

**IMPACTS OF CLIMATE CHANGE ON PADDY PRODUCTION  
IN KAPILVASTU DISTRICT, NEPAL**

**A Thesis**

**Submitted to the Central Department of Economics  
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**RECOMMENDATION LETTER**

This thesis entitled “**IMPACTS OF CLIMATE CHANGE ON PADDY PRODUCTION IN KAPILVASTU DISTRICT, NEPAL**” prepared by Keshab Sharma is recommended for the external examination as a partial fulfillment of the requirement for the **DEGREE OF MASTER OF PHILOSOPHY** in **ECONOMICS**.

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### VIVA-VOCE SHEET

We certify that this thesis entitled "IMPACTS OF CLIMATE CHANGE ON PADDY PRODUCTION IN KAPILVASTU DISTRICT, NEPAL" submitted by KESHAB SHARMA to the Central Department of Economics, Faculty of Humanities and Social Sciences, Tribhuvan University, in partial fulfillment of the requirements for the Degree of Master of Philosophy (M.Phil.) of Arts in Economics has been found satisfactory in scope and quality. Therefore, we accept this thesis as a part of said degree.

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## **DECLARATION**

I (Keshab Sharma) hereby declare that the work reported in this thesis entitled **“IMPACTS OF CLIMATE CHANGE ON PADDY PRODUCTION IN KAPILVASTU DISTRICT, NEPAL”** submitted to Central Department of Economics, Faculty of Humanities and Social Sciences, Tribhuvan University prepared in the form of partial fulfillment of the requirements for the Degree of Master of Philosophy (M.Phil.) under the supervision and guidance of Dr. Krishna Prasad Pant is my own original work. The thesis does not contain materials which has been accepted or submitted for any other degree at the University or other institution. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

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## ABSTRACT

**Purpose:** Various manifestations of climatic change such as increased temperatures, rainfall fluctuations, and frequent weather extremes have both beneficial and harmful impacts on crop productions. Agriculture sector in Nepal contributes 24.3% to the national economy and 57% to nations' employment.

**Objectives:** The main objective of this study is to analyze the impacts of climate change on paddy production whereas, the specific objectives are to: (i) measure the impacts of climate change on paddy production in Kapilvastu district, (ii) analyze the trend, pattern and composition of the impacts of the climate change and (iii) analyze technologies adopted by the farmers to cope with the impacts of climate change related hazards on paddy production and their effectiveness.

**Methods:** This study employs an explanatory research design. In order to meet the above stated objectives, trend analysis method as well as explanatory research design was adopted. Structured questionnaire was developed and disseminated among paddy farmers. Likewise, regression analysis was done for inferential part of the study where one dependent variable Paddy Production was regressed with 13 independent variables such as age, sex, household size, rainfall, land fertility, cultivated area etc. Also, descriptive methods were used to analyze data with the help of graph and bar diagram.

**Findings:** The findings revealed that from the year 2010-2020 the land used as paddy production area seems to be decreased drastically. As the temperature plays crucial role in paddy yield however temperature pattern is fluctuating. Maximum temperature is fluctuating more than minimum temperature. Likewise, some of the major adaption techniques used by farmers as to reduce the effect of climate change are changing crop varieties, building water harvesting scheme, and implementing soil conservation techniques for paddy production schemes.

**Conclusion:** The study concluded that most of the farmers of Kapilvastu district are aware of the climate change, its measure and adaptation strategies. The impact of climate change is being witnessed as change in temperature, rainfall pattern, which affects crop production. Likewise, farmers are aware that such conditions occurred due to change in climate and its condition. Further, they believe that this might

continue and they should be well prepared for the possible future scenarios. Adaptation of technology is found to increase the production as well. Various alternatives being adopted are helping farmers to cope with the climate changes. Adoption in technology would aid in increment in agriculture production. Technology would be beneficial for coping with the risks of climate change.

**Key Words:** Agriculture, Paddy production, Climate change, Technological Adaption

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## **CHAPTER 1: INTRODUCTION**

The background of the study unfolds, providing context to the research. The statement of the problem crystallizes the focus, articulating the specific challenges addressed. Clear-cut objectives then guide the study's trajectory, while the significance elucidates its broader impact. Concluding this introductory section is the organizational framework, outlining the study's structure. In essence, the introduction lays the foundation, ensuring readers embark on a well-guided exploration of the study's purpose and intricacies.

### **1.1 Background**

Nepal is a least developed and land locked South Asian country between two highly populated nations of the world China and India (Adhikari, 2018). The country is naturally gifted with diverse climatic conditions i.e. Terai, Hills and Himalayas with the altitude ranging from 60 meters to 8848.86 meters with the total area of 1,47,181 sq. km. (Devkota & Phuyal, 2017). According to Central Bureau of Statistics (2022), the total population of the country is 29,192,480. Further, Magar et al. (2021) stated that agriculture sector contributes 24.3% to the national economy and 65% to nations' employment which depicts that two-third of Nepalese population is dependent on agriculture. Likewise, 21.88% land of Nepal is cultivable. Out of the total arable land terai region covers 56% cultivable land (Timilsina et al., 2019). As revealed by the economic survey 2020/21 agriculture contributes 20.2% to the nations' GDP (Ministry of Finance, 2021).

Agriculture has always remained a top-most prioritized sector in developing economies as this sector contributes major share in a nation's economy, balance of trade, employment and presents great development challenges for the global community (Adhikari, 2015; Devkota & Paija, 2020). However, existence of traditional farming process, high dependence of agriculture on certain climatic conditions, involvement of semi-skilled or unskilled farmers in agriculture along with various other bottlenecks like lack of efficient agricultural market, timely availability of improved seed and chemical fertilizer and less subsidies from government for commercial farming have impacted to achieve the desired level of agriculture development (Le, 2016; Islam et al., 2009).

According to Bashmakov et al. (2007), climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or variability of its properties, and that usually persists for an extended time period, typically decades or even longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (Adhikari, 2015). However, the United Nations Framework Convention on Climate Change has made a distinction between climate change closely attributable to various human activities which has altered the atmospheric composition, and climate variability that is attributable to natural causes (Field et al., 2014). The climate in Nepal is governed by its topographic existence. Tropical, temperate and arctic types of climates are respectively encountered in Terai, Midland Mountain and high Himalaya. Almost all climatic zones of the earth exist here within a small area. Monsoon starts from mid June and lasts till September.

The direct exposure of agriculture and reliance on weather conditions (Le 2016), climate is still a key determinant for overall agriculture productivity and sustainability (Chowdhury & Khan, 2015) in many developing countries. Various climatic changes such as increased temperatures, rainfall fluctuations, and frequent weather extremes will have both the beneficial and harmful impacts on crops, mainly on their growth, development, and return (Karn, 2014; Amin et al., 2015; Le 2016; Riad & Peter, 2017). On a similar note, a change in the climate will impact on the distribution and the severity of rice diseases and insect pests as well (Riad and Peter, 2017; Devkota et al., 2018). Dhakal et al. (2016) urged that over the previous 30 years, yearly average rainfall has decreased at a pace of 10.21 mm/year, while annual mean temperature has climbed at a rate of 0.02 °C/year increasing in seasonal monsoon as well in Nepalese agricultural context which have further increased cost of production of all sort of crops. According to Chalise et al. (2017) due to the resulting loss of agricultural output, climate change has a considerable detrimental influence on the total Nepalese economy. Rural communities in Nepal, whose livelihoods are predominantly based on subsistence farming, will be subjected to extra climate change-related strains as a result of already-stressed poverty and a weak social security system. Malla (2008) already warned that it was already high time for Nepalese agriculture sector to start adapting to climate change issues and find the way for its mitigation.

Paddy is produced in two seasons in Nepal. Chaitey paddy (spring season paddy) is planted in the month of Chaitra (early April) in the areas with irrigation water where as Barkhey paddy(main season crop) is grown widely during rainy season of June to November. Paddy production, the main food staple, is the most vulnerable to climate change and its variability and any changes in climate will, thus, increase uncertainty regarding paddy production as climate is major cause of year-to-year variability in the productivity of paddy (Sarker, 2012). Further, Chalise and Naranpanawa (2016) stated that government of Nepal should start providing climate-smart paddy to farmers to substantiate their losses as Nepalese agriculture is most affected in south Asian region.

## **1.2 Statement of the Problem**

In developing countries, climate change has multidisciplinary impact on agriculture sector which affects the economy of the developing countries. The involvement of economists and researchers worldwide highlights the importance of the subject matter. According to the Intergovernmental Panel for Climate Change (IPCC), 2014 observed impacts of climate change on agriculture, relate mainly to production aspects of food security rather than access or other components of food security. Nepal is one of many developing countries with an agriculture-dominated economy. On the other hand, Nepal experiences wide range of climatic change within different regions with different altitude covering the wide range of climatic scenario.

In Nepal, production of paddy production comprises of the largest share in farm area and production comprising of 42.64% of area and 50.08% of production as of MOALD (2020). Paddy production has been contributing the largest proportion of several economic indicators however, these contributions have steadily declined as Bhandari et al. (2017) noted that paddy growing households have decreased from 76% in 1996 to 72.3% in 2011. As per the report of MOALD (2020), during 2019/20, the paddy production has been decreased by 1.05%, however, it was increased by 7.74% during 2018/19. The report mentioned the major causes of such decline due to huge rainfall, floods, ultimately caused by change in climatic conditions across the three belts Mountains, hills and terai of Nepal.

Agrawala et al. (2003) has found that recent climatic trends reveal a significant warming trend in recent decades which has been even more pronounced at higher

altitudes. The similar study found that warming trends have already had significant impacts in the Nepal Himalayas – most significantly in terms of glacier retreat and significant increases in the size and volume of glacial lakes, making them more prone to Glacial Lake Outburst Flooding (GLOF). Chaudhary & Aryal (2009) found that the mean annual temperature of Nepal has increased by 0.06 degree Celsius during the period of 1977-1994. Such estimates for average temperature rise in Nepal is 0.5 degree Celsius per decade, which is very high as compared to other developing countries.

On the other hand, as Nepal experiences wide range of climatic variation within different geographical regions along with different altitude covering the wide range of climatic scenario therefore, a study on the impact of climate change might enlighten the various circumstances of climate and its effect on paddy production. Various studies have been initiated in context to impact of climate change on various areas and regions however, only limited studies are conducted which covers impact of climate change in paddy production in terai region of Nepal. In the fiscal year 2016/17, the production of paddy increased by 10.0% due to favorable weather, use of improved seeds and seedlings and modern technology. As the rice production holds 21% share in total agriculture production, fluctuations in its production greatly influences aggregate growth of the agriculture sector (MOF, 2017). This shows the importance of the climate on paddy production of Nepal. There is different evidence of climate change in Nepal. There is evidence of late or pre-monsoon, unusual precipitation, decreased rainy days or intense rainfall events and these events have impacts on agriculture since the agriculture production depends on timely rainfall. Furthermore, traditional rainfall of mid-July has been shifted to mid-August in Kapilvastu, which has negative impact on paddy productivity.

Thus, a proper assessment is required to identify effect of climate change on Nepalese paddy production as paddy is the most produced and consumed crops in Nepalese economy. Therefore, a study of the effects of climate variation might enlighten the different circumstances of climate and its effect on paddy production.

### **1.3 Objectives of the Study**

The major objective of this study is to analyze the effect of climate change on paddy production whereas, some of the specific objectives are:

1. To assess the impacts of climate change on paddy production in Kapilvastu district.
2. To analyze the trend, pattern and composition of the impacts of the climate change on paddy production in Kapilvastu district.
3. Analyze technologies adopted by the farmers to cope with the impacts of climate change and identify the determinants of technology adaptation.

### **1.4 Significance of the study**

In the present days, the investment is increasing rapidly for huge production through education, training, skill-oriented program, improved seeds and technology etc. The lacking behind the paddy production is due to the fact of economic backwardness of the country (Karimi & Ataei, 2022). So, the existence of problem prevails in Nepal, as like other developing countries that makes to undertake this study. This topic has been selected to find out the improvements. According to the Synthesis Report of IPCC (2007), warming of climate system is unequivocal, which has been observed by the evidences of increase in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level. According to Bozkurt et al. (2017) runoff is projected with high confidence to increase by 10 to 40% by mid-century at higher latitudes and in some wet tropical areas. In northern area, climate change may preliminary have positive effect through increase in productivity whereas there may be negative impact of agriculture on the water quality of surface water. In southern area, there will be lower agricultural yields, variability in yield and reduction in appropriate land area used for growing traditional crops.

Climate change is considered to be problematic for many countries and wide spread implications are predicted for agriculture, water resources, fisheries, forestry and human health as well as social, economic and political system (Mishra, 2017). Among the several dimensions, impact on agricultural is one of the prime issues. This study tries to analyze the effect of climate change on agriculture in Kapilvastu, Nepal.

From the earlier studies conducted in the similar fields and literature reviewed it can be observed that climate change has created huge impact on overall agricultural sector of Nepal. Though various adaptation practice and mitigation strategies are being followed and adapted by farmers at their level the consequences of climate change is increasing at increasing trend. A study made by Mendelsohn & Massetti (2017) suggests that both temperature and precipitation have modest effects on farmland value and net revenue. This study also suggests that marginal warming will likely be harmful in low latitudes but beneficial in higher latitudes and that marginal increases in rainfall will be beneficial in semiarid locations but harmful in very wet places. The impacts differ for rain-fed versus irrigated farms and for crops versus livestock. The results imply that global warming will likely have only modest impacts on global food production for the next century since the harm from higher temperatures will likely be offset by the benefits of carbon fertilization and adaptations by farmers.

There are still certain gaps that need to be filled in the field of impact of climate change on Nepalese agriculture sector. Therefore, after the accomplishment of this study, the impact of climate change on paddy production will be determined along with the level of impact on paddy production. Further, the study would also benefit farmers as they can find out the way to cope with impact made by climate change on paddy production by figuring out effective measures to come out of the consequences. Also, various concerned authorities at different level could find out ways how different nations are fighting with the climate change and measures they are taking to mitigate the challenge aroused from climatic change, it would also help in formulating policies related to the matter. The results generated from this study would also be helpful for the nations and regions that shares similar agricultural environment with the field area of this study. Also, this study will be beneficial to future researchers to figure out ways for similar kind of studies. Likewise, the findings can also be useful in various research activities.

### **1.5 Limitation of the Study**

As the impact of climatic change on paddy production is very vast, it is very difficult to grasp all the direct and indirect effects with one empirical analysis. Some major limitations of the study are:

1. This study does mean to explain in detail about the impacts of climate change indicators.
2. The Secondary data are obtained from different government organizations which are not verified for their reliability. Meteorological data for 40 years were purchased from the Department of Hydrology and Meteorology and only the results of analysis are presented. As per the condition of the procurement, the raw meteorological data cannot be shared.
3. The sample for the study was taken from Banganga Municipality of Kapilvastu district and a single product (i.e., Paddy) is covered for 40 years' time period where it may have influence by other unseen and beyond explanatory variables.
4. Due to time and resources constraints the study period spans from 1980-2020 AD.

### **1.6 Organization of the study**

This thesis is divided into five chapters. First chapter is introduction to the study which comprises of subject matters related to the study and brief description on what this study will be dealing about. It also describes objective, significance of our study. Similarly, second chapter in literature review where various studies related to our subject area is reviewed on various contexts, regions which would make things clear regarding the area we are going to cover for the study. Third chapter is research methodology where the methods, instruments used to carry out this study are clearly discussed. Fourth chapter comprises findings of our study. In this chapter the major result for which purpose we are attempting this study will be generated. Lastly, fifth chapter of this study covers summary, conclusion and recommendation that we emphasized from the overall thesis.

## **CHAPTER 2: LITERATURE REVIEW**

The literature review chapter is a comprehensive exploration organized into four crucial sections. Section 1 delves into the intricate relationship between climate change and food production, analyzing its impacts globally and specifically on paddy production, emphasizing its effects in Nepal. Section 2 shifts focus to theoretical perspectives, examining the influence of climate change knowledge on consumer valuation of sustainably produced rice, broader effects on agriculture, and the mechanisms underlying climate change's impact on rice yield. Section 3 extends the investigation into empirical reviews, scrutinizing real-world data and observations related to climate change and paddy production. Finally, Section 4 identifies the research gap, highlighting areas where existing literature falls short, paving the way for the research to contribute novel insights and bridge the identified gaps in understanding climate change's implications on paddy production.

### **2.1 Climate change and food production**

#### *Climate Change*

Climate change has been crucial issue since long time, however, the issue has been emerged as burning issue since few years back around the globe which have caused stress not only to the environment but to the societies we live in as well (Adedeji, 2014). Climate change is a huge threat to human well-being, and in the future decades, it will be the root cause of a range of stressors (Mah et al., 2020). According to Elizabeth et al. (2010) as an evidence to changing climate global phenomena such as rise in sea levels, untimely rains, droughts, changes in seasonal patterns, global warming can be witnessed. Though, impact of climate change has been felt around the world developing and under developed nations are being more affected by the phenomena. Since the late twentieth century, climate change has been without a doubt the most prominent environmental issue. However, the discourse did not exist at that time, nor has it been problematized in the same way since its inception. Climate Change discourse has evolved from a solely scientific concern to a public agenda that is now more likely to be a development issue, according to its history. Every time a transformation occurs, a completely new paradigm emerges (Rahman, 2013).

