Assessment of Impact, Vulnerability and Farm Household's Adaptation to Climate Change: A Study of Flood prone areas of Jorhat district of Assam

(Dissertation Submitted to Mahapurusha Srimanta Sankaradeva Viswavidyalaya in partial fulfilment of the requirements for the award of the degree of Masters of Arts in Economics)

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DECLARATION BY THE CANDIDATE

I hereby declare that the work carried out in this M.A. Dissertation is my original work under the supervision of Dr. Dikshita Kakoti, Assistant Professor,Department of Economics, Mahapurusha Srimanta Sankaradeva Viswavidyalaya, Nagaon, Assam. The present research work has not been submitted previously at any other university or institution of higher education for the award of any other degree.

I have appropriately acknowledged the authors of the research publications by citing or quoting their works in the dissertation. I want to clarify that I have not intentionally included the research work of others reported in various sources of journals, reports, dissertations, theses or websites and claimed it as my own. Instead, I have properly cited these sources and credited them as references in my research work.

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CERTIFICATE

This is to certify that the dissertation titled 'Assessment of Impact, Vulnerability and Farm Household's Adaptation to Climate Change: A Study of Flood prone areas of Jorhat district of Assam' submitted by Ms. Darshona Neog (Roll No: ECO-15/23) in partial fulfillment of the requirements for the degree of Master of Arts (MA) in Economics, is a bonafide record of original research work carried out under my supervision. The contents of this dissertation have not been submitted for any other degree or diploma elsewhere.

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INTRODUCTION

Chapter – I

INTRODUCTION

1.1 Background of the Study:

Climate vulnerability poses significant risks to agricultural systems, particularly in regions heavily dependent on a single crop. Climate variability and extremes pose substantial challenges to livelihoods at global and regional scales (Rajkumar. R, 2021). According to Meeta Goal, the vulnerability of Indian agriculture comes from its exposure to climate variability, high livelihood dependence upon the sector and low adaptive capacity in terms of irrigation coverage and extent of other technological inputs (Goal. M, 2016).

Climate vulnerability in Assam deeply affects human lives, especially marginalized communities dependent on agriculture, forests, and rivers. Frequent floods, riverbank erosion, and changing rainfall patterns displace thousands, destroying homes and livelihoods. Farmers struggle with erratic weather, reducing crop yields and increasing food insecurity. Rising temperatures and shifting monsoons also worsen water scarcity and vector-borne diseases like malaria and dengue. Indigenous communities, who rely on nature for sustenance, face displacement and loss of traditional knowledge. Poor infrastructure in rural areas further limits adaptation, leaving many trapped in cycles of poverty and migration. Climate change is a complex phenomenon. Empirical evidences suggest that climate change is real and already taking place. The climate system is a complex and interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water and living beings (Begum. A, 2016).

Jorhat, a town in Assam, faces significant climate vulnerability that directly affects its people. Frequent floods, caused by heavy monsoon rains and the shifting course of the Brahmaputra River, displace families, destroy homes, and ruin crops, pushing many into financial hardship. Rising temperatures and erratic rainfall patterns also threaten tea plantations, a vital source of livelihood, leading to job losses and economic instability. Waterborne diseases spread rapidly during floods, endangering public health, especially among children and the elderly. Additionally, unpredictable weather patterns make it harder for farmers to plan their crops, increasing food insecurity. The people of Jorhat continue to struggle against these challenges, relying on community support and adaptation efforts to survive in an increasingly uncertain climate.

1.2. Justification of the Study Area:

Jorhat, is highly vulnerable to climate change due to its reliance on agriculture, which is heavily impacted by erratic rainfall, floods, and rising temperatures. These climatic stresses threaten food security and livelihoods, making crop diversification a critical adaptation strategy. By exploring climate trend in Jorhat, this dissertation sought to highlight how farmers can reduce their dependence on single crops, enhance resilience, and improve income stability. The study aimed to provide practical insights into sustainable agricultural practices that can mitigate climate risks while addressing the socio-economic challenges faced by local communities. The sustainable agriculture practices such as, a high-tech nursery at Kakajan Tea Estate promotes agroforestry and carbon sequestration. Assam Agricultural University trains farmers in crop diversification for better resource management. Organic farming research highlights its benefits in enhancing soil health and farmers' incomes. These efforts collectively foster climate resilience and economic sustainability in the region. This makes Jorhat a compelling case for understanding the intersection of climate vulnerability and agricultural adaptation.

Additionally, the importance of analyzing the impact of climate variables on rice production in Jorhat district of Assam lies on the fact that agriculture is a vital sector in Assam, contributing significantly to the state's economy and livelihoods especially rice. Jorhat district in Assam has been considered for rice production due to its rich agricultural heritage, favorable climatic conditions, and fertile alluvial soil, which make it an ideal region for paddy cultivation. The district receives ample rainfall, essential for rice farming, and has a strong network of irrigation facilities. Additionally, rice is a staple food for the local population, and its cultivation plays a significant role in the economy and livelihoods of farmers in the region. By focusing on Jorhat, we acknowledge the hard work of local farmers and the district's contribution to Assam's overall rice production, ensuring food security and economic stability for many families. According to government of Assam, Jorhat district in Assam has a per capita food grain production of 205 kg per annum, with rice being the predominant field crop. The district's rice productivity is estimated at 1,748 kg per hectare, categorizing it within the medium-low productivity group (yield between 1,500- 2,000 kg/ha). This figure is higher than Assam's average rice productivity of 1,435 kg/ha but remains below the national average of 1,947 kg/ha. These statistics underscore the district's significant role in the state's agriculture while highlighting the potential for further productivity enhancements to meet national standards. Understanding the specific impacts in these regions is crucial for targeted adaptation strategies. Assam is highly vulnerable to climate change impacts like: Increased frequency and intensity of floods. Prolonged droughts or erratic rainfall patterns, Rising temperatures, Increased pest and disease outbreaks, Changes in river flow and erosion.

A decline in Rice production directly threatens food security at the household and community levels within Jorhat. Reduced yields can impact the overall food supply within Assam, potentially leading to price increases and increased dependence on external sources. While investigating Jorhat District, helps in understanding the challenges that can provide insights relevants to other rice-growing regions facing similar climate vulnerabilities, contributing to national-level food security planning.

Farmers' incomes are directly tied to crop yields. Climate-related crop losses can lead to significant economic hardship, increased debt, and potential displacement. Agriculture is a major source of employment in these districts. Reduced production can lead to job losses, particularly for agricultural laborers. Climate change can exacerbate existing poverty levels and create new vulnerabilities within farming communities. Thus, analyzing climate impacts provides crucial evidence for developing effective agricultural policies and programs. Understanding the specific vulnerabilities and impacts in Jorhat allows for the design of location-specific adaptation measures, such as: Promoting climate-resilient crop varieties. Improving water management techniques (e.g., rainwater harvesting, efficient irrigation). Implementing integrated pest and disease management strategies, Diversifying farming systems.The analysis can inform the promotion of sustainable agricultural practices that reduce greenhouse gas emissions and enhance the resilience of farming systems. Establishing a baseline understanding of current climate-crop relationships is essential for tracking future changes and evaluating the effectiveness of adaptation measures.

Thus, analyzing the impact of climate variables on rice production in Jorhat district is critical for ensuring food security, protecting livelihoods, informing policy decisions, and promoting sustainable agricultural practices in a region highly vulnerable to climate change. The findings can serve as a model for understanding and addressing similar challenges in other agricultural regions.

1.3 Review of Theoretical and Empirical Literature:

The "Review of related literature" defines the problem of research in the area of study and identifies research gaps. The main purpose of reviewing the literature is to determine what has already been done that relates to your topic. The review of related literature tells what has been done and what needs to be done. The aim of reviewing the literature is to build a strong foundation for answering the research questions and identifying the research gap. This study focuses on reviewing journal articles in the topical area of multiple intelligence and reviewing theories that provide a theoretical framework for multiple intelligence. A review of related literature helped the investigator to formulate objectives and hypotheses and to select the variables under the study. The reviews showed that some studies based on multiple intelligences have been conducted in different areas of the country.

1.3.1 Review of Literature on Climatic Effects on Agricultural Yields:

D. Das (2016), in his article used mixed method to collect the qualitative and quantitative data. The researcher conducts survey and group discussion to identify the sample population. It repeatedly tells that how the climate is changing, and the way it affects Assam by the author, and how vulnerable the region is form climate variability with extreme weather events. Flooding, erratic rainfall and raising temperature pose serious threats to Assam with its geographical and ecological uniqueness, Such changes have deep implications for agriculture, biodiversity and livelihoods, particularly in rural and indigenous communities. The researcher explains requirement of adaptive models and policy in dealing with the negative implications of climate environmental change, in addition to community based actions to build resilience. His work highlights the need for solutions to region's climate vulnerability that marry traditional knowledge with a specific approach.

R. Mahanta and D. Das (2017), in their article based on composite index of combining qualitative and quantitative method. The primary data was collected between the household and the secondary data was collected through record of government, the record of flooding etc. The interviews or case study accured the societal perspective. The researcher found that the deluge create poverty by shoot off livelihood, demaging infrastructure, scramble in agriculture activities. The analysis drew out the need for policy push to ensure more effective flood management, livelihood diversification for the livelihoods cycle of vulnerability in the region.

Baishya et al., (2001) mentioned that out of the net sown area of 2.83 m lakh ha in Assam, area sown more than once is around 1.24 m ha so crop- ping intensity stands around 148%. Total flood prone area of the State is 3,41,00 ha out of which 2,50,000 ha is chronically flood prone and 91,000 ha is occasionally flood prone area. Around 4.9 m ha of land which accounts for 62.6% of total geographical area are moderately and slightly acidic in reaction. Average consumption of NPK fertilizers is 51.83 kg/ha which was far below the national average; the crop removal found to be higher than that of added. The period December to February in the state showing very low moisture availability demanding artifi- cial irrigation for better production of different crops. In Assam more than 83% farmers are having either marginal or small holding size. Inclusion of vegetable crops in the system provides better return; pulses and oilseeds may be included in the system under less moisture available condition, fodder crop may be included in the system to meet up the livestock requirement. If irrigated area is expanded and marketing infrastructure develops, then there is tremendous possibility for crop diversification with high profitability in the state.

Kumar De, U. (2014) tried to analyse the spatio-temporal trend of crop diversification in Assam over the last fifty years. It is pursued through changes in land allocation for the cultivation of various crops and also examined by the changing index of crop diversification. Here, Herfindahl Index is used to understand diversification and locational quotient is used to measure regional crop concentration. The result shows that in almost all districts, crop specialization has been taking place and more so in the last phase of our study period. The hilly and backward districts recorded more diversification but towards lower value crops, in accordance with the changing water availability, weather pattern, access to credit and risk. It goes against the normal feature of crop diversification where farmers diversify in favour of high value crops. Employing Random Effect GLS Robust Regression and Fixed Effect Model, irrigation, chemical fertilizer and growing erratic rainfall found to play important role in determining inter-zonal variation in crop diversification. However, the slow progress of irrigation did not help in crop diversity, particularly in off-monsoon seasons.

1.3.2: Climate-Induced Vulnerability, and Adaptation to Changing Climate:

A. Panda (2013) in his article used mixed-methods to investigate the challenges that the rural households face due to changing environmental conditions. These households, heavily dependent on agriculture, struggle with declining crop yields, water scarcity, and income instability. The study emphasizes how poverty, inadequate infrastructure, and weak institutional support make them more vulnerable to climate risks. To cope, families adopt various adaptation strategies, including shifting to drought-resistant crops, diversifying livelihoods through wage labor or migration, and implementing water conservation measures like rainwater harvesting. However, limited access to resources and institutional support often restricts their ability to adapt effectively. The study underscores the need for stronger government policies, improved access to financial and technological resources, and community-based initiatives to enhance resilience in these drought-prone regions.

Upadhyaya. H. (2014) used primary and secondary data in her article and investigates how climate change is intensifying water scarcity in one of India's driest states. The research highlights declining rainfall, increasing temperatures, and frequent droughts as major threats to Rajasthan's water resources. It explores the vulnerability of rural communities, particularly farmers and pastoralists, who depend on groundwater and seasonal rainfall. The study also discusses adaptation strategies, such as rainwater harvesting, traditional water conservation techniques, and policy initiatives. Overall, it underscores the urgent need for sustainable water management to build climate resilience in the region.

Sahoo. D. (2018) used both primary and secondary data in his article. The researcher examines that how climate change affects agriculture in Odisha, a state heavily reliant on farming. The research highlights rising temperatures, erratic rainfall, and extreme weather events as key challenges that threaten crop yields and farmer livelihoods. It examines the vulnerability of small and marginal farmers, emphasizing socio-economic and environmental factors that heighten their risks. The study also discusses adaptation strategies, including improved irrigation, climate-resilient crops, and policy interventions. Overall, it provides a detailed analysis of the region's agricultural resilience and the urgent need for climate adaptation measures.

R. Guntukula (2021) in his article used both the primary and secondary data. The researcher found that the impact of climate change on agriculture in Telangana, highlighting how temperature and rainfall variations affect crop yields. It finds that rising maximum temperatures harm rice, cotton, and groundnut yields, while changes in minimum temperature can have positive effects. Farmers adapt using strategies like deep ploughing, moisture conservation, and drought-resistant crops. The study emphasizes that education, economic motivation, and access to information play key roles in adopting climate-resilient practices. Overall, it calls for targeted policies to strengthen farm households' adaptation to climate change.

Masroor. M. (2022) follows a mixed method, combining qualitative and quantitative research technique in his article. The researcher highlights that the rising temperatures, erratic rainfall, and increasing frequency of dry spells as key drivers of drought in the region. Studies reveal that small farmers, marginalized communities, and rainfed agriculture are particularly vulnerable. The impact extends to groundwater depletion, food insecurity, and rural distress. Adaptation strategies, such as improved irrigation, drought-resistant crops, and community-based water management, have shown promise. However, gaps in policy implementation and local participation hinder resilience-building. Addressing these challenges requires an integrated approach combining climate science, traditional knowledge, and policy support.

1.4 Research Gap:

It is evidenced that several research works are available on impact, vulnerability and adaptation in the context of climate change in agriculture across the globe and particularly in India. However, there are some specific research gaps on which this study would like to focus. First, most of the impact assessment works on agricultural yields in India are documented at the aggregate or national level and the level of development of impact assessments at the local scale is quite at its infantry stage. Against this backdrop, this study aims to fill the gap by evaluating the climatic effect on the principal crop yield and total production in the Jorhat district of Assam. Second, unlike African countries, climate-related vulnerability studies in the context of Indian farming and farmers are very limited especially states like Assam. Most of these works are conducted at aggregate scales (national or state level) using secondary data. There are very few studies that have focused on climate change vulnerability at the farm-household level. Particularly, there is no organized study in Jorhat district. It is essential to identify the people and places that are vulnerable to climate change impacts for making appropriate policies. Third, research works on adaptation to changing climate among agricultural households is essential in states like Assam because a large number of the population depends on agriculture and allied activities for sustenance and livelihoods. However, there are very limited studies on the farmer's adaptation to changing climate and their determinants at the household level. No single systematic study investigated the adaptation strategies of farmers and determinants of adaptation to changing climate in flood prone areas of Jorhat district of Assam.

1.5 Objectives of the Study:

1. To examine how changing weather pattern, erratic and rainfall, temperature fluctuations affected total rice productivity in Assam.

2. To examine adaptation strategies of the sample farmers and determinants of adaptation measures in the study area.

3. To identify and analyze the barriers hindering the adoption of climate climate change adaptation strategies by famers in the study area.

