. Over 50% of the total population in Sannyasi village lives outside the embankment. In this village, people's livelihood on two sides of the embankment is related to fishing and farming.

3.2.3 Selection of the climate-resilient adaptation strategies

According to FGD, the participants mentioned the various climate-resilient adaptation strategies widely practiced in the study area were different agricultural practices these were saline tolerant seed, irrigation, vermi-compost and homestead gardening system provided by different governmental and non-governmental organizations. They also mentioned that pieces of training for different climate-resilient agricultural practices are highly effective in the study area and homestead gardening; saline tolerant seed, irrigation facilities, and vermi-compost are also effective.

According to FGD and KII, five strategies (Primarily for the Agricultural Sector) were selected for this study. The selected strategies were Salt tolerant rice seed, Homestead-gardening, Training on coping with climate change, Vermi-compost, and Irrigation.

3.2.4 Determination of sample size

The sample of this study was determined based on the CCDB database (2012-2021), findings from FGD and KII. The respondents were selected cautiously on the criteria and to fulfill the objective of this study. Firstly, a population list was prepared based on the people who have practiced at least two adaptation strategies.

Then, from the total population, purposely 50% was taken randomly as the sample for the study (Appendix II). Same procedure was followed for the selected study area. The flow chart of the sample selection procedure is given below:

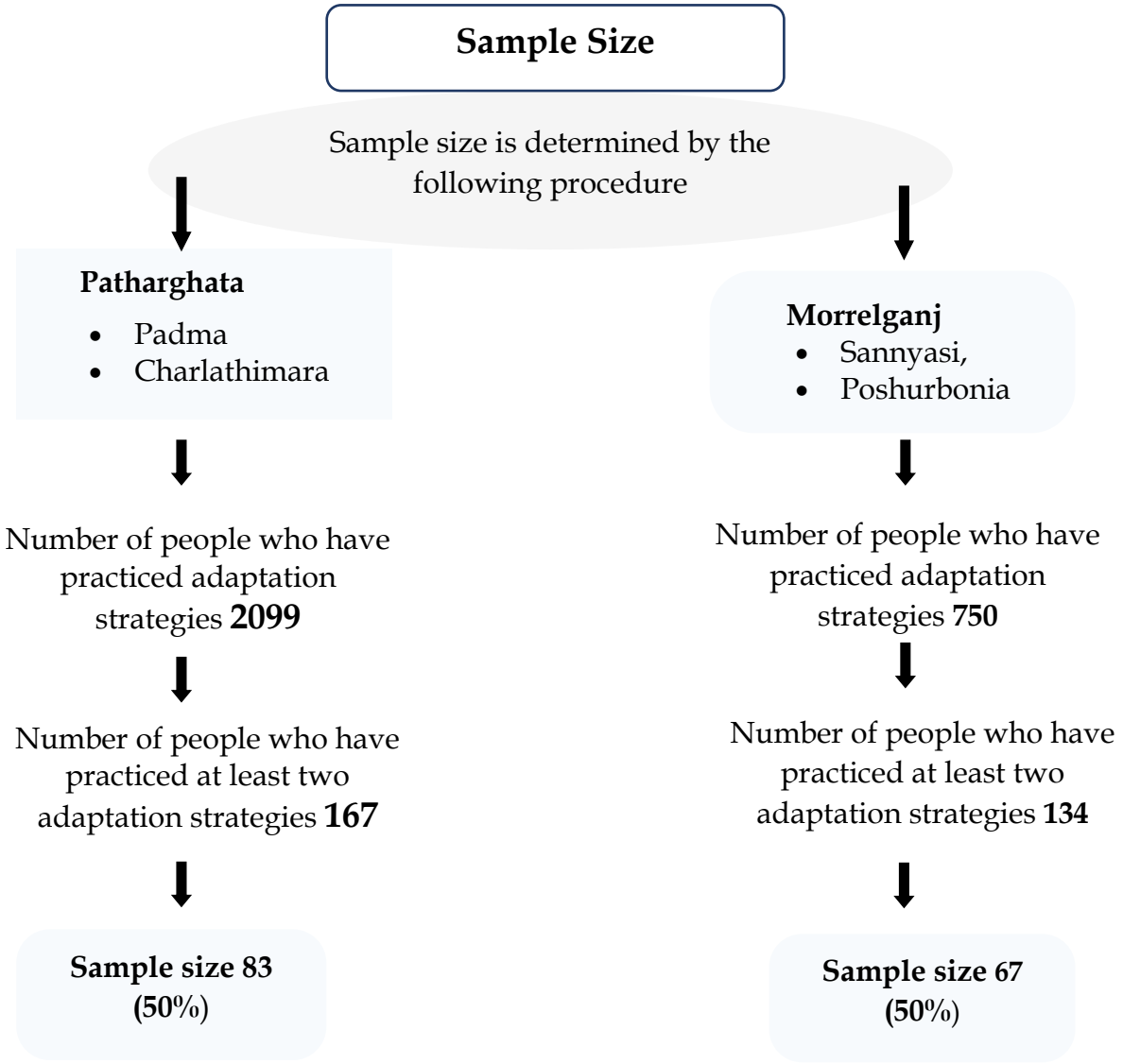

Figure 3.4 Determination of sample size

3.3 Research Instruments

Keeping the study's aims in mind, a structured interview schedule was accurately developed in order to obtain relevant data through literature review, FGDs, and KIIs. The questions in this schedule were phrased in a clear and straightforward manner and placed in a logical sequence to ensure that respondents easily understood them.

The researcher piloted the interview schedule with 15 participants. The pre-test allowed the researcher to discover erroneous and tough questions in the draft schedule; consequently, the researcher made the necessary changes to the schedule based on the pre-test findings. The questionnaire was created in English. Appendix I contains an English translation of the interview schedule. For FGDs, a subsample of 30 farmers (15 from each union) was chosen. Due to climate change, two key informants were additionally questioned to obtain their opinions on the climate-resilient adaptation strategies employed by participants.

3.4 Methods of Data Collection

3.4.1 Survey

The survey was conducted from 22 to 30 March and 9 to 15 May 2022. Before conducting the survey, the interview schedule was pre-tested with 15 respondents to ensure the clarity of the questions and to avoid ambiguity of the questions. A necessary correction was made based on the pretest of the questionnaire. The final list of the respondents was prepared using randomization from the list of the total beneficiaries of CCDB from the selected villages. The appointment was made with sample farmers with the assistance of the local staff of CCDB. At the first step, the researcher established rapport with the respondents and, as far as feasible, communicated the aims of the study. As a result, the respondents answered the questions accurately and without hesitation. Whenever a respondent had difficulty in comprehending the questions, the researcher clarified them. The respondents and CCDB staff in the study areas exhibited exceptional collaboration.

3.5 Processing of Primary Data

3.5.1 Processing of primary data

Collected primary data were coded and taken into Statistical Package for Social Science (SPSS) software package (20.0 Version). This package helps to perform a wide range of Statistical analyses.

3.5.2 Processing of secondary data

In order to develop the conceptual basis of the study, the researcher collected information from different relevant sources, such as books, journals, theses, abstracts, reports and websites. The researcher also collected documents from various organizations like the Upazila Agriculture Office for this purpose. All the secondary information was used for a functional and effective literature review for finding out the research gap as well as development of the conceptual framework of the study.

3.6 Measurement of the Variables

3.6.1 Measurement of explanatory variables

The selected characteristics of the vegetable growers were the explanatory variables of the study. To keep the study manageable 18 explanatory variables were selected. The procedures of measurement of the selected variables were as follows:

3.6.1.1 Age

The age of a respondent referred to the period from his birth to the time of interview. The age was measured in complete years as reported by the respondents. A score of one (1) was assigned for each year of age. Paired sample t test was performed to compare the age between the respondents of Patharghata and Morrelganj. This variable has been shown in the interview schedule in Appendix-I.

3.6.1.2 Level of education

Education was measured by the year of schooling. If a respondent did not attain formal education, his score was assigned as zero (0). If he/she can sign only then his score is 1. A score of one (1) was assigned for each year of schooling, i.e., 10 for S.S.C, 12 for H.S.C., and so on. Paired sample t test was performed to compare the highest level of education between the respondents of Patharghata and Morrelganj. The instrument on education was placed under the interview schedule in Appendix-I.

3.6.1.3 Family size

The household was measured by the total number of members in the family of a respondent. The family members included the respondent himself, spouse, children, and parents. Paired sample t test was performed to compare the family size between the respondents of Patharghata and Morrelganj. This variable has been presented in the interview schedule in Appendix-I.

3.6.1.4 Farm size

Farm size of a respondent include the areas of homestead, cropland, areas given and/or taken on sharecropping, lease, etc. and other like garden, pond, fallow land etc. which could give full benefit to the family, and it was expressed in terms of hectares by using of the following formula:

$FS = a + b + 1/2 (c + d) + (e – f) + g + h$

Where,

FS = Farm Size
a = Cultivable land in and around homestead area
b = Cultivable land under own cultivation
c = Land taken from others on sharecropping/borga
d= Own land given to others on sharecropping/borga
e = Land taken from others on lease/mortgage
f = Land given to others on lease/mortgage
g = Fellow land
h = Pond/Garden etc.

The total area of land thus obtained was considered as the farm size score of the respondents. Paired sample t test was performed to compare the farm size between the respondents of Patharghata and Morrelganj. This variable has been presented in the interview schedule in Appendix-I.

3.6.1.5 Annual family income

This referred to the total earnings in taka of all family members of a respondent from agriculture (crop, livestock, and fisheries), business, employment and other sources. A score of one (1) was assigned for each thousand taka. Paired sample t

test was performed to compare the annual family income between the respondents of Patharghata and Morrelganj. This variable has been presented in the interview schedule in Appendix-I.

3.6.1.6 Credit availability

The credit availability for the respondents was measured based on getting credit or not from GOs, NGO's and other organizations. Scores of 0 and 1were assigned for the responses like "No" and "Yes", respectively. Paired sample t test was performed to compare the availability of credit for the respondents of Patharghata and Morrelganj. This variable appears in the interview schedule as presented in Appendix-I.