Climate change, which was formerly thought to be a problem for the far future, has already firmly established itself in the present (US global change research program, 2014). Further, Adedeji (2014) mentioned that Climate change takes place naturally as a result of changes in the sun's energy or the Earth's orbital cycle (natural climate forcing), or as a result of persistent anthropogenic forcing, such as the addition of greenhouse gases, sulfate aerosols, or black carbon to the atmosphere, or as a result of land-use change. Rosso Grossman (2018) urged that climate change has been identified as "one of the largest worldwide hazards to human health in the twenty-first century," according to new research. 8 Heat waves will afflict 74% of the world's population by 2100 if global GHG emissions are not controlled. Even if GHG emissions are drastically reduced, nearly half of the world's population will be exposed to dangerous heat.

Global citizens will face more unexpected weather and extreme weather events as climate change accelerates (Howe et al., 2019). As mentioned in UNFCCC (n.d.) increases in average global temperature (global warming); changes in cloud cover and precipitation, particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and acidity – due to seawater absorbing heat and carbon dioxide from the atmosphere – are the main characteristics of climate change. National Academies of Sciences, Engineering and Medicine (2016) stated that to most people, climate change is a broad word that encompasses rising greenhouse gas levels, rising global temperatures, rising sea levels, melting ice sheets and glaciers, and more frequent extreme weather events. Also, Sun & Han (2018) depicted that individual and societal factors play important roles in shaping the risk perceptions of climate change. As Field & Barros (2014) revealed changes have been linked to human influences, including a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions

Scientists have been warning for more than 50 years that the combustion of fossil fuels is changing the Earth's climate, and that failing to address climate change will have disastrous effects (Hornsey & Fielding, 2020). As per the findings of Malhi et al. (2020) ecosystems are being impacted by climate change due to changes in mean conditions and variability, as well as other changes such as increased ocean

acidification and atmospheric carbon dioxide concentrations. Climate change can have a wide range of effects on human and animals (Werndl, 2020). However, human system will have to adapt to climatic changes as adaptation action is rarely driven solely or mostly by climate change. (Berrang-Ford et al., 2011). The Royal Society (2020) mentioned that all big climate changes, whether man-made or natural, are disruptive. Many species have perished as a result of past climate shifts, as well as population migrations and significant changes in land surface and ocean circulation. Climate change is happening at a faster rate than most previous occurrences, making it more difficult for human societies and the natural world to adapt.

However, according to Grove (2021) current climatic change and variability definitions are generally ambiguous and subjective. Thus, Climate education and awareness campaigns should be taken more seriously and strategically by policymakers, who should take advantage of the numerous co-benefits associated with adopting pro-environmental behavior (Van de Ven et al., 2018). Several worldwide initiatives, such as the 2015 Paris Agreement on Climate Change and the 2015 Sendai Framework for Disaster Risk Reduction, as well as several European policy actions, such as the EU strategy on Climate Change Adaptation, have been taken (Ciscar et al., 2014). Climate change as a result of human-caused global warming will have a variety of environmental and socioeconomic consequences. Though there are various arguments on causes of climate change Hoogendroon et al. (2020) states that some people believe that natural processes are to blame for climate change, while others believe that human activities are to blame.

### ***Impact of Climate Change on Food Production***

Climate change poses significant threats to the global food system in the twenty-first century, threatening farmers' and communities' lives (Vogel & Meyer, 2018). Climate change is a major contributor to recent increases in food prices and is one of the leading causes of severe food shortages (Molotoks et al., 2021). Crop yields are expected to decline in the future due to changing climate conditions. However, the current impacts on a variety of crops on a subnational level, as well as the implications for food security, are unknown (Ray et al., 2019). The impact of climate change is extensive, but its far-reaching consequences on the agricultural sector, on which the world's food production and economy rely, are now abundantly obvious

(Arora, 2019). According to Amiraslany (2010) direct impacts of climate and price change increase farmland value by 31% while the indirect impacts from different scenarios increase simulated land value by up to 51%. Likewise, when compared to population growth, the rise in crop output per hectare is much slower (WFP, 2018). Similarly, as revealed by FAO (2016) if present GHG emissions and climate change trends continue, major cereal crop yields will drop by the year 2100 (20–45% in maize yields, 5–50% in wheat yields, and 20–30% in rice yields).

Further, as mentioned by UNEP (2017) Drought and desertification have resulted in the abandonment of 500 million hectares of cropland, posing significant social and environmental challenges. Extreme droughts, which are becoming more often as a result of climate change, aggravate crop yield by inducing nutrient immobilization and salt accumulation in soils, leaving them dry, unhealthy, saline, and ultimately infertile. The two climate variables (temperature and precipitation) have a significant and non-monotonic impact on crop yields (Chang, 2002). Climate-related disruptions would have a significant impact not just on food distribution patterns, but also on its quality and accessibility (Arora, 2019). Fanzo et al. (2018) urged that climate change's effects on agriculture will have far-reaching repercussions for food security, and hence human diets and nutrition.

Hasegawa et al. (2018) depicted that food insecurity can be increased directly by climate change due to the effects of warmer and drier conditions on crop production that are projected in significant agricultural regions. Nemecek et al. (2016) unleashed that climate change impacts what food is available and at what price, affecting overall calorie consumption as well as healthy food consumption. According to Bryan et al. (2017) in the face of climate change, agriculture must become smart and it must be attentive to food and nutrition needs while reducing harmful climate effects. As mentioned by Herrero et al. (2013) mixed agricultural and livestock systems reduce the impact of animals on the environment while also improving food nutritional quality. Thus, as recommended by Vogel & Meyer (2018) to satisfy future demands, food production will need to increase dramatically in the coming decades, while also responding to the effects of climate change and lowering greenhouse gas emissions.

### *Effect of Climate Change on Global Paddy Production*

Among the many crops of international interest to such studies, paddy (rice) is one of the most important. Rice is a global crop, produced in at least 95 countries worldwide and feeding significant portions of the world population (IRRI, 2002; Coats, 2003). There is evidence that climate change has affected food security, crop choice, and agricultural output all around the world (Alam et al., 2017). According to Wang et al. (2018) climate change reduce agricultural yields while resulting in food security. Asia is by far the most significant rice producing region, accounting for ca. 94% of total world production, and one of the most intensive areas of rice production within Asia is monsoonal East Asia. Due to the population growth in this century, the demand of rice production will grow to ca. 2000 million metric tons by 2030 (FAO, 2002; Younas et al., 2020). According to the Third Assessment Report of IPCC (2001), if the levels of emissions are not reduced, the global average temperature will increase by 1.4°C to 5.8°C between 1990 and 2100. Another projection said an increase in the average global temperature of 2.4°C between 1990 and 2100, with a 95% chance that the change will be between 1.0°C and 4.9°C (Webster et al., 2002). Other studies conducted by Zwiers (2002) have estimated that the average global temperature is likely to rise by between 0.3°C and 1.3°C during the next 30 years.

On a similar note, Siwar et al. (2014), the UN Framework Convention on Climate Change (UNFCCC) have identified a list of 49 Least Developed Countries (LDCs), which are at high risk from climate change, where 33 are located in Africa. Another study conducted by Lobell et al. (2008) analyzed that that due to climate change, Southern Africa will lose more than 30% of its main crop, maize, by 2030, and Asia, especially South Asia and South East Asia will lose top 10% of many regional staples, such as paddy, millet, and maize. Increased temperatures, rainfall fluctuations, and frequent weather extremes (Karn, 2014; Le, 2016) will have beneficial and harmful effects on crops, mainly on crop growth, development, and yield (Amin et al., 2015; Riad & Peter, 2017). Also, a change in the climate will affect the distribution and the severity of rice diseases and insect pests (Riad & Peter, 2017).

Kim & et al. (2013) investigated the effects of climate change on paddy rice production in the temperate climate regions under the East Asian monsoon system using the CERES-Rice 4.0 crop simulation model. Data were obtained from experiments performed using a temperature gradient field chamber (TGFC) with a

CO<sub>2</sub> enrichment system (Park et al., 2020). The result appeared that the potential negative impact on crop production may be mediated by appropriate cultivar selection and cultivation changes such as alteration of the planting date. Further, the model the CERES-Rice 4.0 model demonstrated the promising potential for its further application in simulating the impacts of climate change on rice production from a local to a regional scale under the monsoon climate system (Choi et al., 2021).

Siwar et al. (2014) studied about the impacts of changing factors of climate, especially rainfall and temperature on paddy production in Malaysian agriculture based on using the micro data of Integrated Agricultural Development Area at North West Selangor, Malaysia from 1992 to 2007. This study found that both temperature and rainfall have significant negative impacts on paddy production. A 1% increase in temperature will lead to 3.44% decrease in current paddy yield, and .03% decrease in paddy yield in the following season. 1% increase in temperature will lead to .12% decrease in current paddy yield, and .21% decrease of paddy yield in the following season. Technology shows a significant positive relationship with paddy production. 1% improvement of technology will lead to .16% increase of the paddy yield. Thus, technology needs to develop to solve the problem such as controlling the pattern of rainfall, sunshine, or to improve shielding resources (Lezoche et al., 2020) such as, protecting crops from excessive rainfall, solving water login problems, or to develop defensive approaches (Massarelli et al., 2021) such as varieties of crops development, rainfall and temperature tolerant plants, or to find alternative approaches such as changing crop cycles and reducing the timing of crop cycles.

### ***Effect of Climate Change on Paddy Production in Nepal***

In Nepal, production of paddy comprises of largest share in farm area and production comprising of 42.64% of area and 50.08% of production as of MOALD (2020). Rice production has been contributing the largest proportion of several economic indicators such as employment, GDP, and raw materials supplied to existing agro-based industries. However, these contributions have steadily declined. For instance, Bhandari et al. (2017) noted that paddy growing households have decreased from 76% in 1996 to 72.3% in 2011.

Central Bureau of Statistics has envisaged the issues related to impact of climate change in Nepal and solutions to overcome those impact through highlighting the Sustainable Development Goals and Nepal in Official Statistics of Nepal: Issues and

Practices (2022). The Goal number 13 states “Climate action” and under the goal five targets are associated within as such:

1. Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters.
2. Integrate climate change measures into national policies.
3. Improve education, awareness-raising and human and institutional capacity on climate change.
4. Implement the commitment undertaken by developed-country.
5. Promote mechanisms for raising capacity for effective climate change-related planning

On a similar note, Shrestha et al. (2016) conducted experiment to study the performance of pipeline varieties of rice and to compare their performance with released variety in Lamjung, Nepal. Randomized complete block design with three replications and eight different treatments with seven new genotypes were used. The results showed that among tested eight genotypes, there was no significant difference observed in case of plant height with average plant height of 89.68cm. It showed that all of the genotypes were semi dwarf type. The sterility in genotypes may be due to failure of proper pollination and insect damage.

Devkota & Paija (2020) assessed the long-run relationship and short-run dynamics between paddy yields and climate variables, particularly maximum and minimum temperature and rainfall, using time-series data from 1971 to 2014 in Nepal applying ARDL bounds testing approach. The result depicts that positive and significant relationship exists between rice yields and rainfall and that this relationship is unidirectional. Rainfall impacts on rice yield and holding all things constant, a 1 mm increase in rainfall increases rice yields by 0.65%. Given the effects of temperature on rice crops and increasing climate change vulnerabilities, agricultural scientists should focus on research and development of temperature tolerant rice varieties in the production of rice yields. This study notes that the current average maximum temperature for the decade of 1999 to 2008 is already 30.8°C. Thus, it is expected that rice yields are already being negatively affected by increases in the daily maximum temperature. Adaptation strategies for increasing rice productivity in future environments will have to integrate these rice characteristics into one ultimate target.

A study conducted by Paudel & et al. (2021), to analyze the production economics and factors contributing to the gross return of rice production in the Gorkha district of Nepal in 2020, among 76 rice-farmers, where a rice block was established under the Prime Minister Agriculture Modernization Project (PM-AMP). The results showed that the average landholding was 0.74 ha and the average area under rice cultivation was 0.52 ha, with a productivity of 3 mt ha<sup>-1</sup>. The findings revealed that the cost of rice production for small farmers was significantly higher (NRs. 171466 ha<sup>-1</sup>) than that for large farmers (NRs. 132088 ha<sup>-1</sup>). The production function analysis reveals that a 10% increase in expenditure on seeds, total labor, and nutrients, keeping all other variables constant, could increase the gross return of rice by 2.97%, 2.19%, and 0.62%, respectively. The sum of coefficients was 0.56, reflecting a decreasing return to scale. Thus, a 100% increase in expenditure on variables presented in the model caused a 56% increase in the gross return of rice production. The study suggests that, training and extension activities focusing on scientific production technology is needed to counter the negative consequences of climate change.

Similarly, Adhikari (2015) examined the possible impacts of climate variation in paddy production of Nepal. Panel data model based on Ricardian approach of climate variation was adopted for the study based on two different datasets for two different geographical regions of Nepal, Hill and Terai. It was found that the variation in maximum temperature over the study period has negative impact in paddy yield of both regions and the precipitation experienced during the study period has negative impact in paddy yield of the Terai Region. The calculation from the test results showed that one-degree increase of maximum temperature will cause 127 kg per hector and 94.99 kg per hector decrease in paddy yield in Hilly and Terai Region respectively. One-millimeter increase in rainfall in Terai Region will cause 1.59 Kg per hector decrease in paddy yield.

Agrawala et al. (2003) found that recent climatic trends reveal a significant warming trend in recent decades which has been even more pronounced at higher altitudes. Climate change scenarios for Nepal across multiple general circulation models meanwhile show considerable convergence on continued warming, with country averaged mean temperature increases of 1.2°C and 3°C projected by 2050 and 2100. Warming trends have already had significant impacts in the Nepal Himalayas – most significantly in terms of glacier retreat and significant increases in the size and volume of glacial lakes, making them more prone to Glacial Lake Outburst Flooding

(GLOF). Continued glacier retreat can also reduce dry season flows fed by glacier melt, while there is moderate confidence across climate models that the monsoon might intensify under climate change. This contributes to enhanced variability of river flows. A subjective ranking of key impacts and vulnerabilities in Nepal identifies water resources and hydropower as being of the highest priority in terms of certainty, urgency, and severity of impact, as well as the importance of the resource being affected.

According to Statistical Information on Nepalese Agriculture 2019/20, conducted by Ministry of Agriculture and Livestock, the following table shows the salient features of paddy production in Nepal.

*Table 2.1: Salient features of Paddy production*

<b>Cereal Crop</b>	2018/19		2019/20	
	Area (Hectare)	Production(MT)	Area(Hectare)	Production(MT)
<b>Paddy</b>	1491744	5610011	1458915	5550878

Source: MOALD (2020). *STATISTICAL INFORMATION ON NEPALESE AGRICULTURE 2076/77 (2019/20)*

From the above table, we can see the decrease of paddy production in 2019/20 by 1.05%. However, it was increased by 7.74% during 2018/19. The major cause of such decline primarily goes to huge rainfall, floods, ultimately caused by change in climatic conditions across the three belts of Nepal.

Similarly, the 15<sup>th</sup> periodic plan of Nepal has envisaged the climate change adaptability under the “Healthy and balanced environment” as the seventh national goal as shown in table below:

*Table 2.2: National Goals*

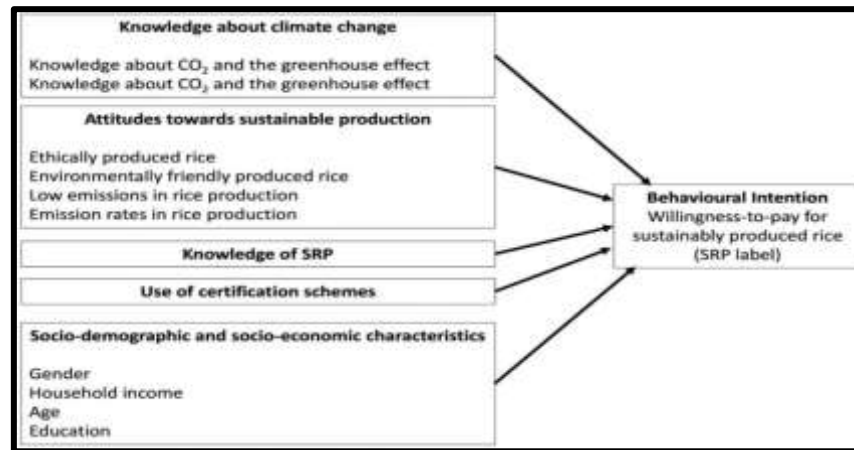
<b>National goals, target, and indicators</b>			
Goal 7: Healthy and balanced environment	Unit	Status in FY 2018/19	Target for FY 2023/24
7.3 Climate change adaptability			
7.3.1 Local levels that have prepared and implemented the adaptation plan	Number	217	460

By the end of the planning period, the contribution of the agriculture sector to GDP will be decreased to 22.3% from the current 27%. Agricultural productivity will have increased to 4 Metric Ton (MT) per hectare from 3.1 MT per hectare. The seed replacement rate for major crops will have reached 25% by the end of the planning period. The productivity of major cereal crops per hectare will have reached including 4.5 MT alone for paddy.