1.6 Hypotheses of the Study:

1. H_0: There is no relationship between climate change and rice productivity of Jorhat districts.

2. H_0: Selected factors have no impact on the adaptation strategies practiced by the farmers.

1.7 Data Source and Methodology of the Study:

1.7.1: Data Source: The study will be based on both primary and secondary data. These sources are Directorate of Economics and Statistics, Krishi Bhawan, Regional Meteorological Centre, Government Press, various publications of journals, periodicals, Statistical Handbook of Assam and Economic Survey of Assam. The Statistical Handbook of Assam (SHA), a yearly state government publication along with NASA data access viewer is used to extract the district level rainfall data for the period 1981-2024. Maximum and minimum temperature data for estimation collected from IMD gridded data. The production and productivity of the rice crop in the state as well as the respective district (time series data from 2000 to 2024) collected from Nicra-icar.in (ICRISAT) district level database.

1.7.2 Methodology: The study is based on climate vulnerability in Jorhat district of Assam; the researcher was used a combination of primary and secondary data to understand how rice production is affected due to changing climatic conditions. Analysis and discussion was made on rainfall variables namely Monsoon Rainfall, Post-Monsoon rainfall, Winter rainfall and Summer Rainfall and on the temperature variables namely Annual mean temperature, Annual mean maximum temperature, Annual mean minimum temperature and Temperature range. In addition, the annual and seasonal temperature and rainfall trends were covered using Mann Kendall trend analysis test (The detailed methodology is mentioned in respective chapters). To study of our 1stobjective i.e. to study the relationship among climate change on rice productivity and its related hypothesis i.e., the climate change has no impact on the rice productivity of in Assam, log linear regression equation was formed. To interpret the result of the study log linear regression equation model was formed for the analysis. The Cob-Douglas type productions function in the log linear form was set. The equation for the study is as follows:

$$Logyikt = log\beta 1 + \beta 2 logPkt + \beta 3 logMaxiTKt + \beta 4 logMiniT\,Kt + \mu iT - - - -(i)$$

Here,

Yi Kt = Annual rice production in quintals hectare for Jorhat districts.

P Kt = Annual Precipitation level in millimetre for the Jorhat District,

MaxiT T Kt =Maximum mean temperature (Annual) in degree celcious for the 'k'th (Jorhat) district,

MiniT T Kt =Minimum mean temperature (Annual) in degree celcious for the Jorhat district

$\mu\ i\ t$ = error term

Here β1, β2………β7 are the parameters of the equation,

Where, 't' stands for time period from 2010 to 2024,'I' stands for the total rice production in Jorhat district.

For 2nd objective, primary data was collected through field surveys, structured interviews, and focus group discussions with local farmers. This helped to capture first hand experiences, challenges, and traditional knowledge about climate adaptation strategy. The adaptation checklist was made for four selected forms of adaptation- micro level adaptation & market response adaptation, institutional adaptation and technological adaptation. For each form of adaptation, as per their practices, farmers were classified into four basic levels- level 0 to level 1. Those farmers who did not adopt any adaptation fell in the first category, while those farmers who trained possible measures were included in level and the rest were categorized accordingly. Additionally, the determinants of those selected 7 adaptation approaches is investigated by using 7 binary logistic regression model (total 7 selected but 2 rejected due to multicollinearty issue) and later Likert scale was used for checking the barriers of choosing those adaptation practices on Farm level. The data analysis was done with the help of statistical packages of SPSS, XLStat trial, EViews trial and Stata trial). Secondary data was sourced from government reports, agricultural department records, climate data, and previous research studies. By analyzing both types of data, the researcher will aim to assess the key factors influencing farmers' choices in response to climate risks.

1.8 Conceptual Framework:

To understand how climate change especially frequent flooding affects farm households in the flood-prone areas of Jorhat district, Assam, this study is built around three key dimensions: Impact assessment on agricultural productivity, Adaptation strategies, and Barriers to adaptation. This framework connects real challenges faced by farmers with how they respond and what holds them back.

1. Impact Assessment on Agricultural Productivity

- Patten of rainfall.
- The maximum and minimum temperature impact.
- Fertilizer consumption, irrigated area, HYV seed impact.

2. Adaptation Strategies Adopted by Farm Households

- Using flood-tolerant or short-duration crop varieties to reduce risk.
- Leasing land in safer areas or higher ground during flood season.
- Changing farming practices, such as early planting.

3. Barriers to Adopting Adaptation Measures

- Unpredictable weather.
- Lack of money to buy better seeds or invest in protective measures.
- Limited access to information and training on new techniques or technologies.
- Weak infrastructure, lack of irrigation.
- Low education levels, which make it harder to understand or adopt new practices.
- Inconsistent government support or delays in aid and insurance.

Some of the Limitations of the Study are as follow-

The findings are based on a specific group of farmers, which may not fully reflect the diversity of all farming communities in Assam. The study focuses mainly on one district so the results may not be generalizable to other regions with different climate or socio-economic conditions. Some data rely on farmers' memories and perceptions, which may introduce bias or inaccuracy. While binary logit models help understand influencing factors, they may not fully capture the complexity of human decision-making. The study does not deeply explore the role of government policies or institutional support, which are also crucial for adaptation.

1.9 Tentative Chapterisation of Study

For the convenience of analysis, the present dissertation is being organized into Fivechapters.

Chapter I: Introduction: It deals with the Background on climate change and its impact on agriculture, Why Jorhat? (Geographical and climatic significance),Review of literature on climatic effects on agricultural yields, climate-induced vulnerability, and adaptation to changing climate,Objectives of the study,Hypothesis, Methodology, limitation of the study followed by tentative chapterization.

Chapter II: Study Area, Sample Design and Profile of the Sample Households: It presents the historical description of natural disasters in Assam, and describes the sampling strategy and data collection and profile of the sample farm households.

Chapter III:Analysis of Rainfall and Temperature Trends in Assam and Selected Districts: It Overview of climate risks (rainfall patterns, temperature variations, extreme weather), Status of total food-grain production in Jorhat district of Assam, Empirical analysis of impact of changing climate condition on total rice production of Jorhat District of Assam followed by Conclusion.

Chapter IV: Perception of farmers on climate change and adaptation options along with determinants in flood prone areas Jorhat District of Assam: This chapter includes Introduction, The Design-Dependent variables in the estimated models, list of Independent variables in the study area, Farmers' Perceptions on Undergoing Climate Change,Choice of Adaptation of selected farmers in the study area,Determinants of Adaptation approaches of selected farmers in the Study area followed by Conclusion.

Chapter V: Summary and policy implications: This Chapter includes summary of findings, conclusions and policy suggestions of the study.

CHAPTER - II

Study Area, Sample Design and Profile of the Sample Households

Chapter II

Study Area, Sample Design and Profile of the Sample Households

2.1 Introductory Statement:

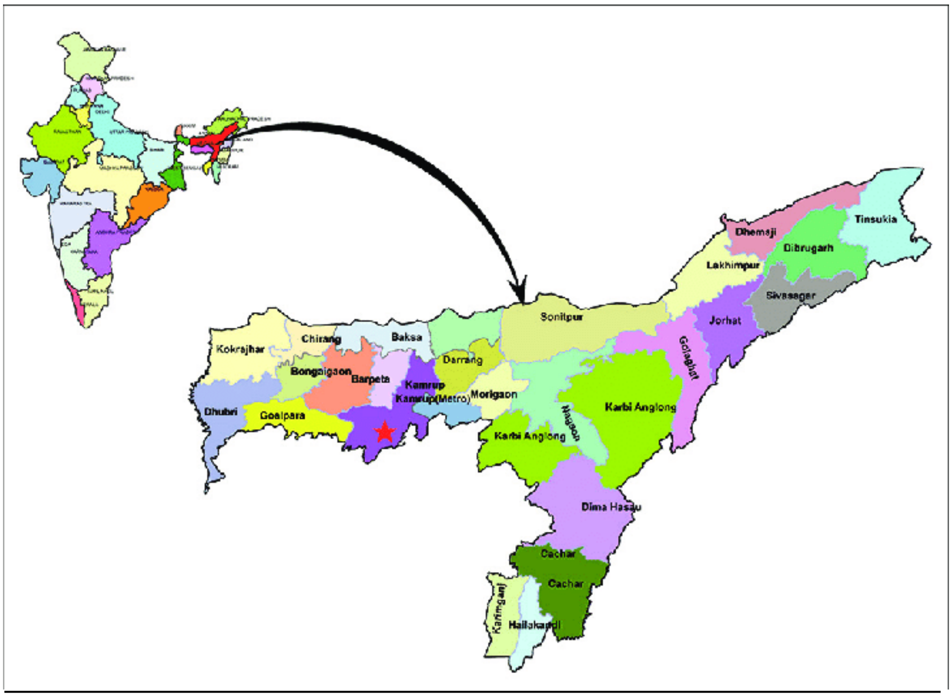
This chapter includes the understanding of demographic information such as age, education, and family size which helps in assessing their capacity to adapt to changing conditions. The information of land size and input use provide insights into farming efficiency, resource allocation, and productivity. Access to credit determines a farmer’s ability to invest in better technology, seeds, and infrastructure, which influences long-term sustainability. However, farmers are increasingly affected by climatic damages such as droughts, floods, and erratic weather, requiring them to develop coping strategies like diversifying crops or adopting resilient farming techniques. Their awareness of climate change is crucial, as it shapes how they respond to environmental threats. Finally, vulnerability to climate change varies based on factors like economic stability, access to information, and support systems. Understanding these aspects helps in designing policies that empower farmers, ensuring food security and rural development in the face of a changing climate.

2.2. Introduction of Demographic Profile and natural calamities of Assam:

Assam is a state in northeastern India, nestled south of the eastern Himalayas and spread across the Brahmaputra and Barak River valleys. Covering 78,438 square kilometers, it's the second-largest state in the region by area and the most populous, home to over 31 million people. The state shares borders with Bhutan and Arunachal Pradesh to the north, Nagaland and Manipur to the east, Meghalaya, Tripura, Mizoram, and Bangladesh to the south, and West Bengal to the west. Assam is divided into 35 districts across five administrative divisions. Guwahati is the largest city in northeastern India, is also home to Dispur, the state's capital.

Assam is famous for its world-renowned Assam tea, rich silk industry, and lush green landscapes**.**

Figure 2.1



Source: Indian Journal of Medical Microbiology

A demographic profile is like a snapshot of a group of people, showing who they are and they live. It includes details like age, gender, income, education, and interests. Businesses, governments, and organizations use this information to understand people's needs better and offer services that actually matter to them. A summarizing Assam's demographic profile are detailed in the following table-

Table 2.1: Assam's demographic profile

Year	Population	Decadal growth (%)	Literacy rate (%)	Sex Ratio	Life expectancy
1901	0.33	-	-	-	-
1911	0.38	15.2	-	-	-
1921	0.46	21.1	-	-	-
1931	0.56	21.7	-	-	-
1941	0.67	19.6	-	-	-
1951	0.8	19.4	-	-	-
1961	1.08	35.1	-	-	-
1971	1.46	35.2	-	-	-
1981	1.8	23.3	-	-	-
1991	2.24	24.4	-	-	-
2001	2.67	19.9	-	-	-
2011	3.12	16.9	72.2	958	-
2021	3.42	9.6	-	-	-
2024	3.59	5	-	-	-

Source: Census of India reports

Assam frequently faces natural calamities like floods, landslides, and earthquakes, which deeply affect the lives of its people. Every year, heavy monsoon rains cause the Brahmaputra and its tributaries to overflow, submerging homes, farmlands, and roads. Families lose their livelihoods, children miss school, and access to food and clean water becomes a struggle. Landslides in hilly areas cut off villages, making rescue efforts difficult. During earthquakes, homes and infrastructure are damaged, leaving people homeless and in fear of aftershocks. The psychological impact is immense many communities must rebuild their lives repeatedly, facing uncertainty about the future.

The trend of natural calamities in Assam from 1901 to 2024 shows a significant increase in both frequency and intensity, primarily due to climate change, deforestation, and population growth which is show in the following table:

Earthquake		Flood		Drought	
Year	Magnitude	Year	Death toll	1967-1978	Moderate
1897	8.1	2019	117	1994-1996	Severe
1950	8.6-8.7	2020	65	1997-2002	Moderate
2016	6.9	2021	278	2006-2011	Extreme
2021	6.4	2022	73	2012-2013	Severe
		2023	190	2014-2015	Moderate
		2024	157	2016-2021	Severe
				2022	Moderate

Table 2.2: Some major natural disaster trend record in Assam.

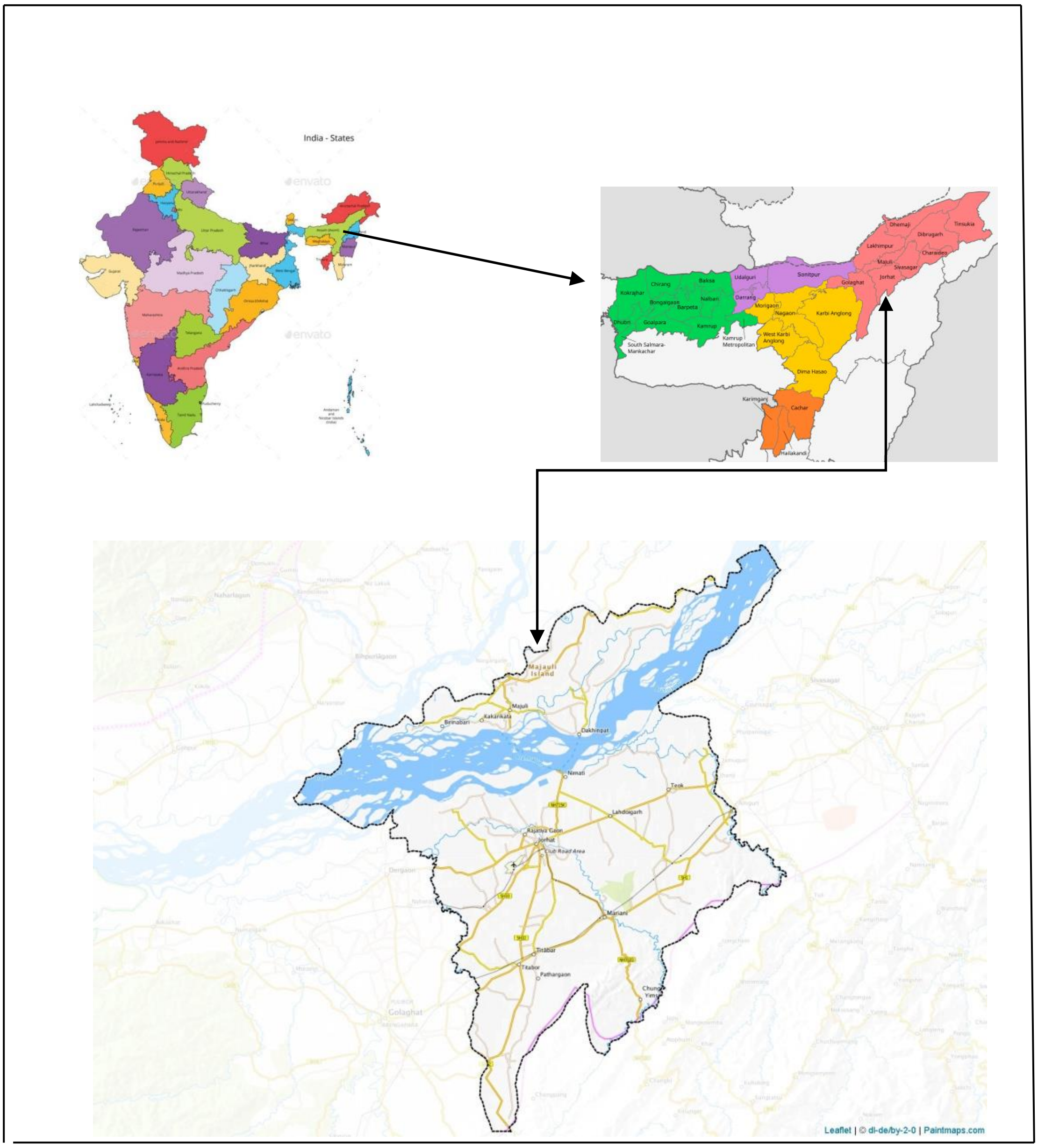
Source: Assam State Disaster Management plan and Census reports 2011

2.3. Introduction of Demographic Profile and Natural Calamities Selected District (Jorhat Profile):

Jorhat is an administrative district located in Assam situated in the central part of the Brahmaputra Valley. The district lies in between 26°20’and 27°10’3”north latitude and 93°39’and 94°36’30east longitudes. The district is bounded by Majuli district on the north, Nagaland state on the south, Sivasagar district on the east and Golaghat district on the west. The district covers total 1758 sq km area and the mean elevation is 116 meters (381 feet). The district has ranks 12th in comparison to other districts in the term of area in the state of Assam. It contains 5 Revenue Circle with 648 villages. It has 6 Community Development Blocks. In the district, four statutory and seven Census Towns are located. The climate of Jorhat is classified as mesothermal wet climate and characterized by highly humid atmosphere, abundant rainfall and coolness. The summer season consists of May to July and winter season starts from November and ends in January. Heavy rainfall coupled with storms and thunderstorms; the result of south-west monsoon characterizes the rainy season in the district.

