CLIMATE IMPACTS ON AGRICULTURE AND ECONOMIC CONDITION OF FARMERS, CHANDINA, COMILLA

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APPROVAL

This paper titled "**Climate impacts on agriculture and economic condition of farmers, Chandina, Comilla**", submitted by "**Tasnuva Rahman"** to the Department of Environmental Science and Disaster Management, Daffodil International University, has been approved for submission for the degree of B.Sc. in Environmental Science and Disaster Management. Her work demonstrates a commendable level of scholarship, research, and critical analysis, and it meets the standards by our university. Throughout her thesis, she has exhibited a thorough understanding of the subject matter, supported by a well-structured argument and comprehensive literature review. Her methodology section effectively outlines the research design and approach, ensuring the validity and reliability of her findings.

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DECLARATION

I hereby declare that this paper has been done by us under the supervision of **Dr. Mahfuza Parveen, Associate Professor, Department of** Environmental Science and Disaster Management**,** Daffodil International University. I also declare that neither this paper nor any part of this thesis has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

This thesis explores the multifaceted relationship between climate change, agriculture, and the economic well-being of farmers, focusing on the region of Comilla, specifically Chandina. Climate change poses significant challenges to agricultural productivity, and the livelihoods of farmers worldwide. In the background of Comilla, where agriculture assists as a primary source of income for a substantial portion of the people, understanding the specific effects of climate change on this sector and its implications for farmer livelihoods is of paramount importance. Through a combination of quantitative analysis, field surveys, and interviews, this study investigates the direct and indirect effects of climate change on agricultural activities in Chandina, shedding light on how shifts in temperature, precipitation patterns, and extreme weather events have influenced crop yields, farm incomes, and overall economic conditions. Additionally, the study examines the adaptive strategies employed by farmers to cope with these challenges, including changes in cropping patterns, adoption of new technologies, and participation in government-led initiatives. The results add to a better understanding of the complicated relationships between climate, agriculture, and socioeconomic factors in rural areas, providing valuable insights for policymakers, development practitioners, and stakeholders seeking to enhance the resilience of agricultural groups in the look of climate change. Ultimately, this research underscores the urgent need for coordinated action at local, national, and global levels to mitigate the effects of climate change on agriculture and to support the adaptive size of vulnerable farming populations like those in Chandina, Comilla.

Keywords: Climate Change, Adaptation, Crop Farming, Agriculture, Rainfall, Temperature.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Climate change is recognised as one of the most important challenges of the twenty-first century, severely impacting various sectors of society, with agriculture being among the most vulnerable. In regions like Comilla, Chandina, Bangladesh, where agriculture provides the foundation for the economy and sustains the livelihoods of millions, the possessions of climate change on farming does and the financial situations of farmers are of utmost concern. This thesis explores the complex relationship between climate change, agricultural productivity, and the socio-economic well-being of farmers in the context of Comilla, Chandina.

Chandina, a sub-district in the Comilla District of Bangladesh, is predominantly an agrarian region where agriculture serves as the backbone of the local economy and sustains the livelihoods of a significant portion of the population. The area is characterized by its fertile land, favorable climate, and traditional farming practices, which have historically supported a variety of crops including rice, jute, vegetables, and fruits.

However, in recent years, the region has been increasingly pretentious by the opposing impacts of climate change, posing significant challenges to agricultural productivity and the economic well-being of farmers. Climate change-induced phenomena such as erratic rainfall patterns, prolonged droughts, increased frequency and intensity of cyclones, and rising temperatures have led to considerable disruptions in agricultural activities and have exacerbated the vulnerability of farmers in Chandina.

The effects of climate variation on farming in Comilla, Chandina are multifaceted. Changes in precipitation patterns, including erratic rainfall and prolonged droughts, have led to water scarcity issues, affecting crop growth and yield. Additionally, rising temperatures have accelerated the spread of pests and diseases, posing further challenges to crop cultivation. Limited access to resources, including land, credit, and technology, restricts the adaptive capacity of farmers to cope with climate-related challenges. Moreover, existing social inequalities and gender disparities further marginalize vulnerable groups, such as women and landless farmers, intensifying their exposure to climate risks.

Sympathetic the complex interactions among climate change, agriculture, and the socio-economic conditions of farmers is essential for developing effective adaptation strategies and policy interventions in Comilla, Chandina. By elucidating the challenges faced by farmers and identifying opportunities for resilience-building initiatives, In light of climate change, this thesis seeks to further the development of evidence-based policies that protect agricultural publics' well-being and means of subsistence.

In the subsequent chapters, this thesis will delve deeper into the specific impressions of climate change on agriculture in Comilla, Chandina, assess the socio-economic implications for farmers, and propose adaptive strategies to enhance resilience and sustainability in the agricultural sector. Through empirical analysis and stakeholder consultations, valuable insights will be gained to inform policy recommendations and interventions aimed at modifying the negative impact of climate change on agriculture and improving the economic conditions of farmers in the region.

1.2 OBJECTIVES

1. To identify the possessions of climate change on vegetable harvesting, storage, and preservation systems.
2. To understand climate change's impact on small farmers' income and livelihood.
3. To identify adaptation strategies to mitigate climate changes impact on vegetable harvesting, storage, and preservation systems in the local level of Bangladesh.

Since the key purpose of this paper is to know the farmer’s perspective on the possessions of climate change on agricultural manufacture, it has investigated the lives of the agriculturalists who were affected by climate change. Thus, a qualitative study would be far more effective than a quantitative study.

1.2.1 CONNECTION WITH SDG GOALS

The objectives I seek correlate with numerous Sustainable Development Goals (SDGs), indicating the potential for my thesis to contribute to larger global sustainability initiatives. Here's how my objectives link to certain SDGs.

1. SDG 1: No Poverty

Objective 2: Understand climate change's impact on small farmers' income and livelihood.

Connection to SDG 1: By studying the effects of climate change on small farmers' profits, my study helps to better understand the relationship among climate change and poverty. Identifying resilience-building measures can help alleviate poverty.

2. SDG 2: Zero Hunger

Objective 1: Identify the effects of climate change on vegetable harvesting, storage, and preservation systems.

Addressing the consequences of climate change on vegetable systems is closely related to agricultural sustainability, as stated in **SDG 2**. Sustainable vegetable cultivation is critical to ensuring food security and eradicating hunger.

3. SDG 13: Climate Action

Objective 1: Identify the effects of climate change on vegetable harvesting, storage, and preservation systems.

Objective 3: Identify adaptation strategies to mitigate climate change's impact on vegetable harvesting, storage, and preservation systems in the local level of Bangladesh.

Connection to SDG 13: Both targets highlight the significance of knowing and dealing with the effects of climate change. Identifying adaptation ideas makes a direct contribution to climate action and resilience in vulnerable industries like agriculture.

4. SDG 15: Life on Land

Objective 1: Identify the effects of climate change on vegetable harvesting, storage, and preservation systems.

Connection to SDG 15: Agricultural practices and climate change have a substantial influence on biodiversity and ecosystems. Studying the consequences on vegetable systems helps to promote sustainable land use.

5. SDG 8: Decent Work and Economic Growth

Objective 2: Understand climate change's impact on small farmers' income and livelihood.

Connection to SDG 8: The focus on small farmers' income and livelihoods correlates with the objective of advising sustained, equitable, and sustainable economic growth together with fair work opportunities for all.

6. SDG 9: Industry, Innovation, and Infrastructure

Objective 3: Identify adaptation strategies to mitigate climate change's impact on vegetable harvesting, storage, and preservation systems in the local level of Bangladesh.

Connection to SDG 9: The identification of adaption strategies include examining technical and innovative solutions to improve agricultural infrastructure and practices.

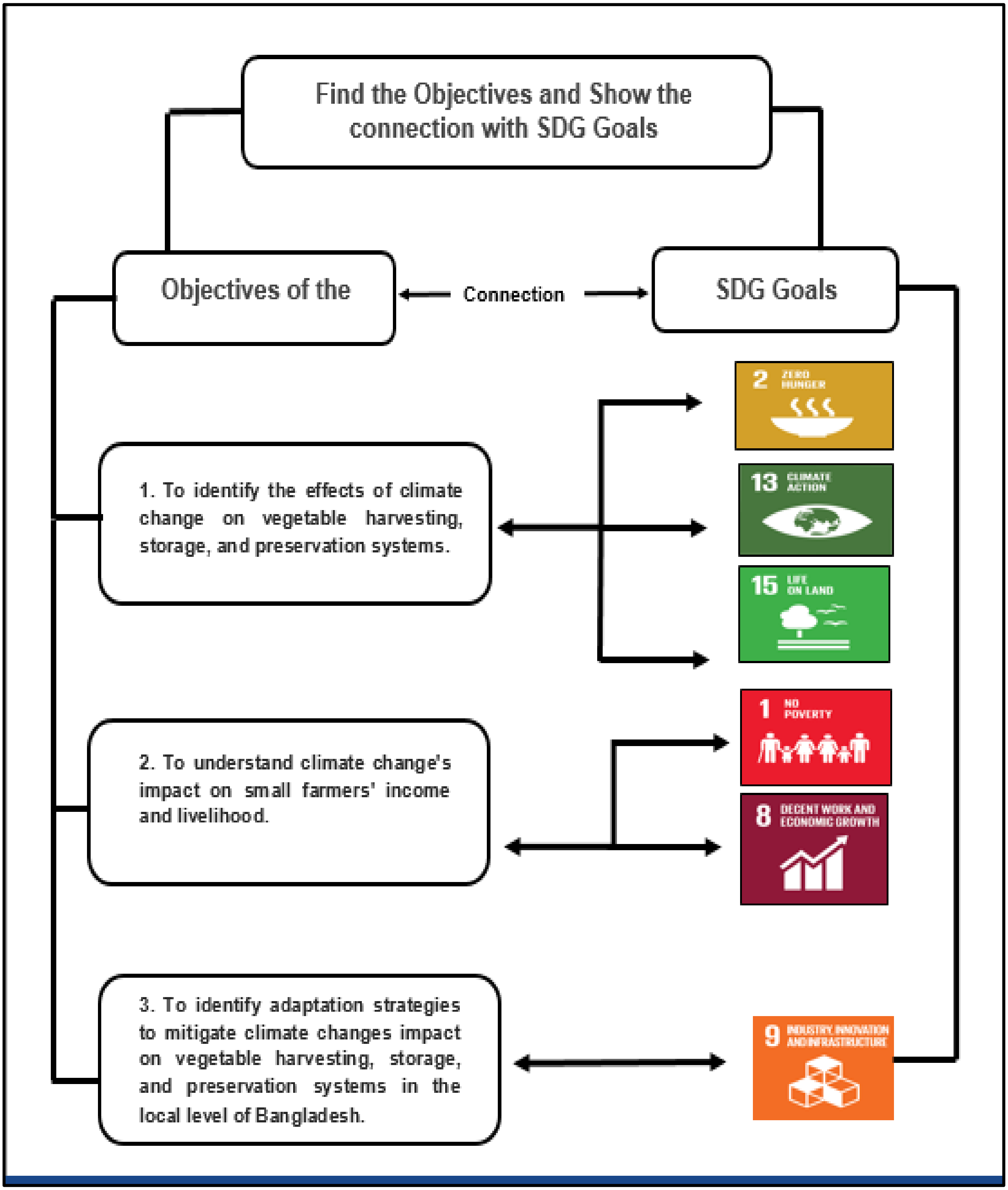


Figure 1: Connection between Objectives and SDG Goals

1.3 SIGNIFICANCE OF THIS PAPER

The significance of climate impacts on agriculture and the economic condition of farmers in Chandina, Comilla, Bangladesh, cannot be overstated. This region, like many others in Bangladesh, heavily relies on agriculture as a primary source of income and sustenance for its population. Here are some key points regarding the significance of climate impacts:

- ✓ **Vulnerability to Climate Change:** Chandina, Comilla, being an agrarian region, is particularly weak to the adverse belongings of climate change. Variations in temperature, rainfall patterns, and thrilling weather actions directly affect crop produces, cattle health, and overall agricultural production.
- ✓ **Crop Yield Variability:** Climate change can lead to erratic rainfall patterns, prolonged droughts, or unexpected floods, all of which can significantly affect crop yields.
- ✓ **Increased Insects and Illness Pressure:** Moisture and temperature changes might provide advantageous circumstances for bugs and illnesses to thrive.Farmers in Chandina may face challenges in controlling pest outbreaks and preventing crop diseases, leading to additional costs for pesticides and losses in crop yields.
- ✓ **Water Scarcity and Irrigation Challenges:** Water shortage may occur from changes in patterns of precipitation, altering irrigation systems and lowering water availability for agricultural growing. Farmers may face difficulties in accessing water for irrigation, leading to decreased crop yields, and increased financial burdens.
- ✓ **Economic Instability:** The economic condition of farmers in Chandina is closely tied to agricultural productivity.
- ✓ **Adaptation Challenges:** While adaptation strategies such as crop diversification, improved irrigation techniques, and the adoption of climate-resilient crops exist, many farmers in Chandina may lack the resources, knowledge, or support to implement these measures effectively. Climate adaptation thus becomes a critical challenge for sustaining agricultural livelihoods in the region.

CHAPTER 2

LITERATURE REVIEW

Agriculture is Bangladesh's biggest occupation. Its employments more than 40% of the total employment force and 13% of GDP (World Bank 2019). It is therefore valuable for the economy and for the country's total food production. A broad definition of agriculture is possible. This covers cultivation of crops, planting and cultivation of trees, cattle and poultry, fishing, and forestry. Historically, agronomy played an important part in the GDP. But over time this has fallen, despite the increase in absolute size. Agriculture accounted for almost 30% of GDP two decades ago (World Bank 2008).

It is now down to 13% or so. Another 33.71% is contributed by manufacturing industries (BBS 2018). The rest are services. Agriculture would therefore appear to have little economic importance. These are not true at all. Agriculture is central in the field of food shelter because it provides rice, the principal food in the country, with 90 percent or more of its supplies. In addition, apart from staples, it provides the animal protein in the form of fish and meat that are important for keeping people's nutritional grade, meanwhile three are hardly ever imported. Secondly, farming distributes important raw materials to productions such as rice, jute, sugar, leather, oil, paper, etc. Third, agriculture continues to be the economy's largest employer. Agriculture was the key foreign-exchange earner at one time. All such agriculture contributions show that this is an economic sector of the utmost importance.

The fact that national GDP has historically been associated with agriculture also underlines this. If agricultural growth was good, GDP would coincide with low farm growth and low GDP growth. Therefore, any significant disruption to agriculture caused by long-term factors such as climate change is a life and death problem in Bangladesh. Climate change and inconsistency affect worldwide. Increasing infections, changing rain outlines, increasing sea heights, and rising incidence and power of dangerous climate actions are badly affecting environment, farming and food safety, organization, and social health (IPCC 2014).

However, there is considerable discussion as to the detrimental belongings of climate change in numerous fragments of the world. Signal shows that developing countries in moderate areas are challenged with less opposing effects and may advantage from weather variation (Mendelsohn and Dinar 2003). Researchers analyze the complex interactions between climate, water, and agriculture to develop policies and strategies that promote both agricultural productivity and environmental sustainability. This may involve assessing the economic Costs and advantages of different land use practices, evaluating the impacts of climate change on agricultural systems, and identifying opportunities for innovation and technological advancement in agriculture. Key topics in the study of climate, water, and agriculture within the field of land economics include- Water rights and allocation mechanisms, Irrigation efficiency and water conservation, Climate-smart agricultural practices, Sustainable land use planning, Economic incentives for environmental stewardship, Risk management strategies for climate-related hazards, Market-based mechanisms for promoting sustainable agriculture.

There is methodical agreement, by contrast, that the low-income countries in steamy and sub-tropical climates are extra affected by the harmful consequences of climate change (Ruamsuke et al. 2015). The energy and financial effects of global climate change policies on Southeast Asian nations can change based on numerous aspects such as the type of the policies implemented, the energy mix of each country, their level of economic development, and their vulnerability to climate change.

Change in climate will have an important effect on crop production and productivity, resulting in important agricultural outcome variations (IPCC 2014; Arshad et al. 2018). The weather is still an important cause of agricultural production, despite the technical loans, where the temperature and rain help as key drivers for crop manufacture and as a result, country food safety. Policymakers and agricultural stakeholders play a crucial role in supporting farmers' adaptation efforts by providing access to information, financial incentives, extension services, and research and development initiatives aimed at enhancing climate resilience in farming communities. Collaboration between government agencies, research institutions, farmer organizations, and private sector entities is essential for developing comprehensive adaptation strategies that address the multifaceted challenges posed by climate variability and change in agriculture.

In Bangladesh, there is already a high-pitched increase in temperature and variations in rainfall outlines (Shahid 2010; Shahid et al. 2012). The effects of agricultural production will be adverse. Overall, the impact of climate change on irrigation water demand during the dry season can vary

Depending on indigenous climatic conditions, water operation practices, and the adaptability of agrarian systems to acclimatize to changing environmental conditions. Effective water operation strategies, including water conservation measures, bettered irrigation technologies, and adaptive agrarian practices, are essential for mollifying the impacts of climate change on irrigation water demand and icing sustainable agrarian product. Since 1995, Bangladesh has graded 6th between the country's outside grandiose by climate change (Global Climate Risk Index 2017)(Kreft etal. 2017). Bangladesh is hierarchical 158 of 181 climate vulnerability countries in the considerably used ND- GAIN indicator (2019). Bangladesh is the 33rd most helpless country and the 25th lowest country to help or reduce the goods of climate change, indeed if it's largely vulnerable. In six areas supporting life food and water force, ecosystem services, health care, mortal niche and structure, weakness measures the country's disclosure, vulnerability, and volume to copy the dangerous goods of climate change. Amenability events a country's capacity, witching profitable, power, and social readiness into account, to use means and convert it into action on adaption. Bangladesh must thus substance on climate variation because it's one of the country's most vulnerable to climate change. To address this issue, it's veritably important to understand the change in husbandry from the planter's perspective. Mindfulness refers to the procedure of entering information from the atmosphere and understanding it (Maddox 1995). Growers must first see a change in climate and also identify and apply useful adaptations (Maddison 2007). Utmost of the other recent trainings discovery that growers are apparent about temperature increase and downfall drop(Gbetibouo 2009, Maddison 2007, Nhemachena and Hassan 2007). Between the inadequate pieces of study on perception of growers in Bangladesh, utmost of the studies attention on the ocean zones and veritably many of them on hill tracts. veritably many studies have concentrated on anon-coastal zone and anatomized how growers explain their reasons behind the change in the climate. also, there are n't colorful studies that attention on growers rising objectiveness and crop husbandry and a keen interest in moving to other professions. This can have veritably bad consequences in the coming decades. In utmost developing countries, including Bangladesh, the lack of sufficient information on climatic changes and the effect on husbandry product is a problem to long- term justifiable husbandry. In a different study(Moniruzzaman 2013) exposed a measured reduction in climate variation knowledge and tone- assurance between adult groups and youthful groups. The results of the study support the claim that as people learn about climate change, both knowledge and confidence situations will rise. Farmer's perception of climate change and how it affects their lives is, thus, a pivotal step to mollifying the negative impacts of climate change. The change in husbandry practice and how climate change affects their livelihood is crucial to understanding the future of husbandry in Bangladesh.

CHAPTER 3

MATERIALS AND METHODS

3.1 STUDY AREA

Chandina is located in the eastern part of Bangladesh. Chandina is a sub-district (Upazila) in the Comilla quarter of Bangladesh. It's framed by other sub-districts of Comilla and Brahmanbaria sections. Husbandry is the crucial profitable exertion in Chandina. The area is generally pastoral, with a significant portion of the population engaged in husbandry. Rice, jute, and legumes are the main crops tended in the area also colorful vegetables, and colorful fruits. Due to its rich soil and favorable climate, Chandina contributes to the agrarian affair of the Comilla quarter and the broader agrarian sector of Bangladesh. Chandina knowledge's a tropical thunderstorm rainfall, distributed by high temperatures, heavy downfall, and separate wet and dry seasons. The thunderstorm season generally lasts from June to September, bringing significant rush which is essential for agrarian conditioning. The downfall helps in flushing the fields and replenishing water sources, contributing to agrarian productivity. still, inordinate, or erratic downfall can also lead to flooding and waterlogging, which may negatively impact crops and agrarian livelihoods. Temperature variations throughout the time impact the growth cycles of crops, with warmer temperatures generally favoring crop growth. The experimenter communicated to the original growers and led In- depth interviews. These interviews were informal,semi-structured and more like a particular talk with the growers so that they feel at home and can express their opinions and passions duly. The experimenter tried to hold no judgment or his own opinion and tried to explore and gain new information from the growers. This Data was grounded on applicable journal papers, books, exploration papers on this issue and collected applicable information. A aggregate of 24 husbandry families were named grounded on-

1. Minimal 10 times of experience in husbandry.

2. They either own lands, get lands on parcel in crop seasons or both.

3. They are/were farmers at some points in their lives.

Between these farmers, there were some people who have left farming and shifted to other occupations such as Dairy farming, Easy-bike driving, Fish farming, etc. It will help to understand their opinion on why they have quit farming and whether there is a relation with climate change.