## 2.2 Theoretical Reviews on Climate Change and Paddy Production

The influence of climate change knowledge on consumer valuation of sustainably produced rice

*Figure 2.1: Climate change knowledge on consumer valuation of sustainably produced rice*



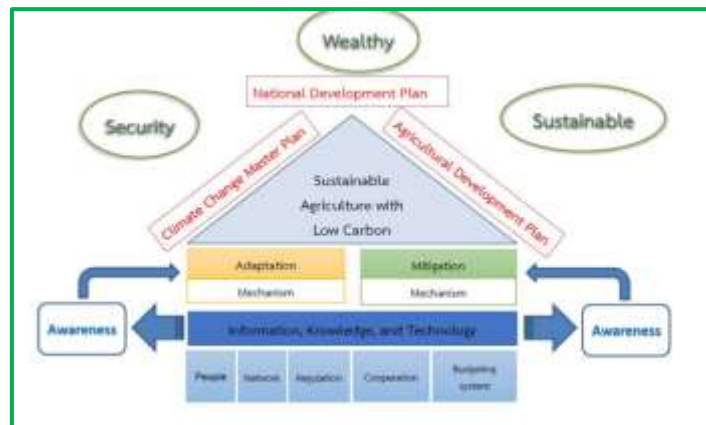
Source: Cuong et al. (2022)

As captured in above figure, the perceptions and concerns about climate change influence consumers and can in turn influence purchase decisions as several studies have shown the importance of knowledge in consumer decision making and acceptance of new technologies. It has been assumed that greater scientific knowledge or knowledge about certain technologies result in greater acceptance (Connor & Siegrist, 2010). Further, if there is no demand for sustainable certification for cheaper, staple food products, like rice, sustainable production is unlikely to scale sufficiently to combat the negative impacts globally, such as climate change and environmental degradation.

### *Climate change Effect on Agriculture*

The figure below depicts about the goals of the 2017-21 Strategy which includes: 1) All sectors have the higher level of awareness to the effect of climate change; 2) All sectors obtain information, knowledge and technologies developed to support climate change adaptation thoroughly; 3) The agricultural sector has the contribution to reduce the greenhouse gas emission appropriately; 4) Integration and driving measures and guidelines to adapt to climate change with support from all sectors; 5) Farmers have a better quality of life, agricultural sector grows in the sustainable pathway and resilient to climate change, and strengthening national food security; 6) The agricultural sector has higher capacity for competition.

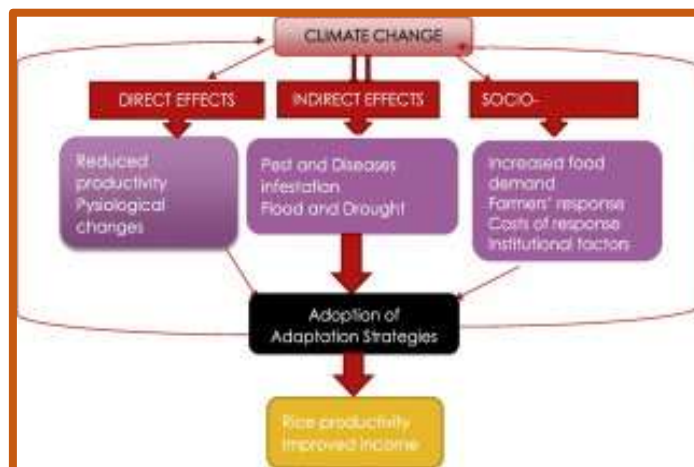
*Figure 2.2: Climate Change Effect on Agriculture*



Source: Attavanich (2018)

### *Effect of climate change adaptation strategies on rice productivity*

*Figure 2.3: Effect of climate change adaptation strategies on rice productivity*



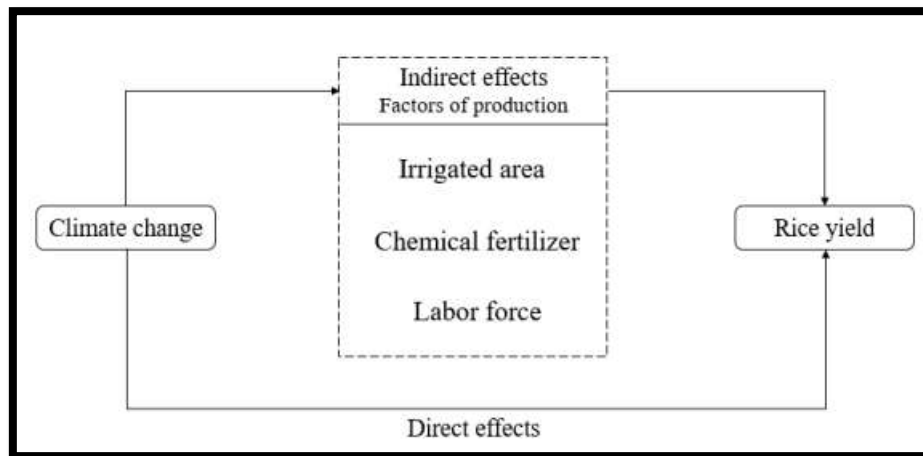
Source: Ojo & Baiyegunhi (2020)

As shown in above theoretical framework, the SFA (Stochastic Frontier Model) model is a parametric method and works under the assumption of a properly defined functional form of the frontier technology and inefficiency term, and can handle noisy data effectively (Kumbhakar et al., 2009). As the climate change shows multiple effects such as direct, indirect and socio-economic effects as shown above, and with the adoption of appropriate strategies, its impact can be reduced as rice productivity improves and income multiplies.

***Mechanism of climate change on rice yield***

As per the theoretical model in figure 4 climate change directly impacts the rice yield however, there are various other factors that impacts rice yield. Indirect effects on production on rice yields are irrigated area, chemical fertilizer and labor force. Though direct and indirect effect can be witnessed it can be seen that either way climate change is associated with the impact on rice yield.

*Figure 2.4: Mechanism of Climate Change on Rice Yield*



Source: He et al. (2020)

**2.3 Empirical Reviews on Climate Change and Paddy Production**

The study conducted by Takama et al. (2014) regarding climate change vulnerability to rice paddy production in Bali, Indonesia with the help of focus group discussion, participatory research and policy assessment showcased that climate change has reduced the suitability for rice paddy production on Bali Island by 20% in the previous 20 years, and climate change is expected to continue in the future. Similarly,

this study on the other hand suggested that actual impacts will be determined by the location of rice paddy and the farmers' ability to adapt.

Kaffashi et al. (2014) conducted a study on assessing the impacts of climate change on paddy production in Malaysia. This study used the annual data from 1980-2010, a time series data to generate the outcome which aimed to identify impact of various indicators of climate change in paddy production. The findings unveiled that temperature and rainfall had negative impact on paddy production. Increase in temperature would result in loss of paddy production to up to tune of RM 312.20. Beside that the projection shows that the loss would reach to RM 7608.9 by the year 2099.

Impact of climate change on paddy production: Evidence from Nepal was assessed by Devkota & Paija (2020) using time series data from 1971 to 2014 in Nepal using regression and ARDL technique. The results indicate that rainfall has a significant impact on rice productivity. In particular, there is a positive and strong link between rice yields and rainfall, which is unidirectional. Rainfall has an effect on rice yield, and if all other factors remain constant, 1 mm increase in rainfall boosts rice yields by 0.65%. Given the impacts of temperature on rice crops and the growing vulnerability to climate change, agricultural experts should focus their efforts on developing temperature-tolerant rice cultivars to increase rice yields.

On a similar note, Kamruzzaman et al. (2020) assessed the impact of climate change on water balance components in irrigated paddy cultivation. The research used APEX-Paddy (Agricultural Policy/Environmental eXtender) model based on conventional management during the cropping period of 2013 and 2014. The results showed that due to the effect of rising temperature, the stomatal closure under elevated CO<sub>2</sub> has a significantly greater effect in reducing transpiration levels than increasing transpiration rate. However, the major change in irrigation water demand is expected to increase in the 2040s by 3.21%, while the lowest increase was found to be 0.36% in 2010s.

However, Santikayasa et al. (2018) evaluated the potential impact of climate change on paddy field production and water resources based on Aquacrop crop simulation model in Indonesia. The outputs showed that an increase of the rainfall by average of 27% impacts the increase in paddy field productivity by 19% in the period of 2021 –

2050. It also indicates that increase of the flood and plant diseases and influence to the paddy production in the future. These findings suggest that the good water management on flood impact is crucial to mitigate the negative consequences of the future climate and secure the future paddy field production.

Firudas et al. (2020) conducted a study with an attempt to discuss impact of climate change on rice production and food security in Malaysia using Mann–Kendall and Sen's slope. The results highlighted that climate change poses a severe threat to paddy production as precipitation has shown an increasing trend, ranging from 133 mm to 200 mm, which eventually will affect food security because of highly interrelation. Thus, Malaysia needs to revamp its paddy and rice intervention strategies by giving due attention to enhance the capacity of paddy farmers to resist climate change.

It is estimated that the ability of farmers to adapt to and mitigate climate change will be significantly influenced in the near future by the development of new agricultural practices and the effective distribution of technologies (Adenle et al., 2015). Suman (2021) mentioned that adaptation of renewal source of energy plays crucial role in mitigation of farm issues raised due to climatic change in highly vulnerable nations like Nepal. Further, Aryal et al. (2020) stated that it is important to adopt to agriculture technology rather than focusing on other mitigation techniques only. But, Harvey et al. (2018) stated that many farmers could not adapt to technological strategies such as building of irrigation systems, planting of new crops, or a rise in the usage of fertilizers and agrochemicals due to their various economic and social limitations.

From the above empirical reviews, it can be seen that climate change has vulnerable impact on paddy production. So based on the impacts of temperature on paddy crops and the growing vulnerability to climate change, agricultural experts should focus their efforts on developing temperature-tolerant paddy cultivars in order to increase paddy yields.

## 2.4 Research Gap

During the process of reviewing the relevant literature for the study, it was observed that numerous studies had been carried out in relation to climate change after taking into consideration a variety of climate change indicators. For the same reason, a number of different pieces of literature were introduced that discussed the impact that climate change would have on the agricultural sector in Nepal. In addition to the effect, the studies concerning the adaptation and mitigation strategies and techniques that are currently being implemented and those that are going to be implemented were also analyzed. The Nepalese context contains a number of review papers and empirical studies that are comparable to those found in the context of Nepal.

Despite the fact that a number of studies were discovered that discussed the impact of climate change on the agricultural sector of Nepal, the majority of these studies were inclined to discuss the impact of climate change on the agricultural sector of Nepal as a whole since 2008. In the same vein, Rayamajhee et al. (2021) recently carried out their research on the impact that climate change has on rice production. Khadka et al. (2020) also carried out their research on farmers' adaptation to the impact of climate change on rice yield. Sharma et al. (2020) analyzed the impact of climate change on paddy-wheat production and local adaptation practice. Poudel et al. (2018), on the other hand, conducted research on the impact of climate change on paddy production and adaptation strategies in Tharu communities located in the Dang district of Nepal.

Bista (2019) conducted research on the effects of climate change on paddy production in Nepal's rural hilly regions and the adaptive practices of farmers. A study that is related to this one was carried out by Devkota and Paija (2020) regarding the impact of climate change on paddy production: evidence from Nepal. Despite this, there has been a limited amount of research conducted in terms of numbers regarding the impact that climate change has had on agriculture in Nepal. A clear indication of the lack of relevant research is the fact that the majority of Nepalese families, which accounts for 50.67 percent of the population never ever heard of climate change.

Given that a number of studies have investigated the ways in which climate change has impacted agricultural productivity in countries other than Nepal, this is cause for concern. Because of this ignorance, effective policymaking at the municipal or regional level is met with significant obstacles, and private players are unable to put

into action adaptation plans that are designed to last for an extended period of time. It is still unknown how extensive and what kind of trade-offs were made during the adaptation process, as well as what new vulnerabilities were created as a result of the adaptation process. This is the second point. Even though there is evidence that some families have adapted to climate change, it is still unknown. Therefore, in order to successfully minimize climate-vulnerability among Nepalese farmers, it is necessary to evaluate the effects of climate change on the way of life of agricultural households and discover the technological inefficiencies that exist.

However, despite the fact that the Terai region of Nepal is commonly referred to as the "basket of grains for Nepal" and that the Kapilvastu region is one of the most important rice-producing districts in Nepal (Sapkota & Sapkota, 2019), there have been very few studies and reviews conducted on that region that identify and analyze the current situation. The vast majority of research has been concentrated on rice production and the overall climate effect; however, the issues of climate impact on paddy production in major rice producing districts have been scarcely discovered. As a result, the purpose of this study is to investigate the impact that climate change has had on the production of paddy in the Kapilvastu district of Nepal, using a variety of indicators and the adaptation strategies that the farmers in the area have implemented.

## **CHAPTER 3: RESEARCH METHODOLOGY**

The research methodology includes research design, area of the study, research hypothesis, data collection instruments, population and sample size, and analysis and research gap. This chapter has been discussed under various sections. Section first describes research design of the study, which is based on explanatory research design. Similarly, section second explains about the conceptual framework of the study. Third section deals with empirical framework followed by variable and its definition. Fourth section depicts study area and population along with sampling technique and sample size determination in next section. Likewise, research instrument and data analysis tools used in the Chapter are discussed in last section of this chapter.

### **3.1 Research Design**

This study employs an explanatory research design. Explanatory type of research is created to answer why and how question. In business research, we often find that cause-effect relationship is less explicit. We are interested in understanding, explaining, predicting and controlling relationship between variables than we are in detecting cause. Explanatory studies go beyond description and attempts to explain the reasons for the phenomenon that the descriptive study only observed. In an explanatory study, the researcher uses theories or hypothesis to account for the forces that caused a certain phenomenon to occur (Narasimhan et al., 2005).

The explanatory research focuses on describing the cause-and-effect relationship, as well as how and why it occurs (Shmueli, 2010). The explanatory design of research is used to test causal hypothesis in many scientific domains, particularly in the social sciences. Explanatory study seeks to refine, broaden, and test hypotheses in order to better understand why things occur. This research design is characterized by a high level of flexibility and a lack of formal structure, and it focuses on thoroughly discussing the various components of study (Baskerville & Pries-Heje, 2010).

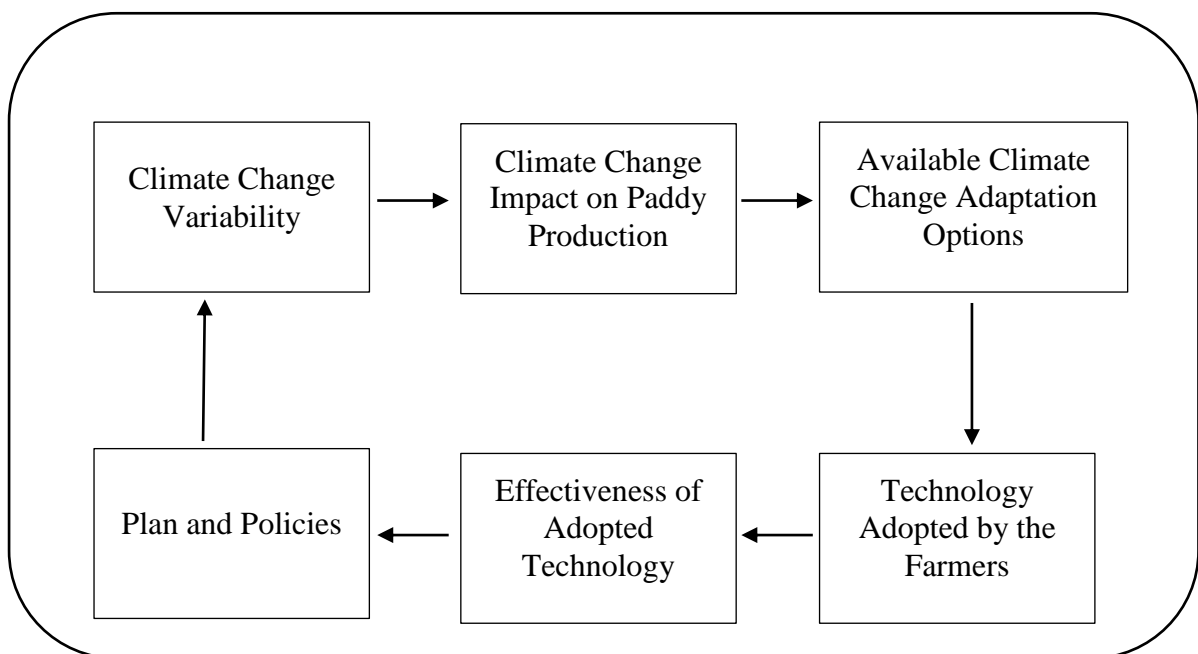
In order to measure the effect of climate change on paddy production primary data is collected among farmers of Kapilvastu district. Survey questionnaire were developed and then farmers were interviewed on the same questionnaire. Same method was used in order to analyze technologies adopted by the farmers to cope with the effect of climate change related to negative effects on paddy production and their effectiveness.

Further, in order to analyze the trend, pattern and composition of effect of the climate change trend analysis has been conducted. Also, various descriptive and inferential data are analyzed and presented to generate the effective outcome of the study.

### 3.2 Conceptual Framework

We assume that farmers are aware of the issue regarding climate change and will often ascribe change in farm productivity to changes in temperature and rainfall patterns in the process of paddy production. However, the nature of climate variation depends on how people perceive about climate change and variability.