Temperature starts falling from November and rises from the month of March every year. The highest maximum temperature in the district is 42°C and the lowest is 8°C. January is the coldest month with minimum average temperature of 11.6° and September is the hottest month with average maximum temperature of 31.78°C.

Figure 2.2



Source: Graphicriver, Wikimedia.org,

https://images.app.goo.gl/TzzAPAmoeR3Kxiq6A

A large number of tributaries of the river Brahmaputra such as Jhanji, Teok, Mudaijan, Tepajan kokila, Bhogdoi, Bekajan, Toklai, Tarajan, Kakodonga, etc. forms a network of waterways in these Sub-Divisions. During flood season those tributaries/rivulets which are flowing from Nagaland to Brahmaputra are inflated with rain water every year. Most of these rivers /rivulets don’t have dykes and those such as Jhanji and Bhogdoi which have embankments has opening at the mouth. Hence during floods the water level of Brahmaputra flows back through these rivers inundating most of the areas of the district on the Northern side of NH 37. In Southern side of the NH flood normally occurs at the adjacent areas of river Kakodunga in both Jorhat and Titabar Sub-Divisions. Many areas are also affected by swelling waters of rivulets like Teremerijan , Bekajan, Kachajan,etc during the flood season. (Flood contingency and response plan and Jorhat district 2023). The following table shows the flood damage report during last few years in jorhat

Table 2.3 : Flood damage report during last few years in Jorhat

Year	Area effected (ha)	Farm family affected (nos)
2014-2015	11907	29226 (including Majuli)
2015-2016	6224	21388 (including Majuli)
2016-2017	3628.44	14809
2017-2018	3864	10285
2018-2019	Nil	Nil
2019-2020	2634.22	8395
2020-2021	5455.09	13015
2021-2022	Nil	Nil
2022-2023	Nil	Nil

Source: (Flood contingency and response plan and Jorhat district 2023)

Among all the flood prone area in jorhat, Nimatighat Kokilamukh, and Borkheliya Phehukoli pothar are the two most flood prone area in jorhat district. In these villages people face immense challenges during the monsoon season. These villages, located near the Brahmaputra River and its tributaries, frequently experience devastating floods that submerge homes, destroy crops, and disrupt livelihoods. Every year, families are forced to evacuate, seeking shelter in relief camps or makeshift higher ground, while struggling to secure food, drinking water, and medical aid. The recurring floods not only damage infrastructure but also create long-term hardships, making education, health services, and economic stability difficult to sustain. Despite efforts by the government and local communities to build embankments and improve disaster preparedness, the people of these villages continue to live with uncertainty, hoping for more effective and permanent solutions to their struggles.

2.3.1. General household information:

In the flood-prone areas of Jorhat district, Assam, life revolves around the rhythms of the Brahmaputra River. Most households rely on agriculture, fishing, and daily wage labor for their livelihood, but frequent floods disrupt their earnings and daily routines. Homes, often made of bamboo and thatch, are vulnerable to rising waters, forcing families to seek shelter in relief camps or higher ground during the monsoon. Despite these hardships, people have adapted with raised homes, bamboo bridges, and boats for transport. Community bonds remain strong, with neighbors helping each other during crises. Access to clean water, healthcare, and education becomes difficult during floods, making survival a constant challenge. Yet, resilience and hope define these communities as they continue to rebuild their lives year after year.

2.3.2. Demographic information:

Jorhat district in Assam, as per the 2011 Census, had a population of around 10.92 lakh people, with nearly equal distribution between males (5.56 lakh) and females (5.35 lakh), giving a sex ratio of 962 females for every 1,000 males. The district had a young population, with children aged 0-6 years making up about 11.4% of the total.

Encouragingly, Jorhat had a high literacy rate of 82.15%, with male literacy at 87.63% and female literacy at 76.45%. While urban areas has a higher literacy rate (around 90.39%), rural areas still maintained a strong rate of 80.01%. The district had a moderate population density of 383 people per square kilometer. Jorhat also had a diverse social composition, with Scheduled Castes making up 8.12% and Scheduled Tribes around 12.81% of the population.

2.3.3. Information on land size and input use:

Rice cultivation in Jorhat district plays a crucial role in the local economy and food security. The district primarily grows three types of rice—Ahu (Autumn Rice), Sali (Winter Rice), and Boro (Summer Rice), with Sali rice being the most widely cultivated. Most farmers have small to medium-sized landholdings, and traditional farming methods are still prevalent, though mechanization is gradually increasing. Irrigation mainly relies on canals, ponds, and tube wells, while fertilizers such as urea, DAP, and organic manure are commonly used to enhance productivity. Farmers also use pesticides and herbicides to protect crops from pests and weeds. High-yielding varieties like Ranjit, Bahadur, and Swarna, along with hybrid and indigenous seeds, are grown based on soil conditions and climate. While rice farming remains the backbone of agriculture in Jorhat, challenges such as unpredictable weather, floods, and soil degradation continue to impact productivity, necessitating better irrigation facilities, improved seed technology, and sustainable farming practices.

2.3.4. Information on credit:

It is a mix of formal and informal credit sources, with farmers, small businesses, and rural households often relying on local banks, microfinance institutions, and government schemes for financial assistance. While commercial banks play a significant role in providing agricultural loans and rural credit, informal lenders, such as moneylenders and local traders, continue to be prevalent in certain areas. This blend of formal and informal credit systems aims to cater to the diverse needs of the population, especially in rural areas where access to formal banking is limited. The district also benefits from various state and central government schemes aimed at boosting financial inclusion, ensuring that more people, including those in remote areas, have access to credit and financial support.

2.3.5. Information on climatic damages and coping mechanisms:

Jorhat district in Assam, known for its fertile alluvial soil and abundant rainfall, faces significant climatic challenges that impact rice cultivation. The region frequently experiences erratic weather patterns, including floods, droughts, and extreme temperature variations, which disrupt the growth cycle of rice. Heavy rainfall often leads to waterlogging and soil erosion, reducing soil fertility and increasing the vulnerability of crops to pests and diseases. Conversely, unexpected dry spells can lead to moisture stress, hampering yields.

To cope with these climatic adversities, farmers in Jorhat have adopted several strategies. Traditional flood-resistant rice varieties like Ranjit and Bahadur are widely cultivated to withstand waterlogging. Improved irrigation techniques, such as rainwater harvesting and efficient canal systems, help manage water supply during dry periods. Many farmers are also shifting towards climate-resilient farming methods, including the System of Rice Intensification (SRI), which enhances productivity with less water. Additionally, community-based approaches, such as cooperative farming and knowledge-sharing networks, strengthen resilience by enabling farmers to adapt better to changing climatic conditions.

2.3.6. Information on farmer's awareness on climate change:

Farmers in Jorhat district, Assam, are aware of climate change through both traditional knowledge and modern science. They observe natural signs like animal behavior and flowering patterns to predict weather changes. Training programs by institutions like Assam Agricultural University help them adopt better farming practices to cope with climate shifts. Studies show that farmers with more resources and support are better able to adapt. Overall, Jorhat’s farmers are blending old wisdom with new methods to deal with climate change.

2.3.7. Information on farmer’s vulnerability to climate change:

In Jorhat, farmers face increasing hardships due to climate change. Unpredictable rainfall, prolonged dry spells, and intense floods disrupt their traditional farming cycles, leaving them struggling to protect their crops. Rising temperatures also make it harder to grow staple crops like rice and tea, which are vital to their livelihoods. Many small-scale farmers, who rely solely on agriculture, find it difficult to adapt due to a lack of resources, knowledge, and financial support. Soil erosion and pest outbreaks, worsened by climate shifts, further threaten their yields. Despite their resilience, these farmers need better access to climate-resistant seeds, improved irrigation, and government assistance to secure their future against the growing climate crisis.

2.4. Cropping Pattern in Jorhat District:

In Jorhat district, located in Assam, the cropping pattern is heavily influenced by the region's climate, soil, and water availability. The primary crops grown in this district include rice, tea, mustard, and vegetables. Rice is the dominant crop, cultivated during the kharif season (monsoon months), as the district experiences heavy rainfall, making it ideal for paddy farming. Alongside rice, tea plantations are widespread, with Jorhat being one of the key tea-producing areas in Assam. Mustard and various vegetables like potatoes, tomatoes, and cauliflower are grown during the rabi season (winter months), taking advantage of the cooler and drier conditions. Farmers also engage in mixed cropping, growing multiple crops simultaneously on the same land to reduce risks and improve productivity. This combination of rice, tea, and vegetables forms the backbone of Jorhat’s agricultural economy, reflecting the area's diverse agricultural practices tailored to its environmental conditions.

2.5: Conclusion:

Jorhat, a district in Assam, has a diverse demographic profile, with a mix of rural and urban populations engaged primarily in agriculture and allied activities. The region is prone to natural calamities like floods and occasional droughts, which significantly impact livelihoods. General household information suggests that families here rely heavily on farming, with varying land sizes and input use depending on access to resources and financial stability. Credit availability plays a crucial role in agricultural practices, though many farmers still struggle with accessibility to formal financial institutions. Climatic damages, particularly due to erratic rainfall and rising temperatures, have forced farmers to adopt different coping mechanisms, such as changing sowing times, using resilient crop varieties, and seeking alternative income sources. Awareness of climate change is growing, but vulnerabilities remain high, especially among small and marginal farmers who lack adequate resources to adapt. The cropping pattern in Jorhat is diverse, with rice being the staple crop, alongside tea plantations, pulses, and vegetables. However, climate change is gradually influencing traditional farming practices, pushing farmers to explore more sustainable and adaptive methods.

CHAPTER - III

Analysis of Rainfall & Temperature Trends and Impact of climatic as well as non climatic factors on Rice productivity of Assam

CHAPTER III

Analysis of Rainfall & Temperature Trends and Impact of climatic as well as non climatic factors on Rice productivity of Assam

3.1: Introductory statement:

The broad objective of the present chapter is to detect and analyse the trends and patterns in the rainfall and temperature data in Assam state and study district. Generally, a trend is a substantial change over time demonstrated by a random variable determined by "parametric and non-parametric" statistical tests. To achieve the aim, "non-parametric" statistical techniques used for yearly seasonal and monthly temperature and rainfall data as explained below. Moreover, rainfall characteristics such as central tendency (Mean), coefficient of variation (CV) and standard deviation (SD) were calculated for monthly, seasonal and annual data. This study used meteorological department of India's classification of rainfall seasons such as "pre-monsoon or summer (March to May or MAM), monsoon (June to September or JJAS), post-monsoon or autumn season (October to November or ON) and winter (December and February or DJF)".

This chapter also dealt with an econometric Analysis of the Impact of climatic change considering temperature i.e., both maximum mean temperature and minimum mean temperature, precipitation and non-climatic factors like irrigation and fertilizer consumption and (District irrigated area and fertilizer consumption data collected from Krishibhavans) on the paddy production.The selected crop production and yield data were collected from the Centre for Monitoring Indian Economy (CMIE) Database, 2025 and the climatic data were collected from IMD (gridded data later extracted using Phyton IMDLIB software) and NASA database (Prediction of Worldwide Energy Resources (POWER) for the period 2000–2023.

3.2: An overview of rainfall and temperature trend in Assam and selected district (Jorhat):

3.2.1: Rainfall and temperature in Assam:

As per the Indian Meteorological Department (IMD), the rainfall trend in Assam has been showing clear signs of change over the past few decades. While Assam is traditionally known for its abundant monsoon rains, recent observations indicate that the rainfall pattern is becoming more erratic and uneven. Instead of consistent rainfall spread over the monsoon season, the state is now experiencing shorter but more intense spells of rain. This has led to frequent flash floods, especially in low-lying areas, and prolonged dry periods in others. The total amount of rainfall may still be high, but its distribution over time and space has become irregular. Moreover, K. Gogoi and K. N. Rao (2022), studied the Assam's rainfall pattern from 1981 to 2017 and have shown notable changes. The study reveals that the overall annual rainfall has increased; the distribution across months and seasons has become more erratic. Specifically, the months of May, June, and August have experienced significant increases in rainfall, whereas September, December, January, and February have seen decreasing trends. Seasonally, both the pre-monsoon and monsoon periods have shown statistically significant increases in rainfall, while the post-monsoon and winter seasons have exhibited decreasing trends, though these were not statistically significant. Geographically, the southern and northeastern regions, including areas like Karimganj, Hailakandi, Silchar, and Dhubri, have recorded higher average annual rainfall compared to the central Brahmaputra valley. These shifts in rainfall patterns are concerning for Assam, a state characterized by floodplains and sub-Himalayan terrains, as they can exacerbate flooding, disrupt agriculture, and impact livelihoods. The study underscores the need for policymakers to consider these changing patterns in climate adaptation and resource management strategies.

According to the Indian Meteorological Department (IMD), Assam has been witnessing a steady shift in its temperature trends in recent years, marked by both rising maximum and minimum temperatures. Typically known for its humid subtropical climate, the state is now recording warmer days and nights across many districts. During the peak summer months—especially from May to July—the maximum temperatures in parts of Assam often touch or even exceed 35°C, a threshold that used to be crossed only occasionally in the past. Meanwhile, the minimum temperatures during summer nights, which used to over around 22–24°C, are now frequently reported above 25°C, contributing to more uncomfortable and humid nights. In winter, the state once experienced pleasantly cool weather with minimum temperatures dipping to around 8–

10°C, especially in central and upper Assam. However, recent IMD data shows a consistent warming trend, with minimum winter temperatures now often staying above 12°C in many areas. This narrowing gap between day and night temperatures, particularly the rise in nighttime lows, is a clear indicator of climate change's growing impact. Alongside, increased occurrences of erratic weather, heat waves, and prolonged dry spells further highlight the evolving climate scenario in Assam, signaling challenges ahead for agriculture, biodiversity, and daily life.

3.2.2: Rainfall and temperature trend in the Jorhat district :

Jorhat district in Assam experiences a humid subtropical climate, characterized by significant rainfall during the monsoon season. The district receives the majority of its annual precipitation between June and September, with July being the wettest month, averaging approximately 318 mm of rainfall. Over recent years, there has been a noticeable variability in rainfall patterns. For instance, in 2022, Jorhat recorded an all-time high daily rainfall of 1,169.3 mm on July 26, while on April 19, 2025, no rainfall was recorded. This fluctuation indicates a trend towards more erratic rainfall events, which can impact agriculture and water resource management in the region. Despite these variations, the overall annual rainfall in Jorhat remains substantial, averaging around 2,699 mm. The IMD continues to monitor these patterns to provide accurate forecasts and support local planning efforts. Moreover, A. Sarmah et.al. found that overall, the district has experienced a general decline in rainfall balance, particularly during the monsoon season. Using statistical analyses like the Mann-Kendall test, they observed a significant decreasing trend in monsoon rainfall balance at a 6% probability level. While May showed a slight increase in rainfall, other months did not exhibit significant changes. Pre-monsoon rainfall displayed a non-significant increase, whereas post-monsoon and winter seasons showed non-significant decreases. These shifts suggest that Jorhat is facing more erratic rainfall patterns, with potential implications for agriculture, water resources, and overall climate resilience in the region.