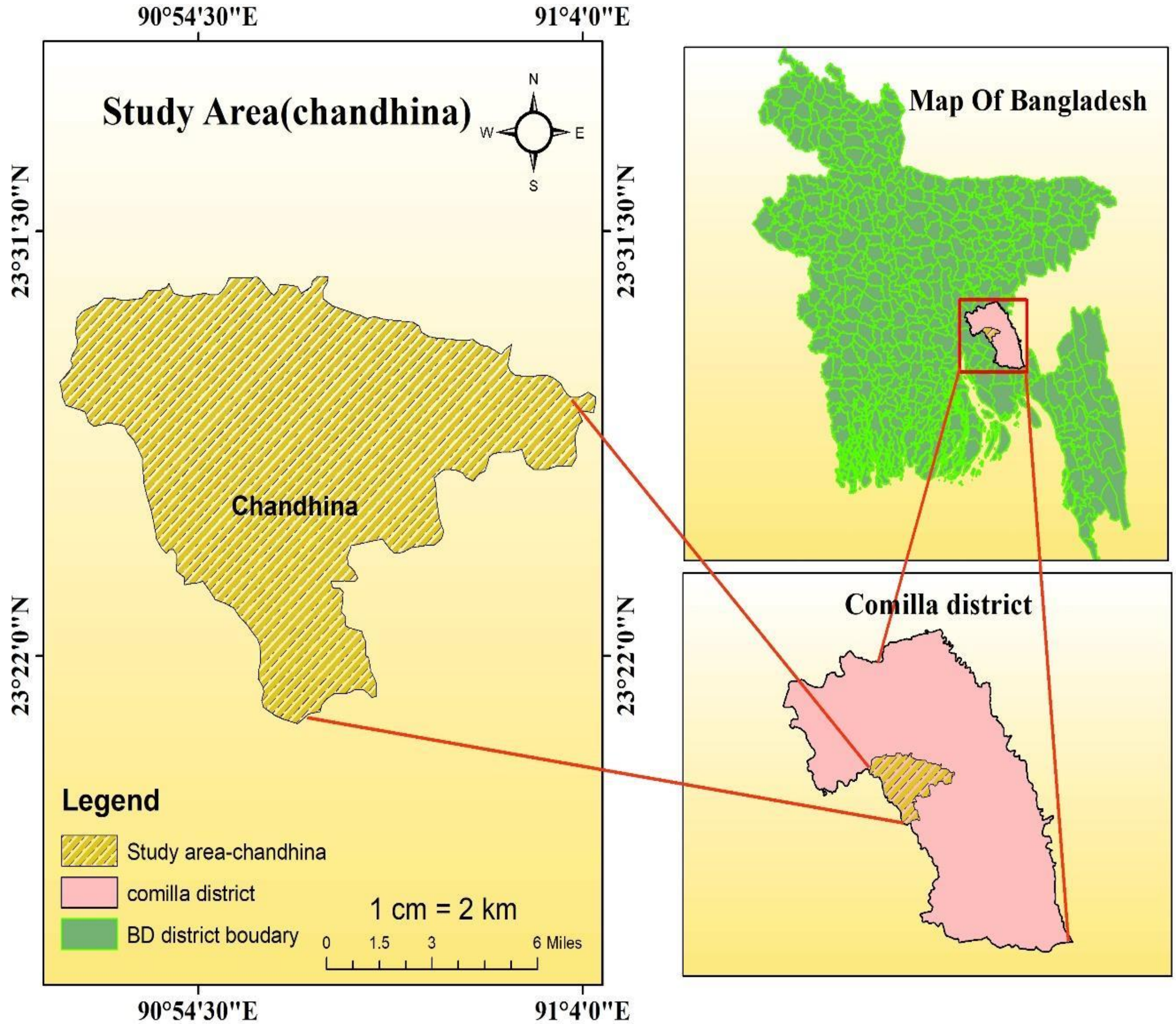


FIG-2 MAP OFSTUDY AREA (COMILLA, CHANDINA)

3.2 MATERIALS AND METHODS

3.2.1 Primary Data:

A interactive technique was used to collect information on the impact of climate change on agricultural communities in Chandina, Comilla, Bangladesh. 24 households participated. The study took a "micro-level" case study method, using Participatory Rural Appraisal (PRA) approaches that involved learning from and alongside rural people. PRA has advantages in terms of flexibility, enabling communities to add, improve, divide, and assess their knowledge, in contrast to conventional questionnaire-based approaches. To examine the vulnerabilities of rural communities, a range of methods were used, including resource mapping, income research, in-depth interviews, Focus Group Discussions (FGDs), seasonal analysis, and trend analysis. For primary data collection, the study used risk and resource mapping (RRM), vulnerability assessment (VA), and focus group discussions (FGD), with the instruments chosen based on past ecological and land use studies in the district. A seven-day field test in Chandina revealed the efficiency of semi-structured FGDs in gathering extensive community perspectives and information.FGDs, VA, and RRM were used to collect data, with an emphasis on people's incomes, resource vulnerabilities, and vulnerability rankings that other approaches to study may not have caught properly. Group conversations with 24 members from each farming family were held to address the research goals and investigate community potential to climate change, which included resource availability, changes in the environment, degradation, and extreme weather occurrences.

During the conversations, groups defined and determined their social, economic, environmental, human, and physical vulnerabilities to climate-related acts, exposing the interlinked nature of various vulnerabilities and how they interact.

Table 1: Methods used in the PRA process.

METHODS	TECHNIQUES USED	PURPOSE: TO CREATE INFO ON
FGD	Semi structured discussions	• Risk, income, climate change effects, major tragedy effects
	Vulnerability Investigation (Discussion)	• Farming vulnerability • Income vulnerability • Interconnection on weakness
	Risk and resource mapping (discussion and illustration)	• Key resources • Main risks • Resource weaknesses

In order to collect data on land, water, harvests, and other local resources (resource mapping) and the implications of climate change on notable local incomes (risk mapping), the authors also employed risk and resource mapping (RRM). RRM was accepted by the same set of members. The groups were asked to create public (Chandina, Comilla) maps depicting major resources.

Secondary Data:

The secondary data used in this learning were composed an unequal stratified chance selection method to have an illustrative sample diagonally all climatic districts in Bangladesh. The climatically districts shown in picture were used as a source for stratum. Individually climatically district was preserved as one section. This resulted in 24 farm families from Chandina, Comilla. The chosen district (Comilla) represents a wide range of climatic, economical, and topographical aspects that are typical of Bangladesh. Data obtained during field experiments conducted between January 2017 and April 2017 relate to the agricultural seasons of 2015-16. The study was to gather complete information on the economic status of the participating households, including basic demographic statistics (gender, age of agriculturalists, education level, number of family members, and so on) as well as farm-related information.

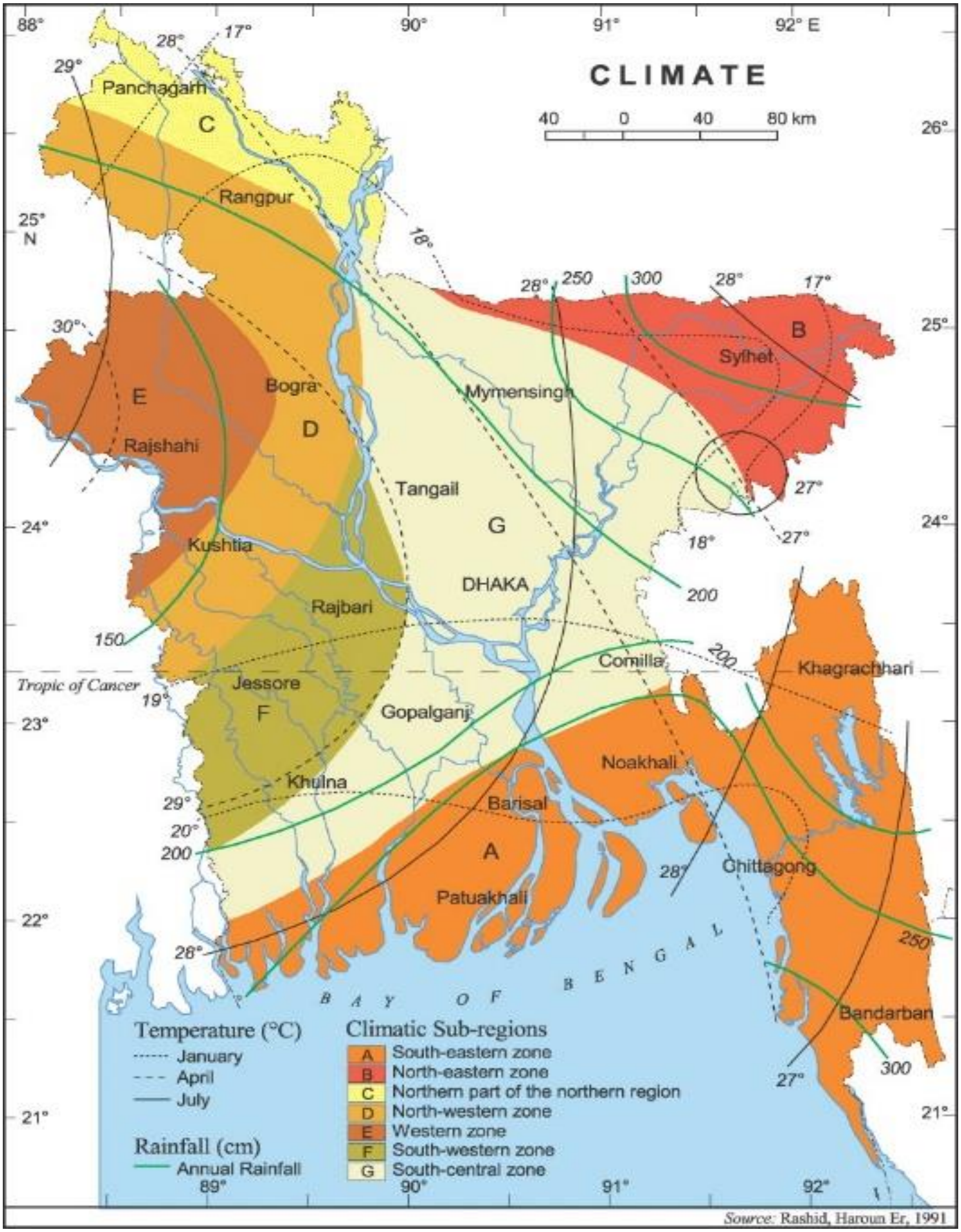


FIG-3- SEVEN CLIMATIC REGION OF BANGLADESH

I gathered information pertaining to farming expertise, agricultural zones, soil types, proximity to markets, access to extension services, and irrigation facilities. Additionally, I collected data on farmers' perceptions of weather changes and local climatic patterns observed in previous years. Furthermore, I documented current adaptation strategies adopted by farmers in the study area (as detailed in Table 4). The primary variable for Ricardian regression analysis is net crop income per hectare. To assess net crop income, farmers were extensively interviewed about their farming practices, input costs, and production expenses. These interviews covered aspects such as types of crops grown, planting seasons, transportation costs, and input quantities including labor, irrigation, seeds, pesticides, fertilizers, etc.