*Figure 3.1 Conceptual Framework*



The impact of climate change depends on the vulnerability especially on temperature and rainfall and magnitude from irrigated to rain fed paddy production. The impact can be negative if climate variable results in high temperature, low rainfall, occurrence of floods, low crop yields and so on. These impacts determine what adaptation options (short-term or long-term adaptations) farmers should take to protect themselves from the effect of climate change and variability. Adaptation options for paddy production include planting drought resilient crops, paddy diversification, use of chemical fertilizer, irrigation, changing nursery date, changing the plant date and so on.

Likewise, farmers have started adopting to green technology which have less effect on environment and allows sustainable development. Thus, many agricultures led countries are finding innovative ways to adopt technology in paddy production. Countries have also started using green fertilizers understanding the concern of climatic change due to various chemical based fertilizers. Further, with the adoption of modern technology paddy productivity were found to be enhanced and modern technology were found to be more adopted by paddy growers rather than farmers growing other crops.

Though the bulk of adaptation options available to cope with climate induced vulnerability, farmers do not easily choose all the adaptation options available in the market. It depends on their ability to adapt technology and capital. A common assumption in the adaptation literature is that richer farmers have more technology and capital to choose from than poor farmers (Ali & Erenstein, 2017). And we believed that having more substitute allow rich farmers to adapt and able to adapt more readily.

Since, better adaptation options help sustainable livelihood and also helps to mitigate the problem of climate change. Therefore, understanding the income level of farmers plays crucial role to in decision making process. It also allows proper allocation of scare resources with efficient management. Further, it helps policy makers to promote successful adaptation on paddy production which is affordable and popular to the farmers.

### 3.3 Empirical Framework

Following Deressa et al. (2008) and Gbetibouo (2009), this section presents farmer's adaptation options to climate change and vulnerability. The decision on whether or not to adapt any adaptation options is considered under the general framework of utility and profit maximization. It is assumed that a rational farmer uses adaptation methods only when the net benefit from using such a method is significantly greater than in the case without it.

Although the utility is not directly observed, the action of economics agents are observed through the choices they make. Suppose that  $Y_j$  and  $Y_k$  represent a household's utility for two choices, which are denoted by  $U_j$  and  $U_k$ , respectively.

The linear regression model could then be specified as:

$$U_j = \beta_j'X_i + \varepsilon_j \text{ and } U_k = \beta_k'X_i + \varepsilon_k \dots \dots \dots (1)$$

In the case of adaptation method, if a household decides to use option  $j$ , it follows that the perceived benefit from option  $j$  is greater than the benefit from other options (say  $k$ ) depicted as:

$$U_{ij}(\beta'_j X_i + \varepsilon_j) > U_{ik}(\beta'_k X_i + \varepsilon_k), k \neq j \dots \dots \dots (2)$$

Where,  $U_{ij}$  and  $U_{ik}$  are the perceived benefits of adaptation options  $j$  and  $k$  respectively by farmer  $i$ ;  $X_i$  is the vector of explanatory variables influence the choice of the adaptation options;  $\beta_j$  and  $\beta_k$  are parameters to be estimated; and  $\varepsilon_j$  and  $\varepsilon_k$  are the error terms assume to be independently and identically distributed.

The probability that household will use method  $j$  among the set of climate change adaptation options could then be defined as follows:

$$\begin{aligned} P(Y = 1/X) &= P(U_{ij} > U_{ik}/X) \dots \dots \dots (3) \\ &= P(\beta'_j X_i + \varepsilon_j - \beta'_k X_i - \varepsilon_k > 0/X) \\ &= P(\beta'_j - \beta'_k) X_i + \varepsilon_j - \varepsilon_k > 0/X) \\ &= P(\beta^* X_i + \varepsilon^* > 0/X) = F(\beta^* X_i) \end{aligned}$$

Where,  $P$  is probability function,  $U_{ij}$  and  $U_{ik}$  and  $X_i$  are as defined above,  $\varepsilon^* = \varepsilon_j - \varepsilon_k$  is random disturbance term,  $\beta^* = \beta'_j - \beta'_k$  is a vector of unknown parameters that can be interpreted as a net influence of the vector of explanatory variables influencing adaptation, and  $F(\beta^* X_i)$  is the cumulative distribution function of  $\varepsilon^*$  evaluated at  $\beta^* X_i$ . The exact distribution of  $F$  depends on the distribution of the random disturbance term,  $\varepsilon^*$ .

Depending on the assumed distribution that the random disturbance terms follows, several qualitative choice model such as linear probability, logit or probit model can be estimated.

The logit regression equation is used to determine the variables that influence the similar technology adoption by the farmers to cope with impact of climate change related to hazards on paddy production and their effectiveness.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \dots + \beta_n X_n + \mu_0 \dots \dots (3.4)$$

Where,

Y= Dependent variable

$\beta_0$ = Intercept term

$\beta_1 \dots \beta_n$ = Coefficient

$X_1 \dots X_n$ = Independent Variables

If farmers adopt multiple technology like tractor, thresher, pump set, irrigation etc. then there will be possibility of significant increase in the production of Paddy.

### 3.4 Variables and Its Definition

The variables used in this study can be classified into dependent and independent variables. Table 3.1 below depicts explanatory variables and how they are measured in the later part of this study.

Table 3.1: Dependent and Independent Variables

Variables	Description	Value	Expected sign
<b><i>Dependent variable</i></b>			
Technology adopted	Technology Adopted by farmers to cope with climate change like tractor, pampset etc.	1 = Yes, 0 = Otherwise	±
<b><i>Independent variables</i></b>			
<b>Socio-Demographic Characteristics</b>			
Age	Age of farm household head	Years	±
Sex	Gender of farm household head	1= Male, 0= Otherwise	±
Marital_status	Marital status of the respondent	1= Married, 0= Otherwise	+
HH_Size	Total family member at a household	Number	±
Farm_size	Size of land possessed by a farmer	In Kattha	±
Occupation	Occupation of the respondent's household	1 = Farmers, 0 = Otherwise	±
Farm_experience	Total experience in farming	Years	±
Land_fertility	Farmer 's perception about their own Land	1= Fertile, 0=Otherwise	±
Cultivated_areaa	Total land under cultivation	In Kattha	+
Irrigation_access	Whether the land has irrigation access	1 = Yes, 0 = Otherwise	±
Rainfall_change	Whether there are change in rainfall in last 15 years	1 = Yes, 0 = Otherwise	+
Change_in_production	Change in paddy production due to climate change	1 = Yes, 0 = Otherwise	±
Adjustment_benifit	Whether adjustments in Paddy beneficial or harmful	1 = beneficial, 0 = Otherwise	+

## Description of Variables

### **Dependent Variable**

#### **Technologies adopted by the Farmers**

In order to manage their farming practice, farmers have started to use various technologies, mostly environment friendly, to cope with impact of climate change related to hazards on paddy production and their effectiveness. Thus, use of such adopted technology such as tractor, thresher, pump set might affect production of paddy positively or negatively.

### **Independent Variables**

*Age:* The expected result of age is an empirical question. The study found that age negatively influence the decision to adopt new technologies. It may be that older farmers are more risk-averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting new technologies. In another case, this study found that age positively influence the decision to adopt. It could also be that older farmers have more experience in farming and are better able to assess the characteristics of modern technology than younger farmers, and hence a higher probability of adopting the practice.

*Sex:* Sex of the household head is hypothesized to influence the decision to adopt changes. The way gender influences adaptation is location-specific. A number of studies in Africa have shown that women have lesser access to critical resources (land, cash, and labor), which often undermines their ability to carry out labor-intensive agricultural innovations.

*Marital Status:* Marital status is considered one of the important factors determining climate change related adjustment by the farmers. It is hypothesized that married person has more adaptation interest and caution than unmarried one.

*Household Size:* The influence of household size on the decision to adapt is ambiguous. Household size as a proxy to labor availability may influence the adoption of a new technology positively as its availability reduces the labor constraints.

*Farm Size:* Adoption of an innovation will tend to take place earlier on large farms than on small farms.

*Occupation:* Occupation determines the knowledge that the people pose. In this study farmers are considered as the main respondents to support their adjustment. So, it is unsure whether occupation plays positive role or negative role to their technological adjustment.

*Farming Experience:* It increases the probability of uptake of all adaptation options because experienced farmers have better knowledge and information on changes in climate condition and crop management practices.

*Land Fertility:* Farmers having less fertile land are more likely to adopt any adaptation techniques that will help improve their productivity.

*Cultivated Area:* Another important aspect of technological acceptance is total area that farmers are cultivating. Farmers investment risk increases as per the cultivation land increases, so they may be more cautious. Therefore, it is positively influencing the acceptance of technology for better practices.

*Irrigation Access:* Irrigation is important aspects of paddy production, because paddy needs lots of water in land to grow. Studies shows that availability of irrigation facility means less hamper of climate change to the production compared to not having irrigation facility.

*Rainfall Changes:* Change in rainfall pattern may alter crop cycle. It could be positive for some crops while negative for other crops even at the same region. So, changes in rainfall enhance technological adaptation in context of paddy. So, we hypothesize such alteration in rainfall increase the adaptation practices. Due to lack of uniformity of rainfall there has been significantly drop in the production of paddy and it's trend can be reflected in the government record.

*Change in Production:* Change in production may bring two effects, first farmers may adopt technologies and continue the same crops; second, they may shift to other crops. Farmers adopts such technology only if they are remaining to the paddy farming. Therefore, in this study we hypothesize change in production could have both positive and negative effect of technological adaptation.

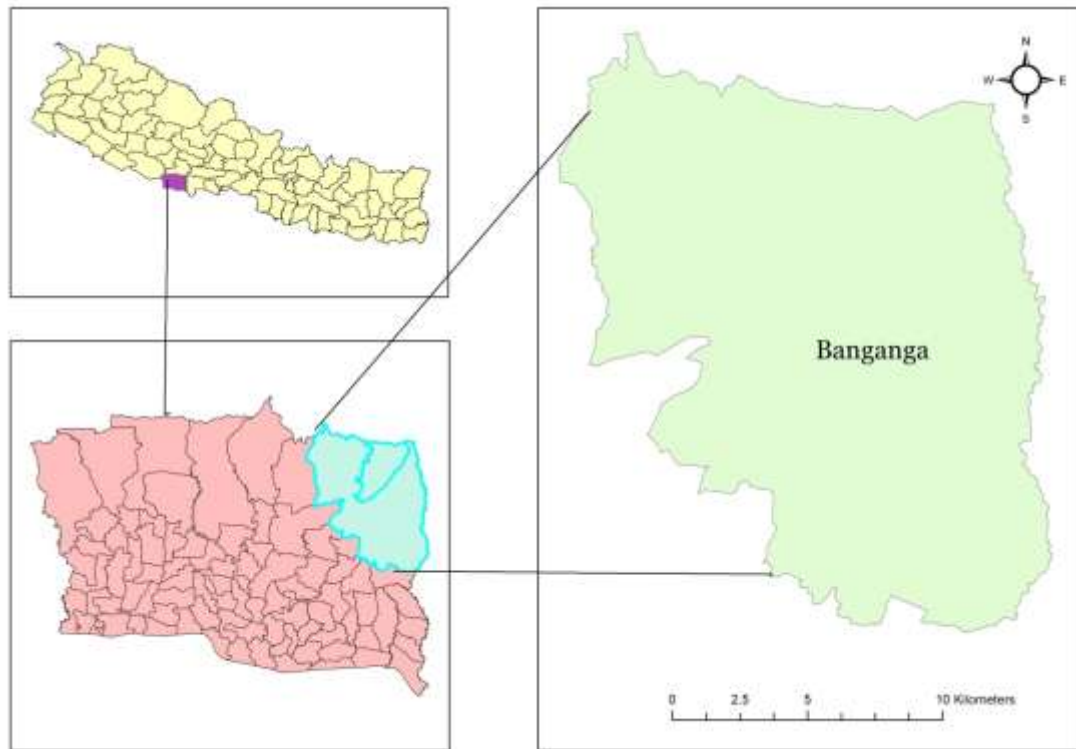
*Adjustment Benefit:* Another important aspect of farmers to adopt such technologies is adjustment benefit. Farmers only accept any new technology if it is beneficial for their

farm. Hence, technological adaptation can be hypothesize positive changes in our context.

### **3.5. Study Area and Population**

The area for this study is Banganga Municipality, Kapilvastu district of Nepal. It is located in Lumbini province of Nepal. As terai region of Nepal is considered as grain basket of the nation, Kapilvastu one of the crops growing area of terai region is chosen for the study. Kapilvastu district of Nepal was purposively selected for the study as the area was noted for high rice production potential. The total area of rice production in Kapilvastu was 70,560 ha with a total production of 1,54,230 t/ha (DADO, 2016). With realization of modernization in agriculture sector, Government of Nepal started Rice Zone program in Kapilvastu since the fiscal year of 2073/074. At present Super Zone covers 1 to 11 wards of Banganga, 1, 2, 3, and 4 wards of Buddhabhumi, 7, 8, 9, 10 and 11 wards of Kapilvastu Municipality, 1 to 6 wards of Suddhodhan Rural Municipality and 1 to 8 wards of Mayadevi Rural municipality. As Banganga municipality is fully covered by this program, we purpose this area for our study. It is because, the sample undertaken can be widely selected and it can be representative for other rice super zone program within the district and in Nepal. The study site is located at latitude of 27°25'-27°84'N and longitude of 82°75'-83°14' E. The mean annual precipitation, minimum and maximum temperature of the study site are 1285 mm, 6° C and 38° C respectively (Sapkota & Sapkota, 2019). Likewise, population for this study is all the paddy farmers of Kapilvastu district.

*Figure 3.2: Study Area*



### **3.6 Data**

This study used both logit time series and field-based data in order to complete the study. The time series analysis is based on data from 1981/1982 to 2019/2020 of Kapilvastu district. Total production, total land related data were gathered from Ministry of Agriculture and Livestock Department and Central Bureau of Statistics (CBS). Data concerning Hydrology, temperature and precipitation came from Ministry of Energy, Water Resources and Irrigation, Department of Hydrology and Meteorology, Babarmahal, Kathmandu, Nepal. As per Department of Hydrology and Meteorology, Kapilvastu district has 3 meteorological stations – Taulihawa, Pattharkot (West), and Bhagawanpur. Only Taulihawa provides climatology data available from 2070 AD while rest two stations only provide precipitation data. As this study needs both temperature and rainfall data, Taulihawa station is based for the required meteorological data. The data for cross sectional analysis is based on field survey which gathers data using sampling technique. The detail sampling methods and data collection process are given in next section.

### **3.7 Sampling Technique**

This study used two stage sampling technique. Area is selected purposively, because the government of Nepal has started Kapilvastu as rice zone program. From the Kapilvastu, Banganga Municipality is selected because it is the only municipality from which each ward has been selected for rice super zone. The details of the study area and its population are given in table 4. It shows that there are total 20,322 HH in Banganga municipality among which 18,290 HH belongs to rice farm HH. This study tried to list all paddy for HH for each ward of Banganga municipality, for that ward office is contacted but unable to make a sampling frame, thus we select the wards and samples of HH following previous researcher's techniques. Adhikari (2012) and Devkota et al. (2017) in their study applied technique that first they select one HH and collect the data from that HH and then left next 5 HH before taking second HH, to make their study representative when detail HH information is lacked. They adopted this technique to reduce respondent bias and coverage the study population. This study repeated same process with each ward to collected HH information.

### **3.8. Sample Size Determination**

The procedure of selecting the number of observations for a sample is known as sample size determination. An important component of any examination or examination in which the goal is to derive inferences about the population from a sample is the sample size. When all is said and done, the sample size used in an investigation is determined by the cost of data collection and the presence of sufficient factual evidence. The surveys were conducted during the month of March 2021. Field observation was used to verify or add new information. Structured questionnaires were used to collect the primary data from farmers/ households (HH) and the various other actors of the value chain. A total of 231 respondents were selected from 11 wards of Banganga Municipality, Kapilvastu district using purposive sampling technique (based on researcher's experience and knowledge). In this survey, paddy farmers account for 90% of all households<sup>1</sup>.

The following formula for the sample size n:

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<sup>1</sup> This 90% is based on Municipal Agricultural Division Officials

$$n = N * X / (X + N - 1),$$

Where,

$$X = Z_{\alpha/2}^2 * p * (1-p) / MOE^2,$$

MOE is the margin of error, p is the sample proportion, and N is the population size, and Z/2 is the critical value of the Normal distribution at /2 (e.g., for a confidence level of 95%, is 0.05 and the critical value is 1.96), MOE is the margin of error, p is the sample proportion, and N is the population size.

$$X = Z_{\alpha/2}^2 * p * (1-p) / MOE^2$$

$$X = 1.96^2 * 0.90 * 0.10 / 0.05^2$$

$$= 3.8416 * 0.90 * 0.10 / 0.0025$$

$$= 0.345744 / 0.0025$$

$$= 138.30$$

$$n = N * X / (X + N - 1),$$

$$n = 18290 * 138.30 / (138.30 + 18290 - 1)$$

$$= 2529507 / 18427.3$$

$$= 137.26$$

Population (N)	18290
Sample size /calculated HH (n)	138
Sample Size (Field Survey HH)	231

According to the formula, the sample size for a 95% confidence interval and a 5% margin of error with the known population would be 138 farm HH. The available sample size is further break as per ward level. This study use proportionate sampling technique and calculate the final HH required from each ward (see table 3.2). From each ward level we collect specific HH as sample suggested and finally total 138 HH has been selected for the study purpose.