Jorhat has been experiencing a noticeable shift in its temperature patterns over recent years, as observed by the Indian Meteorological Department (IMD). Historically, Jorhat enjoyed a subtropical climate with moderate temperatures and abundant rainfall. However, recent data indicates a trend of rising temperatures, both in terms of daily highs and lows. For instance, in September 2024, Jorhat recorded its highest-ever temperature for that month, with the mercury crossing 39°C . This was part of a broader pattern across Northeast India, which experienced its hottest September since 1901. The average maximum temperature during that month was 32.59°C, surpassing the previous record of 32.47°C set in 2023. Similarly, the average minimum temperature reached 24.93°C, exceeding the earlier record of 24.72°C. These rising temperatures are not isolated incidents but part of a consistent upward trend observed over the past few years. The IMD's climatological data for Jorhat from 1991 to 2020 shows that the mean daily maximum temperature in May was around 30.1°C, while in July and August, it hovered around 32.6°C and 33.0°C, respectively. However, recent years have seen these figures being surpassed, indicating a warming trend. This increase in temperature has significant implications for the region, affecting agriculture, water resources, and overall quality of life. The rising temperatures, coupled with altered precipitation patterns, are signs of the broader impacts of climate change on the region. As Jorhat continues to grapple with these changes, understanding and adapting to these new climate realities becomes increasingly crucial.

3.3: Data and methodology:

3.3.1 Data:

This chapter completely depends on secondary data for analysis. The relevant data on climate variables have been collected from the various government departments, related research institutions, and other online sources. The rainfall (monthly, seasonal and annual) data of Assam and selected study districts are gathered from the several issues of Statistical Abstracts of Assam and Statistical Year Books of Assam, available at Directorate of Economics and Statistics, Government of India, Indian Institute of Tropical Meteorology (IITM) and Indiawaterportal.org. Similarly, data on mean, minimum and maximum temperatures (monthly, annual and seasonal) for Assam and selected study district are collected from Indiawaterportal.org. and Nasa data access viewer. The study period for trend analysis of temperature and rainfall is 1990-25.

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3.1 Variable Description

Variable	Measuring G Unit	Data Source
Yield on rice production	KG/Hector	Directorate of Economics and Statistics (DES) from Department of Agriculture, 2021, Department of Agriculture and farmer's welfare, Govt. of India, 2023.
Gross irrigated area	Percentage of total crop area	RBI database, 2023
Average annual temperature	Degree Celsius	Regional Meteorological Centre, Guwahati,2023
Average annual rainfall	Millimetre	Power data access viewer, NASA, 2024 & WRIS India portal.
Land under rice production	Thousand hector	Economic survey of Assam, 2022-23, Directorate of Economics & Statistics, DAC&FW. Assam, Department of Agriculture and farmer's welfare Ministry of Agriculture and farmers welfare, Government of India,2023.

Source: Researcher's own

Table 3.1 shows the explanation and the data sources of variables. Further, data are converted to the natural log value so that changes in the variables represent the relative changes or percentage changes after multiplied by 100 (Gujrati, n.d.), 1998,(Kakoti, 2019).

3.3.2: Methodology:

A time series trend analysis involves both the extent and statistical significance of the trend. Change in a series can occur in numerous ways: for example, abruptly (a step change), gradually (a trend), or in a more complex form. However, different studies have employed different methods for trend detection. Both parametric as well as non-parametric tests are available to analyse the trends in the climatic variables. However, the non-parametric tests are extensively used in several research works to analyze rainfall and temperature statistics better (for instance: Radhakrishnan et al., 2017; Mondal et al., 2015; Jain and Kumar, 2012; Subash and Sikka, 2014; Jain et al., 2013). Because 'non-parametric' tests are distribution free techniques (Hirsch et al., 1982).Moreover, non-parametric statistical tests usually tolerate the outliers in the data (Lanzante, 1996). Among non parametric tests, the most widely utilized techniques for identifying trends and magnitudes of meteorological variables are the Mann-Kendall (MK) and Sen's slope tests (Patra et al., 2012). This test initially originated by Mann (1945) and eventually "test statistic distribution" was derived by Kendall (1948). The present study utilized non-parametric trend tests such as Mann-Kendall (MK) alongside Sen's slope techniques for temperature as well as rainfall data. Several studies have been employed the aforementioned methods and evidenced reliable outcomes.

The Cobb-Douglas production function technique is used in the following form:

$$Yt = \beta_1 R_{1t} + {}^{\beta}{}_1 T_{2t} + {}^{\beta}{}_3 A_{3t} + {}^{\beta}{}_4 S_{4t} + {}^{\beta}{}_5 I_{5t} + F_{6t}{}^{\beta}{}_7 + L7t\,{}^{\beta}{}_8 + e^{u}{}_i \quad \text{--------------------- (1)}$$

If we convert the Cobb- Douglas formula into log-linear form we got the following equation:

$$\begin{aligned} ln\,Yt = {} & ln\,\beta 1 + \beta 2\,ln\,Rt + \beta 3\,lnTt + \beta 4\,ln\,At + \beta\,5\,St + \beta 6\,It \\ & + \beta 7Ft + \beta 8\,Lt + ut \end{aligned}$$

Here Y_t, refers rice productivity in k.g. per hectare at time t i.e. 2000-2024, R_{1t} is the Yearly average rainfall of the state in millimeter from time t (2000-2024), T_{2t} is the yearly average temperature of the state in degree celcious, A_{3t} is the area of rice cultivation in hectare, S_{4t} is the area covered by HYV seeds in hectare, I_{5t} is the area covered by irrigation in hectare, F_{6t} is the fertilizer used in k.g. per hectare and L_{7t} is the average size of land holding in hectare in the state. For all t which refers the time i.e. 2000-2024.

3.4: Results and Discussion:

3.4.1 Results and Discussion in Assam:

As mentioned earlier, the selected study variables are rainfall and temperature and the rainfall data has been categorized based on IMD arrangement (summer, monsoon, post monsoon and summer). Systematic analysis and discussion are done on rainfall variables such as annual rainfall, monthly rainfall, monsoon rainfall, summer rainfall, post-monsoon rainfall, winter rainfall and on the temperature variables such as annual and monthly mean temperature and annual and monthly mean minimum and maximum temperatures. The following figure 3.1 (A), 3.1 (B) and 3.1 (C) shows the average rainfall, average maximum and average minimum temperature of Assam from the year 2002-2024.

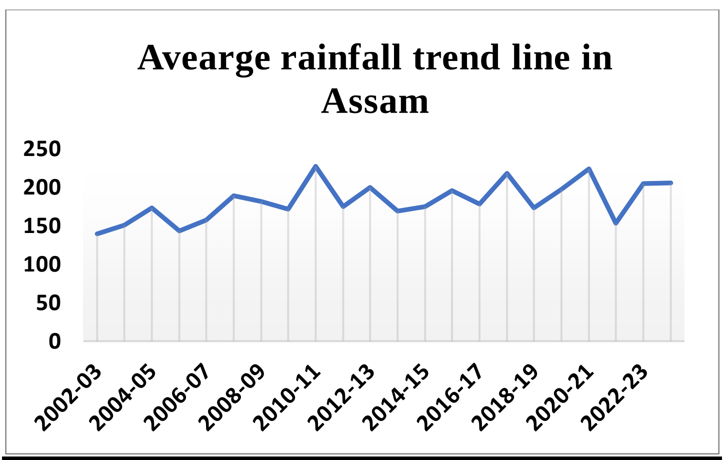
The figure 3.1(A) shows the average rainfall trend in Assam from 2002–03 to 2023–24. Overall, the trend is quite irregular, with noticeable ups and downs throughout the years. In the early years, there is a gradual increase in rainfall, reaching a significant peak around 2010–11; indicating that this year experienced unusually high rainfall. After that, the rainfall pattern becomes inconsistent, with several years showing sharp rises followed by sudden drops. This fluctuation continues, highlighting the unpredictable nature of rainfall in the region. A notable dip is observed around 2020–21, but the rainfall rises again in the following years, eventually appearing to stabilize by 2023–24. This erratic trend suggests that Assam has been experiencing uneven rainfall over the years, which could impact farming, water resources, and climate-related planning in the state.

Figure 3.1(B) shows the average maximum temperature trend in Assam from 2002–03 to 2023–24. The overall trend is fluctuating but slightly rising over the years. In the early years, the temperature was relatively high around 32.5°C but then dropped slightly after 2003–04. From 2005–06 to around 2009–10, there were noticeable ups and downs, with one of the lowest average maximum temperatures recorded around 2009–10, just above 30.5°C. After that period, the temperature began to gradually increase, peaking around 2014–15. Between 2015–16 and 2022–23, the trend remains uneven, with several small drops and rises. However, the final year in the graph, 2023–24, shows another sharp increase, taking the temperature close to earlier peak levels.

The figure 3.1(C) shows the average minimum temperature in Assam from 2002–03 to 2023–24. Overall, the trend is rising, especially after 2010, with the highest point around 2015–16. Though there were some ups and downs, including a drop in 2021–22, the temperature increased again in 2023–24. This suggests a gradual warming over time, possibly due to climate change.

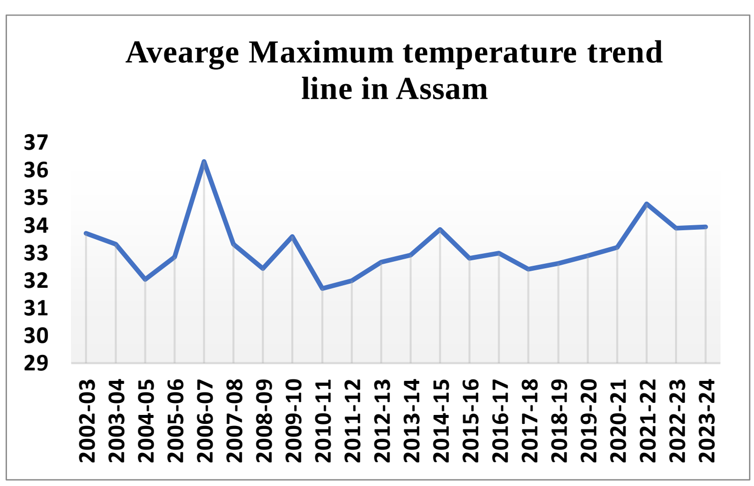
Figure 3.1 Rainfall and Temperature trend of Assam 2002-2024

<u>Figure 3.1 (A):</u>



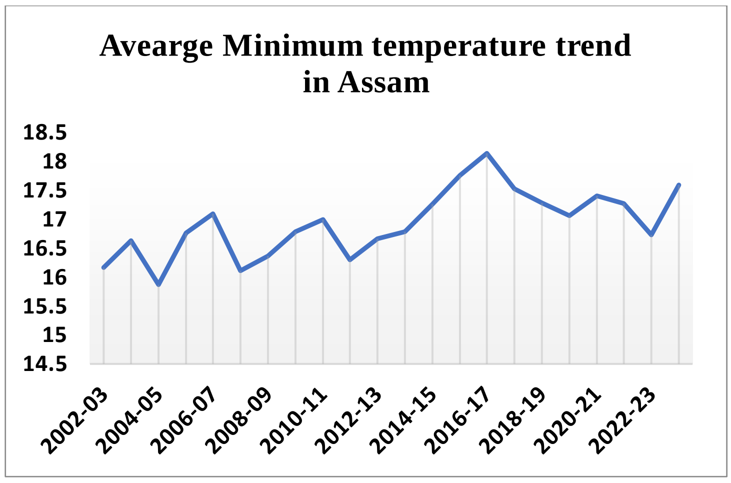
Source: Author's own calculation based on secondary data

<u>Figure 3.1 (B):</u>



Source: Author's own calculation based on secondary data

Figure 3.1 (C):



Source: Author's own calculation based on secondary data

3.4.2: Results and Discussion in Jorhat:

3.4.2.1 Mann Kendall trend test:

Mann-Kendall (MK) test is used to determine monotonic upward or downward trend in a time series data. This test does not require the assumption of data normality because it is non-parametric. MK is also less sensitive to sudden breaks, which are instigated by non-homogenous time series. It is based on two hypotheses: the null hypothesis (H0) which indicates no trend (no change in the series mean) and the alternative hypothesis (H1) which indicates the presence of a monotonic trend (a rise or decrease in the mean over time); (Mamo B.M, Ndunda, E. and Murijuki, J, 2024).

$$S = \sum_{i=1}^{k} \sum_{j=i+1}^{k} sign(Xj - Xi)$$

Where, k is the total number of data points, Xi and Xj are the data values in time series i

and j (j>i), and sign(Xj - Xi) is the sign function. The sign function is calculated as shown

below:

sign (Xj-Xi) = [1, if Xj - Xi > 0]

[0, if Xj – Xi = 0]

[-1, if Xj – Xi < 0]

3.4.1.1A: Mann Kendall Test for Rainfall in Jorhat (1990-2024):

The estimated results of the Mann-Kendall test on rainfall are presented in table 3.2. In this test reveals that annual rainfall and the summer season exhibit significance at the 1% level, indicating a strong relationship during these periods. In contrast, rainfall during the winter and monsoon seasons does not show statistical significance, suggesting weaker or more variable patterns in these periods. Notably, the data indicates negative rainfall anomalies in the months of January, February, and September, highlighting a decline in precipitation during these specific months.

Table 3.2: Estimated Mann Kendall Test for rainfall

Mann Kendall and Sen's slope results for Rainfall in Jorhat (1990-2024)				
Series\Test	Kendall's tau	p-value	Trend interpretation	Sen's slope
January	-0.163	0.173	Not Significant	-0.282
February	-0.082	0.495	Not Significant	-0.275
March	0.126	0.293	Not Significant	0.853
April	0.247	0.038	<< Significant	2.544
May	0.281	0.018	<< Significant	3.725
June	0.173	0.147	Not Significant	2.912
July	0.156	0.191	Not Significant	2.34
August	0.032	0.798	Not Significant	0.175
September	-0.015	0.01	<<< Significant	-0.161
October	0.173	0.147	Not Significant	1.441
November	0.055	0.65	Not Significant	0.093
December	0.126	0.293	Not Significant	0.129
Annual	0.21	0.008	<<< Significant	10.816
Winter	-0.055	0.65	Not Significant	-0.275
Summer	0.311	0.009	<<< Significant	5.875
Monsoon	0.139	0.244	Not Significant	5.94
Autumn	0.17	0.156	Not Significant	1.301

Source: Calculated by Researcher. (<<< 1%, << 5%, < 10% level of significant)

3.4.1.1B: Mann Kendall Test for Minimum Temperature in Jorhat (1990-2024):

The estimated results of the Mann-Kendall test on minimum temperature are presented in table 3.3. It is evident that the annual minimum temperature is statistically significant at the 1% level, suggesting a strong relationship in the data. Additionally, temperature trends during the summer season also show significance at the 1% level, highlighting notable changes or patterns during this period. In contrast, the winter and monsoon seasons are statistically significant at the 5% level, indicating a moderately strong relationship. Furthermore, the minimum temperatures remain consistently above zero throughout the year, suggesting that freezing temperatures are not characteristic of this region.