3.6.1.7 Natural Disaster and Climate Variability (NDCV)

Natural disaster and climate variability was measured based on the extent of severity of each natural disaster and climate variability. All the respondents were interviewed through a series of natural disasters and climate variabilities with the responses like "low", "medium", and "high". Each response was assigned by 1, 2 and 3 for low, medium, and high, respectively. The score was obtained by adding weights of responses against the selected 7 natural disasters and climate variabilities and therefore, the score for the extent of severity could vary from 7 to 21 for each respondent where 7 indicating 'low severity' and 21 indicating 'highest severity. Paired sample t test was performed to compare the extent of severity of natural disaster and climate variability between the respondents of Patharghata and Morrelganj. This variable appears in the interview schedule as presented in Appendix-I.

3.6.1.8 Extension media contact

Extension media contact is to one's accessibility to the influence of extension services through different extension media. Extension media contact of the respondent farmers was measured by using a 4-point rating scale. The extension media contact score was measured by calculating farmers' extent of contact with 4 selected media. Each respondent was asked the frequency of his/her contact with each of the selected media.

The score of this variable could range from 0 to 12, where 0 indicates no extension media contact and 12 indicates maximum extension media contact. Paired sample t test was performed to compare the extension media contact between the respondents of Patharghata and Morrelganj. This variable appears in the interview schedule as presented in Appendix-I.

3.6.1.9 Support received from GO and NGOs

Support received from different organizations was measured based on some selected items (seed, fertilizer, training, financial support, advisory service, irrigation) from GOs and NGOs with the responses from the respondents like yes or no. Each response was assigned by 0 for no response and 1 for yes response by the respondent. The score was obtained by adding weights of responses against the selected 6 support items and therefore, the score for the support received from GO and NGOs for a respondent could range from 0 to 12. Where, 0 indicating 'no support received from GO and NGOs' and 12 indicating 'highest support received from GO and NGOs'. Paired sample t test was performed to compare the support received from GO and NGOs between the respondents of Patharghata and Morrelganj. This variable appears in the interview schedule as presented in Appendix-I.

3.6.2 Measurement of focus variable

The perceived effectiveness of climate-resilient agricultural adaptation strategies was the dependent variable of the study. A comparative scenario of perceived effectiveness of the climate-resilient adaptation strategies between Patharghata and Morrelganj were also explored. There was a list of 5 selected adaptation strategies in the interview schedule. Perceived effectiveness of an adaptation practice was computed by using a four-point rating scale.

Responses	Scores (%)
Not effective	0
Less than average effective	1-50
Above average effective	51-75
Completely effective	76-100

Each of the respondents was asked to mention his or her perception towards each of the selected climate-resilient adaptation practices. The response of the respondent was expressed in percentage. Thus, the response of the respondent was between 0-100. Paired sample t test was performed to compare the perceived effectiveness of adaptation strategies by the respondents in Patharghata and respondents in Morrelganj.

3.7 Data Analysis

3.7.1 Compilation of data

The collected data were coded, categorized, tabulated, and analyzed scientifically. The local units were converted into standard units. The qualitative data were transferred into quantitative data by appropriate scoring techniques.

3.7.2 Statistical analyses

The coded data were put into the computer for statistical analyses. The Statistical Package for Social Science (SPSS) computer program was used for analyzing the data. Various descriptive statistical measures such as range, frequency, number, percentage, mean, standard deviation (SD), coefficient of variation (CV) and rank order were used for categorization and describing the variables.

Multiple linear regression analysis was used to identify influential reasons that have effects on the effectiveness of climate-resilient agricultural adaptation intervention practices by the smallholder beneficiary and respondents in Morrelganj and to determine the determinants and their contribution to predicting the focus variable of the study (Sakiluzzaman et al., 2018 and Izzah et al., 2020).

The equation of multiple linear regressions is as follows:

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

Here,

$y = y\hat{} + e$ = Use of eco- friendly crop production practices

β_0 = Intercept

X_1= Age

X_2= Level of education

X_3= Family size

X_4= Farm size

X_5= Annual family income

X_6= Credit availability

X_7= Natural Disaster and Climate Variability

X_8= Extension media contact

X_9= Support received from GO and NGOs

X_{10}= Perceived effectiveness of climate-resilient adaptation strategies

e = Error term

CHAPTER IV

RESULTS AND DISCUSSION

This Chapter deals with the systematic representation and interpretation of results. Keeping the objectives in mind, findings of the study have been presented in four sections. The first section deals with the selected characteristics of the respondents. Second section deals with the effectiveness of climate-resilient adaptation strategies by the respondents. Third section deals with the reasons for the effectiveness of climate-resilient adaptation strategies by the respondents. Fourth section deals with the reasons for not adopting climate-resilient adaptation strategies.

4.1 To Determine the Socio-Economic Characteristics of the Farmers of the Saline Prone Areas

There are many interrelated constituents that characterize a farmer and form an integral part in the development of his or her behavior and personality. The behavior of an individual is determined to a substantial extent by his/her characteristics. It was therefore assumed that the extent of use of environment-friendly crop production practices will be influenced by their various characteristics. The individual characteristics included i) age ii) level of education iii) household composition iv) farm size v) annual family income vi) credit availability vii) Disaster impact viii) extension media contact and ix) support received from GO and NGOs. These characteristics of the farmers have been shown in Table 4.1 and described in this section in more detail.

4.1.1 Age

The age of the respondents in Patharghata ranged from 22 to 85 years, with an average of 44.94 years and a standard deviation of 12.76. On the other hand, the age of the respondents in Morrelganj ranged from 27 to 79 years, with an average of 49.40 years and a standard deviation of 9.43. Based on their age, the respondents were classified into three categories i.e., young, middle aged and old. Distribution of the respondents according to their age has been shown in Table 4.1.

Table 4.1 Characteristics profile of the respondents

Characteristics (Measuring units)	Categories	Patharghata (n_1=83)			Morrelganj (n_2=67)			t value
		No.	%	Mean ± SD	No.	%	Mean ± SD	
Age (years)	Young (18-35)	25	30.0	44.94± 12.76	17	25.0	49.40± 13.66	-2.47* (0.016)
	Middle-aged (36-55)	45	54.0		28	42.0		
	Old (>55)	13	16.0		22	33.0		
Level of Education (Total years of schooling)	Illiterate (0)	3	3.6	5.23± 3.38	3	4.5	5.46± 3.27	-0.736 (0.464)
	Primary (1-5)	54	65.1		40	59.7		
	Secondary (6-10)	22	26.5		21	31.3		
	Higher secondary and above (>10)	4	4.8		3	4.5		
Family size (No. of members)	Small (2-4)	39	47.0	4.63± 1.20	20	30.0	5.45± 2.03	-2.55* (0.013)
	Medium (5-6)	41	49.4		33	49.0		
	Large (>6)	3	3.6		14	21.0		
Farm size (Hectare)	Marginal (0.002-.02ha)	2	2.41	0.50± 0.40	6	8.9	0.53± 0.67	-0.68 (0.499)
	Small (.021-.99ha)	71	85.54		52	77.6		
	Secondary (1-3)	10	12.05		8	11.94		
	Large (>3)	0	0		1	1.49		
Annual family income ('000' BDT)	Low (1-75)	12	14.5	148.11± 76.99	10	14.9	137.10± 76.15	-0.109 (0.913)
	Medium (75.01-200)	56	67.4		48	71.7		
	High (>200)	15	18.1		9	13.4		
Credit availability	Yes (1)	46	55.4	---	27	40.3	---	1.00 (0.321)
	No (0)	37	44.6		40	59.7		
Natural Disaster and Climate Variability (Scores)	Low (up to 7)	19	22.9	10.29± 4.21	17	25.4	8.60± 1.93	4.27* (0.000)
	Medium (8-14)	48	57.8		50	74.6		
	High (>14)	16	19.3		0	0		
Extension media contact (Scores)	Low (up to 4)	32	38.6	5.65± 3.23	14	20.6	7.03± 2.39	-2.74* (0.008)
	Medium (5-8)	31	37.3		25	36.8		
	High (>8)	20	24.1		28	41.2		
Support received from GO and NGOs (Scores)	Low (up to 7)	60	72.3	3.70± 2.34	45	67.2	3.87± 2.10	-1.29 (0.202)
	Medium (8-14)	20	24.1		22	32.8		
	High (>14)	3	3.6		0	0		

Note. Data shows in the parentheses show the p values (p = < 0.05)
The t value at a 5% level of significance is 1.97 with 148 df
*Significant at 0.05 level of significance

Data presented in Table 4.1 show that more than half of the respondents in Patharghata (54.0%) were in the middle-aged category, compared to 16.0% of them being old aged and 30.0% young. Similarly, the highest number of the respondents in Morrelganj (42.0%) was in the middle-aged category, compared to 33.0% of them being old aged and 25% of them being young. The t value of -2.47 indicated that there was a significant difference between the ages of respondents in Patharghata and respondents in Morrelganj. It therefore spells out that middle aged farmers of the study area could have considerable influence on the decision making relating to farming activities. Akter (2011) and Liza (2019) also found comparable results in their study. They found that most of the small farmers in their study areas were middle to young aged.

4.1.2 Level of education

The score of educational level of respondents in Patharghata ranged from 0 to 15, with an average of 5.23 years and a standard deviation of 3.38. On the other hand, scores of educational levels of respondents in Morrelganj ranged from 0 to 15, with an average 5.46 years and standard deviation 3.27. Based on their educational level, the respondents were classified into four categories i.e., illiterate, primary, secondary and above secondary.

Data presented in the Table 4.1 show that the considerable proportion of the respondents in Patharghata (65.1%) was in primary level, where 3.6%, 26.5%, and 4.8% of them were in the illiterate, secondary level, and above secondary level, respectively. In case of the respondents in Morrelganj, a considerable proportion of them (59.7%) was in primary level, where 4.5%, 31.3%, and 4.5% of them were in the illiterate, secondary level, and above secondary level, respectively. The t value of -0.68 indicated that there was no significant difference between the educational level of the respondents in Patharghata and respondents in Morrelganj. Literate respondents are comparatively innovative than the illiterate respondents. However, the illiteracy of the majority of the respondents was a limiting reason in this case.

4.1.3 Family size

Family size of respondents in Patharghata ranged from 2 to 9, with an average of 4.63 and standard deviation of 1.20. On the other hand, Family size of the respondents in Morrelganj ranged from 2 to 13, with an average of 5.45 and standard deviation of 2.03. For both respondents in Patharghata and respondents in Morrelganj, the average Family size of 4.63 and 5.45 are higher to that of the national average of 4.2 (BBS, 2018). On the basis of their Family size, the respondents were classified into three categories i.e., small, medium and large. Distribution of the respondents according to their Family size has been shown in Table 4.1.