Table 3.2: Study Area and Sampling

S.N.	Total Male	Total Female	Total Population	Total HH	Agricultural HH*	Total Sample Ratio Required	Total Sample Undertaken
1	3506	3339	6845	1405	1265	10	16
2	5833	5582	11415	2370	2133	16	27
3	3898	3601	7499	1417	1275	10	16
4	5842	5452	11294	2329	2096	16	27
5	3762	3558	7320	1406	1265	10	16
6	3217	3094	6311	1217	1095	8	13
7	4895	4556	9451	1902	1712	13	24
8	6226	5717	11943	2551	2296	17	28
9	4216	3977	8193	1690	1521	11	17
10	5018	4349	9367	1813	1632	12	22
11	6250	5037	11287	2222	2000	15	25
Total	52663	48262	100925	20322	18290	138	231

Source: Banganga Municipality Profile

(<https://bangangamun.gov.np/sites/bangangamun.gov.np/files/ward%20profile.jpg>)

\*95% as per Municipal Agriculture Department; \*\* Total sample at 5% level

### 3.9. Research Instrument and Data Analysis

The Primary data were collected from questionnaire survey. Also, secondary data were used to gather various information related to the study. The information was gathered through a standardized questionnaire. Farmers cultivating paddy was used to collect responses. KoBo toolbox is used to collect the response from the farmers. Initially, questions were also set in the KoBo toolbox and later interviewed with the farmers. Likewise, Descriptive, value chain analysis, and inferential approaches were all used in the data analysis. STATA software is used to code, add, and measure variables, while Excel is used for data entry and tabulation.

### 3.10 Research Matrix

Based on the title of the study, objective is assumed, methods is adopted and hypothesis is plan, the overall plan of the study is summarize in the given research matrix (Table 3.3).

*Table 3.3: Research Matrix*

Objectives	Data and source	Analytical tools/Models	Result
To assess the impacts of climate change on paddy production in Kapilvastu district.	Secondary and time series	Time Series analysis	Climate change play crucial role in paddy yield as higher rainfall higher will be production where as higher temperature lower will be the production.
To analyses the trend, pattern and Composition of the impacts of the climate change in Kapilvastu district.	Primary data and Questionnaire	Statistical Test	Paddy production is increased with the change in climate specially rainfall. However trend of increasing producing is decreasing years to years.
To analyses technologies adopted by farmers to cope with the impacts of Climate change and identify the determinants of technology adaptation.	Primary and Secondary data, Field visit	Descriptive analysis	Due to climate change situation, farmers started to choose alternative farm technique which result in increment in paddy production.

## **CHAPTER 4: DATA ANALYSIS AND PRESENTATION**

In this chapter data were analyzed as per its nature and structure. It employs a multifaceted approach to analyze both secondary and primary data for a comprehensive study. Secondary data undergoes Trend Analysis and time series regression model, estimating parameters such as production area, paddy production, paddy area vs. production, paddy yield per hectare, temperature pattern, and rainfall pattern. The inferential analysis encompasses a spectrum of statistical tests, including stationary tests, optimum lag length selection, AR characteristics polynomial examination, VAR residual serial correlation LM tests, and Granger causality tests. Similarly, primary data sourced from surveys is subjected to descriptive statistics, unraveling insights into socio-economic status, land ownership and utilization, and perception of climate change and adaptation methods. Econometrics estimation of field-based data involves a comprehensive suite of analyses, from summary statistics and correlation to regression and post-estimation tests, including the Collin test to address multi-collinearity concerns. Final logistic regression culminates the analysis, with results presented and discussed in accordance with the research objectives.

### **4.1 Trend Analysis of Effects of Climate Change**

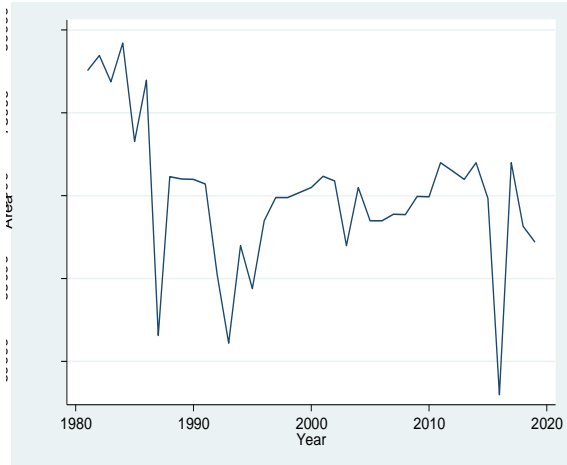
This study uses trend analysis method for inferential data analysis as its main aim is to find out effect of climate change on paddy production. Trend analysis is based on idea of what happened in the past and predicts the idea of what will happen in the future. Paddy production related variables such as land ownership and utilization, perception on climate change and adaptation strategy has been analyzed using time series and other statistical techniques.

Figure 4.1 shows that the land used as production area is in decreasing trend. Further from the year 2010-2020 the land used as production area seems to be decreased drastically. Similarly, figure 4.2 shows production of paddy which depicts that the production of paddy is fluctuating upward. However, the production seems to be drastically increased in the year 2017. Likewise, as revealed from the figure 4.3 the area of production and rate of paddy production seems to be in line with each other. When less land is used for production, less paddy is produced and vice-versa.

The study shows that paddy yield seems to be increasing year after year recently. As the temperature plays crucial role in paddy yield temperature pattern seems to be fluctuating. Maximum temperature seems to be more fluctuating than minimum temperature. Rainfall also seems to be fluctuating the rainfall seems to be drastically decreased in the year 2005 and further it seems to be decreased in the year 2020 as well. For the details figures are placed at the Annex.

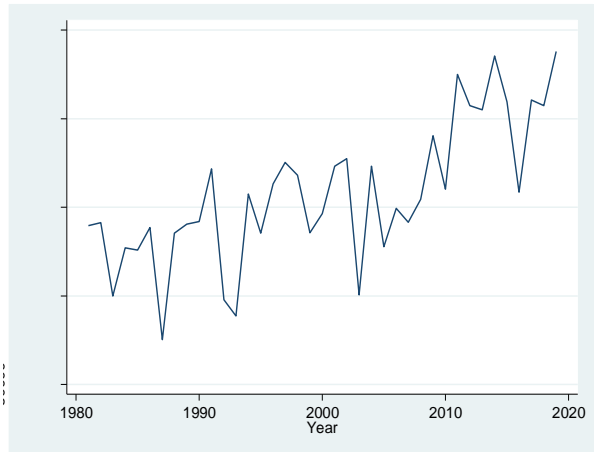
### Production Area

Figure 4.1: Production Area in Katha (1980-2020)



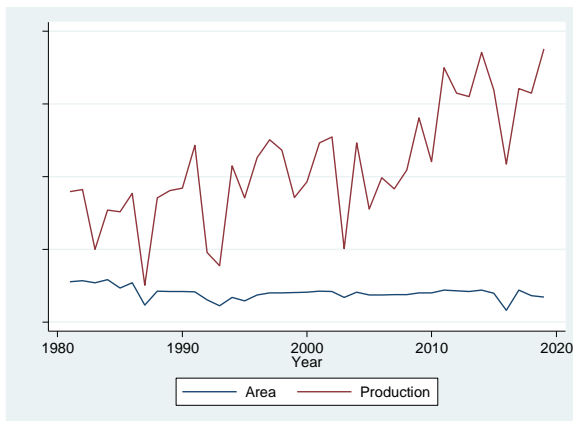
### Production of Paddy

Figure 4.2: Paddy Production in Kg (1980-2020)

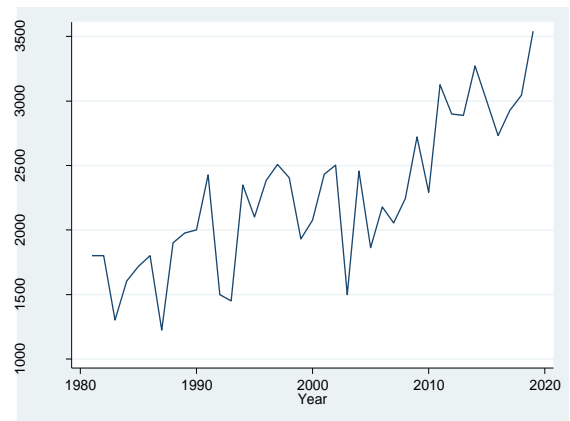


### Paddy Area vs Production

Figure 4.3: Paddy Production vs. Production Area (1980-2020)

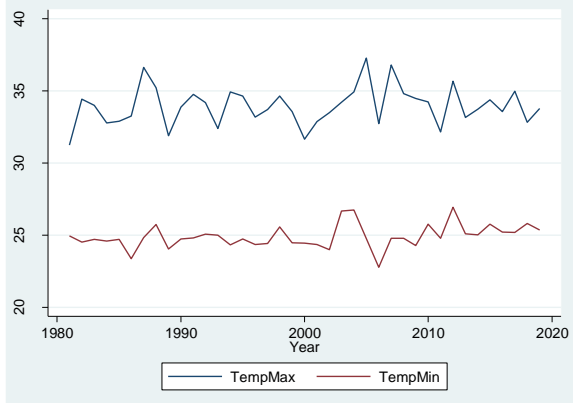


### Paddy Yield Per Hectare



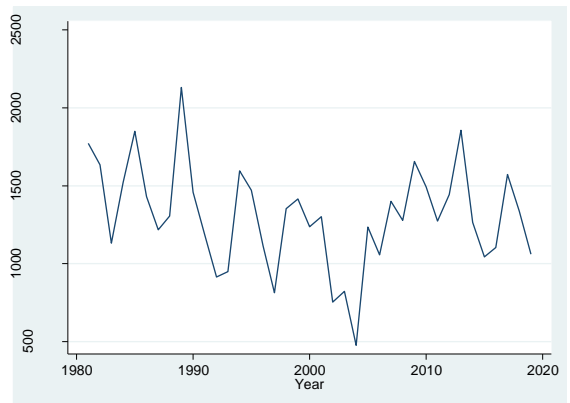
### Temperature Pattern

Figure 4.5: Temperature Pattern in °C (1980-2020)



### Rainfall Pattern

Figure 4.6: Rainfall Pattern (1980-2020)



## 4.2 Inferential Analysis

The inferential analysis covers summary statistics, stationary test, optimum lag length selection, Inverse roots of AR characteristics polynomial, VAR residual serial correlation LM tests, Granger causality test and son on which are further explained as;

### 4.2.1 Summary Statistics

This study examines effect on paddy production due to climate change for 39 years. Paddy production area, year, rainfall, minimum and maximum temperature were obtained and analyzed in this study. Table below provides summary of basic descriptive statistics of variables utilized in this study. The mean paddy yield and rainfall is 2254.576 kg/ha and 1305.974 mm respectively. The minimum temperature observed during the time is 22.78 degree Celsius whereas, the maximum is 37.2 degree Celsius. Likewise, the standard deviation for the rainfall is 330.77 whereas, for paddy yield is 569.57.

*Table 4.1: Summary Statistics*

Variable	Observation	Mean	Std. Dev.	Min	Max
Year	39	2000	11.40	1981	2018
Rainfall	39	1305.97	330.78	476.00	2130.70
Temp. Max	39	33.95	1.34	31.24	37.27
Temp. Min	39	24.91	0.82	22.78	26.93
Paddy Yield	39	2254.58	569.58	1222.48	3540.00
Area	39	70012.95	4380.50	58000.00	79220.00
Production	39	157684.40	39847.71	75280.00	237945.00

### 4.2.2 Stationary Test

Stationary test generally states that variable's value does not change with the time which means change in time does not serve as a factor to bring change in variable. This study tries to conduct stationary test for the variables such as temperature (minimum, maximum), Rainfall and paddy yield which are stated as below:

## Temperature Maximum

Stationary of the data must be checked for every variable taken in the study. Here, stationary of temperature maximum has been analyzed.

*Figure 4.7: Stationary at I(0)*

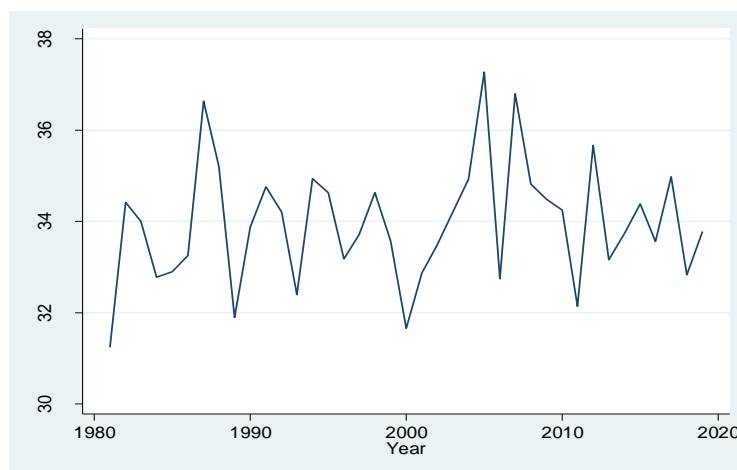


Figure 4.7 shows that the data of temperature maximum is stationary at I(0). Since, it has been observed that data is stationary at I(0) level, it is not required to check the stationary at other levels, respectively. Moreover, checking the stationary of data by line graph does not properly shows the stationary properly. Therefore, Dickey-Fuller test is carried out to ensure the stationary of data and to carryout the unit root test. Hereby, if the  $z(t)$  value is lesser than 0.05 then the data is considered as stationary or else data is not considered as stationary.

*Table 4.2: Dickey-Fuller Test for Unit root*

Test Statistics	1% Critical Value	5% Critical Value	10% Critical Value	No. of Obs. 38
Z(t)	-6.921	-3.662	-2.964	-2.614

MacKinnon approximate p-value for Z(t) = 0.0000

Table 4.2 shows that, p-value for Z(t) is 0.0000 which is less than 0.05. Therefore, the data is stationary at I(0) level. If the p-value is greater than 0.05 the data will not be stationary at I(0), then, stationary of the data should be checked at I(1) level.

## Temperature Minimum

Figure 4.8: Stationary at  $I(0)$

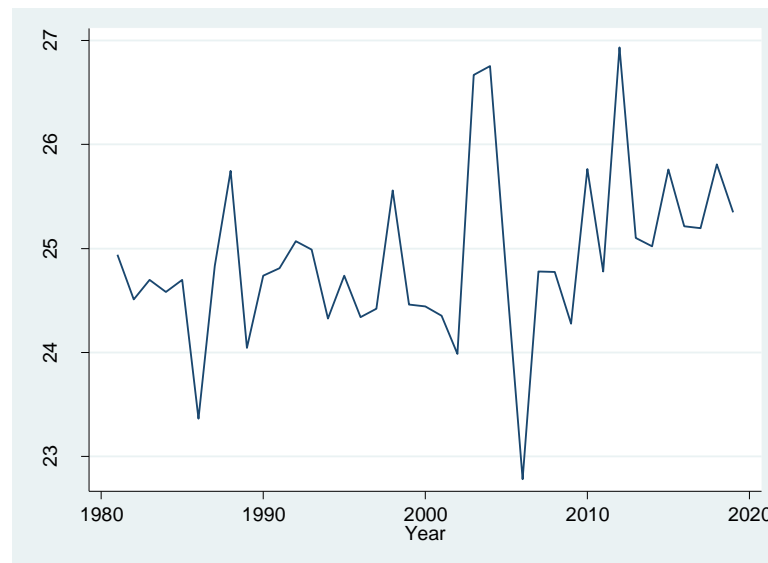


Figure 4.8 shows that data of temperature minimum is stationary at  $I(0)$  level by the line graphs. However, line graphs do not ensure stationary of dataset. Therefore, Dicky-Fuller test is required to validate the stationary of data. Since, Dicky-Fuller test shows that p-value is significant, as it lies below 0.05 which is shown in below dfuller test, respectively.

Table 4.3: Dickey-Fuller test for unit root (Interpolated Dickey – Fuller

Test Statistics	1% Critical Value	5% Critical Value	10% Critical Value	No. of Obs. 38
Z(t)	-5.207	-3.662	-2.964	-2.614

MacKinnon approximate p-value for  $Z(t) = 0.0000$

## Rainfall

In this section, data stationary has been analyzed by using both line graph and Dicky-Fuller test. The data of rainfall has also been seen stationary at level  $I(0)$  (see figure 4.9). However, line graph does not properly ensure the stationary of data therefore, Dicky-Fuller test is required to identify the unit root test.