Table 3.3: Estimated Mann Kendall Test for Minimum temperature

Mann Kendall and Sen's slope results for Minimum Temperature in Jorhat (1990-2024)				
Series\Test	Kendall's tau	p-value	Trend interpretation	Sen's slope
January	0.518	0	<<< Significant	0.061
February	0.18	0.216	Not significant	0.044
March	0.393	0.006	<<< Significant	0.06
April	0.273	0.049	<< Significant	0.046
May	0.043	0.779	Not significant	0.006
June	0.187	0.049	significant	0.02
July	0.171	0.242	Not significant	0.012
August	0.01	0.963	Not significant	0.002
September	0.484	0.001	<<< Significant	0.082
October	0.09	0.544	Not significant	0.016
November	0.147	0.315	Not significant	0.025
December	0.187	0.099	significant	0.029
Annual	0.477	0.001	<<<Significant	0.06
Winter	0.34	0.018	<< Significant	0.048
Summer	0.427	0.003	<<< Significant	0.051
Monsoon	0.353	0.014	<< Significant	0.03
Autumn	0.06	0.691	Not significant	0.01

Source: Calculated by Researcher. (<<< 1%, << 5%, < 10% level of significant)

3.4.1.1C: Mann Kendall Test for Maximum Temperature in Jorhat (1990-2024):

The estimated results of the Mann-Kendall test on minimum temperature are presented in table 3.4. The table shows that the annual maximum temperature shows a decreasing trend during the summer and monsoon seasons. Among the different seasons, both winter and autumn demonstrate statistically significant trends at the 1% level, indicating a high level of confidence in these results. In contrast, the summer season shows significance only at the 10% level, suggesting that while a decreasing trend is present, the evidence is relatively weaker. These seasonal variations in temperature trends may reflect broader shifts in regional climate patterns and highlight the importance of season-specific climate monitoring.

Table 3.4: Estimated Mann Kendall Test for Maximum temperature

Mann Kendall and Sen's slope results for Maximum Temperature in Jorhat (1990-2024)				
Series\Test	Kendall's tau	p-value	Trend interpretation	Sen's slope
January	0.035	0.776	Not Significant	0.009
February	0.094	0.435	Not Significant	0.022
March	-0.076	0.532	Not Significant	-0.015
April	-0.192	0.109	< Significant	-0.048
May	-0.304	0.011	<< Significant	-0.085
June	-0.197	0.009	<<< Significant	-0.046
July	0.002	1	Not Significant	0
August	0.067	0.58	Not Significant	0.01
September	0.076	0.532	Not Significant	0.017
October	0.384	0.001	<<< Significant	0.056
November	0.015	0.91	Not Significant	0.002
December	0.274	0.021	<< Significant	0.041
Annual	0.32	0.098	< Significant	0.009
Winter	0.371	0.002	<<< Significant	0.156
Summer	-0.217	0.069	< Significant	-0.05
Monsoon	-0.017	0.898	Not Significant	-0.001
Autumn	0.33	0.006	<<< Significant	0.031

Source: Calculated by Researcher. (<<< 1%, << 5%, < 10% level of significant)

Table 3.5 Trend and Pattern of Rainfall from 2010 to 2023 in Jorhat district of Assam:

SL.No	Month/Season	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Mean	SD	CV
I	**Winter**																	
1	December	9.26	16.97	14	8.23	4.41	15.05	4.06	2.22	25.6	3.3	5.94	8.38	15.21	10.9	**10.251**	**6.53258**	**63.7236**
2	January	0.59	14.16	14	5.72	3.38	10.4	27.5	6.09	11.2	12.6	31.6	15.9	29.09	29.9	**15.149**	**10.3897**	**68.5822**
3	February	6.32	11.71	6.72	7.36	46.7	29.62	62.8	68.4	23.4	45.7	28.8	6.69	64.89	61.6	**33.629**	**24.2555**	**72.1276**
	Total	**16.2**	**42.84**	**34.8**	**21.3**	**54.5**	**55.07**	**94.4**	**76.7**	**60.2**	**61.6**	**66.4**	**31**	**109.2**	**102**	**59.029**	**29.0229**	**49.1669**
II	**Summer**																	
1	March	165	132.2	40.7	83.2	24.6	34.81	94.9	104	102	58	25.4	57.4	56.34	60.1	**74.199**	**41.5069**	**55.9403**
2	April	337	125.5	199	128	31.5	203.3	294	254	142	119	334	61.2	313.2	324	**204.66**	**105.513**	**51.5554**
3	May	260	250.9	264	287	430	349.6	239	327	218	365	343	292	313.7	300	**302.75**	**56.9713**	**18.8178**
	Total	**762**	**508.6**	**504**	**497**	**486**	**587.7**	**628**	**685**	**461**	**542**	**702**	**410**	**683.2**	**684**	**581.61**	**108.808**	**18.7081**
III	**Monsoon**																	
1	June	536	291.4	457	311	345	556.5	296	415	321	396	520	416	577.1	587	**430.32**	**109.061**	**25.344**
2	July	414	615.3	436	416	343	291.4	482	559	458	606	507	311	291.3	298	**430.69**	**114.152**	**26.5046**
3	August	431	299	365	407	449	539.1	184	340	387	184	311	391	260.4	261	**343.44**	**101.282**	**29.4906**
4	September	451	314.3	430	194	386	228.5	343	309	310	386	354	159	244.3	203	**308.04**	**90.9735**	**29.5332**
	Total	**1834**	**1520**	**1688**	**1328**	**1523**	**1615**	**1305**	**1623**	**1476**	**1572**	**1692**	**1277**	**1373**	**1350**	**1512.5**	**169.288**	**11.1927**
IV	**Autumn -**																	
1	October	69.2	9.14	163	181	25.6	67.19	100	224	39	184	205	115	276.3	321	**141.34**	**95.9475**	**67.8821**
2	November	45.1	18.72	10.7	1.36	12.1	23.05	13.4	7.98	40.9	10.2	23.5	9.42	12.01	8.9	**16.946**	**12.5319**	**73.95**
	Total	**114**	**27.86**	**174**	**182**	**37.7**	**90.24**	**113**	**232**	**79.9**	**194**	**229**	**124**	**288.3**	**330**	**158.29**	**90.4091**	**57.1159**

Source: Researchers' own calculation based on secondary data.

Jorhat district in Assam experience a distinct seasonal pattern of rainfall throughout the year, and this cycle plays a major role in the lives of its people, especially those who involved in agriculture. The year can be divided into four seasons in terms of rainfall- winter, summer, monsoon and autumn. Each season are contributing differently to the district's overall climate and environment.

The winter season from December to February is the driest with very little rainfall only around 20 millimeters to 50 millimeters (mm). The weather remains cool and dry and farmers typically use this time for harvesting and preparing for the next agricultural cycle.Second one is summer season from March to May brings moderate rainfall average between 200 mm to 500 mm. These showers often accompanied by thunderstorms, help prepare the soil for sowing crops and replenish moisture levels. Thirdly the monsoon season, spanning from June to September is significant contributing approximately 83.2% of the annual rainfall. During this season the district receives average 600 mm of rainfall with July being the peak month. This heavy rainfall is crucial for rice cultivation and replenishing water bodies but can also lead to flooding in low-lying areas. Lastly, in the autumn season from October to November sees a gradual decline in rainfall, with the district receiving about 100 to 200 mm. These showers aid in the final stages of crop growth and maintain the greenery before the dry season.

Overall, Jorhat district's annual rainfall averages around 2,029 mm with the monsoon season playing a pivotal role in shaping the region's agricultural calendar and water resource management.

3.5 Impact of Climate Change on rice productivity in Assam:

The impact of climate variability on rice productivity in Assam is considering the time period 2019 to 2024. The impact of climate change becomes severe only after 2000.

Table 3.6: Impact of Climate and non-climatic factors on Rice productivity in Assam

Variables	Coefficient	Std. Error	t-Statistic	P-value
C	-13.94343	3.957948	-3.522894	0.0024
Minimum Temperature	0.321138	0.473853	0.677716	0.5066
Maximum Temperature	3.860218	2.055694	1.877817	0.0467**
Fertilizer Consumption	0.071444	0.110607	0.645924	0.5265
HYV Seed	7.658801	1.087646	7.041629	0.00***
Total Rainfall	-0.048215	0.042807	-1.126327	0.0348**
Gross Irrigated Area	0.134643	0.045082	2.986594	0.0079***

Number of Observation = 25

R-squared = 0.92

Adj. R-squared = 0.89

To assess the impact of climate variability on rice productivity in Assam, a log linear regression model based on the Cobb-Douglas production function is employed. The coefficient of the determination of the variable shows here the R^2 is 92%, which indicating that the explanatory variable included of this study is reasonable for the estimation.

The result shows that minimum temperature and fertilizer consumption do not significantly affect rice productivity in Assam because their p-values are greater than 0.05 (0.5066 and 0.5265 respectively), which means their impact is statistically insignificant. In simple words, changes in minimum temperature or the amount of fertilizer used did not show any clear or consistent effect on how much rice was produced. This could be because the variation in minimum temperature is not large enough to influence crop growth or because the fertilizer is either underused or not effectively managed.

On the other hand, maximum temperature, HYV (High Yielding Variety) seeds, total rainfall, and gross irrigated area have a strong and significant impact on rice productivity. The maximum temperature (with a p-value of 0.0467) may help rice grow better during certain growth stages, especially if it stays within an optimal range. HYV seeds have the strongest positive effect (p-value 0.00), meaning that using improved seeds directly increases productivity. Total rainfall shows a significant negative impact (p-value 0.0348), possibly because excess or untimely rainfall can damage crops, waterlog fields, or delay harvesting. Lastly, gross irrigated area has a highly significant positive effect (p-value 0.0079), showing that more irrigation helps ensure steady water supply and supports healthy rice growth, especially when rainfall is uncertain. In summary, proper use of HYV seeds, controlled irrigation, and balanced climate conditions, especially temperature, play a major role in boosting rice productivity in Assam.

3.6 Conclusion:

Climate change is no longer a distant threat—it is a lived reality for farmers in Assam, especially in regions like Jorhat, where rice farming is both a livelihood and a way of life. The shifting rainfall patterns, rising temperatures, and increased frequency of floods and droughts are creating uncertainty in a sector that depends heavily on nature's rhythm. In Jorhat, where rice cultivation is deeply rooted in tradition and sustains countless families, these changes are more than just statistics—they directly affect food security, incomes, and rural stability. Yields have become less predictable, and traditional farming practices are under growing pressure.

There is still hope. With the right mix of scientific innovation, local knowledge, climate-resilient rice varieties, and supportive policies, it is possible to adapt and protect the future of rice farming in Assam. Listening to farmers, empowering them with knowledge and tools, and taking strong action to address climate change will be crucial steps in ensuring that rice remains the heartbeat of Jorhat's agricultural identity.

CHAPTER - IV

Perception of farmers on climate change and adaptation options along with determinants in flood prone areas Jorhat District of Assam

Chapter IV

Perception of farmers on climate change and adaptation options along with determinants in flood prone areas Jorhat District of Assam

4.1: Introductory statement:

Climate change is no longer a distant threat its impacts are already being felt, especially by those whose livelihoods depend on nature. Among them, farmers in flood-prone areas face a unique set of challenges. In chapter includes Jorhat district in Assam, where agriculture is deeply intertwined with the rhythms of the land and water, changing weather patterns and frequent floods are reshaping how farming is practiced. Farmers here are not just witnesses to these changes; they are active participants in the process of adaptation. Their perceptions of climate change what they observe in their fields, how they interpret these changes, and what actions they take are critical for understanding how agricultural communities can build resilience. By focusing on a region where floods are both a natural phenomenon and an increasing threat, this research aims to shed light on the lived experiences of farmers and contribute to the development of more effective and locally grounded adaptation policies.

4.2: Features of Agro Climatic Zones in Assam:

Based on the rainfall patterns, a terrain and soil characteristic, Assam is divided into six Agro Climatic Zones as shown in the following table no. 4.1.

Table No: 4.1 Features of Agro Climatic Zones in Assam

Zones	**Districts**	**Area in Sq-Km**[1]	**Cropping Intensity (in %)**[2]	**Normal Rainfall(in mm), 2008-10**[3]	**[Temperature (Max. and Min in Degree Celcius), 2008-10**[4]	**Soil Type**[5]
(i) Barak Valley Zone	Cachar, Hailakandi and Karimganj	6962	131.5	3100	39°C - 11°C	Old reverine alluvial, old mountain alluvium, Non-laterised red soil, Laterised red soil ans peat soil
(ii)Central Brahmaputra Valley Zone	Nagaon and Morigaon	5561	146.5	1807	38°C - 10°C	Most recent immature soil (Entisol) and Olp mature soil (Alfisols)

(iii)Lower Brahmaputra Valley Zone.	Kokrajhar, Bomgaigao, Goalpara, Dhubri, Nalbari, Kamrup Metro, Kampur Rural, Chirang and Baksa.	20148	148.4	2450	31°C - 10°C	New alluvium soil and old alluvium soil.
(iv)North Bank Plain Zone	Lakhimpur, Sonitpur, Darrang, Dhemaji and Udalguri	14421	152.5	2350	37°C - 8°C	Old alluvial (Alfisols), Old alluvial soil (Inceptisols) and New alluvial soil (Entisols)
(v)Upper Brahmaputa Valley Zoner	Dibrugarh, Sivsagar, Jorhat, Golaghat and	16,192	129.7	1800	37°C - 11°C	Most recent alluvium, Mature ultisol,

	Tinsukia					Sandy loam, Silty loam and Loamy sand
(vi) Hill Zone	Karbi Anglong and NC hilis	15322	149.1	1125	37°C - 9°C	Red loamy soil and old alluvial soil

Source: Statistical Handbook of Assam, 2009 & Economic Survey Assam, 2009-10, 3 & 4 - Regional Meteorological Centre, Guwahati, 5 – National Agriculture Research Project, 2008-09.

4.2.1: The Upper Brahmaputra Valley Zone:

The Upper Brahmaputra Valley Zone of Assam includes four districts: Dibrugarh, Sivasagar, Jorhat, and Tinsukia. This region experiences a typical climate with an average annual rainfall of about 1800 mm. Temperatures vary seasonally, reaching up to 37°C during the summer months and dropping to around 11°C in winter. The valley is home to diverse soil types, including recent alluvium, mature ultisols, sandy loam, silty loam, and loamy sand. The primary crops cultivated in this area are rice, oilseeds, and pulses.

4.3: General Characteristics of study area:

General characteristics of the sample respondents will help us to understand the overall social and economic background of the sample farmers.

4.3.1: Age Distribution of Sample Households:

The age of the household head is a key factor that shapes farming practices, particularly in influencing the adoption of climate adaptation technologies. Hence, the same is analyzed and the results are reported in table 4.2.

Table 4.2: Age Distribution of Sample Farmers

Age Group	No	Percentage to the total
20-39	30	30%
40-59	61	61%
>60	9	9%
Total	100	100.00

Source: Researcher's own

It is understood from the table 4.2 that 91 percent of farmers were in the age group 39 to 59. Respondents in the age group 60 above constituted 9 percent of the total respondents, which indicate the dominance of active age group of 39 to 59, in the study area.

4.3.2: Educational Status:

The level of education among farm households plays a crucial role in shaping their awareness of available options, influencing their adoption of new technologies, and determining their level of social participation. The educational status of the surveyed households was analyzed, and the findings are presented in table 4.3.

Table 4.3: Educational Status of Sample Households

Category	No	Percentage to the total
Literate	9	9%
Secondary	63	63%
Higher Secondary	20	20%
Degree	8	8%
Total	100	100.00

Source: Researcher's own

It could be inferred from the tables that about majority of the respondents (63%) have attained education up to the secondary level. About 20% of the households have completed higher secondary education, while 9% of the respondents are simply literate without completing secondary education. Additionally, 8% of the households have obtained a degree. Overall, this indicates that a significant portion of the households have basic to moderate educational qualifications, which may influence their capacity to adopt new technologies and participate in various social and agricultural activities.