The relationship between net harvest earnings and environmental variables was estimated using a Ricardian model. Past weather statistics and agricultural local regional information from all climatic districts of Bangladesh were used to make this judgement. A regression approach was then developed to compare total produce revenue per hectare to for a long time meteorological, local, and farm characteristics. The current impacts of climatic variance and potential future implications of predicted climate scenarios on net harvest earnings were also assessed.

Methodological Framework

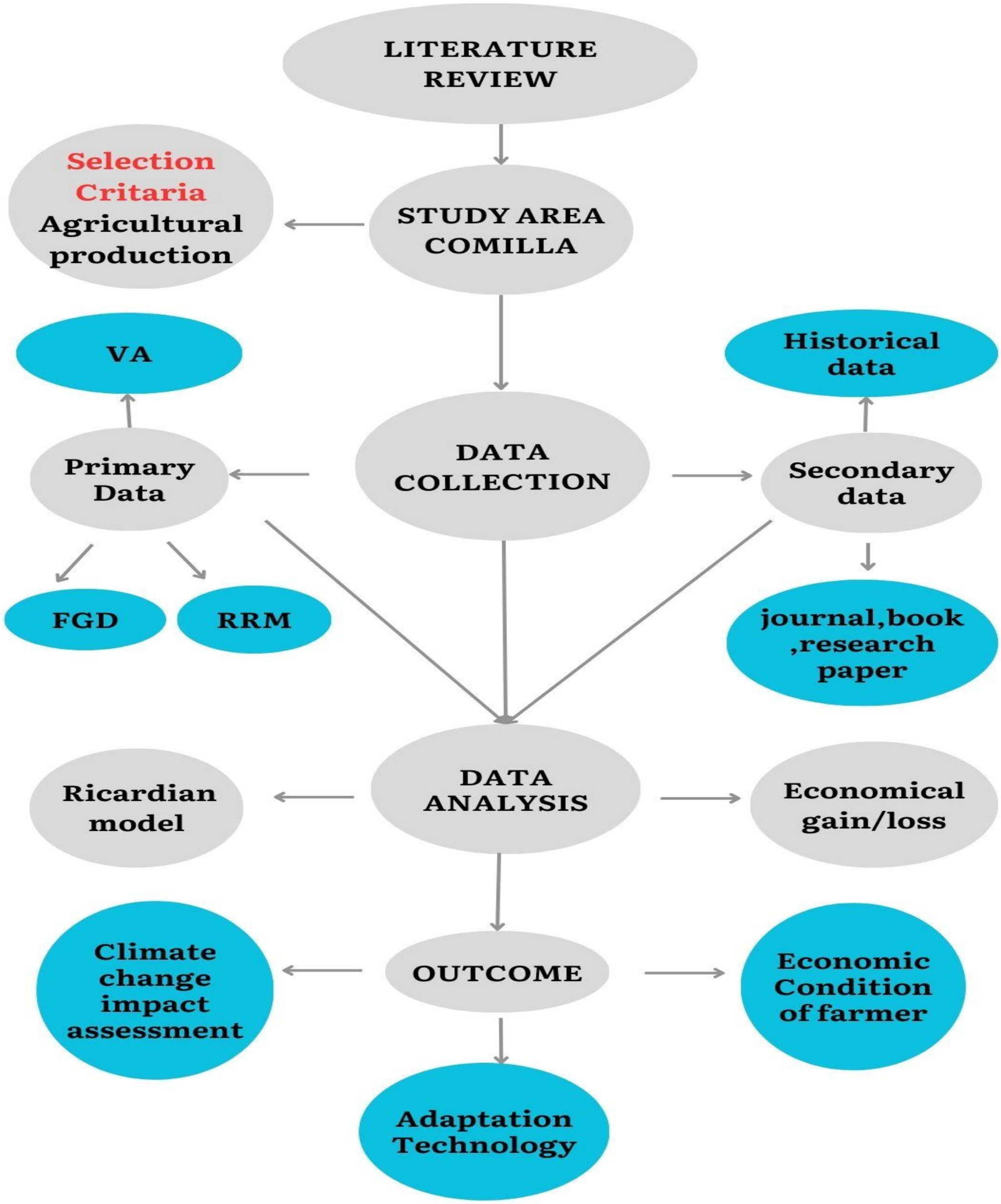


FIG-4 Methodological Framework

3.2.1.1 Ricardian methodology

Climate and husbandry are frequently represented using three introductory styles crop development simulation models, fiscal models, and integrated computation models like quantified general harmony and entire ranch models. These models are grounded on the relations of climate, crop composition, and growth. While the first two model styles may regard for some dissonances and crop operation strategies, they fall suddenly of counting for other rudiments similar as fiscal impulses, value difference, and crop variability, and multi-cropping. This constraint may affect in an overestimation or undervaluing of the impacts of rainfall. To produce a further thorough estimate of rainfall goods, a whole- ranch system with multiple responses is needed. In order to estimate the fiscal consequences of climate change on the husbandry assiduity, the" Ricardian model" is presently constantly employed across numerous countries. This model examines ranch performance across lands, taking into account climatic changes as well as other aspects similar as input prices, soils, and socioeconomic situations, with the land price reflecting the current value of the unborn sluice of net ranch profit. Grounded on the idea that land rents reflect the ranch's long- term affair, the Ricardian model gets its name from the work of a fiscal expert. It accounts for 3D differences in climatic points and other rudiments, performing in a full assessment of climate change's influence on agrarian. Because growers generally modify their operations to maximize yields and gains, this model has the important benefit of account for adaption. Other important advantages of the model are Information about climatic points over geographic space is demanded rather of time statistics, which are delicate and precious to collect. The model is adaptable, allowing for analysis of any significant enterprise events. Perpetration is simple. Still, the Ricardian model has limitations. The first issue is the possibility of absent flexible bias, which is new in all cross-sectional studies. Another source cause for concern is the lack of organization of agrarian and labor values requests, which could lead to price changes. It does not regard for CO_2 reduplication goods. Likewise, the model cannot postpone the costs of an immediate adaption to a new technology against climate. Still, unanticipated adaption to new technology is no way respectable. Another contentious issue enterprises irrigation. It's also not an issue in the exploration area because extreme granges calculate on irrigation.

3.2.1.2 Formulation of the Empirical Model

In accordance with the approach described by Mendelsohn et al. (1994), I complete the Ricardian model as:

$$V = f\ (C, H, F)\ldots\ldots\ldots\ldots.1$$

V represents harvesting revenue per hectare; C denotes climate factors such as temperature and rainfall; H encompasses various family characteristics such as age, education level, size of family, and agricultural expertise; and F covers farm-related variables such as agricultural district, access to storage facilities, distance to market, availability of credit for farming, soil types, and access to irrigation. Net crop profits are calculated by multiplying the farm gate price by the quantity sold and subtracting the total production costs, which include workers salary, fertiliser, pesticides, seeds, irrigation expenses, and transportation costs. Total agricultural earnings were calculated using the following equation:

$$V = \sum P_i\, Q_i(X, C, H, F) - \sum P_x\, X\ldots\ldots\ldots\ldots...2$$

In this context, Pi represents crop i's market price, Qi represents crop i's yield, X refers to the aggregate input factors used in crop i's production, and Px indicates the price of each individual input. Climate variables are formulated quadratic ally in the traditional Ricardian model.

$$V = \beta_0 + \beta_1 C + \beta_2 C^2 + \beta_3 H + \beta_4 F + u\ldots\ldots\ldots\ldots\ldots\ldots\ldots3$$

C and C2 denote the levels and quadratic equation relations for climate variables, respectively, and u is an error term. To capture the nonlinear relations, quadratic equation time is included. If the quadratic equation term is found to be positive, the function accepts a U-shaped technique; if it is negative, the function accepts a hill-shaped method. From equation (3), I calculated the bordering effects of a change in both precipitation and temperature on net crop income, which can be outlined as:

$$\frac{\partial NR}{\partial T} = \beta_1 + 2\beta_2 T \text{ and } \frac{\partial NR}{\partial R} = \beta_3 + 2\beta_4 R\ldots\ldots\ldots\ldots\ldots.4$$

CHAPTER 4

CONCEPTUAL AND ANALYTICAL FRAMEWORK

- **Conceptual Framework**

Rainfall had a direct influence on cultivation (rice, jute, vegetables, and fisheries) in Chandina, Comilla. When sufficient precipitation occurred during the growing paddy season production was high but there was a decrease in crop production and area under less rains, irregular and untimely precipitation. Due to erratic precipitation variability, production has declined steadily. The risk of climate variability in crop production, in general, mainly depends on the crop's growth stage when the weather aberration takes place.

The fluctuation of the crop production in Chandina could be caused by numerous factors, but the main cause is rainfall. The variation in rainfall is caused by climate change. Precipitation is influenced in many ways by climate change. Change in precipitation pattern, rainfall frequency and intensity, etc. Although it is generally agreed that average temperatures will gradually grow, changes in precipitation regimes are much uncertain about their distribution, frequency, and intensity. There is now more scientific evidence on the variability of rainfall and its important impact on crop output than ever before. Moreover, grains in most parts of the world serve as basic food. Factors note here: the severity of the consequences on crop yields in relation to precipitation activities vary between regions. Farmers in Comilla a livelihood of subsistence farming, which depends on the rainfall level and distribution. In the peak rainfall season, the principal growth season takes place between March and May, and between October and December the second growing season.