Figure 4.9: Stationary at I(0)

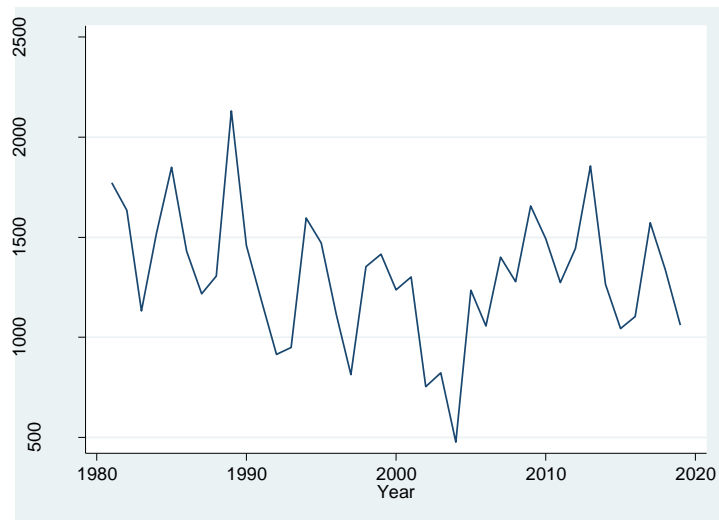


Table 4.4: Dickey-Fuller Rainfall

Test Statistics	1% Critical Value	5% Critical Value	10% Critical Value	No. of Obs. 38
Z(t)	-4.367	-3.662	-2.964	-2.614

MacKinnon approximate p-value for Z(t) = 0.0003

Here, Dicky-Fuller test shows that p-value is significant. As it lies below the threshold value i.e. 0.05. Therefore, the dataset is declared as stationary.

### Paddy Yield

Before carrying out a time series analysis, it is important to confirm that the entire dataset is stationary. The stationary of the data for paddy yield is displayed at the I(1) level (figure 4.11). However, figure 4.10 demonstrates that data are not stationary at the I(0) level, nevertheless.

Figure 4.10: Stationary at I(0)

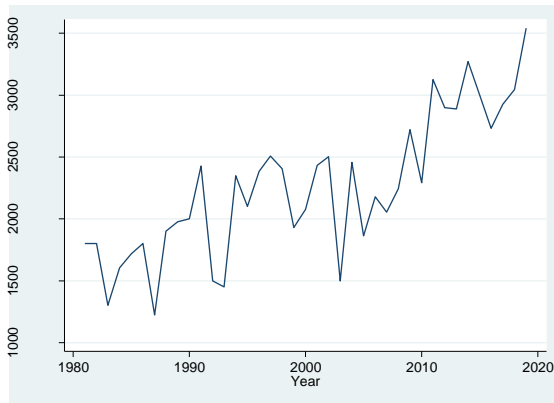
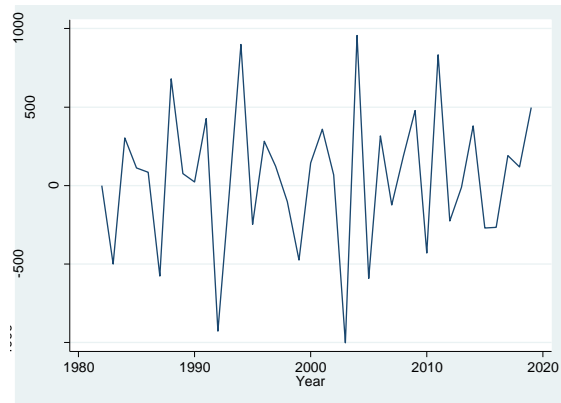


Figure 4.11: Stationary at I(1)



**Dickey Fuller Test in Stationary**

Table 4.5: Dickey Fuller Paddy Yield Test in Stationary

Test Statistics	1% Critical Value	5% Critical Value	10% Critical Value	No. of Obs. 38
Z(t)	-2.181	-3.662	-2.964	-2.614

MacKinnon approximate p-value for Z(t) = 0.2130.

**Dickey Fuller Test in First Difference**

Table 4.6: Dickey Fuller Test in First Difference

Test Statistics	1% Critical Value	5% Critical Value	10% Critical Value	No. of Obs. =37
Z(t)	-9.958	-3.668	-2.966	-2.616

MacKinnon approximate p-value for Z(t) = 0.0000

Here, in paddy yield, stationary of data is checked in I(0) level at first but the fuller test does not satisfy the condition for the significance. Therefore, Dicky Fuller test at first difference is conducted. The result indicates that unit root test at first difference is significance.

Since temperature minimum is stationary at I(0), temperature maximum is also stationary at I(0) and paddy yield is stationary at I(1), VAR model is chosen to determine optimal lag length.

**Optimum Lag Length Selection**

After examining the descriptive statistics and stationary, one of the most challenging tasks to apply the Vector Autoregressive Model (VAR) to determine the ideal optimal lag length, since it requires precision, as adding lags to time series models have a

direct effect on the estimate process. To find an optimum lag length, a VAR model in level variables is set up for sample case. The optimum lags were selected which makes the model well behaved. The lags that minimizes the Akaike information criterion (AIC) or as per democracy of criterion are used to analyzed the VAR stability condition, serial correlation, multivariate normality condition. Finding optimum lags was hence an iterative process and involve process that loops back and forth on lags selection and test on VAR stability condition, serial correlation, multivariate normality condition.

*Table 4.7: VAR Lag Order Selection Criteria*

VAR Lag Order Selection Criteria

Endogenous variables: YIELD RAIN MIN MAX

Exogenous variables: C

Date: 02/24/22 Time: 14:19

Sample: 1981 2019

Included observations: 36

Lag	LogL	LR	FPE	AIC	SC	HQ
0	136.4952	NA	7.47e-09	-7.360846	-7.184899*	-7.299436
1	159.4572	39.54560*	5.11e-09	-7.747622	-6.867889	-7.440571*
2	176.2775	25.23051	5.06e-09*	-7.793196*	-6.209677	-7.240505
3	186.7744	13.41272	7.54e-09	-7.487469	-5.200164	-6.689138

\* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

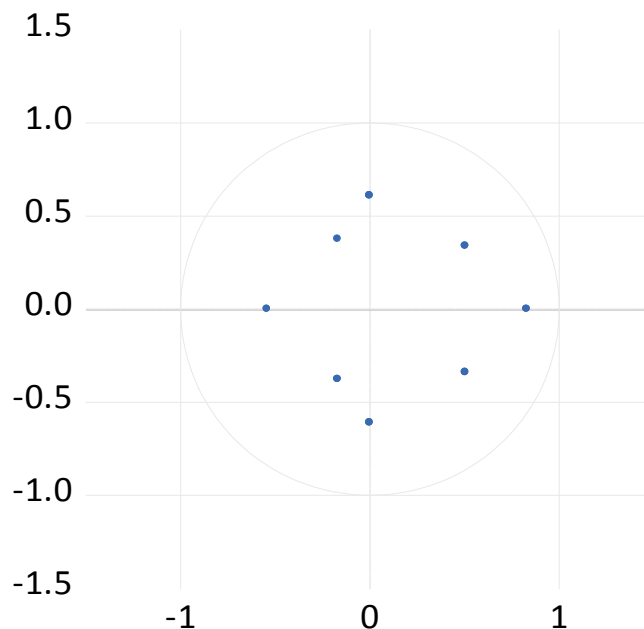
Table 4.7 shows the optimum lags as 2 as per AIC for our sample period, but all of the information criterions suggest different type of lags AIC and FPE suggest 2, and LR and HQ suggest 1 lag. However, SC suggests that 0 lags. However, while performing VAR stability, residual correlation LM tests and normality: for the sample period, model with 2 lags was well behaved. Hence, optimum lag would be considered as 2.

### Inverse Roots of AR Characteristic Polynomial

Inverse Roots of AR characteristic Polynomial reveals the dynamic stability of VAR model. For the dynamic stability of the VAR model, the values of the roots should be less than unity, modulus values should also be less than unity and graphically and inverse roots of the AR characteristic Polynomials. The Figure 4.12 shows that dynamically stable as the inverse roots of the AR Characteristic Polynomials reside within the Unit Circle.

Figure 4.12 : Inverse Roots of AR Characteristic Polynomial

### Inverse Roots of AR Characteristic Polynomial



Source: Author's calculation

### VAR Residual Serial Correlation LM Tests

VAR Residual Serial Correlation LM Tests reports the multivariate LM test statistics for residual serial correlation up to the specified order. The test statistic for lag order  $h$  is computed by running an auxiliary regression of the residual  $u_t$  on the original right-hand regressors and the lagged residual  $u_{t-h}$ , where the missing first  $h$  values of  $u_{t-h}$  are filled with zeros. Under the null hypothesis of no serial correlation of order  $h$ , the LM statistic is asymptotically distributed with  $\chi^2$  degree of freedom  $\kappa^2$ .

*Table 4.8. Autocorrelation lm test*

VAR Residual Serial Correlation LM Tests

Date: 02/24/22 Time: 14:20

Sample: 1981 2019

Included observations: 37

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Null hypothesis: No serial correlation at lag h

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Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	14.05875	16	0.5943	0.875969	(16, 64.8)	0.5981
2	16.15805	16	0.4420	1.022123	(16, 64.8)	0.4463
3	11.47747	16	0.7791	0.702021	(16, 64.8)	0.7816
4	8.960453	16	0.9150	0.538319	(16, 64.8)	0.9161
5	38.72816	16	0.0012	2.895632	(16, 64.8)	0.0013
6	15.53929	16	0.4856	0.978600	(16, 64.8)	0.4898

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Source: Author's calculation

Table-4.8 results reveal that there is consists of no auto correlation at all except 5<sup>th</sup> lags. This leads to conclusion that VAR residuals no auto correlation problem for sample period and broadly, no auto correlation problem suffers for the auto correlation as well. Therefore, the residuals are well behaved in terms of auto correlation.

## Var Set Up

Table 4.9: VAR set up

Vector Autoregression Estimates

Date: 02/24/22 Time: 14:17

Sample (adjusted): 1983 2019

Included observations: 37 after adjustments

Standard errors in ( ) & t-statistics in [ ]

	YIELD	RAIN	MIN	MAX
YIELD(-1)	0.455516 (0.15977) [ 2.85110]	0.300937 (0.21863) [ 1.37649]	0.028805 (0.02707) [ 1.06424]	0.048249 (0.03089) [ 1.56201]
YIELD(-2)	0.278994 (0.15574) [ 1.79145]	-0.624174 (0.21311) [-2.92888]	0.035126 (0.02638) [ 1.33137]	-0.040998 (0.03011) [-1.36160]
RAIN(-1)	0.241730 (0.11881) [ 2.03456]	0.374379 (0.16258) [ 2.30271]	-0.039730 (0.02013) [-1.97391]	-0.066797 (0.02297) [-2.90792]
RAIN(-2)	-0.158958 (0.13318) [-1.19354]	0.060011 (0.18225) [ 0.32929]	0.018871 (0.02256) [ 0.83640]	0.006295 (0.02575) [ 0.24446]
MIN(-1)	3.135899 (1.06279) [ 2.95063]	1.367826 (1.45432) [ 0.94053]	0.060217 (0.18005) [ 0.33445]	-0.350183 (0.20548) [-1.70424]
MIN(-2)	-1.884602 (1.17108) [-1.60929]	0.290279 (1.60250) [ 0.18114]	-0.252785 (0.19839) [-1.27418]	0.020767 (0.22641) [ 0.09172]
MAX(-1)	-1.798586 (0.96548)	0.988495 (1.32116)	-0.146787 (0.16356)	0.057842 (0.18666)

		[-1.86289]	[ 0.74820]	[-0.89745]	[ 0.30987]
MAX(-2)	1.806289	2.024457	-0.046802	-0.127414	
	(0.82350)	(1.12688)	(0.13951)	(0.15921)	
	[ 2.19342]	[ 1.79652]	[-0.33548]	[-0.80027]	
C	-2.576221	-9.454118	4.174433	5.205209	
	(6.43660)	(8.80783)	(1.09041)	(1.24444)	
	[-0.40025]	[-1.07338]	[ 3.82830]	[ 4.18279]	
R-squared	0.633110	0.393962	0.349931	0.333832	
Adj. R-squared	0.528284	0.220809	0.164196	0.143498	
Sum sq. resids	0.918827	1.720515	0.026370	0.034345	
S.E. equation	0.181150	0.247885	0.030688	0.035023	
F-statistic	6.039647	2.275217	1.884040	1.753931	
Log likelihood	15.86743	4.262715	81.55880	76.67019	
Akaike AIC	-0.371212	0.256069	-3.922097	-3.657848	
Schwarz SC	0.020633	0.647914	-3.530252	-3.266003	
Mean dependent	7.698919	7.123002	3.214976	3.525914	
S.D. dependent	0.263753	0.280820	0.033568	0.037843	
Determinant resid covariance (dof adj.)		1.90E-09			
Determinant resid covariance		6.23E-10			
Log likelihood		182.1287			
Akaike information criterion		-7.898848			
Schwarz criterion		-6.331469			
Number of coefficients		36			

## Granger Causality Test

*Table 4.10: Granger Causality test*

VAR Granger Causality/Block Exogeneity Wald Tests

Date: 02/24/22 Time: 14:21

Sample: 1981 2019

Included observations: 37

Dependent variable: YIELD

Excluded	Chi-sq	df	Prob.
RAIN	4.412979	2	0.1101
MIN	10.07490	2	0.0065
MAX	8.368370	2	0.0152
All	15.19359	6	0.0188

Dependent variable: RAIN

Excluded	Chi-sq	df	Prob.
YIELD	8.668424	2	0.0131
MIN	0.993181	2	0.6086
MAX	3.759410	2	0.1526
All	12.74169	6	0.0473

Dependent variable: MIN Rainfall

Excluded	Chi-sq	df	Prob.
YIELD	6.474095	2	0.0393
RAIN	3.923488	2	0.1406
MAX	0.911724	2	0.6339
All	12.98236	6	0.0433

Dependent variable: MAX Rainfall

Excluded	Chi-sq	df	Prob.
YIELD	2.793189	2	0.2474
RAIN	9.111705	2	0.0105
MIN	2.934062	2	0.2306
All	13.43999	6	0.0366

It was found that the maximum order of integration of variables are I(2). At the time to test the Granger causality, we set up same VAR as exogenous 4 variables yield,

rainfall, minimum and maximum temperature. Any one equation of a VAR system will always have one independent variable, its lags and three dependent variables. Table-4.10 shows the Granger causality tests are performed under 3 types of null hypothesis: all coefficient of 1st dependent variable joints do not Granger cause dependent variable; all coefficient of 2nd dependent variable joints do not Granger cause dependent variable; and 3rd dependent variable does not Granger cause dependent variable; and all the coefficients of both dependent variables do not Granger cause dependent.

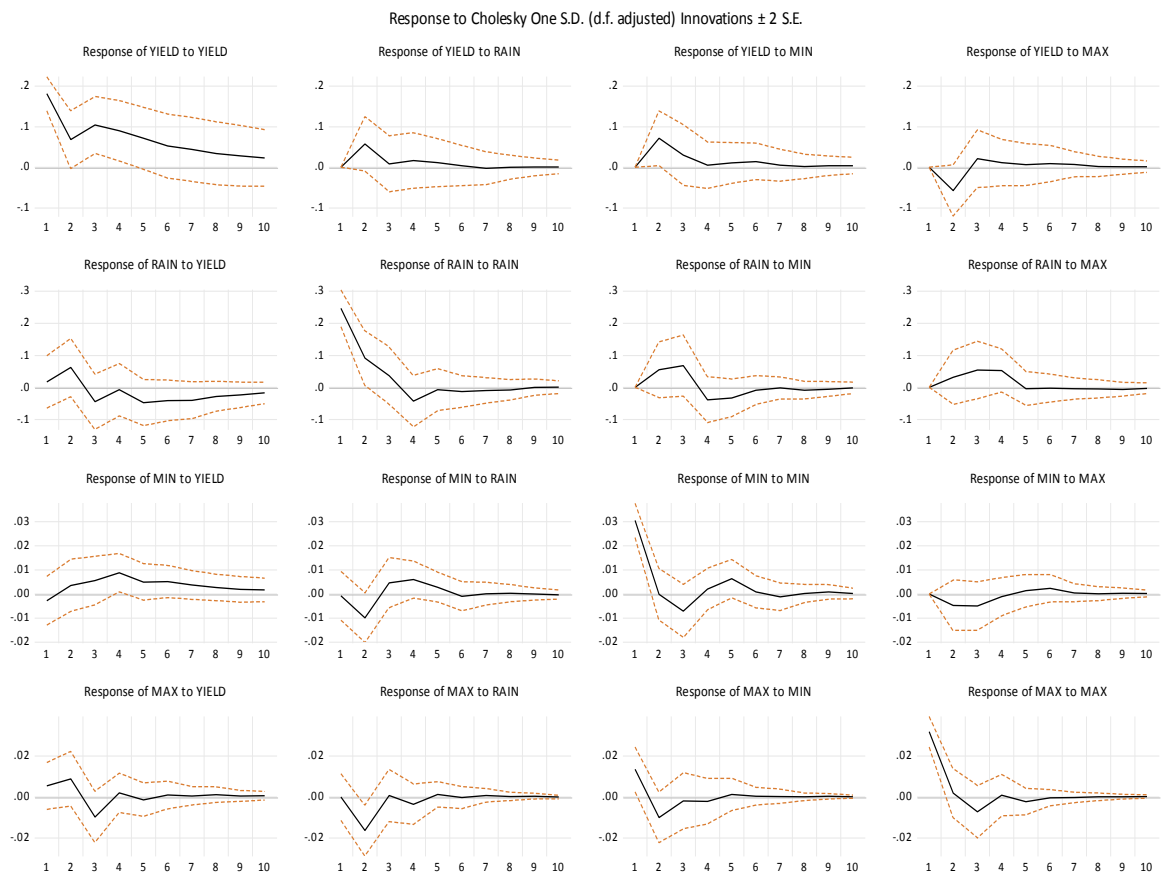
Table-4.10 results show that the rainfall, minimum and maximum temperature do Granger caused on yield i.e. null is rejected based on the chi-squared test of (4.41), (10.07), and (8.37), with  $df = 2$  and  $p$ -value (0.11), (0.01), and (0.02) respectively. Similarly, there is also the Granger caused by jointly tested. Furthermore, there is bidirectional Granger causality between the yield and rainfall, yield and minimum temperature. However, there is unidirectional Granger causality between yield and maximum temperature.