4.3.3: Family Composition:

Since family size plays a significant role in determining household income and influences the willingness to adopt new technologies, this aspect was thoroughly examined to better understand its impact.

Table 4.4: Distribution of family

Category	No	Percentage to the Total
Up to 3	18	18%
4-6	67	67%
>6	15	15%
Total	100	100.00

Source: Researcher’s own

The results reveal that a majority of the families (67%) consist of 4 to 6 members, indicating that medium-sized families are the most common in the study area. In contrast, 18% of the households have up to 3 members, while 15% comprise more than 6 members. This distribution suggests that most families are of moderate size, which may provide an optimal balance between labor availability and resource management within the household. Understanding this composition is essential for designing interventions and strategies aimed at enhancing technology adoption and improving livelihoods.

4.3.4: Farming Experience:

It is understood that the farming experience influences the farming efficiency. Therefore the experiences of the sample farms were assessed and furnished in the table 4.5.

It is observed that the majority of respondents (59%) fall within the experience range of 16 to 30 years, indicating a strong presence of moderately experienced individuals in the sample. About 27% of the respondents have more than 30 years of experience, reflecting a significant portion of highly experienced individuals. On the other hand, 14% of the respondents have less than 15 years of experience, representing the least experienced group in the study.

Table 4.5 Farming Experience of the Sample Farmers

Experiences	Total	Percentage to the total
<15	14	14%
16 to 30	59	59%
>30	27	27%
Total	100	100.00

Source: Researcher’s own

4.3.5: Annual Income Levels of the Sample Farmers:

The annual income of farm households shows wide variation. Most farmers (about 60%) earn a modest Rs.11,000 to Rs.70,000 annually. A smaller group earns either very low (4% with no income, 12% below Rs.10,000) or higher incomes (13% between Rs.71,000 to Rs.1,00,000 and 12% above Rs.1,00,000). Overall, the majority have modest earnings, with fewer households in the higher income range.

Table 4.6: Annual income levels of the Sample farmers

Annual income (average per farm	Numbers	Percentage to the total
Nil	4	4%
Up to 10000	12	12%
11000 to 40000	31	31%
41000 to 70000	28	28%
71000 to 100000	13	13%
Above 100000	12	12%
Total	100	100.00

Source: Researcher's own

4.4: Methodology:

This chapter completely depends on primary data for analysis. To assess the adoption of climate change adaptation strategies among farmers, a Binary Logit Model was employed to examine how various independent variables (such as age, education, landholding size, access to extension services, income, and experience with climate events) influence the likelihood of adopting adaptation measures. Data were collected from a sample of 100 farmers in Jorhat district through structured questionnaires. The dependent variable was binary (1 = adoption of at least one adaptation strategy, 0 = no adoption) and total seven selected but two rejected after VIF result due to multicollinearity issues. In addition, to identify the most significant barriers to adoption, farmers were asked to rate a list of potential constraints (e.g., lack of awareness, financial limitations, poor access to technology, institutional support) using a 5-point Likert scale in SPSS. Mean scores were calculated to determine the highest perceived barrier. Furthermore, farmers' cropping strategies (such as shift to short-duration varieties, mixed cropping, crop diversification, and flood-tolerant crops) were recorded and visually represented using a pie chart to show the proportion of farmers practicing each strategy. This comprehensive approach provided insights into both the factors influencing adaptation and the practical responses being implemented at the farm level.

The binary logit model is used in the following form:

$$\text{Li} = \text{In}\left(\frac{\pi}{1-\pi}\right) = \alpha + \beta x1 + \beta x2 + \beta x3 + \beta x4 + \text{Ui} \text{ ---------------------------- (i)}$$

Table 4.7: Dependent Variable & Independent Variable Description

Dependent Variable	Independent Variable
Crop Insurance	Age
Using different variety of seed	Education
Organic fertilizer	Sex
Adjusting date of cropping	Distance to the market
Crop diversification	Family size
Disease management	Income
Irrigation	Land holding
	Farming experience

Source: Researcher’s own

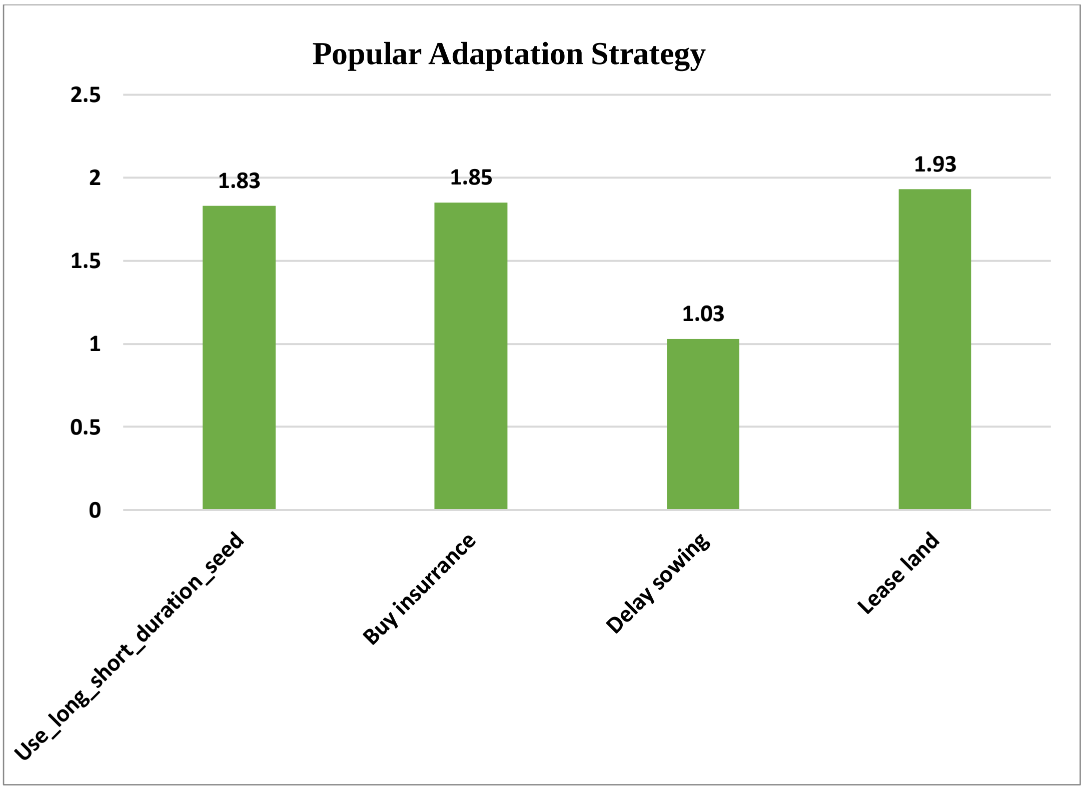
In the list of dependent variables, we initially considered a total of seven variables. However, only five dependent variables were ultimately included in the analysis. This is because the farmers in the study area rely entirely on rainfall for their agricultural activities, as they lack access to irrigation facilities. Additionally, most farmers do not adopt any specific strategies for disease management.

4.5: Result and Discussion:

4.5.1: Popular Adaptation of the study area:

Adaptation strategies have become extremely important in agriculture, especially because of the growing risks and uncertainties caused by climate change. Farmers are increasingly vulnerable to extreme weather events like floods, droughts, heatwaves, irregular rainfall, and shifting seasons, all of which can severely damage crops and reduce agricultural productivity. These climate-related challenges are not only affecting crop yields but also threatening the livelihood of farmers, especially small and marginal ones who depend entirely on farming for their income. In such a situation, adopting adaptation strategies becomes a key way to survive and continue farming sustainably. These strategies may include shifting to climate-resilient crop varieties, altering sowing and harvesting periods to match the new weather patterns, adopting water conservation techniques like rainwater harvesting or drip irrigation, using organic methods to improve soil health, and even diversifying income through livestock or allied activities. Some farmers also adopt crop insurance to protect themselves from unexpected losses. These changes help reduce the risks and impacts of climate variability and ensure more stable agricultural production over time. Adaptation is not just a technical response but also a way to build resilience, improve food security, and ensure that farming communities can face future climate shocks with more strength and hope. It empowers farmers to make informed choices and adjust to the changing environment while maintaining their dignity and ability to provide for their families. Figure

Figure 4.1: Adopting Popular Adaptation Strategy



The figure shows how farmers are responding to climate challenges through different adaptation methods. Among the four strategies presented, leasing land is the most commonly adopted, with a score of 1.93, indicating that many farmers prefer to lease land to reduce their farming risks. Buying insurance and using long to short duration seeds are also popular strategies, both scoring around 1.83 to 1.85. These strategies help farmers manage uncertainty related to weather and crop failure. On the other hand, delaying sowing is the least adopted strategy, with a much lower score of 1.03, suggesting that most farmers do not find it practical or beneficial in their local conditions. Overall, the figure highlights that farmers are making thoughtful choices to adapt, mostly favoring strategies that help reduce risks while maintaining productivity.

4.5.2: Result of binary logit model:

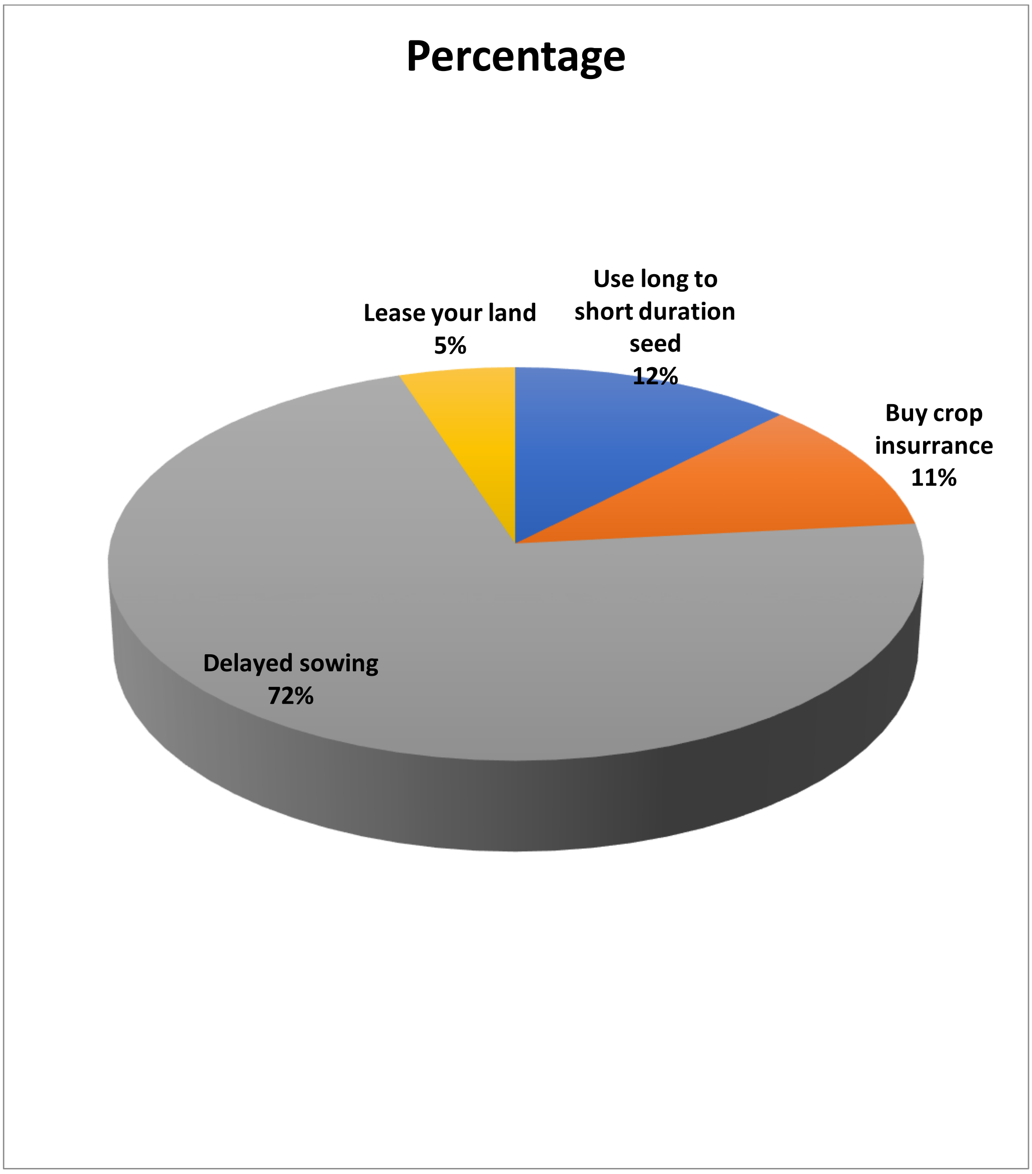
The table 4.8 presents the results of five regression models examining the factors influencing farmers' adoption of various agricultural adaptation strategies. The dependent variables include adjustment of plantation date (Model I), crop insurance adoption (Model II), crop diversification (Model III), use of organic fertilizers (Model IV), and adoption of different crop varieties (Model V). Across the models, education emerges as a consistently significant and positive determinant, suggesting that more educated farmers are more likely to adopt adaptive practices. Age negatively influences the likelihood of adopting crop insurance, indicating that younger farmers are more inclined toward insurance uptake. Landholding size is positively associated with the adoption of different crop varieties, reflecting that farmers with larger landholdings may have more capacity to experiment with new varieties. Gender shows a significant positive influence only in Model I, with male farmers being more likely to adjust plantation dates, but it is not significant in other models. Income, family size, and farm experience (FE) show mixed or insignificant effects across the models. Overall, the results highlight the pivotal role of education and landholding size in shaping farmers' adaptive behavior, while other factors exhibit more context-specific influences. The results are shown in the following table.

Table 4.8: Binary logit model result (Source: Derived from system (Eviews Student trial version). Note: "***" 1%, "**"5%, "*" 10%

Selected Variable	Model I		Model II		Model III		Model IV		Model V	
Description	Adjustment Plantation Date		Crop Insurance		Crop Diversification		Organic Fertilizer		Using Different Variety Crop	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Age	0.062463**	0.025946	-0.004***	0.02628	-0.066077*	0.020312	0.03402**	0.024032	0.052802**	0.022898
DT_Mar	-0.2346*	0.094106	-0.2254**	0.113373	0.142853*	0.071401	-0.069914	0.072556	-0.081728	0.06515
Edu	0.63746*	0.16914	0.296319***	0.168873	-0.127212	0.138937	0.038854**	0.113467	0.419854	0.151414
Family_Size	0.022391***	0.106152	-0.072169	0.118904	0.129428*	0.088207	0.097169	0.049459	-0.055485	0.091779
FE	0.005973***	0.043998	0.04832**	0.045359	0.108555*	0.041003	3.610005	1.2600-05	-0.024896	0.045241
Income	2.4500-05**	1.2800-05	7.900-06	1.3200-05	1.6900-05	1.00-05	-0.002366	0.016463	2.2400-05	1.0500-05
Land_holding	-0.00175***	0.017369	0.01225***	0.018557	-0.014457	0.016025	0.972265	0.415099	0.026925**	0.0168
Sex	0.702557***	0.41134	0.141483*	0.471435	-0.266987	0.32051	0.375166	0.151753	-0.426278	0.32936
Constant	-3.6369*	-1.48377***	-0.11533***	1.638569***	-0.401965***	1.138353***	-5.383537*	1.442182***	-2.42611**	1.156794***

4.5.3: Copping Strategies adopted by farmers of the study area:

Figure 4.2: Percentage of coping strategies adopted by farmers



Source: Researcher's own

In this study, six adaptation strategies were initially considered to assess how farmers cope with climatic challenges. These included the use of long to short duration seeds, drip irrigation facilities, continuous cropping, purchasing crop insurance, delayed sowing, and leasing out land. However, only four of these strategies were included in the analysis. This is because farmers in the study area do not have access to drip irrigation facilities and rely entirely on rainwater for their agricultural activities. Additionally, continuous cropping is not practiced in this region, and therefore, it was excluded from the list of coping strategies.