The annual rainfall trend in Comilla had improved a condition for good farm livelihood performance. In contrast, the district's survival farming was falling. This was caused by changing precipitation patterns. The yearly numbers of rain days declined but the intensity of the rain improved. The number of rain days failed in March and May during the main growing season but remained steady in April. In March, the intensity of the rainfall declined, but in April and May increased. A decreased growth period and unproductive precipitation with a general negative impact on yields have shown the effect of the moving rainfall pattern on subsistence farming. In Chandina, Comilla of Bangladesh, annual total rainfall presented a cumulative trend in the study.

With a total rainfall of 2000 mm (approximately 80 inches) per year, annual total rainfall in Chandina increased by 1.820 mm / year.

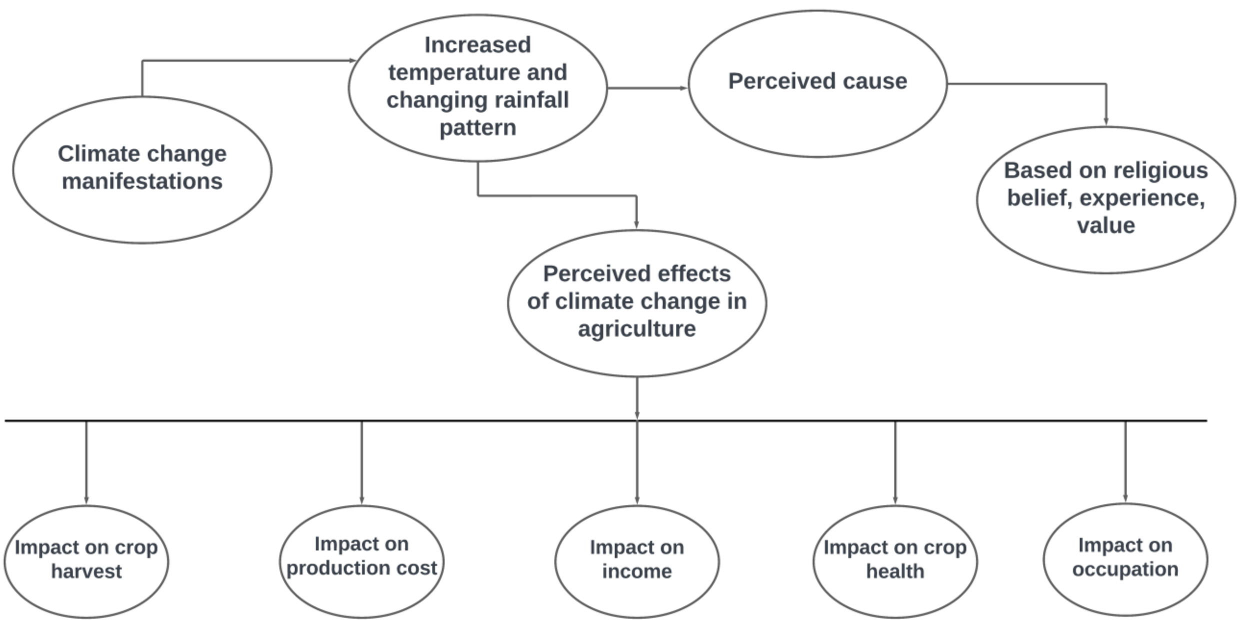
The temperature and precipitation data from all 34 weather stations in Bangladesh were analyzed in a study for the period 1976-2008. Temperature analyzes showed that the annual average maximum and minimum temperatures at most of these stations are growing. Except for January and April, analysis of the average monthly maximum temperature, there has been an increasing trend in all months of the year; for the months of May to September and February, the growing trend was particularly significant. The average temperature increases in these months for the period between 1976 and 2008 was calculated at approximately 1°celsius over the 33 years. Increasing trends for all months except January and November have also shown in monthly usual minimum temperature. The monthly usual minimum temperature rise was approximately 0.7 ° C, with an average decrease of approximately 0.06 ° C in January and November in the same period. There is a considerable increase in the maximum and minimum month’s average temperatures over the 33-year period between 1976 and 2008.

Furthermore, for the annual and monthly averages and for the eastern region, significant increases in the maximum temperature have been observed in the south-east region. The higher temperature in hot regions affects the yield calendar. In the tropics, though only small, global warming is likely to decrease the effective growth season, particularly in those regions where more than one crop is grown each year. In developing countries, rice is one of the main sources of calories. Multimethod ensemble analysis reveals that an average global temperature rises of 1 ° C reduces global rice returns by 3.2 ± 3.7% on average. Some 60% of Bangladesh's arable lands are N, P and K compost deficient. The soil content of organic matter is well below the critical 1.5% level. Urea in recommended doses usually is used in farmers. The P and K composts at rates that are significantly below the recommended amount are applied due to the high prices. Usually, biological composts do not include the chemical composts. It is therefore obvious that farmers use almost no balanced composts needed for high efficiency. A task force of the Department of Agriculture stated that the efficiency of crops for the last few years or so has either festered or failed even though fertilizer use in the country has nearly improved in three folds.

Researchers found that the maximum rates of population growth of insect species which will adapt to the warmer climate will also increase, leading to increased insect populations in global warming.

Global warming is expected to result in a rise in the application of pesticides, offensive type, bugs, and insect-borne sicknesses. The belongings of weather variation will be seen in future years and are already beginning to be seen. The occurrence of diseases and pests has recently become extremely serious because of the adverse effects and, particularly, rising temperatures, of climate change. In Bangladesh, it is estimated that 4-14% of rice production is lost by various bug pests yearly. The serious rice bugs are now the bacterial leaf disease and roundworm. The winter, dry season in Bangladesh has also fallen in length. Through the monsoon season (June-August) the usual temperature is increasing at 0.07 °C a period, and during early winter (September-November), at 0.12 °C a period.

- **Analytical Framework**



The researcher anxious to assume how crop farmers might perceive climate variation with their knowledge, experience, and ethics. Firstly, the question raises which manifestation of climate change the researcher focuses on. By considering the geographical area and the type of farmers that are affected by climate change, two manifestations of climate change

(a) Increased temperature and

(b) Changing rainfall,

Are focused on. Since farmers can perceive and feel the changes in climate, the researcher expected a similar response about increased temperature and erratic rainfall. But their perceived reasons behind climate change were unidentified. We tried to find how the crop farmers explained the reasons behind climate change. Of course, since most farmers lack formal education and scientific knowledge, the researcher expected their explanation based on their beliefs, experience, and values.

CHAPTER 5

RESULT AND DISCUSSION

the software STATA version 14.0 was used to analyse the data to execute the Ricardian model. These tables 2, 3, and 4 present details on those datasets containing climate information and other relevant data. To solve the diversity concerns, instead of using a physical model, a simplified model was used. Our analysis had no a crucial stage variable related to agricultural knowledge. The distance from location to market variable was also included in our study, despite its lack of statistical significance. Stable testing were used to estimate mean errors in order to reduce variation. A total of 24 households were classified as unusual events due to the fact that they reported extremely high or low incomes and extremely large or small family sizes.

- **Climate attributes and net agricultural yield profits**

Table 5 shows the reversion constants calculated based on the two Ricardian models. The initial model investigates the effects of seasonal temperatures and rainfall levels on net crop profits, whereas the second model includes land and household characteristics parameters to account for additional factors influencing crop productivity and profitability.

Table 2. Summary of the factors used in the study (model size n = 396).

Factors	Mean	Standard Deviation
Net income from crops (US$)	410.34	249.95
Temperature during wet season (°C)	28.11	0.53
Temperature during dry season (°C)	21.16	0.98
Rainfall during wet season (mm)	300.38	106.21
Rainfall during dry season (mm)	20.88	8.79
Gender of farmers (1 = male, 0 = female)	0.97	0.18
Age of farmers	48.39	9.24
Years of education of farmers	6.11	2.17
Family size (number of members)	6.15	1.42
Years of farming experience	26.49	9.05
Access to bank credit (1 = yes, 0 = no)	0.40	0.49
Access to farming extension services (yes = 1, No = 0)	0.80	0.40
Access to irrigation (yes = 1, No = 0)	0.64	0.48
Distance to market (km)	2.60	1.27

Presence of sandy soil (1 = sandy soil, 0 = non-sandy soil)	0.27	0.44
Presence of clay soil (Clay soil = 1, non-clay soil = 0)	0.10	0.29
Land size (hectare)	1.79	0.46

Both models' results show robustness. The majority of the model's constraints show predicted signals, and the prediction models account for 3–16% of the observed variability in net crop profits per hectare. I observed that some continuous factors have very high values even when their quantitative significance is small. The variation can be related to the small number of justifications and a lack of descriptive factors. Climate factors have a nonlinear connection with net crop profitability, which is consistent with findings from recent Ricardian research. It is fairly interesting to see clear increasing and declining patterns in the temperatures throughout the rainy and dry seasons, respectively. However, given that these temperatures correlate to the summer and winter harvesting seasons, it is in accordance with agricultural methods.

Key spring, summer, and autumn months are combined into Bangladesh's summer harvest period, whereas winter and the early spring months make up the winter harvest season. Increased temperatures during the beginning of the rainy season may be beneficial for crops, since they facilitate vital growth and development. Warmer conditions, on the other hand, may have a negative impact on crop development in the long run. The phenomenon might explain why rainy temperatures follow an inverted U-shaped pattern.

On the other hand, the comparatively low temperatures in the early stages of the dry season may be harmful to crop development. However, when temperatures rise over time, they become better suited to crop ripening and maturity. As a result, the pattern of dry temperatures shows a U-shaped tendency. In contrast, rainfall trends for both wet and dry seasons follow a hill-shaped pattern, showing that early-stage rainfall is beneficial to crop growing in Bangladesh.

Table 3. Variability in net crop profits diagonally climatic regions of Bangladesh.