### **Impulse Response Function**

The impulse response analysis is estimated to examine how the effect of a shock in one variable transmits through the dynamic lag structure of the VAR model to other endogenous variables in the VAR model.

In Figure-4.13, the impulse response functions reveal that a one standard deviation positive impact in rainfall results into a positive impact in yield. Furthermore, the response of yield is positive for a very short period but is almost negative after the fifth time horizon after a 1 standard deviation shock from minimum temperature. This means that an increase in minimum temperature gradually reduces the yield. However, the response of yield is negative for a very short period but is positive and remain constant after the time horizon of 3<sup>rd</sup> period due to maximum temperature being exposed to a 1 standard deviation shock. This implies that the rise in maximum temperature would decrease the yield.

Figure 4.13. Impulse response function



## Variance Decomposition Error

Table 4.11. Variance decomposition error

Variance Decomposition of YIELD:					
Period	S.E.	YIELD	RAIN	MIN	MAX
1	0.181150	100.0000	0.000000	0.000000	0.000000
2	0.221722	76.20659	6.724936	10.39332	6.675152
3	0.247893	78.64394	5.501923	9.791447	6.062686
4	0.264535	80.62148	5.236875	8.634447	5.507196
5	0.274509	81.62248	5.039459	8.170166	5.167899
6	0.280021	81.94908	4.865061	8.116615	5.069241
7	0.283612	82.29916	4.749977	7.943129	5.007733
8	0.285679	82.54310	4.681497	7.834649	4.940751
9	0.287083	82.69365	4.636570	7.775317	4.894461
10	0.288041	82.78432	4.606467	7.745297	4.863920

Variance Decomposition of RAIN:					
Period	S.E.	YIELD	RAIN	MIN	MAX

1	0.247885	0.484917	99.51508	0.000000	0.000000
2	0.278859	5.405964	89.40696	3.912421	1.274658
3	0.297838	6.952864	79.88205	8.705158	4.459932
4	0.307967	6.554975	76.64399	9.680858	7.120179
5	0.313354	8.607123	74.07649	10.42793	6.888457
6	0.316336	10.09763	72.84026	10.29874	6.763365
7	0.319023	11.50742	71.70259	10.12805	6.661934
8	0.320477	12.15847	71.10932	10.11085	6.621357
9	0.321397	12.60129	70.70264	10.07872	6.617352
10	0.321856	12.84227	70.50183	10.05094	6.604965

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Variance Decomposition of MIN:

Period	S.E.	YIELD	RAIN	MIN	MAX
1	0.030688	0.832127	0.059213	99.10866	0.000000
2	0.032767	1.916468	9.114746	86.93311	2.035679
3	0.034643	4.267576	9.971056	81.90394	3.857423
4	0.036308	9.725448	11.78450	74.88274	3.607310
5	0.037321	10.98472	11.73407	73.73075	3.550461
6	0.037770	12.58051	11.52373	72.03751	3.858238
7	0.037972	13.40221	11.40181	71.36459	3.831388
8	0.038073	13.84666	11.35094	70.99044	3.811948
9	0.038132	14.05709	11.31603	70.81993	3.806950
10	0.038171	14.22331	11.29859	70.67535	3.802744

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Variance Decomposition of MAX:

Period	S.E.	YIELD	RAIN	MIN	MAX
1	0.035023	2.386949	0.000103	14.91254	82.70040
2	0.040884	6.469683	15.81403	16.82584	60.89045
3	0.042672	11.09246	14.54554	15.63321	58.72879
4	0.042926	11.18543	15.05081	15.68340	58.08036
5	0.043042	11.22336	15.05459	15.68199	58.04005
6	0.043058	11.26597	15.04888	15.67989	58.00526
7	0.043069	11.27645	15.07009	15.67633	57.97713
8	0.043085	11.33499	15.06342	15.66540	57.93619
9	0.043091	11.34869	15.06524	15.66712	57.91894
10	0.043096	11.36498	15.06198	15.66419	57.90885

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Cholesky Ordering: YIELD RAIN MIN MAX

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From an estimated VAR, we compute VDCs, which serve as tools for evaluating the dynamic interactions and strength of causal relations variables in the system. In stimulating VDCs, it should be noted that VAR innovation may be

contemporaneously correlated. It means that a shock in one variable may work through the contemporaneous correlation with innovations in other variables. The response of a variable to innovations in another variable of interest cannot be adequately represented since isolated shocks to individual variables cannot be identified due to contemporaneous correlation (Lutkepohl, 1991). Hence, we use Cholesky factorization which orthogonalizes the innovations as suggested by Sims (1980) to solve this identification problem. The strategy requires a pre-specified causal ordering of the variables. The results from VDC may be sensitive to the variables' ordering unless the error terms' contemporaneous correlations are low. The ordering of variables suggested by Sims (1980) starts with the most exogenous variable in the system and ends with the most endogenous variable.

The forecast error variance decomposition estimates the proportion of a shock to a given variable due to its own shock or shocks to other variables within the VAR model in a given forecasting time period. For the purpose of study this analysis, variance decompositions are used to measure fraction of each variable attributed shock to yield. Table-4.9 reports the results from the variance decomposition approach. For instance, 10<sup>th</sup> period, the results suggest that 82.78% of yield are explained by their innovation shocks, however, innovation shocks of rainfall, minimum and maximum temperature respectively contribute to yield by 4.61%, 7.75% and 4.86%.

### **4.3 Descriptive Analysis**

In order to characterize the features of the sample, investigate for assumption violations in the variable, and respond to particular research questions, descriptive statistics are used. Examples include percentages, graphs, charts, means, frequencies, proportions, and means (Mudombi, 2014). Descriptive analysis is made as follows for this study; gender of the respondents, household size, and family size and so on.

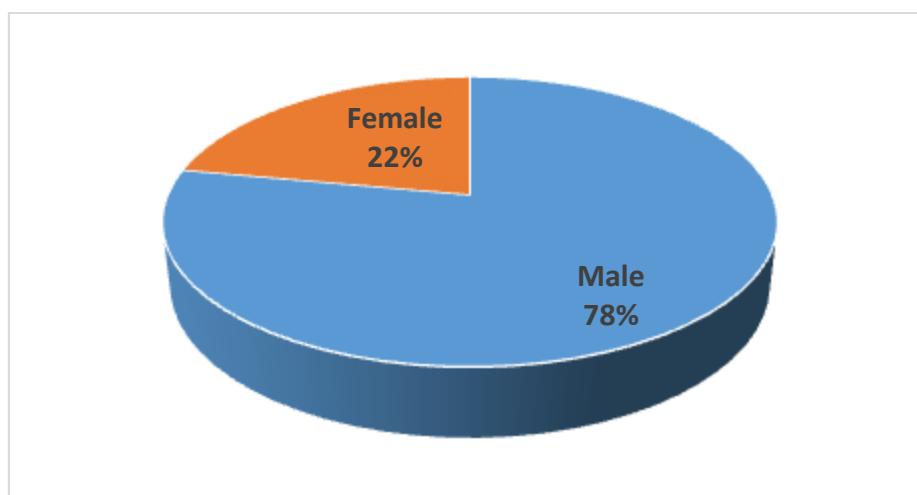
#### **Socio-Demographic Status**

Socio-Demographic status of the respondents as per this study can be analyzed as follows:

### *Sex*

The study was conducted among 231 paddy farmers in Kapilvastu, Nepal. Among total respondents sampled for the study it was displayed that 78% male are engaged in paddy production or farm activities whereas, only 22% female are engaged in paddy production. This shows that majority of male are involved in farm activities and paddy production in Kapilvastu district of Nepal. Further, among all the respondents 215 were also household heads and only 16 respondents were not household heads among which 73.59% were male household heads. This also shows that majority of household head in the study area are male.

*Figure 4.14: Gender of the Respondents*

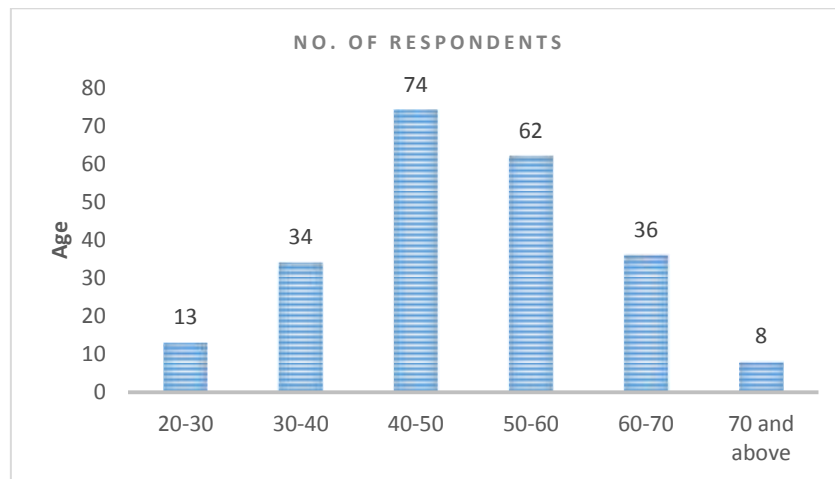


Source: Field Visit

### *Age*

The study revealed that majority (32.03%) of farmers who are involved in paddy production are in between age of 40-50. From the data it can be stated that generally middle-aged people are more engaged in farm activities in the study area. Likewise, only 3.46% farmers who are above 70 years are involved in paddy production activities and only 5.62% farmers who are involved in paddy production are of 20-30 years.

*Figure 4.15: Age*

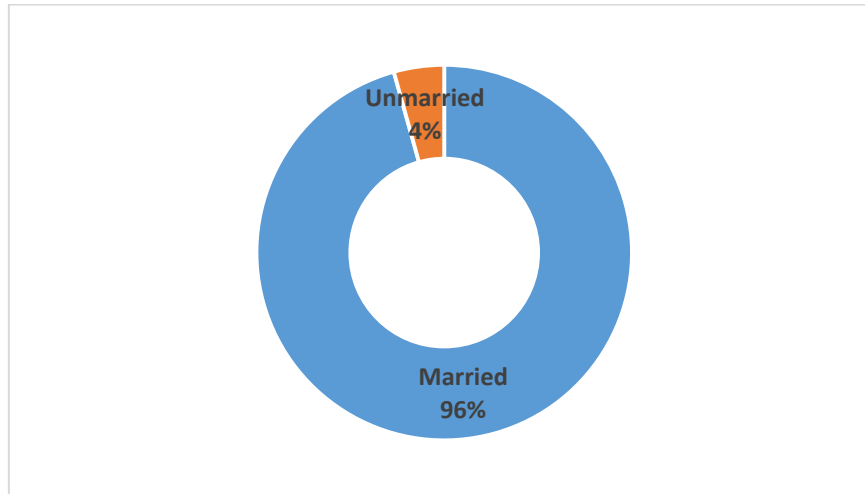


*Source: Field Visit*

### ***Marital Status***

The findings of the study depict that almost all i.e. 96% respondents who are married are involved in paddy production. This generalizes that married people are more inclined towards farming activities than unmarried.

*Figure 4.16: Marital Status*



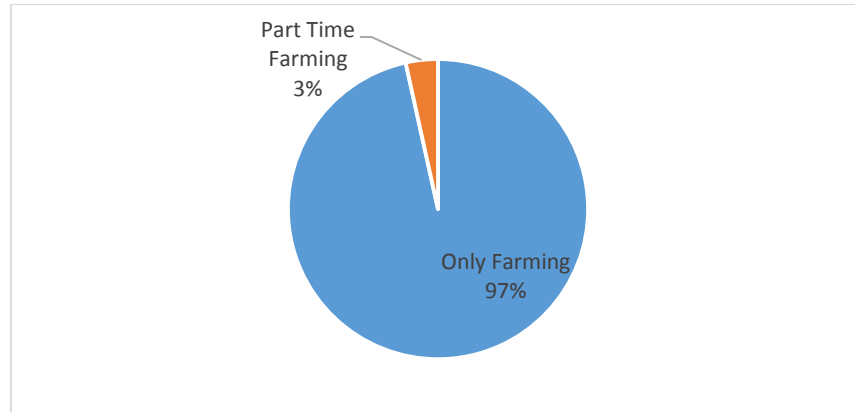
*Source: Field Visit*

### ***Major Occupation***

From the study it was analyzed that majority (97%) farmers who are involved in paddy production are sole farmers. They have embraced farming as their main occupation without being engaged in other sectors whereas only 3% farmers are involved in farming as part-time farmers. 3% farmers include businessman, teacher, pensioner, social servant who works in farm as well as embrace other occupation as

well. Thus, this study shows that in Kapilvastu district majority of people embrace farming as their main occupation.

*Figure 4.17: Occupation*

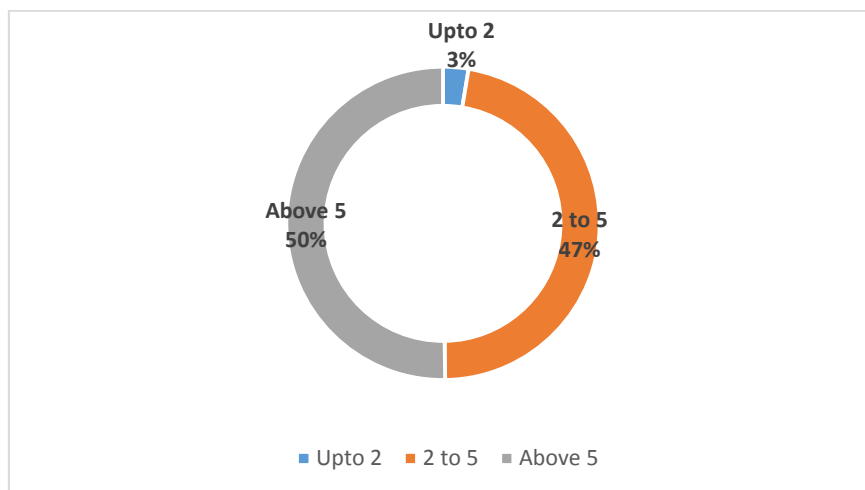


*Source: Field Visit*

### ***Family Members***

The study also analyzed number of family members in each household which showcased that majority of family i.e. 50% have more than 5 family members in their family whereas, only 3% family members have up to 2 family members in their family. This also reveals that in Kapilvastu district majority of family still lives in joint family.

*Figure 4.18: Family Members*

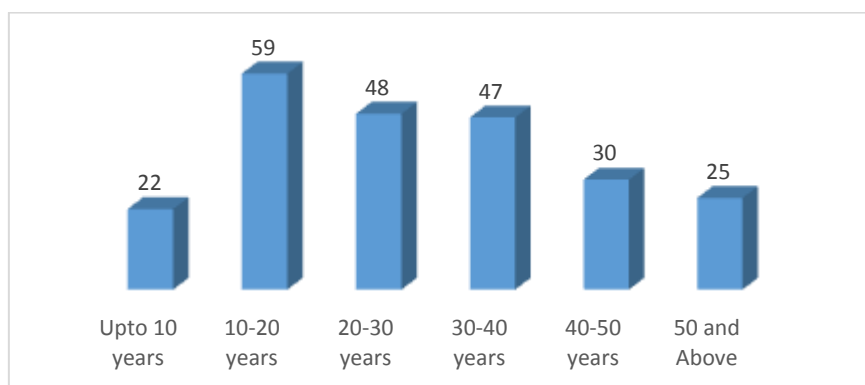


*Source: Field Visit*

### ***Farm Experience***

Majority of farmers have resided in the study area for more than 20 years. In the similar context the study depicted that 25.54% are engaged in farming since 10-20 years. Only 9.52% had farm experience up to 10 years. Similarly, 10.82% had experience up to farm experience above 50 years.

*Figure 4.19: Farm Experience*



*Source: Field Visit*

### **Land Ownership and Utilization**

#### ***Land Size***

Land size has been measured in Kattha for this study. The minimum area of land used by Chaitey farmers for paddy production is 2 Kattha and maximum was 50 Kattha. Likewise, the minimum area of land used by Barkhey paddy farmers for paddy production is 2 Kattha and maximum was 120 Kattha. According to both chaitey paddy farmers and barkhey paddy farmers all the land size they have is used for cultivation.

#### ***Access to Irrigation Facility***

Irrigation facility plays crucial role while cultivating any agricultural products. If agricultural products get proper access to irrigation facility then crops would grow properly. Similar case applies in paddy as well, proper irrigation facility leads to growth of paddy properly. This study tried to examine paddy cultivation of Chaitey paddy and Barkhey Paddy which revealed that 5% gets access for irrigation of chaitey paddy whereas, 95.67% gets access to irrigation facility for Barkhey paddy. It shows that farmers could get easy irrigation facility for Barkhe paddy it might be because barkhey paddy is cultivated in rainy season and we receive natural rain facility in

rainy season which makes easy for irrigation. Similarly, farmers (89.61%) also responded that they have 80-100% cultivable land under irrigation facility. However, only 0.43% farmers responded that their 20-40% cultivable land is under irrigation facility.