Data presented in Table 4.1 show that the highest proportions of the respondents in Patharghata (49.4%) had a medium sized Family, compared to 47% of them being small Family size and 3.6% of them in the large Family size. Similarly, the highest proportions of the respondents in Morrelganj (49.0%) had medium sized Family, compared to 30.0% of them being small Family size and 21.0% of them in the large Family size. The t value of -2.55 indicated that there was a significant difference between the Family size of the respondents in Patharghata and respondents in Morrelganj.

The findings indicate that 54% of the respondents in Patharghata and about 70% of the respondents had medium and large sized families. This may be due to the poor adoption of family planning measures by the respondents or prevalence of more joint family systems in the study area Rakib (2002), Sarker (2007) and Hoque (2011) also found almost similar findings in their respective studies.

4.1.4 Farm size

Farm size of the respondents in Patharghata ranged from 0.013 to 1.684, with an average of 0.50 hectares and standard deviation of 0.40. On the other hand, farm size of the respondents in Morrelganj ranged from 0.004 to 4.542, with an average of 0.53 hectares and standard deviation of 0.67. On the basis of the farm size, the respondents were classified into four categories i.e., marginal, small, secondary and large.

Data presented in Table 4.1 show that the highest proportion of the respondents in Patharghata (85.54%) had small farm size, where 2.41% of them had marginal farm size, 12.05% of them had secondary farm size and there were no large farm sizes. Similarly, the highest proportion of the respondents in Morrelganj (77.6%) had small farm size, where 8.49% of them had marginal farm size, 11.94% of them had secondary farm size and 1.49% of them had large farm size. The t value of -0.68 indicated that there was no significant difference between the farm size of the respondents in Patharghata and respondents in Morrelganj.

The small-sized farm heads always try to increase their productivity through their indigenous farming resources. They communicate with other progressive farmers and extension agents about their farming problems. On the other hand, landless or marginal farmers are dependent on different earning pursuits, and they are not aware about their needs. Nahar (2003) also found similar results in her study. She found that most of the small farmers in her study area had marginal to small farm size and that was around 73 percent.

4.1.5 Annual family income

The annual family income of the respondents in Patharghata ranged from 37 to 440 ('000' BDT), with an average of 148.11 BDT and standard deviation of 76.99. On the other hand, the annual family income of the respondents in Morrelganj ranged from 24 to 463 ('000' BDT), with an average of 137.10 BDT and standard deviation of 76.15. Based on their annual family income, the respondents were classified into three categories i.e., low, medium and high income. Distribution of the respondents according to their annual family income has been shown in Table 4.1.

Data presented in Table 4.1 show that the highest proportion of the respondents in Patharghata (67.4%) were in the medium where 18.1% of them were in the high and 14.5%of them were in the low-income category. Similarly, the highest proportion of the respondents in Morrelganj (71.7%) was in the medium where 13.4% of them were in the high and 14.9%of them were in the low-income category. The t value of -0.11 indicated that there was no significant difference

between the farm size of the respondents in Patharghata and respondents in Morrelganj. The findings indicate that all (100%) of both respondents in Patharghata and respondents in Morrelganj group were in the medium income category. So, it can be mentioned that more efficient intervention might play a vital role to increase the production and production will positively influence the income of the farmers. Standard of living of farmers could be improved Hanif (2000) reported similar findings.

4.1.6 Credit availability

Data presented in Table 4.1 showed that about 55.4% of the respondents had received credit and 44.6% of the respondents did not receive credit from different GOs, NGOs and other organizations in Patharghata. On the other hand, data presented in Table 4.1 showed that about 40.3% of the respondents had received credit and 59.7% of the respondents did not receive credit from different GOs, NGOs and other organizations in Morrelganj. The t value of 1.00 clearly indicated that there was no significant difference between the credit availability of the respondents in Patharghata and respondents Morrelganj.

It is due to farmers receiving credit with high interest rates which becomes a huge burden for them to pay the interest rate if production is not satisfactory. These findings are similar to Popp et al. (2013).

4.1.7 Natural disaster and climate variability (NDCV)

Disaster severity scores of the respondents in Patharghata ranged from 3 to 20 against a range of 0 to 21, with an average 10.29 and standard deviation 4.21. On the contrary, disaster severity scores of the respondents in Morrelganj ranged from 3 to 12 against a range of 0 to 21, with an average 8.60 and standard deviation 1.93. Based on their disaster severity experience, the respondents were classified into three categories i.e., low, medium, and high disaster severity experiences.

Data presented in Table 4.1 show that the highest proportions of the respondents in Patharghata (57.8%) were in the medium category of NDCV, where 22.9% of them were in the low category of NDCV and 19.3% of them were in high

category of NDCV. Again, the highest proportions of the respondents (74.6%) were in the medium category of NDCV, where 25.4% of them were in the low category of NDCV and 0% of them were in the high category of NDCV. The t value of -2.99 clearly indicated that there was a different severity of NDCV in Patharghata and respondents in Morrelganj. These findings are similar to khan et al., 2015.

4.1.8 Extension media contact

Extension media contact scores of the respondents in Patharghata ranged from 0 to 12 against a range of 0 to 12, with an average 5.65 and standard deviation 3.23. On the contrary, extension media contact scores of the respondents ranged from 0 to 10 against a range of 0 to 12, with an average 7.03 and standard deviation 2.39. On the basis of their extension contact, the respondents were classified into three categories i.e., low, medium and high contact. Distribution of the respondents according to their extension media contact has been shown in Table 4.1.

Data presented in Table 4.1 show that the highest proportions of the respondents (38.6%) were low where 37.3% of them were medium and 24.1% of them were in the high category of extension media contact. Again, the highest proportions of the respondents (41.2%) were high where 36.8% of them were medium and 20.6% of them were in the low category of extension media contact. The t value of -2.60 clearly indicated that there was a different extension media contact of the respondents in Patharghata and respondents in Morrelganj.

Therefore, the findings indicate that the extension media contact of the respondents in Patharghata ranged from low to medium whereas it became high to low for the respondents in Morrelganj. Contact with different extension media increases the opportunity of respondents to get information about farming activities. So, it can be mentioned that the respondents were not aware about different aspects of practicing adaptation strategies Solanki et al., (2011) reported similar findings.

4.1.9 Support received from GOs and NGOs

Support received scores of the respondents in Patharghata ranged from 0 to 10 against a possible range of 0 to 12, with an average 3.70 and standard deviation 2.34. On the contrary, Support received from GO and NGOs scores of the respondents in Morrelganj ranged from 0 to 8 against a possible range of 0 to 12, with an average 3.87 and standard deviation 2.10. On the basis of their support received from GO and NGOs experience, the respondents were classified into three categories i.e., low, medium and high support received from GO and NGOs experiences. Distribution of the respondents according to their support received from GO and NGOs has been shown in Table 4.1.

Data presented in Table 4.1 show that the highest proportions of the respondents in Patharghata (72.3%) were in the low category of support received from GO and NGOs, where 24.1% of them were in the medium category of support received from GO and NGOs and 3.6% of them were in the high category of support received from GO and NGOs. Again, the highest proportions of the respondents (67.2%) were in the low category of support received from GO and NGOs, where 32.8% of them were in the medium category of support received from GO and NGOs and none of them were in the high category of support received from GO and NGOs. The t value of 1.29 clearly indicated that there was no significant difference between the support received from GO and NGOs by the respondents in Patharghata and respondents in Morrelganj.

4.2 To Measure the Effectiveness of Climate-Resilient Adaptation Strategies in the Study Areas

4.2.1 Adoption status of the selected climate-resilient adaptation strategies

Climate-resilient agricultural strategies were introduced to the respondents of both areas by CCDB. We will analyze the status of the uses of these climate-resilient adaptation strategies in both areas. The data are presented in Table 4.2.

Table 4.2 Adoption status of the climate-resilient agricultural adaptation strategies

Name of adaptation strategies	Adoption by the respondent farmers			
	Patharghata (n_1=83)		Morrelganj (n_2=67)	
	No.	%	No.	%
Salt tolerant rice seed	73	87.95	39	58.21
Homestead gardening	63	75.90	38	56.72
Training on coping with climate change	70	84.34	65	97.01
Vermi-compost	22	26.51	35	52.24
Irrigation	10	12.05	4	5.97

4.2.1.1 Salt tolerant rice seed

Data presented in Table 4.2 showed that 87.95% respondents had adopted salt tolerant rice seed in Patharghata, and 58.21% respondents had adopted salt tolerant rice seed in Morrelganj. The findings indicated that, in Patharghata the percentage of adoption is higher than Morrelganj because the salinity is higher in the Patharghata than the Morrelganj. Islam et al., (2016) and Miah et al., (2020) also had found similar findings.

4.2.1.2 Homestead gardening

Data presented in Table 4.2 showed that 75.90% respondents had adopted homestead gardening in Patharghata, and 56.72% respondents had adopted homestead gardening in Morrelganj. The findings indicated that Patharghata has a greater adoption rate than Morrelganj because the increased salinity there creates a barrier to produce vegetables on the land, leading respondents of patharghata to adopt more homestead gardening. Abedin & Shaw (2013) had found similar findings.

4.2.1.3 Training on coping with climate change

Data presented in Table 4.2 showed that 84.34% respondents had adopted training on coping with climate change in Patharghata and 97.01% respondents

had adopted training on coping with climate change in Morrelganj. The findings indicated that Morrelganj has a greater adoption rate than Patharghata because the vulnerability is higher in Morrelganj than in Patharghata, leading Morrelganj respondents to adopt more training on coping with climate change. Islam et al., (2021) had found also similar findings.

4.2.1.4 Vermi-compost

Data presented in Table 4.2 showed that 26.51% respondents had adopted vermi-compost in Patharghata and 52.24% respondents had adopted vermi-compost in Morrelganj. The findings indicated that Morrelganj has a greater adoption rate than Patharghata because the increased salinity there creates a barrier for the livestock rearing, for that Patharghata's respondents adopt less vermi-compost. Miah et al., (2020) also had found similar findings.

4.2.1.5 Irrigation

Data presented in Table 4.2 showed that 12.05% respondents had adopted irrigation in Patharghata, and 5.97% respondents had adopted irrigation in Morrelganj. The findings indicated that Patharghata has a greater adoption rate than Morrelganj because the increased salinity there creates a barrier for getting freshwater for crop production which leads Patharghata's respondents to adopt more irrigation. Dutta et al., (2020) had similar findings.