The pie chart illustrates the various coping strategies adopted by farmers in response to climate-related challenges. Among the strategies, delayed sowing is the most widely practiced, with 98% of farmers relying on this method to adjust their planting time based on rainfall availability. About 17% of farmers have adopted the use of long to short duration seed varieties, which helps in managing the cropping period more effectively. Meanwhile, 15% of farmers have opted to buy crop insurance as a financial safeguard against potential crop failure. A smaller portion, around 7%, has chosen to lease out their land, possibly due to persistent farming difficulties. This distribution reflects a greater dependence on traditional, climate-responsive practices like delayed sowing, with fewer farmers adopting financial or structural measures as part of their coping strategy.

4.5.4: Barriers in adopting adaptation strategies:

Table 4.9: Difficulties in adopting adaptation strategies

Difficulty	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean	Median	Standard deviation
Unpredictable weather	2	3	1	5	89	4.76	5	0.793
Lack of money	16	10	4	41	29	3.57	4	1.416
Insufficient seed	47	41	4	4	4	1.77	2	0.993
Shortage of land	59	17	8	9	7	1.88	1	1.289
No government support	9	30	2	18	41	3.52	4	1.494
Lack of market	79	75	1	3	2	1.34	1	0.819
No access to information	79	15	2	2	2	1.33	1	0.792

Source: Researcher's calculation.

The table presents the major barriers faced by farmers in adopting adaptation strategies, based on a Likert scale survey. Among the listed difficulties, unpredictable weather emerged as the most significant challenge, with the highest mean score of 4.76 and a median of 5, indicating that most respondents strongly agreed with this issue. Lack of money and no government support also ranked high, with mean scores of 3.57 and 3.52 respectively, suggesting that financial constraints and insufficient institutional backing are major obstacles. On the other hand, insufficient seed, shortage of land, lack of market, and no access to information received lower mean scores (all below 2), indicating these were perceived as less critical barriers by most respondents. The low standard deviation for some of these lower-rated barriers, such as no access to information (0.792), shows consistency in responses. Overall, the data suggest that weather unpredictability, financial limitations, and lack of government support are the most pressing issues hindering farmers from adopting adaptation strategies.

4.6: Conclusion:

The findings clearly show that while farmers recognize the importance of adopting adaptation strategies to cope with climate change and agricultural uncertainties, several key barriers significantly hinder their efforts. The most prominent challenge faced by the farmers is unpredictable weather conditions, which received the highest mean score. This indicates that sudden and erratic changes in weather patterns, such as unseasonal rainfall or extended dry spells, have made it extremely difficult for farmers to plan their agricultural activities, leading to reduced productivity and income uncertainty. Another major obstacle is the lack of financial resources. Many farmers reported that they do not have sufficient money to invest in modern farming techniques, purchase climate-resilient seeds, or adopt improved irrigation methods. Without adequate funding or credit support, their ability to implement effective adaptation strategies remains limited. Closely related to this is the lack of government support. Although policies and schemes may exist on paper, their implementation appears to be weak or inaccessible, leaving farmers without the institutional backing they need to transition towards more resilient farming practices.

On the other hand, some factors such as insufficient seed supply, shortage of land, lack of market access, and limited access to information were considered less significant by the respondents, as reflected in their relatively lower mean scores. This suggests that while these issues do exist, they are not the primary reasons preventing farmers from adopting adaptation measures. Overall, the study underscores the urgent need for interventions that directly address the most critical barriers. These include improving access to accurate weather forecasts, providing financial assistance or affordable credit facilities, and strengthening the delivery of government support programs. Without tackling these core challenges, the adoption of adaptation strategies among farmers will remain slow, leaving them more vulnerable to the impacts of climate change. Empowering farmers with the right tools, knowledge, and support systems is essential for building a resilient agricultural future.

CHAPTER - V

SUMMARY FINDINGS AND POLICY IMPLICATION

Chapter - V

SUMMARY FINDINGS AND POLICY IMPLICATION

5.1: Introductory statement:

This chapter serves as the final part of the study and brings together its most important elements summary of findings, conclusions, and policy suggestions. After an in-depth analysis of the research problem, data, and relevant literature, this section aims to reflect on what has been discovered and how it contributes to understanding the issue at hand. The first part of the chapter presents a summary of the major findings drawn from the data collected and analyzed. These findings highlight the key patterns, relationships, and insights that emerged during the study. They offer a clearer picture of the research problem and help identify areas that require further attention. Following the summary, the conclusions section interprets the significance of the findings in relation to the research objectives. It explains what the results mean, how they answer the research questions, and what implications they have in a broader context. The conclusions help connect the data to real-world challenges and solutions. Finally, the chapter ends with policy suggestions and recommendations based on the study’s outcomes. These suggestions are designed to offer practical guidance for stakeholders, policymakers, or institutions that may benefit from the study's insights. The aim is to contribute not only to academic understanding but also to meaningful change in the real world. Overall, this chapter ties together the research work by providing a thoughtful reflection on the results and offering ways forward.

5.2: Objective wise summary findings of the study:

5.2.1: To examine how changing pattern, erratic rainfall, temperature fluctuations affected total rice production Jorhat district of Assam:

5.2.1. A: For Assam:

Firstly, the researcher sees the rainfall trend, maximum and minimum temperature trend in Assam and the result shows that-

- The overall trend is fluctuating, meaning **rainfall** has not followed a steady increase or decrease. From 2002-2003 to around 2010-2011, there is a general increase in rainfall, with some ups and downs. The highest peak is around 2010-2011, suggesting that year had unusually high rainfall. After that rainfall levels rise and fall alternatively, showing no consistent pattern. Around 2020-21, there is a sudden drop, but then rainfall increase again in the following years. By 2023-24, the rainfall seems to have stabilized close to the average seen in earlier years (around 200 mm).

- For **average maximum temperature** trend in Assam from 2002–03 to 2023–24. The overall trend is fluctuating, but shows a slight upward movement over the years. In the early 2000s, the temperature remained relatively high around 32.5°C, followed by a slight dip after 2003–04. From 2005–06 to 2009–10, the temperature showed noticeable variations, with a low point just above 30.5°C in 2009–10. After 2009–10, the temperature began to gradually rise, reaching a peak around 2014–15. Between 2015–16 and 2022–23, the pattern remained uneven, with minor increases and decreases over the years.In 2023–24, there was a sharp rise, bringing the temperature back near the earlier peak levels. This trend indicates a gradual warming pattern, with short-term fluctuations, which may affect crop growth, weather stability, and heat-related stress in the region.

- For average minimum temperature in Assam, the overall pattern indicates a gradual rise in minimum temperature over the two decades, with some year-to-year fluctuations. From 2002–03 to 2010–11, the minimum temperature remained fairly stable, mostly between 16.5°C and 17.5°C. A clear upward trend began around 2011–12, with the temperature peaking near 18.8°C in 2015–16. After reaching this peak, the minimum temperature began to decline slowly, showing fluctuating values in the following years. The period 2021–22 and 2022–23 saw a noticeable drop in minimum temperatures. In 2023–24, the temperature rose again, suggesting a possible return to warmer minimum temperatures. This trend reflects a gradual warming of night-time temperatures, which can impact crop cycles, pest activity, and climate-sensitive livelihoods.

Secondly, to evaluate the impact of climate variability on rice productivity in Assam, a log-linear regression model based on the Cobb-Douglas production function was applied. The model yielded a high coefficient of determination ($R^2 = 0.92$), indicating that the selected explanatory variables effectively capture variations in rice productivity. The results reveal that minimum temperature and fertilizer consumption have no statistically significant impact, as their p-values (0.5066 and 0.5265 respectively) exceed the 0.05 threshold. This suggests that fluctuations in minimum temperature are not substantial enough to influence crop growth, and that fertilizer use may be inadequate or inefficiently applied. Conversely, maximum temperature, the use of High Yielding Variety (HYV) seeds, total rainfall, and gross irrigated area show significant relationships with productivity. Maximum temperature ($p = 0.046$) appears beneficial when within optimal ranges. HYV seeds demonstrate the strongest positive effect ($p < 0.001$), underscoring their critical role in enhancing yields. Total rainfall exhibits a significant negative effect ($p = 0.0348$), likely due to issues such as waterlogging or unseasonal rainfall. Finally, gross irrigated area has a strong positive influence (p = 0.0079), highlighting the importance of assured irrigation in stabilizing yields under variable rainfall conditions.

In summary, the findings emphasize that improved seed use, effective irrigation, and favorable temperature conditions are key determinants of rice productivity in Assam, while fertilizer and minimum temperature play lesser roles under current usage and variability patterns.

5.2.1. B: For Jorhat:

To see the changing pattern, erratic rainfall, temperature fluctuations affected total rice production in Jorhat district of Assam the researcher has used the Mann-Kendall method. The test reveals that-

- A mixed trend that likely impacts total rice production in the region. While the annual and summer rainfall shows a significant increasing trend, the crucial monsoon months, especially June to September, which are vital for rice cultivation in which do not show a consistent or significant pattern. This irregularity in rainfall during the peak growing season can create uncertainty for farmers, affecting planting schedules and crop growth. Notably, September shows a significant decreasing trend in rainfall, which can negatively affect the flowering and grain-filling stages of rice. Although the rise in summer rainfall may support early field preparation, the lack of reliable monsoon rainfall and the decline in late-season rain could lead to inconsistent yields. Overall, the changing rainfall trends suggest that rice production in Jorhat may be under pressure due to climatic variability, requiring adaptive strategies such as better water management and climate-resilient farming practices.

- According to the test, the minimum temperatures in Jorhat have been rising steadily over the years, especially during important months for rice cultivation like March, April, and September. These months are crucial for the growth and development of rice, and an increase in night temperatures can affect the crop's health. When nights get warmer, rice plants tend to lose more energy through respiration, which can reduce their ability to grow properly and form healthy grains. The significant rise in September is particularly worrying, as this is the stage when rice is flowering and filling grains any stress at this point can directly reduce the final yield. The overall trend of rising minimum temperatures across seasons and annually suggests that rice production in Jorhat may be under increasing pressure due to climate change. As a result, farmers may face more challenges in maintaining productivity unless steps are taken to adapt, such as using heat-tolerant rice varieties and adopting better farming practices.

- Also the maximum temperature in Jorhat district of Assam has gone through some important changes that can affect rice production in Jorhat district in a very real way. For rice crops, too much heat during the day can be harmful, especially during sensitive stages like flowering and grain filling. The data shows that maximum temperatures in May and June in the early stages of rice planting that have significantly decreased. While this might reduce heat stress during the early phase, excessive cooling can delay growth and affect the timing of crop development. However, October and December show a significant increase in maximum temperatures. October is a critical month for harvesting and grain maturity, and higher temperatures during this time can lead to grain drying too fast, which can reduce grain weight and quality. A similar trend is seen in winter, where the maximum temperature has risen significantly, which may disrupt the traditional cool-season crop cycle and affect soil moisture and irrigation patterns. The overall annual trend also shows a slight significant increase, though small, suggesting that daytime heat is slowly rising over the years. These subtle but significant shifts in maximum temperatures could contribute to changes in planting dates, water demand, and yield patterns in Jorhat, making rice farming more uncertain.

Also the researcher analyzes monthly and season wise rainfall pattern in Jorhat district of Assam from 2010 to 2023. The rainfall is categorized into Winter, Summer, Monsoon, Autumn. The result shows that-

- Monsoon season (June–September) receives the highest average rainfall (1,510.2 mm), with July and August being the wettest months. Summer and Autumn receive moderate rainfall, while Winter records the least. The coefficient of variation (CV) indicates high variability in winter rainfall, especially in January and February, suggesting inconsistent rain patterns in those months.

5.2.2: To examine adaptation strategies of the sample farmers and determination of adaptation measures in the study area:

To see the popular adaptation strategies the researcher draws a bar chart to explain the adaptation strategies of the sample farmers. The charts shows that among the strategies, leasing land (mean score: 1.93) is the most adopted, suggesting that many farmers are choosing to expand or adjust their farming area based on seasonal or economic conditions. This is followed closely by the use of flood-resistant and short-duration crops (1.85), which helps reduce risk from unpredictable rainfall and changing weather. Crop diversification and substitution (1.83) is also a common response, as it helps farmers spread their risks by not relying on a single crop. However, debt borrowing (1.03) is less popular, likely because it can lead to financial insecurity. Overall, these strategies reflect the farmers' practical and experience-based efforts to adapt to climate stress and sustain their livelihoods.

To analyse the factors that influence the farmers' adoption of various agricultural adaptation strategies, the researcher using the binary logit model. The model represents that farmers are more likely to adjust planting dates (Model I) but less inclined to adopt crop insurance (Model II), possibly because they rely on experience-based timing or distrust formal risk-management tools. Education plays a key role that more educated farmers are more open to insurance and date adjustments, likely due to better awareness of benefits, yet they may avoid crop diversification (Model III), perhaps seeing it as less efficient than specialized farming. Distance to markets also matters: farmers farther away tend to avoid insurance and date adjustments (likely due to limited access to services) but embrace diversification (Model III), which may help them cope with isolation by spreading risk across multiple crops. Household size encourages diversification (Model III), as larger families may need varied food sources or have more labor to manage diverse plots. Income’s impact is mixed while it supports some strategies (e.g., adjusting planting dates), it has little effect on organic fertilizer use (Model IV), suggesting wealth alone doesn’t drive eco-friendly adoption. Smaller landholders prefer flexible strategies like date adjustments, while those with more land invest in insurance (Model II) or new crop varieties (Model V), possibly to protect larger investments. Gender disparities persist: male farmers are more likely to adopt date adjustments and insurance, reflecting unequal access to resources or decision-making power.

Farmers adapt to agricultural challenges in different ways, with the majority (72%) choosing delayed sowing as their primary coping strategy. This makes sense - it's a simple, low-cost adjustment that doesn't require new resources or technology. About 12% switch to short-duration seeds, a more proactive approach that helps crops mature before droughts or floods hit, though this requires access to and knowledge about improved seed varieties. Another 11% invest in crop insurance, showing some farmers are willing to pay for financial protection against losses. A small minority (5%) lease out their land, often a last resort when other options aren't viable. The heavy reliance on delayed sowing suggests most farmers are making minimal, reactive changes rather than transformative adaptations. This highlights an opportunity for agricultural extension services to bridge the gap by making more advanced strategies like improved seeds and insurance more accessible and affordable. The small percentage using insurance or leasing also indicates that many farmers still lack adequate safety nets when facing severe challenges. Supporting farmers in adopting a wider range of coping strategies could make agricultural systems more resilient overall.

5.2.3: To identify and analyze the barriers hindering the adoption of climate change adaptation strategies by famers in the study area:

The researcher analyzes the barriers in adopting adaptation strategies facing by farmers for that the researchers using the likert scale which shows that farmers face several challenges when trying to adopt adaptation strategies to cope with climate change and other agricultural pressures. One of the biggest barriers is the unpredictable weather with the highest mean score of 4.76 and a median of 5, which makes it hard for farmers to plan their crops effectively.