Climatic Zone Title	Average net crop yield profits (US$)	SD
South-central	381.04	239.87
South-western	456.21	232.47
Western	473.16	296.86
North-western	420.46	319.95
Northern part of the north region	405.33	239.23
South-eastern	370.18	186.29
North-eastern	366.02	228.59
Average	410.34	

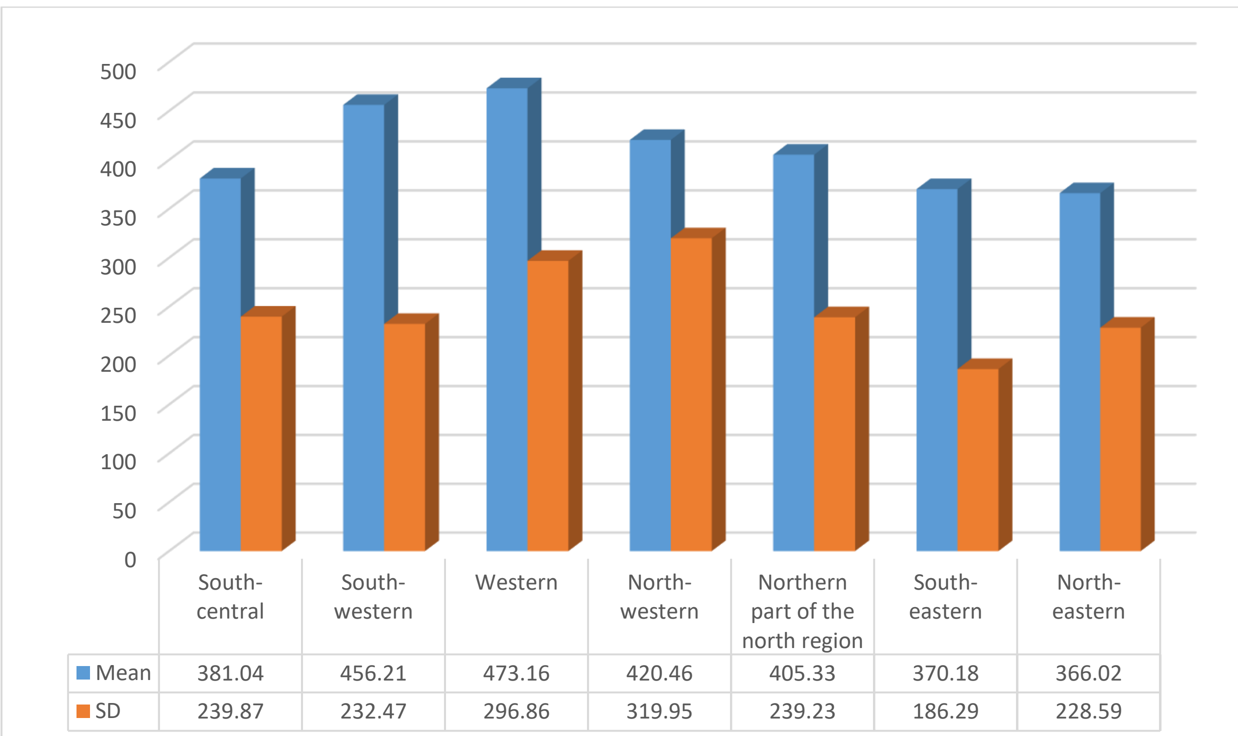


FIG-5 Variability in net crop profits diagonally climatic regions of Bangladesh.

Table 4. Present the farmers' specific adaptation strategies for irrigation.

Adaptation plans	(%) of model families
Exploring different crop varieties	52
Adjusting planting schedules	48
Crop variation	33
Cropping outline and alternations	21
Combined farming structures	16
Encouraged to non-farm events	13
Find off-farm work	11
Other plans	13

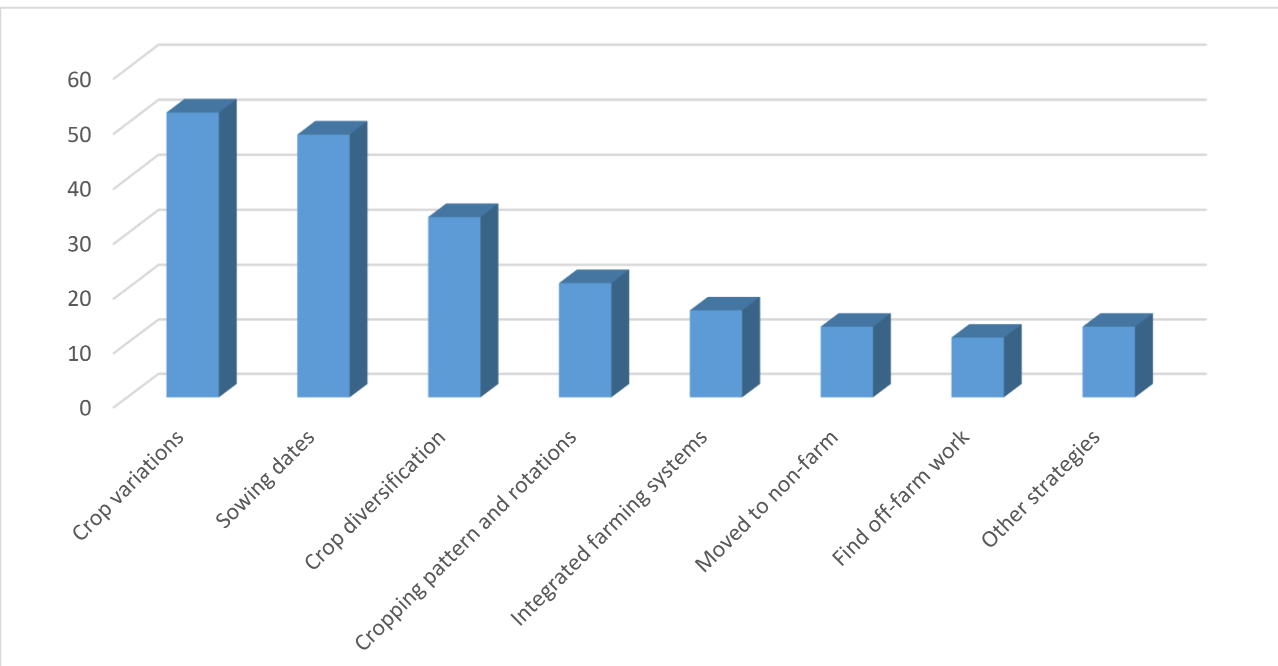


FIG-6 Present the farmers' specific adaptation strategies for irrigation.

Table 5. Ricardian regression models explanation net crop profits.

Variables	Model 1		Model 2	
	Coefficient	**Strong t-statistics**	**Coefficient**	**Strong t-statistics**
Temperature during the wet season	-13367.93***	-2.84	-11318.51**	-2.28
Temperature during the wet season (squared)	241.07***	2.86	205.42**	2.31
Dry Period Temperature	2656.94***	2.93	3060.22***	3.60
Dry Period Temperature (Squared)	-62.83***	-2.97	-72.31***	-3.63
Rainfall during the wet season	6.19***	3.43	7.04***	3.95
Rainfall during the wet season (squared)	-0.00***	-3.16	-0.00***	-3.58
Dry Period Rainfall	27.44*	1.91	26.17*	1.86
Rainfall dry period squared	-0.52	-1.56	-0.50	-1.56
Agricultural Expertise			8.11	1.43
Years of farming experience			3.86**	2.59
Household Size			10.74	1.21
Availability of Agricultural Extension Services			50.11*	1.91
Access to bank credit			19.71	0.79
Availability of Irrigation Facilities			46.40**	2.04
Farm Area			56.80***	3.01
Clay soil			-50.55*	-1.69
Sandy soil			-18.04	-0.70
Constant	156,177.10**	2.57	121,768.80*	1.90
Number of Observations	396		396	
F-statistic	3.21***		2.81***	
Coefficient of determination (R^2)	0.0358		0.1653	
Notes: ***p < 0.01; **p < 0.05; *p < 0.1				

Family demographics and agricultural abilities correlated significantly with net harvest earnings ($p < 0.05$). This shows that experienced farmers are better land owners and may be able to adjust to local climatic swings. For example, they can reduce the effects of weather variability and climate change by applying different soil conservation measures and current farming practices. Furthermore, access to irrigation services was significantly and positively related with net crop earnings ($p < 0.05$).In order to reduce the hazards of heat stress and drought, a large number of farmers in Bangladesh extensively rely on irrigation, particularly groundwater irrigation, which has a positive impact on productivity and, ultimately, net crop profits. However, the excessive extraction-related groundwater level decline in a number of Bangladeshi regions may result in higher salinity and irrigation expenses, which would ultimately impact farmers' earnings. Farm size has a strong positive influence on net crop revenue ($p < 0.01$), highlighting economies of scale. Larger farms often produce more than smaller farms. Access to agricultural extension services was positively associated with net crop earnings ($p < 0.1$). According to this, farmers who have access to timely information and support services are better able to grasp crop management techniques, which helps them adapt to climate change and increase crop yields and earnings. Soil type coefficients showed reduced net profits for both sandy and clay soils, with clay soil being statistically significant ($p < 0.1$).

Calculation of borderline effects

Table 6 presents a summary of the results obtained from the investigation of the marginal impacts of climatic factors on net crop earnings per hectare. In the rainy season, an increase in temperature of 1°C is linked to a profit rise of almost US$15.64 per hectare, whereas in the dry season, it results in a minor drop of roughly US$0.22 per hectare. Due to its relationship with autumn, the influence of temperature throughout the summer cropping period is especially significant. While early summer temperatures promote crop growth, later climbs may negatively impact profitability if farmers do not modify their techniques. On the other hand, because of the impact of spring, hard temperatures during winter harvesting actually increase profitability.

Conversely, an increase in rainfall has a consistently favourable impact on net earnings throughout both the wet and dry seasons. Across all climatic areas, a combined 1°C temperature rise and 1 mm/month increase in rainfall results in a considerable profit boost of US$19.66 per hectare. It is important to note that appropriate rainfall distribution is crucial for optimal crop development, while excessive rainfall during the summer harvesting period has limited positive effects. According to this, there is a statistically significant correlation between more rainfall during winter harvesting and improved crop growth and profit.

These findings highlight the importance of seasonal fluctuations in influencing net crop profitability, with temperature changes being more adaptable than rainfall changes. The study's findings show a positive correlation between temperature and profits, defying predictions that rising temperatures in a tropical climate would result in lower profits. This may be because Bangladesh has access to groundwater resources that make irrigation possible, as well as enough rainfall during the monsoon season.

Table 6. Borderline effects of climate on net crop profits (US$)

Variable	Full model
1°C rise in temperature on net crop earnings (in US dollars)	
Wet temperatures	15.64
summer farming periods	-54.23
Dry temperature	-0.22
Winter farming period	33.46
Yearly temperature	15.42
Yearly elasticity	1.13
1 mm/month rise in rainfall on net crop earnings (in US dollars)	
Rainfall wet	0.30
Summer farming period	0.34
Rainfall dry	3.94**
Winter farming period	4.23**
Yearly rainfall	4.24
Yearly elasticity	0.42
Total	19.66

Notes: **p < 0.05; US$1 = 80.65 BDT as average exchange rates through the study

Farmers in the district can handle substantially higher temperatures because to widespread irrigation use and greater expertise. This study on Bangladesh found that climate change will increase the regular usage of water for irrigation by 0.88 mm/day by the end of this timeframe. With irrigation, problematic temperatures have led to longer harvesting seasons every year, allowing farmers to increase their net income. So, Bangladesh's agricultural appears to be adapting to warming and will be marginally aided even in a hotter environment.