4.2.2 Categorical combined effectiveness of the climate-resilient agricultural adaptation strategies

This subsection will present the findings of the Distribution of the respondents according to their combined effectiveness of climate-resilient agricultural adaptation strategies. The scores obtained for combined effectiveness of climate-resilient adaptation strategies by the respondents of Patharghata ranged from 10 to 84 against a possible range of 0-100, with an average of 44.56 and standard deviation of 16.99. On the other hand, the scores obtained for the combined effectiveness of climate-resilient adaptation strategies by the respondents of Morrelganj ranged from 14 to 80 against a possible range of 0-100, with an average of 47.16 and standard deviation of 18.81. On the basis of the combined

effectiveness of climate-resilient adaptation strategies, the respondents were classified into four categories i.e., completely, above average, less than average and not effective, respectively. Distribution of the respondents according to their combined effectiveness of climate-resilient agricultural adaptation strategies has been shown in Table 4.3.

Table 4.3 Categorical combined effectiveness of the climate-resilient agricultural adaptation strategies

Effectiveness of climate-resilient agricultural adaptation strategies	Upazilla name						t value
	Patharghata			Morrelganj			
	No.	%	Mean ± SD	No.	%	Mean ± SD	
Not effective (0)	0	0	44.56± 16.99	0	0	47.16± 18.81	-1.129 (0.263)
Less than average (1-50)	56	67.47		37	55.22		
Above average (51-75)	26	31.33		23	34.33		
Completely effective (76-100)	1	1.20		7	10.45		

Note. Data shows in the parentheses show the p values (p = < 0.05)
The t value at a 5% level of significance is 1.97 with 148 df
* Significant at 0.05 level of significance

Data presented in the Table 4.3 show that the highest proportion (67.47%) of the respondents of Patharghata had found slightly effective, where 31.33% and 1.20% of them had found moderately effective and fully effective of the climate-resilient adaptation strategies, respectively and none of the respondents had found not effective. On the contrary, data presented in the Table 4.3 show that the highest proportion (55.22%) of the respondents of Morrelganj had found slightly effective, where 34.33% and 10.45% of them had found moderately effective and fully effective of the climate-resilient adaptation strategies, respectively and none of the respondents had found not effective. The t value of -1.129 clearly indicated that there was no significant difference in the combined effectiveness of climate-resilient adaptation strategies by the respondents of Patharghata and Morrelganj. Similar findings were found by Masset et al., (2012), Kabir et al., (2021) and Swami & Parthasarathy, (2022).

4.3 Reasons Associated with Their Level of Contribution in Explaining the Effectiveness of Climate-Resilient Adaptation Strategies

4.3.1 Linear regression analysis (socio-economic characteristics)

The coefficient of correlation only indicates the linear relationship between two variables. It does not express the influence and contribution of a particular independent variable to the dependent variable. The independent variables in isolation will not give a comprehensive picture of the effectiveness of climate-resilient adaptation strategies by the respondents. The different characteristics of the respondents may interact together to contribute to a combined influence on the effectiveness of climate-resilient adaptation strategies by the respondents. For this reason, a linear regression analysis was used to assess the influence of the independent variables to the dependent variable which was shown in Table 4.4.

To determine the influential reasons on the effectiveness of climate-resilient adaptation strategies by the respondents, linear regression analysis (enter method) was conducted.

Table 4.4 Linear regression analysis explaining the dependent variable

Independent variables name	Patharghata (n_1=83)		Morrelganj (n_2=67)	
	Standardized Coefficients B	p value	Standardized Coefficients B	p value
1 Age of the respondents (X_1)	0.177	0.144	0.140	0.093
2. Level of education (X_2)	0.220	0.001*	0.403	0.000*
3. Family size (X_3)	0.153	0.263	0.102	0.744
4. Farm size (X_4)	-0.211	0.843	0.020	0.249
5. Annual family income (X_5)	-0.047	0.887	0.014	0.665
6. Credit availability (X_6)	-0.109	0.519	-0.059	0.236
7. Disaster severity (X_7)	0.164	0.997	0.000	0.196
8. Extension media contact (X_8)	0.321	0.003*	0.604	0.000*
9. Support received from GO and NGOs(X_9)	0.425	0.000*	-0.131	0.220

Note. Adjusted R^2 for Patharghata was 0.46 and for Morrelganj was 0.47

* Significant at 0.05 level of significance (p = <0.05)

From Table 4.4, it was found that the R^2 values both in Patharghata and Morrelganj found in the linear regression analysis were 0.46 and 0.47. The findings of linear regression analysis indicated that out of the nine independent

variables, only three variables namely level of education (X_2), extension media contact (X_8) and GO and NGO support(X_9) were statistically significant in Patharghata because these variables enable respondents to understand and practiced the climate-resilient adaptation strategies perfectly. Two variables namely level of education (X_2) and extension media contact (X_8) was significant in Morrelganj because educated people can understand climate-resilient adaptation strategies properly.

4.3.2 Reasons responsible for perceived effectiveness of the selected climate-resilient adaptation strategies

Climate-resilient agricultural strategies were analyzed based on their reasons for effectiveness. Numbers and percentages of different reasons were used to see which reasons are responsible for the effectiveness of different climate-resilient agricultural adaptation strategies. The data are presented in Table 4.5.

4.3.2.1 Salt tolerant rice seed

Data presented in Table 4.5 showed that the reason"can grow in saltwater" was the highest percentage of the reason for salt tolerant rice seed in both Patharghata and Morrelganj. It is because as salinity is a major threat to crops in those areas, people got relief by using the seeds which are salinity tolerant.

4.3.2.2 Homestead gardening

Data presented in Table 4.5 showed that "meets vegetable demand" reason was the highest percentage of the reason for homestead gardening in Patharghata and "can be done in the water logging situation" reason was the highest percentage of the reason for homestead gardening in Morrelganj. It's because salinity, floods, and cyclones are a major threat to vegetables in those areas, people cannot grow vegetables in the land. But homestead gardening meets their vegetable demand, and they also can do this in flood situations.

4.3.2.3 Training on coping with climate change

Data presented in Table 4.5 showed that "increase knowledge in agriculture" and "increases capacity" reason were the highest percentage of the reason for training

on coping with climate change in Patharghata and "increases capacity" reason was the highest percentage of the reason for training on coping with climate change in Morrelganj. Training helped the respondents to capacity building and increased knowledge of agriculture for that these reasons are highest in the study area.

Table 4.5 Reasons responsible for perceived effectiveness of the selected climate-resilient adaptation strategies

Adaptation strategies and reasons for effectiveness	Patharghata (n_1=83)		Morrelganj (n_2=67)	
	No.	%	No.	%
Salt tolerant rice seed				
1. Can grow in saltwater	55	66.27	39	58.21
2. Provided higher yield	45	54.22	22	32.83
3. Increases farm income	20	24.10	18	26.87
4. Fallow land can be used	26	31.33	3	4.48
5. Provided seed had good quality	11	13.25	4	5.97
Homestead gardening				
1. Empty homestead area can be used	12	14.46	10	14.93
2. Increases family income	27	32.53	13	19.40
3. Meets vegetable demand	45	54.22	17	25.37
4. Can be done in the water logging situation	26	31.32	32	47.76
5. Easily moveable	9	10.84	6	8.96
6. Provided higher yield	4	4.82	12	17.91
Training on coping with climate change				
1. Increases Capacity	46	55.42	51	76.12
2. Increases dignity in society	1	1.20	3	4.48
3. Knowledge of new strategies & crop variety	46	55.42	16	23.88
4. Knowledge of new strategies	24	28.92	23	34.33
5. Self-development	23	27.71	35	52.24
6. Can be taught to others	19	22.89	25	37.31
7. Can apply this knowledge	12	14.46	21	31.34
Vermi-compost				
1. Not need to buy chemical fertilizer	15	18.07	24	35.82
2. Increase fertility of the land	21	25.30	21	31.34
3. Get organic food	2	2.41	14	20.90
4. Increase production	6	7.23	17	25.37
5. Decrease the intensity of salinity	3	3.61	5	7.46
6. Get financial support	8	9.64	9	13.43
Irrigation				
1. Crops can be grown in the dry season	6	7.23	4	5.97
2. Low irrigation cost	4	4.82	2	2.99
3. Available water on time	4	4.82	1	1.49

4.3.2.4 Vermi-compost

Data presented in Table 4.5 showed that the reason "increase fertility of the land" was the highest percentage of the reason for vermi-compost in Patharghata and "not need to buy chemical fertilizer" was the highest percentage of the reason for vermi-compost in Morrelganj. The respondents can increase their land fertility by using vermi-compost that is why this reason was highest in Patharghata. Vermi-compost also reduces the use of chemical fertilizer that is why this reason was highest in Morrelganj.

4.3.2.5 Irrigation

The findings indicated that for both Patherghata and Morrelganj the reason "crops can be grown in the dry season" is the highest because farmers can grow crops in the dry season due to the supply of ample irrigation in their crop field.

4.3.3 Linear regression analysis (Reasons responsible for perceived effectiveness of the selected climate-resilient adaptation strategies)

A linear regression analysis was used to assess the influence of the independent variables to the dependent variable which was shown in Table 4.6. Our regression model produced adjusted R^2 values for seed, homestead gardening, training, vermi-compost and irrigation are 0.67, 0.64, 0.53, 0.79 and 0.89, respectively in Patharghata. On the other hand, adjusted R^2 values for seed, homestead gardening, training, vermi-compost and irrigation are 0.72, 0.88, 0.23, 0.91 and 0.90, respectively in Barguna. Here all adjusted R^2 indicate that it is a suitable model for social science research (Lamichhane et al., 2022). To determine the influential reasons on the effectiveness of climate-resilient agricultural adaptation strategies by the respondents, linear regression analysis (enter method) was conducted.

4.3.3.1 Salt tolerant rice seed associated positive reasons for effectiveness

The findings of linear regression analysis indicated that out of the five reasons, four reasons namely "can grow in saltwater", "provided higher yield", "increases farm income", and "provided seed had good quality" were statistically significant in Patharghata and reasons namely "can grow in saltwater", "provided higher yield", and "increases farm income" were statistically

significant in Morrelganj. Salt tolerant rice seed is suitable for saline prone areas, and it produces high yield for that above mentioned reasons are significant in the study areas.