Many also struggle with a lack of money with mean and median scores of 3.57 and 3.52 respectively, limiting their ability to invest in better seeds, tools, or technologies. Insufficient seed availability with mean 1.77 and median 2 score and a shortage of land with mean 1.88 and medium 1 scores further restrict their options, leaving them with fewer resources to improve yields. Additionally, the absence of government support with mean 3052 and mediam 4 score leaves many farmers feeling abandoned, without access to subsidies or training that could help them adapt. Another major issue is the lack of market access with mean 1.34 and median 1 score, making it difficult for farmers to sell their produce at fair prices. Without proper information or guidance, many are left unsure of how to implement new strategies. These combined challenges create a tough environment where farmers, despite their willingness to adapt, often find themselves stuck in cycles of struggle and uncertainty.

5.3: Policy Implication and suggestion:

Based on the study, it's clear that farmers in Jorhat are facing real and growing challenges due to changing weather patterns. To support them effectively, several policy actions are needed. Firstly, there should be stronger support systems for climate-resilient farming. This means promoting flood-tolerant seed varieties, encouraging timely access to quality inputs, and providing training on climate-smart agricultural practices. Farmers also need regular and accurate weather forecasts so they can make informed decisions about sowing, irrigation, and harvesting. Secondly, irrigation facilities must be improved and expanded. Many farmers still depend entirely on rainfall, which is now unpredictable. Better irrigation infrastructure can help reduce this dependence and increase productivity. Awareness and education also play a key role. Government and local agencies should organize village-level awareness programs to educate farmers on the impacts of flood and the available adaptation options. Special focus should be given to small and marginal farmers, who are the most vulnerable. Access to affordable credit and crop insurance should also be widened. This would help farmers recover from crop loss due to flood and encourage them to invest in adaptation technologies. Lastly, there should be more focus on income diversification. Training in allied sectors like dairy, poultry, fisheries, and small-scale agro-industries can reduce dependence on rice farming alone and strengthen household income. In short, policies must not only respond to climate challenges but also empower farmers to adapt, innovate, and build resilient rural livelihoods for the future.

The Assam Agricultural University (AAU), has recently introduced several new high-yielding and climate resilient seed varieties to help farmers cope with the impacts of climate change, especially in flood prone areas. One of the major developments is the release of new rice varieties that can survive in water logging conditions.

Firstly, flood-tolerant varieties like Dholi, Ranjit Sub-1, and Bahadur Sub-1 can survive complete submergence for up to 12 days. In flood-prone areas like many parts of Assam, unexpected heavy rainfall or rising river water can submerge fields for several days. Most traditional rice varieties die in such conditions, but these improved varieties stay alive under water and recover after the floodwater recedes. Secondly, these varieties have a medium maturity period (135–155 days), which means they can be planted or replanted quickly in case the first crop is damaged by early floods**.** Their shorter growing cycle allows farmers to adjust their planting time according to changing weather patterns. In addition to flood-tolerant rice, Assam Agricultural University has released several high-yielding varieties (HYVs) such as Prachur (Dhan 44), Shatabdi (Dhan 43), and Patkai (Dhan 42). These rice varieties mature in about 150 days and can produce 5.5 to 6.6 tonnes of rice per hectare, helping farmers increase production even in uncertain weather conditions. These seeds are also suitable for lowland and rainfed areas. These varieties are suitable for flood-prone areas because they can withstand submergence, recover quickly, and produce good yields, even in challenging conditions caused by climate change.

5.4: Conclusion:

The study clearly shows that changing weather patterns like irregular rainfall and fluctuating temperatures have significantly impacted rice production in the Jorhat district of Assam. These unpredictable climatic shifts have not only reduced productivity but also increased uncertainty in farming outcomes, affecting the overall livelihoods of farm households. As a result, many farming families in the region are increasingly vulnerable to climate change, especially those with limited resources, small landholdings, and low access to irrigation and modern technology. However, despite these challenges, farmers in the Jorhat district have shown resilience by adopting a variety of adaptation strategies. These include shifting to short-duration crops, using high-yielding or climate-resilient seeds, changing sowing dates, adopting water conservation practices, and diversifying their income sources. The choice of adaptation measures often depends on several factors such as education level, farm size, access to credit, and awareness of climate impacts. Overall, the findings highlight the urgent need for policy support that strengthens farmers' adaptive capacity through better extension services, timely weather information, improved infrastructure, and financial support. With the right support, these communities can better withstand the adverse effects of climate change and sustain their agricultural livelihoods.

Bibliography:

Baishya, A., Ahmed, S., Gogoi, J. K., Kalita, M. C., Medhi, B. K., & Hazarika, J. P. (2001). Constraints and opportunities of crop diversification in Assam. Indian Journal of Agronomy, 54(2), 200–205. https://doi.org/10.59797/ija.v54i2.4781.

Kumar De, U. (2014).Crop Diversification in Assam and Use of Modern Inputs under Changing Climatic Condition. Journal of Climatology & Weather Forecasting, 02(02). https://doi.org/10.4172/2332-2594.1000120

Rajkumar. R (2021). Livelihood Vulnerability of Rice Farmers of Tamil Nadu India to climate variability and extremes.

Goal.M. (2016).Vulnerability of Indian Agriculture to Climate variability.

Begum.A. (2016).The impact of Climate Change on Agricultural Productivity in Assam.

Panda. A. (2013). Climate induced vulnerability and adaptation by rural household: A study of some drought prone districts in Orissa. Shodhganga**. http://hdl.handle.net/10603/32034.**

H. Upadhyaya (2014). Vulnerability and adaptation to climate change in the context of water resource with reference to Rajasthan. **http://hdl.handle.net/10603/24677.**

D. Sahoo (2018). Climatic impact, vulnerability and adaptation: A study of agriculture system in Odisha. http://hdl.handle.net/10603/342791.

R. Guntukula (2021). Assessment of impact, vulnerability and farm household's adaptation to climate change: A study of Telengana. http://hdl.handle.net/10603/419242**.**

M. Masroor. (2022). Climate change induced drought prone in Godavari Middle Sub-basin: Impact, vulnerability and adaptation. http://hdl.handle.net/10603/491390.

K. Vijayasarathy. (2013). Impact of Climate Variability on Agriculture and the Determinants of Climate Adaptation through Agricultural Technologies in the Western Zone of the Tamil Nadu. https://shodhganga.inflibnet.ac.in/bitstream/10603/234910/1/d-453.

J. Upadhyay (2012). Climate Change and its Impact on Rice Productivity in Assam. SSRN; https://share.google/6ZOJtbpollDclPaiv.

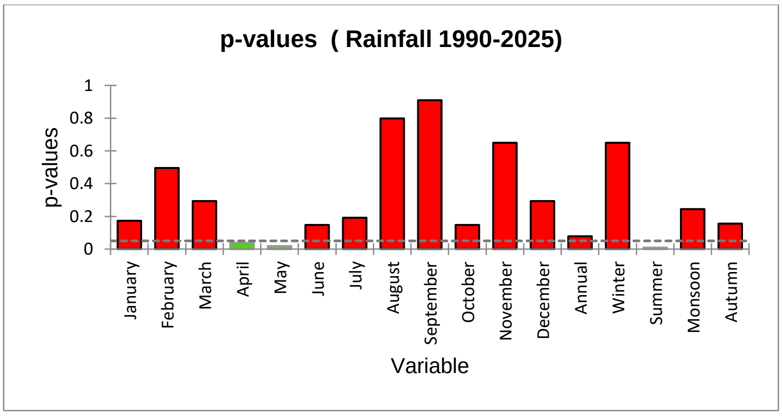
R.K. Tamang and U.K. De (2022). Climate Vulnerability and Yield Rice in Assam: An Assessment. Indian Journal of Agricultural Economics; doi: 10.63040/25827510.2022.03011.

A. Das, S. Kumar, K. Kasala, S. Nedumaran, P. Paithankar, A. Kumar, A. Jain and V. Avinandan (2025), Effects of Climate Change on Food Security and Nurition in India: A Systematic Review ; https://doi.org/10.1016/j.crsust.2025.100286.

A. Chadha (2022), Climate Change Adaptation: A Gendered Study of Organic Agriculture in Three Disaster-Prone Zones of India. Sodhganga ; http://hdl.handle.net/10603/485451.

C. S.Bahinipati (2013), Assessment of Vulnerability and Farm Households Adaptive Behaviour to Extreme Climatic Events A Study of Cyclone and Flood in Odisha India. Sodhganga; http://hdl.handle.net/10603/198501.

ANNEXURE – I


p-values (Rainfall 1990-2025)
p-values
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Annual
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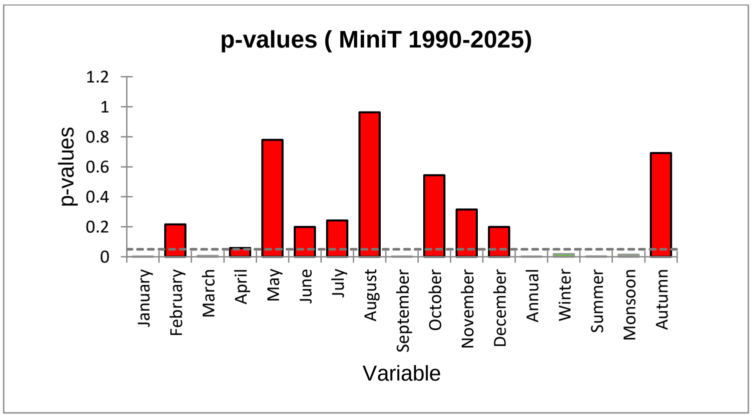
Summer
Monsoon
Autumn
Variable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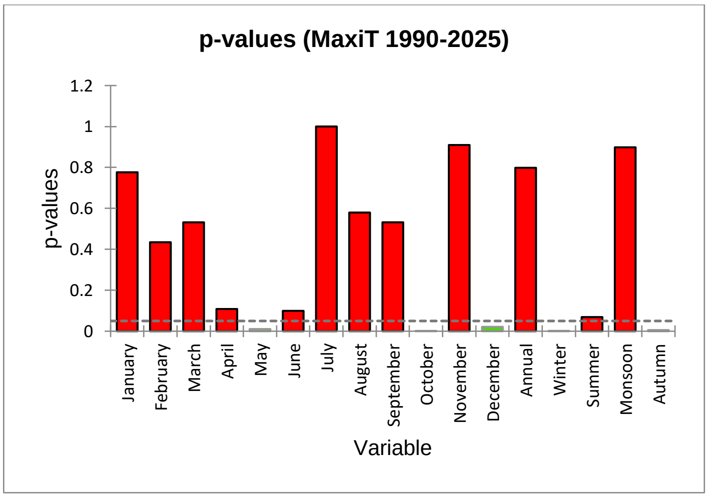
p-values (MaxiT 1990-2025)
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Annexure – II

Interview Schedule

Section I: General Information

1. Identification:

District	Village	Ward

2. Basic Details of Household:

Sl.No.	Names	Sex(Code-1)	Age(year)	Education (code-2)	Occupation (code-3)
Code 1: Male=1, Female = 2. Code 2: (only for 6+years) Illiterate=1, Literate but below primary=2, Primary=3, Secondary (5 to 10 std) =4, Higher Secondary=5, Technical=6, Graduation =7, Non-formal=8. P.G = 9 Code 3: Cultivator=1, Allied Agricultural Activities=2, Agricultural Labor=3, Other Labor=4, Household Industry=5, Trade or Business=6, Service (Government)=7, Service (Private)=8, 9 = MNREGA 10 = Housewife, Other (Specify)=11.					

Section II: Changing Weather Patterns affected the Rice cultivation

1. What is the total area under rice cultivation on your farm (in acres/hectares)?

……………..

2. Production of variety of Rice for last agricultural year

Crops	Variety	Area in Acres			Khariff yield (2021-22)	Rabi yield (2021-22)	Summer Crop (2021-23)	Total quantity
		Wet	Dry	Total				
Rice								

3. Have you changed your farming practices due to weather changes?

- Yes
- No

4. How has erratic rainfall affected your rice production.

- Delayed planting.
- Reduced yield.
- Increased pest attacks.
- Increased soil erosion.
- No impact.

5. Have you observed unusual temperature fluctuations during the rice-growing season?

- Yes.
- No.

Section III: Farmers adaptation activities in Flood prone areas

1. How frequently does your land experience flooding?

- Every year
- Every 2-3 years
- Rarely

2. What type of flood affects your farmland?

- Flash floods.
- Riverbank erosion.
- Waterlogging.

3. How severe was the last flood's impact on your farm

- Low
- Moderate

- High

4. What are the main impacts of floods on your farming activities? (Select all that apply)

- Crop loss
- Soil erosion
- Damage to irrigation systems
- Livestock loss
- Water contamination

6. What adjustment in your farming ways have you made to these long-term shifts in temperature and rainfall?

Sl. No	Adaptation method	Do you adapt this method
1	• Using different varieties ((e.g., flood-resistant crops)	1 = Yes |___| 2 = No |___|
2	Using early maturing varieties	1 = Yes |___| 2 = No |___|
3	Adjusting planting dates	1 = Yes |___| 2 = No |___|
4	Pest and disease management	1 = Yes |___| 2 = No |___|
6	Increase in number of livestock particularly milch animals	1 = Yes |___| 2 = No |___|
7	Livelihood diversification through increase in non-farm employment	1 = Yes |___| 2 = No |___|
8	Shifting from crops to tree crops	1 = Yes |___| 2 = No |___|
9	Migration	1 = Yes |___| 2 = No |___|
10	Installation of new bore wells and wells /Rainwater harvesting	1 = Yes |___| 2 = No |___|
11	Use more organic fertiliser	1 = Yes |___| 2 = No |___|

7. What sources of information do you rely on for adaptation strategies?

- Government extension services
- NGOs
- Fellow farmers
- Mass media (TV, radio, newspapers)
- Social media

8. What factors influence your decision to adaptationmeasures?

- Awareness and knowledge
- Availability of financial support (loans, subsidies)
- Access to agricultural inputs (seeds, fertilizers)
- Government policies and schemes
- Market demand and price stability

1. Coping strategies adopted by Farmers

Sl. No	Coping strategies	Do you adopt this method
1	Use different varieties and crop type like long duration to short duration varieties	1 = Yes |___| 2 = No |___|
2	Application of drip irrigation method	1 = Yes |___| 2 = No |___|
3	Summer Ploughing	1 = Yes |___| 2 = No |___|
4	Continuous Cropping	1 = Yes |___| 2 = No |___|
5	Buy Insurance	1 = Yes |___| 2 = No |___|
6	Put trees for shading	1 = Yes |___| 2 = No |___|
7	Delayed sowing	1 = Yes |___| 2 = No |___|
8	Lease your land	1 = Yes |___| 2 = No |___|

a. If you apply fertilizer and pesticides/herbicide, how often do you practice this?
1. Once a year 2. Twice a year 3. Once every two years 4. Other (specify)

Section IV: Barriers to adaptation

1. Do you face any barriers in adopting adaptation strategies?

- Yes
- No

2. If yes, what are the major barriers? (Select all that apply)

Difficulty	SD	D	Neutral	A	SA	Suggestion/ solution (if any)
Unpredictable weather						
Lack of credit/money						
Insufficient seed						
Shortage of land						
Infertile soil						
No government support						
Lack of market Access						
No access to information						

3. Are you aware of any government schemes supporting farmers in flood-proneareas?If yes, have you availed benefits from any of these schemes? What type of support have you received?

- Financial assistance
- Crop insurance
- Free/subsidized seeds and fertilizers
- Training programs

- Other (specify) _____

11. Do you plan to adopt new adaptation strategies in the future. If yes, what strategies are you planning to adopt?

- More flood-resistant crops
- Improved irrigation techniques
- Crop insurance
- Shift to alternative livelihoods
- Other :_____

Open Ended Questions:

1. How do government policies and agricultural extension services support farmers in mitigating climate-related risks?

2. What market opportunities are available for diversified crops in these districts?

3. What role do traditional knowledge and indigenous farming practices play in adaptation?

4. How effective have government programs and NGOs been in supporting adaptation efforts?

5. What are the major obstacles preventing farmers from fully implementing climate adaptation strategies?