- **Borderline effects of climate diagonally all regions**

To observe the supply of effects diagonally different climatical regions, the peripheral effects of weather for every district is scheduled using the Ricardian regression model's constants. Table 7 demonstrates that for annual net profits to grow from $11 to $48 there must be a 1°C temperature increase. Parts of Bangladesh that get moderately cooler weather, such as the northeast and northwest, suffer from this. The western zone, with its hot environment, gains the most. The favourable relationships between net crop earnings and the marginal effect of higher rainfall during the dry season Diagonally, every region and the majority of them exhibit statistical significance at various levels ($p < 0.05$ and $p < 0.1$) about the results of the rainfall throughout the rainy season. These results indicated that there will be benefits and losses as a result of climate change throughout the various climatic zones and that the borderline impacts are not predictably diffused. It is also important for policy organisers to reduce losses and profit from gains by choosing and measuring the competency of current variation mechanisms and financing methods.

Table 7. Borderline effects of climate diagonally all regions.

Variable	Wet period	Dry period	Yearly
1°C rise in temperature on net crop earnings (US$)			
South-central	13.90	-2.68	11.22
South-western	40.38	-17.06	23.32
Western	39.08	9.24	48.32
North-western	11.30	12.64	23.94
Northern part of the north region	6.96	19.45	26.41
South-eastern	19.85	-29.36	-9.51
North-eastern	-23.85	7.54	-16.31
1 mm/month rise in rainfall on net crop profits (US$)			
South-central	0.33	3.89**	4.22
South-western	0.41	3.94**	4.35
Western	0.41	4.67*	5.08
North-western	0.35	5.01	5.36
Northern part of the north region	0.31	5.40	5.71
South-eastern	0.20*	3.21**	3.41
North-eastern	0.08	1.48	1.56

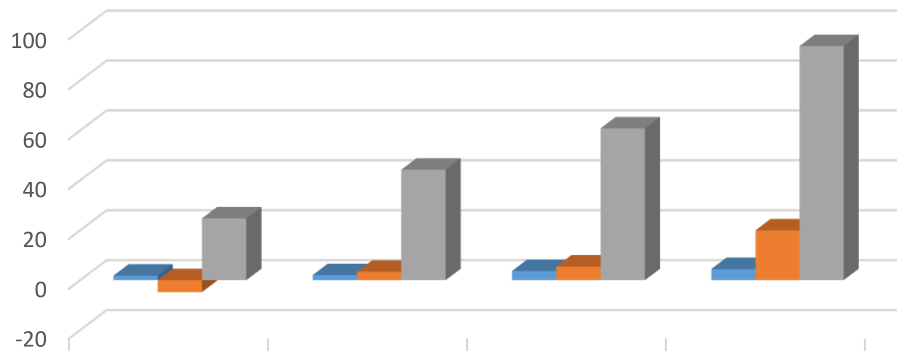
Notes: **$p < 0.05$; US$1 = 80.65 BDT as average exchange rates through the study

- **Forecasts for the future climate and its impact on net crop earnings**

A study on the influence of climatic variability on crop farming in Bangladesh employed two Coupled Atmospheric Oceanic General Circulation Models (AOGCMs) to forecast changes in rainfall and temperature for each district. In comparison to the 1971–2005 baseline, the models calculated monthly average climate changes for the years 2021–2060 and 2061-2100. The resultant projections were used to evaluate the impact on net crop earnings. According to both scenarios, Bangladesh will see temperature rises of 1.81-2.04°C by 2021–2060 and 3.68–4.47°C by 2061-2100. In terms of rainfall, the BNU-ESM model expected a 4.8% decline by 2021-2060, but the CanESM2 model projected an increase (3.39-19.97%) for both time periods. Net revenues per acre increased more over the historical period, according to the study. The analysis discovered that in both scenarios, the growth in net profits per hectare was higher over the historical era of 2061-2100 than it was between 2021 and 2060.

Table 8. Effects of climate situations on net crop profits (US$)

Climate forecast models	Change in temperature ° C	Change in rainfall (%)	Change in net profits
BNU-ESM: 2021-2060	1.81	-4.80	24.77
CanESM2: 2021-2060	2.04	3.39	44.29
BNU-ESM: 2061-2100	3.68	5.47	60.82
CanESM2: 2061-2100	4.47	19.97	93.82
*Note: % changes in calculation.			



	BNU-ESM: 2021-2060	CanESM2: 2021-2060	BNU-ESM: 2061-2100	CanESM2: 2061-2100
temperature ° C	1.81	2.04	3.68	4.47
(%) Change in rainfall	-4.8	3.39	5.47	19.97
net incomes	24.77	44.29	60.82	93.82

FIG-7 Effects of climate situations on net crop profits (US$)

Table 8 displays the outcomes. The outcome demonstrated that different climate zones will not be uniformly harmed as a result of the impending climate change. The results also demonstrate that, as long as Bangladeshi farmers continue to employ irrigation to mitigate various climatic consequences, the benefits of the upcoming climate change will grow over time to their well-being.

- **The Perceived Effects of Climate Change and Economic Condition on Agriculture (Chandina, Comilla):**

The respondents from Chandina have reported many things that they perceive as the effects of climate change. These include **Low Crop Harvest:** Farmer's report that due to untimely rain and lack of rain in the monsoon season, they do not get good harvest. Especially in rice, jutes, vegetables and so on.

"I planted vegetables in my field in the monsoon season. But there was absolutely no rain at that time. Thus, my vegetables did not grow well. I used so many things on the field. I used phosphate, and other composts in my field so that I get a good yield of vegetables. Everything went fine. The plants grew, there were little healthy my plants. Then suddenly, it rained so hard. Then my vegetables caught a virus."- (Ahsanullah, 54)

The respondents have reported that for a good harvest, the timing of the rain, the amount of rain and the intensity and consistency of rain, all are very important. Due to climate change, the pattern of rain has changed so drastically that the respondents are unable to predict rainfall. However, in the past, they used to predict the rainfall with their indigenous knowledge and experience.

"In a good season where there is sufficient rain, I would get 26-30 kg of rice per katha (720 square feet), but this year, I couldn't even get 5kgs per katha. Problems happen where there is to heat as well. A few years back, the leaves of my rice plants were dying because of the excess heat. Some vegetables also don't grow when there is too much temperature. You need a good amount of rain and suitable temperature for crops to grow."- (Shirajul Islam, 50)

The respondents have asserted that too much heat also causes problems in crop production. During monsoon, when there is no rain for 5-6 days at a stretch, it creates too much heat in the lands. One the one hand, temperature is gradually increasing annually, on the other hand, the lack of rain in monsoon creates extreme heat which lowers the productivity of crops.

"I have planted many kinds of vegetables today, but I had to plant it at least 14-20 days ago. However, there was no rain at that time, so I could not plant them. Last year, about 1 bigha cost of vegetables died since there was no rain. I had a huge loss. Some vegetables such as eggplants and chilies do not grow nowadays at all. Many of the farmers had huge losses by farming eggplants and chilies. These plants are dying just before they are about to bring fruits. It has been like that for the last 3-4 years." (Mohammad Romizuddin, 57)

"I planted jute 3 years ago. But there was no rain. Do you know what happened my son? It didn't grow at all. Normally jutes grow by 14-15 feet. But that year, the jute plants raised by only 6-7 feet. I didn't get good prices with these jutes. It didn't even cover my total expenses."- (Nurul Islam, 57)

Many of the respondents have been planting jute for a long time. However, the production of jute is very inconsistent, just like rice. It has good harvest when it rains well, it has bad harvest when there is less rain. Also, the respondents have said that over the years, due to inconsistent behavior of the climate, they are not producing as expected.

Increased Cost of Production: The respondents have said that climate change increases the cost of production. It mainly happens in three ways,

a) increased use of irrigation
b) increased use of composts
c) increased use of pesticide

Increased Use of Irrigation

"A few years ago, I planted rice in my field. But there was no rain. I had to irrigate water using shallow machines. Then how can you preserve it up if there is no rain in the monsoon period at all? I did not have a good harvest. I must think about the cost as well. Using machines significantly increases production costs. Not to mention, more composts and pesticides must be used nowadays."- (Anwar Hossain, 67)

Most of the respondents have said that the production cost increases so much when there isn't sufficient rain in monsoon. That's because they must irrigate the lands with pumping machines. That costs a lot of money. Also, rice is one of the main crops in Chandina. But rice production needs a lot of water. When there isn't enough rain in monsoon, they must irrigate through machines, which increases the cost of production.

Increased Use of Composts

"Extra composts and pesticides have to be used currently. I don't know the exact number of composts or pesticides that I use on the field. Most of the farmers use composts based on intuition. We have no formal training on how to use composts or pesticides. We use it and see how it turns out. If it's good, then other farmers will follow. But if otherwise, then we use more composts. But in the past, this wasn't the case. When there is good and consistent rainfall in the monsoon, the plants automatically get enough nutrition. We didn't have to use composts or pesticides that much."- (Shahbuddin, 65)

The respondents have also reported that more composts and pesticides are being used. One important thing to note that, farmers use composts and pesticides on intuition. They experiment with the amount and share the results with one another and choose the best option for crop production. This gradually becomes common knowledge and thus eventually becomes indigenous knowledge. Here, this knowledge is important. Because, by analyzing this data, more adoptive measures to tackle climate change and newer and better methods of applying composts will be found.

Increased Use of Pesticides

"The more compost and pesticide you use the more it costs. These rats have become such a big problem. In eggplants and in rice, rats can destroy the whole harvest. But in the past, there weren't so many pests"- (Afsar Ali, 54)

"I have planted some eggplants this year, you'll be amazed to hear that, in the past, we would spray insecticides only once a week. But nowadays, in eggplants, we must spray twice a day. Even so, pests attack these plants, and we don't get sufficient crops. There is also the risk of inhaling these poisonous sprays. Farmers often become sick when spraying pesticides constantly every day on these plants."- (Rahamt Shikdar, 60)

Most of the respondents have asserted that there are more insects in crops now. That's why they must use more pesticides than before. Some respondents have said that they are using 4-5 times more pesticides than they used 6-7 years ago. More pesticides cost more money. Also, the average price of pesticides and composts have increased over the last 10 years. However, the price of crops has not relatively increased that much.