Table 4.6 Linear Regression Analysis Explaining the Dependent Variable

Adaptation strategies and reasons for effectiveness	Patharghata (n_1=83)		Morrelganj (n_2=67)	
	Standardized Coefficients B	p value	Standardized Coefficients B	p value
Salt tolerant rice seed				
Adjusted R^2	0.67		0.72	
1. Can grow in saltwater	0.470	0.000*	0.182	0.046*
2. Provided higher yield	0.596	0.000*	0.455	0.000*
3. Increases farm income	0.413	0.000*	0.347	0.000*
4. Fallow land can be used	0.207	1.009	0.032	0.363
5. Provided seed had good quality	0.326	0.013*	0.098	0.272
Homestead gardening				
Adjusted R^2	0.64		0.88	
1. Empty homestead area can be used	0.223	0.002*	0.260	0.000*
2. Increases family income	0.327	0.000*	0.220	0.000*
3. Meets vegetable demand	0.535	0.000*	0.353	0.000*
4. Can be done in the water logging situation	0.252	0.002*	0.444	0.000*
5. Easily moveable	0.247	0.006*	0.079	0.119
6. Provided higher yield	0.166	0.191	0.262	0.003*
Training on coping with climate change				
Adjusted R^2	0.53		0.23	
1. Increases Capacity	0.340	0.000*	0.337	0.001*
2. Increases dignity in society	-0.024	-0.801	0.085	0.383
3. Knowledge of new strategies & crop variety	0.130	0.093*	0.189	0.220
4. Knowledge of new strategies	0.350	0.000*	0.342	0.003*
5. Self-development	0.347	0.001*	0.464	0.001*
6. Can be taught to others	0.157	0.052	0.188	0.320
7. Can apply this knowledge	0.215	0.013*	0.383	0.000*
Vermi-compost				
Adjusted R^2	0.79		0.91	
1. Not need to buy chemical fertilizer	0.280	0.004*	0.384	0.000*
2. Increase fertility of the land	0.554	0.001*	0.264	0.000*
3. Get organic food	0.152	0.159	0.162	0.001*
4. Increase production	0.114	0.148	0.359	0.002*
5. Decrease the intensity of salinity	0.017	0.614	0.218	0.000*
6. Get financial support	0.023	0.266	0.253	0.000*
Irrigation				
Adjusted R^2	0.89		0.90	
1. Crops can be grown in the dry season	0.451	0.000*	.838	0.000*
2. Low irrigation cost	0.261	0.000*	.151	0.001*
3. Available water on time	0.672	0.000*	.107	0.001*

* Significant at 0.05 level of significance (p = <0.05)

4.3.3.2 Homestead gardening associated with positive reasons for effectiveness

The findings of linear regression analysis indicated that out of the six reasons, five reasons namely "empty homestead area can be used", "increases family income", "meets vegetable demand", "can be done in the water logging situation", and "easily moveable" were statistically significant in Patharghata and five reasons namely "empty homestead area can be used", "increases family income", "meets vegetable demand", "can be done in the water logging situation", and "provided higher yield" statistically significant in Morrelganj.

By adopting homestead gardening respondents can produce vegetables in their homestead area and can meets their vegetable demand. That's why the above-mentioned reasons were statistically significant in the study areas.

4.3.3.3 Training on coping with climate change associated with positive reasons for effectiveness

The findings of linear regression analysis indicated that out of the seven reasons, four reasons "increases capacity", "knowledge of new strategies'', "Self-development", and "can apply this knowledge" were statistically significant in both Patharghata and in Morrelganj. Training on coping with climate change can enable respondents with self-development and increase their knowledge on climate change for those above-mentioned reasons was statistically significant in the study areas

4.3.3.4 Vermi-compost associated with positive reasons for effectiveness

The findings of linear regression analysis indicated that out of the six reasons, two reasons namely "not need to buy chemical fertilizer" and "increase fertility of the land" were statistically significant in Patharghata and all reasons were statistically significant in Morrelganj. These reasons were statistically significant because vermi-compost reduce the salinity level of arable land and increase the fertility of land

4.3.3.5 Irrigation associated with positive reasons for effectiveness

The findings of linear regression analysis indicated that out of the three reasons, all reasons were statistically significant in Patharghata and in Morrelganj because it provides water in dry season

4.4 Reasons Responsible for Non-adoption of Climate-resilient Adaptation Strategies by the Farmers of the Saline Prone Areas

Climate-resilient agricultural strategies were analyzed based on their reasons for not adoption of climate-resilient agricultural strategies. Numbers and percentages of different reasons were used to see which reasons are responsible for not adopting climate-resilient agricultural strategies. The data are presented in Table 4.7.

4.4.1 Salt tolerant rice seed associated with reasons for not adoption

Data presented in Table 4.7 showed that reason "insufficient support" was the highest percentage for not adopting salt tolerant rice seed in both Patharghata and in Morrelganj that means they did not get enough support to adopt seed.

Table 4.7 Reasons responsible for not adoption of the selected climate-resilient adaptation strategies

Climate-resilient adaptation strategies	Patharghata (n_1=83)		Morrelganj (n_2=67)	
	Number	%	Number	%
Salt tolerant rice seed				
1. Didn't know	1	1.20	7	10.44
2. Insufficient support	9	10.84	15	22.39
3. No land	0	0.00	6	8.96
4. Low Salinity	0	0.00	1	1.50
5. Don't do	0	0.00	2	2.99
6. Hard to cultivate alone	0	0.00	1	1.50
Homestead gardening				
1. Can't get time	15	18.07	9	13.43
2. Hard work needed	3	3.61	8	11.94
3. Didn't get training	4	4.82	8	11.94
4. Water scarcity	1	1.20	1	1.49
5. Lack of land	1	1.20	5	7.46
6. Financial Problem	1	1.20	5	7.46
Training on coping with climate change				
1. Didn't get offer	12	14.46	1	1.49
2. Engage in other work	0	0.00	1	1.49
Vermi-compost				
1. Engage in other works	10	12.04	10	14.93
2. Didn't have cow and goat	25	30.12	18	26.87
3. Didn't get training about it	29	34.94	7	10.44
4. Didn't have the ability	7	8.43	6	8.96
Irrigation				
1. Insufficient	73	87.95	26	38.81
2. Didn't t have land	1	1.20	1	1.49
3. Didn't t need	0	0.00	34	50.75

4.4.2 Homestead gardening associated with reasons for not adoption

Data presented in Table 4.7 showed that the reason "can't get time" was the highest percentage for not adopting homestead in both Patharghata and in Morrelganj, which means they did not get time to do homestead gardening.

4.4.3 Training on coping with climate change associated with reasons for not adoption

Data presented in Table 4.7 showed that the reason "didn't get offer" was the highest percentage for not adopting training on coping with climate change in both Patharghata and in Morrelganj. The respondents of the study areas want to do training, but they did not get offers or information for training on coping with climate change.

4.4.4 Vermi-compost associated with reasons for not adoption

Data presented in Table 4.7 showed that reason "didn't get training about it" was the highest percentage for not adopting vermi-compost in Patharghata and reason "didn't have cow and goat" was the highest percentage for not adopting vermi-compost in Morrelganj. In Patharghata most of the respondents did not adopt vermi-compost because they did not get training about vermi-compost and in Morrelganj most of the respondents did not adopt vermin-compost because they did not have cows and goats.

4.4.5 Irrigation associated with reasons for not adoption

Data presented in Table 4.7 showed that reason "insufficient" was the highest percentage for not adopting irrigation in Patharghata and reason "didn't need" was the highest percentage for not adopting vermi-compost in Morrelganj. In Patharghata most of the respondents did not adopt vermi-compost. The findings indicated that in Patharghata the respondents did not get enough support for irrigation adoption and in Morrelganj the respondents did not need irrigation support

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This Chapter provides a summary of the empirically important outcomes of the selected features of respondents in relation to their adaptation of climate-resilient agricultural strategies. It also includes conclusions and recommendations for governmental action to take more measures toward expanding the adaptation of climate-resilient agriculture strategies. This chapter concludes by recommending future research attempts that are conceivable.

5.1 Summary of the Findings

5.1.1 The socio-economic characteristics of the farmers of the saline prone areas

Majority of the respondents in both the study areas were middle aged, having a mean value of 44.94 and 49.40 years in Patharghata and Morrelganj, respectively. Most of the respondents in both the study areas were of primary level having a mean value of 5.23 and 5.46 years in Patharghata and Morrelganj, respectively. Majority of the respondents in both the study areas had medium sized families having a mean value of 4.63 and 5.45 in Patharghata and Morrelganj, respectively. Farm size of the respondents in both the study areas was small (ranged 0.21-0.99 ha) farm area. The mean value of farm size was 0.50 and 0.53 ha in Patharghata and Morrelganj, respectively.

Most of the respondent's annual family income was medium in both study areas. The mean value of annual family income ware 148.11 thousand and 137.10 thousand BDT in both study areas. Majority of the respondents in Patharghata had received credit and majority of the respondents in Morrelganj did not received credit. Majority of the respondents in Patharghata and Morrelganj had responded medium natural disaster and climate variability. Most of the respondents in Patharghata had received low to medium extension media contact and most of the respondents in Morrelganj had received high extension media contact. In both study areas most of the respondents had received low support.

5.1.2 Effectiveness of climate-resilient adaptation strategies in the study areas,

5.1.2.1 Adoption status of the selected climate-resilient adaptation strategies

Around 88% of the responders in Patharghata had adopted salt-tolerant rice seed where around 58% of the responders in Morrelganj had adopted salt-tolerant rice seed. About 75.90% respondents had adopted homestead gardening in Patharghata where 56.72% respondents had adopted homestead gardening in Morrelganj. In Patharghata approximately 85%respondents had adopted training on coping with climate change and approximately 97% respondents had adopted training on coping with climate change in Morrelganj. The adoption rate of vermi-compost was higher in Morrelganj. The adoption rate of irrigation was low in both the study areas.

5.1.2.2 Categorical combined effectiveness of the five climate-resilient adaptation strategies

The combined effectiveness of five climate-resilient adaptation strategies practiced by the respondents in Patharghata and respondents in Morrelganj were perceived by the respondents. The highest proportion (67.47%)of the respondents of Patharghata had mentioned that combindly the effectiveness of five climate-resilient adaptation strategies were less than average effective and around 55.22%respondents in Morrelganj had mentioned similar comments.

5.1.3 Reasons associated with their level of contribution in explaining the effectiveness of climate-resilient adaptation strategies

5.1.3.1 Linear regression analysis (socio-economic characteristics)

Among the nine independent variables only three socioeconomic variables in Patharghata, namely level of education (X2), extension media contact (X8), and support received from GO and NGOs (X9) and two variables in Morrelganj, namely level of education (X2) and extension media contact (X8) were statistically significant with the combined effectiveness of five climate-resilient adaptation strategies.

5.1.3.2 Reasons responsible for perceived effectiveness of the selected climate-resilient adaptation strategies

Maximum respondents in both study areas had mentioned that among five positive reasons of salt tolerant rice seed “can grow in saltwater” reason was

highest. The reason “meets vegetable demand” for homestead gardening was the highest reason in Patharghata and in Morrelganj “can be done in the water logging situation” reason was highest for homestead gardening.

Most of the respondents in Patharghata had mentioned that “increases capacity” and “knowledge of new strategies & crop variety” reasons were best for training on coping with climate change and in Morrelganj, “increases capacity “was the highest reason for training on coping with climate change. “Increase fertility of the land” was the best reason in both study areas for vermi-compost. For irrigation, in both study areas the reason “Crops can be grown in the dry season” was best.

5.1.3.3 Linear regression analysis (Reasons responsible for perceived effectiveness of the selected climate-resilient adaptation strategies)

Four reasons namely “can grow in saltwater”, “provided higher yield”, “increases farm income”, and “provided seed had good quality” were statistically significant in Patharghata among the five reasons for salt tolerant rice seed. Reasons namely “can grow in saltwater”, “provided higher yield”, and “increases farm income” were statistically significant in Morrelganj for salt tolerant rice seed. Except for the reason "provided higher yield," all reasons for homestead gardening in Patharghata were statistically significant. For Morrelganj homestead gardening, all reasons except "easily moveable" were statistically significant.

In both Patharghata and Morrelganj out of the seven reasons, four reasons “increases capacity”, “knowledge of new strategies'', “self-development”, and “can apply this knowledge” were statistically significant for training on coping with climate change. For vermi-compost, out of the six reasons, two reasons namely “not need to buy chemical fertilizer” and “increase fertility of the land” were statistically significant in Patharghata and all reasons were statistically significant in Morrelganj. All reasons were statistically significant in Patharghata and in Morrelganj for irrigation.

5.1.4 Reasons responsible for non-adoption of climate-resilient adaptation strategies by the farmers of the saline prone areas.

The "insufficient support" was the main reason for not adopting salt tolerant rice seed in both Patharghata and Morrelganj. The highest reason in both Patharghata and Morrelganj was "can't get time" for not adopting homestead gardening. "Didn't get offer" was the main reason for not adopting training on coping with climate change in both Patharghata and Morrelganj.

"Don't get training about it" was the main reason for not adopting vermi-compost in Patharghata and "don't have cow and goat" was the main reason for not adopting vermi-compost in Morrelganj. "Insufficient" was the main reason for not adopting irrigation in both Patharghata and Morrelganj.

5.2 Conclusions

Based on the findings and their logical interpretations the researcher drew the following conclusions:

- Most of the respondents in both areas were middle aged and their level of education was in primary level. Majority of the respondents had medium size families in both areas. In both areas respondents had small farm and medium family income. In Patharghata most of the respondents had received credit while most of the respondents did not receive credit in Morrelganj. Majority of the respondents had responded to medium natural disasters and climate variability in both areas. The extension media contact was low to medium and support received from GO and NGOs was low in both areas.
- More than half of the respondents in had perceived that five climate-resilient adaptation strategies were less than average effective. One third of the respondents in both areas had perceived that five climate-resilient adaptation strategies were above average effective.
- Socio-economic characteristics of the respondents, including level of education, extension media contact and support received from GO and NGOs had a positive significant relationship with the perceived effectiveness of the climate-resilient adaptation strategies. According to the respondents in Patharghata four were statistically significant for the positive effectiveness of

salt tolerant rice seed and three reasons were statistically significant for the positive effectiveness of salt tolerant rice seed in Morrelganj. According to the respondents in both Patharghata and Morrelganj five reasons were statistically significant for the positive effectiveness of homestead gardening. In both areas four reasons were statistically significant for the positive effectiveness of training on coping with climate change. For the positive effectiveness of vermi-compost in Patharghata two reasons were statistically significant and in Morrelganj all reasons were statistically significant for the positive effectiveness of vermi-compost. According to the respondents, all reasons were statistically significant for the positive effectiveness of irrigation.

- One reason was highest in both areas for not adopting salt tolerant rice seed. In both areas for homestead gardening and training on coping with climate change had the same reason. For vermi-compost and irrigation the highest reason was different in both areas.

5.3 Recommendations of the Study

The recommendations for the study were formulated based on the major findings and conclusions. However, some of the strategic actions are given below.

5.3.1 Recommendations for policy implication

The recommendations for the study were formulated based on the major findings and conclusions in order to find the effectiveness of climate-resilient agricultural strategies practiced by the respondents. A number of measures need to be taken both by major intervening agencies, such as governmental organizations (GOs), non-governmental organizations (NGOs), and the community-based organizations. Some of the strategic actions are mentioned below.

- The findings of the study indicated that the project was significantly effective for finding the effectiveness of climate-resilient adaptation strategies in coastal areas of Bangladesh. By knowing the effectiveness of adaptation strategies, we can give more effort on those strategies and therefore recommend that necessary steps be taken to include a greater number of respondents in the future projects to ensure to practice climate-

resilient adaptation strategies. In this case, different GOs and NGOs can take necessary measures to establish and execute the same.

- Extension media contact helps people to become more conscious, rational decision-makers, and informative about agricultural activities. The extension personnel should provide regular visits to the farmers so that they can make effective communication with them about their farming activities.

5.3.2 Recommendations for further study

There is a huge opportunity to pursue further research related to the effectiveness of climate-resilient agricultural strategies. Some of them are listed below.

- The present study was conducted in only two Upazila under the Barguna and Bagerhat district. However, with this small piece of research work generalization of the overall use of climate-resilient adaptation strategies practices is difficult. Hence, similar studies can be undertaken in other parts of the country, which could be more helpful for the generalization of the overall use of climate-resilient adaptation strategies and practices.
- The current study had considered only five strategies of the respondents in the study area. Further study may be conducted to explore other climate-resilient adaptation strategies.
- In the present study, only twenty-eight reasons were considered that were observed by the respondents in both areas using five strategies. But there are many strategies left. So, further research may be conducted to find out those strategies' effectiveness.

REFERENCES

Abeydeera LHUW, Mesthrige JW, Samarasinghalage TI 2019: Global Research on Carbon Emissions: A scientometric review. *Sustainability* **11**(14) 3972.

Abid M, Shiffrin J, Schneider UA, Elahi E 2019: Farmer perceptions of climate change, observed trends and adaptation of agriculture in Pakistan. *Environmental management* **63**(1) 110-123.

Agriculture Advisory Society 2012: "Annual Activity Report", http://aas-bd.org/wp-content/uploads/2014/04/Annual-Activity-Report-2012.pdf.

After MS 2011: Vulnerability of Farm Households Due to Drought: Evidence from Rajshahi District, MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Alam M, Ahammad R, Nandy P, Rhaman S 2013: Coastal Livelihood Adaptation in Changing Climate: Bangladesh Experience of NAPA Priority Project Implementation. DOI 10.1007/978-4-431-54249-0_14.

Alam MB, Rahman KA 2017: Women and climate change in Bangladesh: analysis from gender perspective. *Cross-Cultural Communication* **13**(8) 7-9.

Alauddin SM Rahman KF 2013: Vulnerability to Climate Change and Adaptation Practice in Bangladesh. *Journal of SUB* **4**(2) 25-42.

Anderson R, Bayer PE, Edwards D 2020: Climate change and the need for agricultural adaptation. *Current opinion in plant biology* **56** 197-202.

Arshad M, Amjath-Babu TS, Aravindakshan S, Krupnik TJ, Toussaint V, Kächele H, Müller K 2018: "Climatic variability and thermal stress in Pakistan's rice and wheat systems: astochastic frontier and quantile regression analysis of economic efficiency", *Ecological Indicators* **89** 496-506.

Bangladesh Centre for Advance Studies 2018: "Community Risk Assessment of Disasters and Risk Reduction Action Plan in Madhukhali Upazila, Faridpur." Ministry of Food and Disaster Management, Government of Peoples Republic of Bangladesh.

BBS 2018: Report on Bangladesh Sample Vital Statistics, Monitoring the Situation of Vital Statistics of Bangladesh (MSVSB) 2nd Phase Project. Bangladesh Bureau of Statistics, Ministry of Agriculture, Dhaka, Bangladesh.

Billah MM, Sarker MA, Miah MAM, Kabir KH 2015: Adaptation of farming practices by the smallholder farmers in response to climate change. *Journal of Agricultural Extension and Rural Development* **7**(2) 33-40.

Bouwer LM 2019: Observed and projected impacts from extreme weather events: implications for loss and damage. *In Loss and damage from climate change* 63-82.

Dastagir MR 2015: Modeling recent climate change induced extreme events in Bangladesh: a review. *Weather Climate Extreme* **7** 49–60.

Delaporte I, Maurel M 2018: Adaptation to climate change in Bangladesh. *Climate policy* **18**(1) 49-62.

Dike E, Dike N 2018: Did Global Warming and Climate Change Cause the Degradation of Lake Chad, Africa's Most Important' Ecological Catastrophe'? *Review of Environment and Earth Sciences* **5**(2) 15-41.

Dow F, Berkhout BL, Preston RJ, Klein G, Midgley M, Shaw R 2013: Limits to adaptation. *Nature Climate Change* **3** 305–307.

Dutta S., Maiti, S., Garai, S., Abrar, F., Jha, S. K., Bhakat, M., ... & Kadian, K. S. (2020). Analyzing adaptation strategies to climate change followed by the farming community of the Indian Sunderbans using Analytical Hierarchy Process. *Journal of Coastal Conservation*, *24*(5), 1-14.

Eckstein D, Hutfils ML, Winges M 2018: Global climate risk index-2019. Who suffers most from extreme weather events.

Fankhauser S 2016: Adaptation to climate change. *Annual Reviews of Resource Economics.*

Field CB, Barros V, Stocker TF, Qin D, Dokken DJ 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change.