Diseases in Crops: Some of the farmers have reported that they due to climate change, some diseases occur in crop farming as well. Due to increased number of pests and insects nowadays, many crops catch virus or diseases.

"In the case of rice, when there is too much heat, the leaves get burned (rice sheath blight). Also, there is a thing called "Chita", it means that inside the rice hulls, there isn't any rice. Most hulls are empty and hollow with no rice grain inside it."- (Nur Ali Sheikh, 58)

Some respondents declare that there are new kinds of bugs in crops that they haven't seen before. Most of them have no idea about how to tackle them. However, their perceived cause of new diseases is the increased number of insects in crops.

Change in Profession: The respondents have reported that they are slowly becoming disinterested in crop farming. Many harvest farmers have already shifted or trying to move to other professions. Most of them are interested in dairy farming.

"For the previous 4 years, I don't get predictable earnings from farming. Each year, profit is lower than the previous year. Among my 5 brothers, 2 of them have completely left agriculture. They sold their lands and bought "easy bikes.". They are both doing much better than me. At least they are not in debt, like me. I'm thinking to shift to dairy farming. At least, I'll have some money selling milk. But there is a problem with that too. The initial cost of buying cows is high. You must invest 1-1.5 lakh taka to buy two cows. Many of the farmers don't have that kind of money. People who can afford it, are moving away from agriculture and some farmers are just stuck with it, like me. The farmers who individual the lands are suffering more than everyone. You know why? Because the price of labor has risen by a lot. So, the day labors who work on lands get money even if the crop-yield isn't sufficient. They are better off. Some people sell their lands and buy cows. Others go to Brick Kilns as laborers. We farmers are in a dire situation. Farmers who are from well-known families can't buy vans or go to brick kilns because of their social status. Nor can they beg. This is a tough time for us indeed."- (Farid Uddin, 52)

Some of the respondents have said that many farmers are not interested in crop farming anymore. Some farmers are shifting to or have already shifted to other profession such as full-time Dairy Farming, Easy-bike driving, working in Brick kilns, going to garments, becoming fish farmer and so on. One thing to note that, many of the respondents already had cows in their houses. However, they are the source of secondary income which is primarily done by the female members of the house. So, when the farmers say that they want to shift to dairy farming, it means that the male members will be fully committed to dairy farming and wants to invest more in dairy-farming. Their chance to move to other occupations depend on two things,

1. Financial Condition- Well-off farmers can sell some of their lands to buy cows. However, poor farmers do not have that kind of capital.
2. Social Standing- Few farmers are becoming easy-bike drivers and workers in brick fields. Very few have gone to work as garment workers. Due to social standing, many farmers are not willing to go to those occupations, even though they are poor.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

In summary, this thesis investigates the important effects of climate change on agricultural and the economic situation of farmers in Comilla, Chandina. The region is facing issues such as erratic rainfall patterns, rising temperatures, and extreme weather events like as droughts and floods, which disrupt traditional farming practices and result in lower yields and crop failures. Farmers in this region are especially susceptible since they rely on rain-fed agriculture and have limited access to resources like irrigation infrastructure, new agricultural methods, and financial assistance programmes. Furthermore, the study uses a Ricardian regression model to analyses the financial effects of weather variability on crop cultivation in Bangladesh. The data suggest that farmers' existing net earnings are vulnerable to climatic variability, with occasional temperature swings imposing a more noticeable effect than scattered showers. Net earnings are heavily influenced by land and family characteristics, access to extension services, farm size, irrigation availability, and agricultural knowledge, whereas clay soils have a negative impact.

Table 9. Predicted average net crop profits (US$) crossways different climatic regions

Climatic regions	BNU-ESM		CanESM2	
	2021-2060	**2061-2100**	**2021-2060**	**2061-2100**
South central	20.55	56.60	38.78	89.60
South-western	23.44	68.83	52.29	101.82
Western	58.50	94.55	78.02	126.67
North-western	34.42	70.47	53.94	103.47
Northern part of north	37.24	73.28	56.75	106.28
South-eastern	-1.29	34.76	18.23	67.76
North-eastern	-9.64	26.40	9.86	59.40
Note: % changes in calculation				

Following small-scale impact analysis, crop net profits were shown to be more vulnerable to temperature changes than rainfall changes, with considerable variability between time periods and geographic dimensions. Projections based on two AOGCMs, BNU-ESM and CanESM2, show that net crop revenues in Bangladesh might rise by an average of US$25-84 per hectare. It is observed that the effects of climate change would differ among climatic zones. These insights can help policymakers and development specialists create effective adaptation measures.

The study's primary focus is on the consequences of climate change on net crop earnings, but future research should look into its implications on other agricultural sectors such as fisheries and livestock to determine financial gains or losses. Furthermore, more extensive research on the financial effects of climate change on rural family incomes should be conducted utilising modern approaches.

Finally, the authors suggest numerous adaptation methods for policymakers and climate change planners:

1. Improving access to healthcare facilities, especially for marginalised groups.
2. Providing economic assistance to smallholder farmers during and after extreme weather events, while assuring long-term budget allocation.
3. Improved access to alternative income and assets for local populations.
4. Improving physical infrastructure, including transportation networks and market access.
5. The digging canals, rivers, and ponds, as well as creating protection barriers, are being used to avoid saltwater entering onto agricultural lands during floods.
6. Promoting community-based efforts to offer crucial social services during and after natural disasters, with local governments and grassroots organisations assisting in the effective dissemination of knowledge, information, and support services.

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APPENDIX

QUESTIONNAIRE

Dear Participant,

Thank you for dedicating your time to engage with this survey. Your insights are crucial for us to comprehend the challenges confronting farmers in Chandina, Comilla, amidst the impacts of climate change on agriculture and the local economy. Please take a moment to respond thoughtfully to the following questions. Be assured that all responses will be treated with utmost confidentiality and utilized solely for research endeavors.

We sincerely appreciate your cooperation and contribution.

Respondent Name **Respondent no** **Village /Para**

Semi-structured interview

Demographic Information

QN	Question	Response/Code	Remarks
1.	What is your gender?	1. Male 2. Female 3. Other (please specify)	
2.	What is your occupation?	1. Farmer 2. Agricultural researcher 3. Government official 4. NGO representative 5. Other (please specify)	
3.	What is your age range?	1. 18-24 2. 25-34 3. 35-44 4. 45-54 1. 5. 55 and above	

Climatic Issues

QN	Question	Response/Code	Remarks
1.	Have you noticed any changes in local weather patterns affecting agriculture in the past 5 years?	1. Yes 2. No	
2.	Are you experienced an increase in the prevalence of pests and diseases affecting crops due to climate change?	1. Yes 2. No	
3.	Have you witnessed shifts in the cropping calendar or changes in the types of crops grown due to climate-related factors?	1. Yes 2. No	
4.	Have you faced challenges in accessing water resources for irrigation due to changes in	1. Yes 2. No	

Respondent Name **Respondent no** **Village /Para**

	precipitation patterns linked to climate change?		
5.	Which of the following climate-related impacts have you observed in your farming practices?	1. increased irrigation needs 2. Changes in crop selection 3. Altered planting and harvesting times 4. Increased use of pest control measures	
6.	Where do you get your information about climate change?	1. Personal observation, 2. news, 3. conferences, 4. TA, 5. conversations	

Agricultural practice, adaption process and issues

QN	Question	Response	Remarks
1.	Are you actively adopting climate-resilient crop varieties or agricultural practices?	1. Yes 2. No	
2.	Is subsidies or incentives provided you specifically to encourage the adoption of sustainable and climate-resilient farming practices?	1. Yes 2. No	
3.	Do you believe that technological advancements can help mitigate the impact of climate change on agriculture?	1. Low 2. Medium 3. High	
4.	What type of support did you think most helpful in adapting to climate change impacts on agriculture?	1. Financial assistance 2. Training and education 3. Access to climate-smart technologies 4. Other	

Respondent Name **Respondent no** **Village /Para**

5.	Have you adopted any climate-resilient agricultural practices or technologies?	1. Yes 2. No 3. Planning to	
6.	How confident are you about the accuracy and reliability of weather forecasts for planning of your agricultural activities?	1. Not confident 2. Somewhat confident 3. Very confident	
7	Have you considered introducing new crops that may be more resilient to changing climate conditions?	1. Yes 2. No	

Economic impacts and supports

QN	Question	Response/code	Remarks
1.	Have you faced any financial challenges due to climate-related issues, such as crop losses or increased input costs?	1. Yes 2. No	
2.	Do you think the government-supported initiatives specifically designed to help farmers adapt to climate change?	1. Yes 2. No	
3.	Is climate change influenced the availability of agricultural loans and financial support for farmers?	1. Yes 2. No	
4.	4 How often can you get information and support about climate-smart farming practices from local agricultural extension agent?	1. Infrequently 2. Occasionally 3. often	
5.	Do you believe that government policies adequately support the	1. Strongly agree 2. Agree 3. Neutral	

Respondent Name **Respondent no** **Village /Para**

	economic well-being for you?	4. Disagree 5. Strongly disagree	
6	In the past year, have you faced financial challenges such as increased debt, bankruptcy, or difficulty meeting financial obligations?	1. Yes 2. No	Remarks
7	Are actively seeking alternative sources of income beyond traditional agriculture to sustain their livelihoods?	1. Yes 2. No	

Awareness

QN	Question	Response / code	Remarks
1.	On a scale from 1 to 5, how would you rate your awareness of the potential impacts of climate change on agriculture? (1 = Not aware at all, 5 = Extremely aware)	1 2 3 4 5	
2.	Have you received information or education about climate-smart agricultural practices?	1. YES 2. NO	
3.	Are all of you adequately informed about the risks and challenges posed by climate change?	1. YES 2. NO	
4.	Do you think government agencies are doing enough to educate farmers about climate change and its implications?	1. YES 2. NO	
5.	What is the primary barrier to raising awareness about climate change among farmers?	1. Lack of information 2. Lack of interest 3. Limited resources 4. Other	
6.	Do you think there is a need for increased collaboration between governmental, non-governmental, and private sectors to address the climate impact on farmers effectively?	1. YES 2. NO	

Respondent Name		Respondent no	Village /Para
7.	If there were workshops or educational programs on climate-smart how likely would you be to attend or encourage others to attend?	1. Very likely 2. Somewhat likely 3. Neutral 4. Not very likely 5. Not likely at all	

Thank you for your participation. Your insights are invaluable in addressing the challenges posed by climate change on agriculture and the livelihoods of farmers in Chandina, Comilla. If you have any further comments or suggestions, please feel free to share them.

Some pictures during survey