Food and Agriculture Organization 2008: Community-Based Adaptation in Action, A case study from Bangladesh, Improved adaptive capacity to climate change for sustainable livelihoods in agriculture sectors. http://www.fao.org/3/a- i0481e.pdf

Habtemariam LT, Gandorfer M, Kassa GA, Heissenhuber A 2016: Reasons influencing smallholder farmers' climate change perceptions: a study from farmers in Ethiopia. *Environmental management* **58**(2) 343-358.

Haddad BM 2005: Ranking the adaptive capacity of nations to climate change when socio-political goals are explicit. *Global environmental change* **15**(2)165-176.

Hanif MA 2000: Comparative Analysis between FFS and non-FFS Farmers Regarding Environmental Awareness, MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Harun-ur-Rashid M, Islam MS 2007: Adaptation to climate change for sustainable development of Bangladesh agriculture. *Bangladesh Agriculture Research Institute*, 1-12.

Hallegatte S, Vogt-Schilb A, Rozenberg J, Bangalore M, Beaudet C 2020: From poverty to disaster and back: A review of the literature. *Economics of Disasters and Climate Change* **4**(1) 223-247.

Hoque MZ 2011: Improvement of Socio-economic Status of the commercial Fish Farmer's Due to Transformation from Crop Farming to Aquaculture, MS Thesis, Department of Agricultural Extension Education. Bangladesh Agricultural University, Mymensingh, Bangladesh.

Hossain MS, Qian L, Arshad M, Shahid S, Fahad S, Akhter, J 2018: Climate change and crop farming in Bangladesh: an analysis of economic impacts. *International Journal of Climate Change Strategies and Management* **11**(3), 424-440.

Hossain MS, Arshad M, Qian L, Zhao M, Mehmood Y, Kächele H 2019: Economic impact of climate change on crop farming in Bangladesh: An application of Ricardian method. *Ecological Economics* **164** 106354.

Hossain PR, Ludwig F, Leemans R 2018: Adaptation pathways to cope with salinization in south-west coastal region of Bangladesh. *Ecology and Society* **23**(3).

Hossain MS, Qian L, Arshad M, Shahid S, Fahad S, Akhter J 2018: Climate change and crop farming in Bangladesh: an analysis of economic impacts. *International Journal of Climate Change Strategies and Management.*

Hossain M, Deb U 2011: Crop agriculture and agrarian reforms in Bangladesh: present status and future options.

Huq N, Hugé J, Boon E, Gain AK 2015: Climate change impacts in agricultural communities in rural areas of coastal Bangladesh: A tale of many stories. *Sustainability* **7**(7) 8437-8460.

IPCC 2007: Climate change impacts, adaptation and vulnerability. In Working Group II Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC (2014): "Climate change 2014", Fifth Assessment Synthesis Report, Intergovernmental Panel on Climate Change, Geneva.

Islam M, Tamanna S, Noman M, Biswas RN, Kharel S, Ahmed I, Fardush J 2021: Climate change impacts and mitigation strategies to develop the low carbon themes in Bangladesh. In *Bangladesh II: Climate Change Impacts, Mitigation and Adaptation in Developing Countries* 319-355.

Islam MM, Sarker MA, Al Mamun MA, Mamun-ur-Rashid M, Roy D 2021: Stepping Up versus Stepping Out: On the outcomes and drivers of two alternative climate change adaptation strategies of smallholders. *World Development* **148** 105671.

Islam ARM, Shill BK, Salam R, Siddik M, Alam N, Patwary MA 2021: Insight into farmers' agricultural adaptive strategy to climate change in northern Bangladesh. *Environment, Development and Sustainability,* **23**(2) 2439-2464.

Islam MR, Sarker MRA, Sharma N, Rahman MA, Collard BCY, Gregorio GB, Ismail AM 2016: Assessment of adaptability of recently released salt tolerant rice varieties in coastal regions of South Bangladesh. *Field Crops Research* **190** 34-43.

Islam MT, Nursey-Bray M 2017: Adaptation to climate change in agriculture in Bangladesh: The role of formal institutions. *Journal of environmental management* **200** 347-358.

Islam MN, Amstel A 2018: Bangladesh I: climate change impacts, mitigation and adaptation in developing countries.

Izzah N, Samad A, Anua SM, Ruslan R, Hamzah NA 2020: Knowledge, Attitude and Practice (KAP) on Pesticide Exposure Among Farmers in Kota Bharu. *Malaysian Journal of Medicine and Health Sciences*. https://www.researchgate.net/publication/34658215

Jahan K, Zahid A, Bhuiyan MAE, Ali I 2022: A Resilient and Nature-Based Drinking Water Supply Source for Saline and Arsenic Prone Coastal Aquifers of the Bengal Delta. *Sustainability* **14**(11) 6703.

Jay A, Reidmiller DR, Avery CW, Barrie D, DeAngelo B 2018: Overview. In Impacts, Risks, and Adaptation in the United States*:* **4**(2) 33-71.

Kabir A, Amin MN, Roy K, Hossain MS 2021: Determinants of climate change adaptation strategies in the coastal zone of Bangladesh: implications for adaptation to climate change in developing countries. *Mitigation and Adaptation Strategies for Global Change* **26(**7) 1-25.

Kahn ME 2020: The climate change adaptation literature. *Review of Environmental Economics and Policy*.

Karimi V, Karami E, Keshavarz M 2018: Climate change and agriculture: Impacts and adaptive responses in Iran. *Journal of Integrative Agriculture* **17**(1) 1-15.

Khan MMH, Bryceson I, Kolivras KN, Faruque F, Rahman MM., Haque U 2015: Natural disasters and land-use/land-cover change in the southwest coastal areas of Bangladesh. *Regional Environmental Change* **15**(2) 241-250.

Kreft S, Eckstein D, Melchior I 2013: Global climate risk index 2014. Who suffers most from extreme weather events.

Kuang F, Jin J, He R, Wan X, Ning J 2019: Influence of livelihood capital on adaptation strategies: Evidence from rural households in Wushen Banner, China. *Land use policy* **89** 104228.

Kuhl L, Van Maanen K, Scyphers S 2020: An analysis of UNFCCC financed coastal adaptation projects: Assessing patterns of project design and contributions to adaptive capacity. *World Development* **127** 104-748. https:// doi.org/10.1016/j.worlddev.2019.104748.

Kumar S, Murthy D, Gumma MK, Khan PE, Khatri-Chhetri A, Aggarwal PK, Whitbread AM 2018: Towards climate-smart agricultural policies and investments in Telangana. *CCAFS Info Note*.

Lamichhane P, Hadjikakou M, Miller KK, Bryan BA 2022: Climate change adaptation in smallholder agriculture: adoption, barriers, determinants, and policy implications. *Mitigation and Adaptation Strategies for Global Change* **27**(6) 1-24.

Liza NZ 2019: Access of Rural Women in Nutritional Program of World Vision: A Comparative Study between World Vision beneficiaries and non-beneficiaries, MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Masset E, Haddad L, Cornelius A, Isaza-Castro J 2012: Effectiveness of agricultural interventions that aim to improve nutritional status of children: systematic review. Bmj 344.

Malhi GS, Kaur M, Kaushik P 2021: Impact of climate change on agriculture and its mitigation strategies: A review. *Sustainability* **13**(3) 1318.

Mapfumo P, Onyango M, Honkponou SK, El Mzouri EH, Githeko A, Rabeharisoa L, Agrawal A 2017: Pathways to transformational change in the face of climate impacts: an analytical framework. *Climate and Development* **9**(5) 439-451.

Miah MY, Kamal MZU, Salam MA, Islam MS 2020: Impact of salinity intrusion on agriculture of Southwest Bangladesh-A review. *International Journal of Agricultural Policy and Research*.

Ministry of Planning (MoP) 2011: Sixth Five Year Plan of Bangladesh, General Economics Division, Planning Commission, Dhaka.

Ministry of Environment and Forest (MoEF) 2015: National Adaptation Program of Action (NAPA), Government of the People's Republic of Bangladesh.

MoA 2014: Ministry of Agriculture (MoA), Government of Bangladesh.http://www.moa.gov.bd/site/page/93798708-007642daa9f5318ddf098a2a

Mondal SM, Islam MT, Saha D, Hossain MSS, Das PK, Rahman R 2019: Agricultural adaptation practices to climate change impacts in coastal Bangladesh. *In Confronting climate change in Bangladesh* 7-21.

Nahar P 2003: Feedback of Homestead Farming Information by the Rural Women, MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh.

National Oceanic and Atmospheric Administration (NOAA) 2020: Available online: www.esrl.noaa.gov (accessed on 15 December 2020).

Owen G 2020: What makes climate change adaptation effective? A systematic review of the literature. *Global Environmental Change* **62** 102071.

Oxfam International 2009: Final Report on Climate Change Adaptation Practices in Thirty Agroecological Zones (AEZs) of Bangladesh.

Pascual U, Termansen M, Hedlund K, Brussaard L, Faber JH, Foudi S, Jørgensen SL 2015: On the value of soil biodiversity and ecosystem services. *Ecosystem Services* **15** 11-18.

Popp J, Peto K, Nagy J 2013: Rice Productivity and Food Security: A Review. *Agronomy for Sustainable Development* **33**(4) 243-255.

Rabbani M, Rahman AA, Shoef IJ, Khan ZM 2015: Climate change and food security in vulnerable coastal zones of Bangladesh. In *Food security and risk reduction in Bangladesh* 173-185.

Rahim MA, Siddiqua A, Nur MNB, Zaman AM 2018: Community perception on adverse effects of natural hazards on livelihood and enhancing livelihood resiliency: A case study at Patharghata Upazila, Barguna. *Procedia engineering* **212** 149-156.

Rahman MS, Haque MM, Kabir MJ, Islam AKMS, Sarkar MAR, Mamun MAA, Kabir MS 2020: Enhancing rice Productivity in the unfavorable ecosystems of Bangladesh. *Bangladesh Rice Journal* **24**(2) 83-102.

Rahman M, Lateh H 2017: Climate change in Bangladesh: a spatio-temporal analysis and simulation of recent temperature and rainfall data using GIS and time series analysis model. *Theoretical and applied climatology* **128**(1) 27-41.

Rhaman MM 2012: Enhancement of resilient of coastal community in Bangladesh through crop diversification in adaptation to climate change impacts.http://dspace.bracu.ac.bd/bitstream/handle/10361/2722/11268019. pdf?sequence=4.

Rakib MA 2002: Transformation of Flood Prone Lands to Mango Production in Shibganj Upazila under Nawabganj District: The Mango Growers' Perception, MS Thesis, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Saha D, Hossain M, Shafayet S, Mondal MS, Rahman R 2016: Agricultural adaptation practices in coastal Bangladesh: Response to climate change impacts. *Journal of Modern Science and Technology* **4**(1) *63–74*.

Sakiluzzaman M, Sarker MA, Rahman MZ, Hasan M 2018: Determinants of Rural Youth's Participation in Commercial Agriculture: A Case Study from Southern Bangladesh. *International Journal of Economics, Commerce and Management* **6**(4) 507-524

Sarker MAR, Alam K, Gow J 2013: Assessing the determinants of rice farmers' adaptation strategies to climate change in Bangladesh. *International Journal of Climate Change Strategies and Management*.

Sarker PK 2007: Perception of Farmers Regarding Transformation of Farming System in a Selected Barind Area, MS Thesis, Department of Agricultural Extension Education. Bangladesh Agricultural University, Mymensingh, Bangladesh.

Sattar SA, Abedin MZ 2012: Option for coastal farmers of Bangladesh adapting to impacts of climate change. *International Conference of Environment, Agriculture and Food Sciences (ICEAFS)*.

Selvaraju R, Baas S 2007: *Climate variability and change: adaptation to drought in Bangladesh: a resource book and training guide* 9.

Shaffril HAM, Krauss SE, Samsuddin SF 2018: A systematic review on Asian's farmers' adaptation practices towards climate change. *Science of the Total Environment* **644** 683–695. https://doi.org/10.1016/j.

Sinha DD, Singh A, Singh U 2014: Site suitability analysis for dissemination of salt-tolerant rice varieties in Southern Bangladesh. *ISPRS Journal of Photogrammetry and Remote Sensing* **8** 961-966.

Sikder R, Xiaoying J 2014: Climate change impact and agriculture of Bangladesh. *Journal of Environment and Earth Science* **4**(1) 35-40.

Solanki D, Lakhera JP, Sharma KC, Johari SK 2011: Knowledge of Respondents and Non-Respondents Regarding Maize Production Technology. *Rajasthan Journal of Extension Education* **19** 51-54.

Stern NH 2007: The Economics of Climate Change: the Stern Review. Cambridge University press.

Sutradhar LC, Bala SK, Islam AKMS, Hasan MA, Paul S, Rhaman MM, Billah M. 2015: A review of good adaptation practices on climate change in Bangladesh. In *5th International Conference on Water & Flood Management Dhaka* 6-8.

Swami D, Parthasarathy D 2022: Assessing effectiveness of agricultural adaptation strategies in context of crop loss: a case study of the Indian subcontinent. *Regional Environmental Change* **22**(2) 1-15.

Tai Amos PK, Martin MV, Heald, Colette L 2014: Threat to future global food security from climate change and ozone air pollution. *Natural Climate Change* **4**(9) 817-821.

Vermeulen SJ, Dinesh D, Howden SM, Cramer L, Thornton PK 2018: Transformation in practice: a review of empirical cases of transformational adaptation in agriculture under climate change. *Frontiers in Sustainable Food Systems* **2**(65).

Wheeler S, Zuo A, Bjornlund H 2013: Farmers' climate change beliefs and adaptation strategies for a water-scarce future in Australia. *Global Environment Change* **23**(2) 537-547.

Wheeler T, Von Braun J 2013: "Climate change impacts on global food security". *Science* **341** (6145) 508-513, doi: 10.1126/science.1239402.

Wikipedia 2014: Conceptual Framework. Retrieved from http://en.wikipedia.org/wiki/ Conceptual framework

Wikipedia 2020: Climate Resilience. Retrieved from https://en.wikipedia.org/wiki/Climate_resilience

APPENDICES

APPENDIX I: INTERVIEW SCHEDULE

Department of Agricultural Extension Education

Bangladesh Agricultural University, Mymensingh

An interview schedule of the study entitled:

"EFFECTIVENESS OF CLIMATE-RESILIENT ADAPTATION STRATEGIES IN SALINE-PRONE AREAS OF BANGLADESH"

Entry No: **Date:**

Name of the respondent:

Mobile Number of the respondent:

Section-A. Interview information

Sl.	Question	Sl.	Question
1	Name of village:	5	Name of data entry officer:
2	Name of Union:		
3	Name of Upazila:	6	Inside/outside the embankment:
4	Name of District:		

Section-B. Household+ Finance + Agriculture Demographic Information

1. Age of the respondent: _____ in years

2. Sex: _____ 1=Male | 2=Female | 99=other (specify) _____

3. Religion: 1=Muslim | 2= Hindu | 3=Buddhist | 4=Christian | 99=other (specify) __

4. Level of education (Years of Schooling**):** _____ in years

5. Family Size (by gender/age group)**:**

	Number		
	<18 years old	18-60 years old	>60 years old
Male			
Female			
Total			

6. Farm size

Please mention your farm size.

Sl. no.	Types of land	Area of land	
		Local unit	Hectare
i.	Homestead area		
ii.	Own land under own cultivation		
iii.	Land rented in		
iv.	Land rented out		
v.	Land mortgaged/leased in		
vi.	Land mortgaged/leased out		
vii.	Others (fallow land, market area, city area, etc.)		
Total			

7. Annual Family Income

Please mention your annual income earned by all family members.

Sl. No.	Sources of income	Total ('000'Tk)
Agricultural sources		
i.	Crops	
ii.	Vegetables	
iii.	Livestock and Poultry	
iv.	Aquaculture	
v.	Others (specify)	
Non-agricultural sources		
vi.	Small Business	
vii.	Services	
viii.	Remittance (in-country and out country)	
ix.	Others (specify)	
Total		

8. Credit Availability

Have you got any credit for your family or farming activities?

Yes ☐ No ☐

9. Natural Disaster and Climate Variability (NDCV)

Name of the disaster	Extent of severity		
	Low	Medium	High
Salinity			
Cyclone			
Hail storm			
Riverbank erosion			
Storm Surge			
Wild animal/pest			
Other (specify)			

10. Extension media contact

Please mention your sources of information about crops and climate impacts

Sources of contact	Frequency of contact			
	Frequently (3)	Occasionally (2)	Rarely (1)	Not at all (0)
Agriculture Extension Officer (AEO) / month				
NGO Workers/month				
Input dealers/ month				
Participation in group discussion/month				

11. What support did you get from different organizations?

	Seed (0,1)	Fertilizer (0,1)	Training (0,1)	Financial Support (0,1)	Advisory Service (0,1)	Irrigation (0,1)
GO						
NGO						
Other						

Name of the intervention	Salt Tolerant Rice Seed			
Adaptation status (1, 0)				
Scaling effectiveness (Fulfillment of the purpose/objective)	**Completely effective (More than 75%)**	**Above average effective (50-75%)**	**Less than average (less than 50%)**	**Not effective (0%)**
Reasons for effectiveness				
Why effective?		**Why not be effective?**		
Reasons for not adoption				

Note:

Name of the intervention	Homestead Gardening			
Adaptation status (1, 0)				
Scaling effectiveness (Fulfillment of the purpose/objective)	Completely effective (More than 75%)	Above average effective (50-75%)	Less than average (less than 50%)	Not effective (0%)
Reasons for effectiveness				
Why effective?		Why not be effective?		
Reasons for not adoption				

Note:

Name of the intervention	Training on Coping with Climate Change			
Adaptation status (1, 0)				
Scaling effectiveness (Fulfillment of the purpose/objective)	**Completely effective (More than 75%)**	**Above average effective (50-75%)**	**Less than average (less than 50%)**	**Not effective (0%)**
Reasons for effectiveness				
Why effective?		**Why not be effective?**		
Reasons for not adoption				

Note:

Name of the intervention	Vermi-Compost			
Adaptation status (1, 0)				
Scaling effectiveness (Fulfillment of the purpose/objective)	**Completely effective (More than 75%)**	**Above average effective (50-75%)**	**Less than average (less than 50%)**	**Not effective (0%)**
Reasons for effectiveness				
Why effective?		**Why not be effective?**		
Reasons for not adoption				

Note:

Name of the intervention	Irrigation			
Adaptation status (1, 0)				
Scaling effectiveness (Fulfillment of the purpose/objective)	Completely effective (More than 75%)	Above average effective (50-75%)	Less than average (less than 50%)	Not effective (0%)
Reasons for effectiveness				
Why effective?		Why not be effective?		
Reasons for not adoption				

Note:

APPENDIX II: Sample Randomization Using Web-Based Tool

Note: The seed value is optional. Leave it blank to generate a new set of numbers. Use it to repeat a previously-generated set of numbers.

How many random numbers?	83
Minimum value	1
Maximum value	165
Allow duplicate entries	False
Seed (optional)	

Calculate

Random Number Table

Random Number Generator | Frequently-Asked Questions | Sample Problems

83 Random Numbers

076 102 068 004 032 034 029 045 118 140 163 094 135 133 019 031 039 013 092 141 117 067 009 017
082 007 022 066 055 165 043 124 073 112 037 099 033 110 001 084 002 038 018 023 095 044 078 097
121 010 057 081 086 116 026 103 109 047 128 154 056 041 053 006 027 050 020 071 048 021 101 028
125 119 061 025 090 060 030 074 107 052 051

Specs: This table of 83 random numbers was produced according to the following specifications: Numbers were randomly selected from within the range of 1 to 165. Duplicate numbers were not allowed. This table was generated on 3/25/2022.

- Enter a value in each of the first three text boxes.
- Indicate whether duplicate entries are allowed in the table.
- Click the **Calculate** button to create a table of random numbers.

Note: The seed value is optional. Leave it blank to generate a new set of numbers. Use it to repeat a previously-generated set of numbers.

How many random numbers?	67
Minimum value	1
Maximum value	134
Allow duplicate entries	False
Seed (optional)	

Calculate

67 Random Numbers

005 023 066 001 133 041 014 022 134 064 085 079 032 003 056 031 007 043 070 025 024
126 062 084 116 055 105 052 114 026 057 027 020 004 044 103 061 088 093 124 033 036
091 095 119 046 131 073 063 080 129 016 123 071 058 060 068 030 012 108 006 047 042
107 048 127 086

Specs: This table of 67 random numbers was produced according to the following specifications: Numbers were randomly selected from within the range of 1 to 134. Duplicate numbers were not allowed. This table was generated on 4/27/2022.

APPENDIX III: Some Pictorial Views


Bring People in Action
জলবায়ু সহনশীল কেন্দ্র
(Climate Resilience Center