From those who responded they get proper irrigation facility among chaitey paddy farmer majority (58.33%) are accessing irrigation facility from canal, followed by tube well (25%) and Rain water (16.67%). Likewise, Barkhey Paddy farmers (71.94%) also stated that they access irrigation facility from canal, followed by rain water (23.98%) and tube-well (8%).

*Table 4.12: Access to Irrigation*

	<b>Chaitey Paddy</b>	<b>Barkhe Paddy</b>
<b>Yes</b>	12 (5.19%)	221 (95.67%)
<b>No</b>	1	4

#### ***Perception about Fertility Level of Land***

While asking about the fertility of their land 61.53% farmers who cultivate chaitey paddy thinks their land is fertile, 7.69% thinks their land is neutral and 30.76% thinks that their land is very fertile. On the same hand, 51.08% farmers who cultivate Barkhey paddy thinks their land is fertile, 44.15% thinks their land is very fertile and only 2.59% thinks their land is neutral.

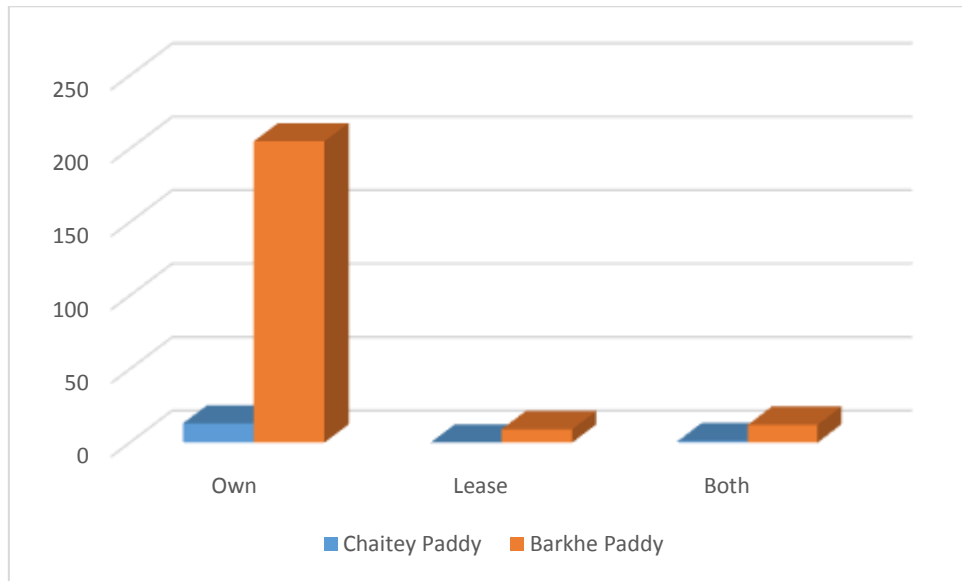
*Table 4.13: Perception on Fertility of Land*

	<b>Chaitey Paddy</b>	<b>Barkhe Paddy</b>
Fertile	8	118
Neutral	1	6
Very Fertile	4	102

#### ***Land Ownership Type***

The study unleashed that 92.85% of chaitey paddy farmers owns their own land and cultivate paddy in their own land and 7.14% uses both own and leased land for cultivation of paddy. Similarly, 90.70% barkhey paddy farmers owns their own land which is used for cultivation. 3.98% uses leased land for cultivating paddy and 5.30% uses both own and leased land for cultivating paddy.

Figure 4.20: Land Ownership Type



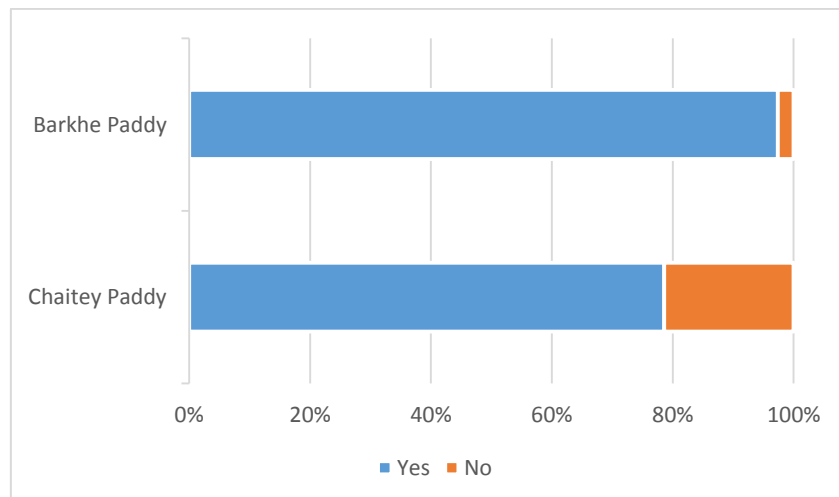
Source: Field Visit

### Perception of Climate Change and Adaptation Method

#### Perception on climate change variability and change

78.57% Chaitey paddy farmers stated that they have understanding regarding climate change variability and change. Likewise, 97.40% Barkhey paddy farmers stated that they have understanding regarding climate change variability and change. It shows that farmers do generally have idea regarding climate change.

Figure 4.21: Perception on Climate Change

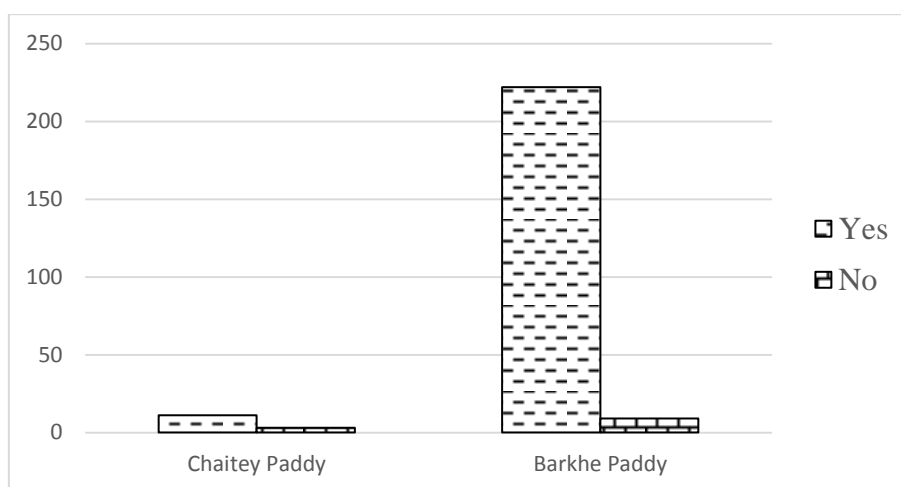


#### Perception regarding Change in Temperature

Recently issue of climatic change and change in temperature due to climatic change is matter of discussion around the globe. On the same context while asked with the

farmers regarding their perception on change in temperature majority, 78.57% stated that they feel temperature have changed since last 15 years according to Chaitey paddy farmers where 64.28% feels temperature has been increased and 14.28% feels it has been extremely hot. Similarly, 96.10% Barkhey paddy farmers perceive that they feel temperature has been changed since last 15 years where 91.34% thinks temperature have increased and has been hot in last 15 years and 4.76% thinks it has been extremely hot.

*Figure 4.22: Perception regarding Change in Temperature*



***Perception regarding Change in Rainfall Pattern***

78.57% Chaitey paddy farmers believes that they have witnessed change in rainfall pattern over last 15 years. Among Chaitey paddy farmers those who witnessed change in rainfall pattern 21.42% feels that they have witnessed change in frequency of flood and drought, change in timing of rain and increased rainfall respectively. On the other hand, among Barkhey paddy farmers' majority (45.88%) perceives change in timing of rainfall whereas, only 4.32% feels decrease in rainfall.

*Table 4.14: Changes in Rainfall Pattern*

Perception	Chaitey Paddy	Barkhey Paddy
Change in frequency of flood and drought	21.42%	17.31%
Change in timing of rain	21.42%	45.88%
Decrease in Rainfall	7.14%	4.32%
Increase in Rainfall	21.42%	28.13%

***Perception regarding Change in Paddy Production due to Climate Change***

According to 78.57% Chaitey paddy farmers and 95.23% Barkhey paddy, climate change have effected paddy production to certain extent. Also, 78.57% Chaitey

paddy farmers and 90.47% barkehy paddy farmers perceives increased production in paddy due to climate change. Only 3.03% barkhey paddy farmers thinks that paddy production have decreased and 1.73% don't know whether paddy production have been increased or decreased due to climate change. Likewise, 50% chaitey paddy farmers thinks that their production have been increased by 5-10% due to change in climate. Further, 52.38% barkhey paddy farmers thinks that their production have been increased by 5-10% due to change in climate. Only 1.73% barkhey paddy farmers thinks that climate change have decreased their paddy production by 5%.

*Table 4.15: Perception regarding change in production due to climate change*

Perception	Chaitey Paddy	Barkhey Paddy
Increased in Production	78.57%	90.47%
Decrease in Production	-	3.03%
Don't Know	-	1.73%

***Adaption Measures Taken in Rice Farming Practices in order to reduce the Effect of Climate Change***

Among all the respondents taken in the study, 78.57% chaitey paddy farmers agreed that they have taken different adaption measures in rice farming to reduce the effect of climate change and 93.07% Barkhey paddy agreed that they have taken different adaption measures in rice farming to reduce the effect of climate change. Some of the major adaption techniques used by farmers as to reduce the effect of climate change are listed in the table below;

*Table 4.16: Measures Adapted by No. of Household*

S.N.	Climate Change Adaptation	Chaitey Paddy	Barkhey Paddy
1	Change crop varieties	7	218
2	Build water harvesting scheme	7	9
3	Implement soil conservation scheme	7	9
4	Diversification of crop types and varieties	31	151
5	Diversification of livestock types and varieties	28	124
6	Changing planting dates	28	110
7	Changing size of land under cultivation	12	43
8	Irrigation	10	191
9	Reduce number of livestock	7	39
10	Diversify from farming to non-farming activities	14	77
11	Others	-	-

According to table 4.16 major adaption technique used by farmers to reduce effect of climate change is changing crop varieties (97.40%). Among them 94.37% Barkhe paddy farmers changed their crop variety and 3.03% chaitey paddy farmers changed their crop variety. Similarly, least i.e. 3.03% chaitey paddy farmers whereas 3.89% barkhey paddy farmers have adopted technique: building water harvesting scheme and implementing soil conservation scheme respectively.

### **Climate Change Adaptation and Diversification**

Among different climate change adaptation adopted by farmers.

*Table 4.17: Climate Change Adaptation and Diversification*

<b>S.N.</b>	<b>Climate Change Adaptation</b>	<b>Chaitey Paddy</b>	<b>Total Cost incurred (in NRs.)</b>	<b>Barkhey Paddy</b>	<b>Total Cost incurred (in NRs.)</b>
1	Change crop varieties		-		<b>7193000</b>
2	Build water harvesting scheme		<b>2500</b>		<b>58900</b>
3	Implement soil conservation scheme		<b>66000</b>		<b>18500</b>
4	Diversification of crop types and varieties		<b>500</b>		<b>79600</b>
5	Diversification of livestock types and varieties		<b>1000</b>		<b>224500</b>
6	Changing planting dates		<b>15000</b>		<b>292700</b>
7	Changing size of land under cultivation		-		<b>24700</b>
8	Irrigation		<b>101500</b>		<b>546350</b>
9	Reduce number of livestock		-		<b>58000</b>
10	Diversify from farming to non-farming activities		-		<b>84000</b>
11	Others		-		<b>12800</b>

According to 50% chaitey paddy farmers such adjustments in adaptation strategies is harmful whereas, 28.75% thinks it is beneficial. As per the point of view of Chaitey paddy farmers such adjustments are beneficial in terms that farmers produced mustard oil seed, banana spices and so on, community irrigation is also benefitting farmers in many terms. Also they think if government could provide quality seeds, pesticides then that would promote production in case of chaitey paddy. However, 87% Barkhey paddy farmers such adjustments are beneficial for farmers but 6.06% thinks it is harmful for them. Barkhey paddy farmers thinks it is beneficial because better quality

seeds can be accessed, additional income can be earned, adjustment increase in level of farmers' quality of life, adjustment in barkhey paddy increases opportunity cost. It is economically benefitted, production can be increased and so on. Further, it is regarded harmful by some fathers because of untimely rainfall, leaving animals haphazardly is harmful as it creates great loss of paddy and so on.

Also, the study showed that large number of money is incurred during changing crop varieties of Barkhey paddy. Further, total 8,593,050 NRs. is incurred during the climate change adaptation and diversification of Barkhey paddy. Similarly, looking towards the cost incurred in chaitey paddy total of 1,01,500 NRs seems to be incurred in irrigation. However, it is seen that huge number of cost is incurred in barkhey paddy. In average 807.35 NRs. is expensed by each farmer for Chaitey paddy whereas, 37199.35 NRs. is expensed by each farmer for Barkhey paddy. Thus, it can be assumed that NRs. 8,694,550 is expensed by farmers as adaptation and diversification measure to tackle climate change.

#### **4.4 Econometrics Estimation of Field Based Data**

Econometrics estimation based on the data collected for this study includes summary statistics, correlation among the variables, regression and the post estimation test and Collin test was also performed in order to encounter problem of multi-collinearity. Inferential statistics use a random sample of data taken from a population for describing and making inferences about the population and valuable when the examination of entire population is not valuable or convenient (Devkota & Phuyal, 2017).

Summary statistics provide a description of the data in order to communicate the information in the simplest way possible. The study variables are analyzed based on their observation, mean, minimum and maximum value, and standard deviation, which are presented in a table to provide information about the data collected. Variables except age, household size, farm size, farm experience, cultivated area were represented in dummy variables 0 and 1 for the purposes of the study. Remaining variables have been presented as open-ended values.

*Table 4.18: Econometrics Estimation*

Variable	Obs	Mean	Std. Dev.	Min	Max
Technology	231	.9307359	.254454	0	1
Age	231	49.93939	11.509	21	82
Sex	231	.7792208	.4156726	0	1
Marital Status	231	.95671	.2039512	0	1
Household size	231	5.930435	3.053302	2	40
Farm size	231	16.43723	15.64731	2	120
Occupation	231	.974026	.1594032	0	1
Farm Experience	231	23.55411	11.5858	2	60
Land Fertility	231	.952381	.2134213	0	1
Cultivated Area	231	16.51948	16.15195	2	120
Irrigation	231	.95671	.2039512	0	1
Rainfall	231	.961039	.1939223	0	1
Change in Production	231	.952381	.2134213	0	1
Adjustment	231	.8701299	.3368905	0	1

The study has been conducted among 231 paddy farmers'. The above table illustrates that 14 variables has been used in the study. It presents the analysis of one dependent and 13 independent variables. Under socio-demographic characteristics age has the highest mean and standard deviation i.e. 49.93 & 11.509 respectively. Likewise, the table portrays mean, standard deviation, minimum value, maximum value of all the variables used in the study.

### **Pre-estimation test**

Under this estimation we perform specification error, goodness of fit and other diagnostic test. Specification error is done to find out whether the variable or assumptions of statistical model is correct or not. Similarly, goodness of fit is a statistical hypothesis test that determines how well sample data fits a normal distribution from a population. In Specification Error, we came to know that hat value is statistically significant and hat.sq. value is not statistically significant. As hat. value

is 0.000 and hat. sq. value is 0.143 we can conclude that we have chosen meaningful predictors and the variables chosen are correct. When performed goodness of fit, the result obtained for model is Prob > chi2 = 0.1334. In order to be goodness of fit, p-value should be greater than 5% i.e. 0.05 and so we can say that there is goodness of fit in our model. We also performed other diagnostics tests to understand model fit. We look towards count  $R^2$  in this diagnostic and the more it is, more its better. The count  $R^2$  for model is 0.448. So, it can be considered good.

*Table 4.19: Pre-estimation Test*

Iteration 0: log likelihood = -58.077954  
 Iteration 1: log likelihood = -49.134126  
 Iteration 2: log likelihood = -44.639219  
 Iteration 3: log likelihood = -32.981403  
 Iteration 4: log likelihood = -32.04304  
 Iteration 5: log likelihood = -32.035231  
 Iteration 6: log likelihood = -32.035223  
 Iteration 7: log likelihood = -32.035223

Logistic regression	Number of obs =	230
	LR chi2(2) =	52.09
	Prob > chi2 =	0.0000
Log likelihood = -32.035223	Pseudo R2 =	0.4484

Technology Adopted	Coef.	Std. Err.	Z	P> z	95% conf.
Hat	1.435812	.3989199	3.60	0.000	.6539438
Hat Sq	-.0999766	.0683393	-1.46	0.143	-.233919
Constant	-.1315941	.5145305	-0.26	0.798	-1.140055

Logistic model for Technology \_ Adopted, goodness-of-fit test

number of observations = 230  
 number of covariate patterns = 229  
 Pearson chi2(215) = 238.14  
 Prob > chi2 = 0.1334

#### Measures of Fit for logit of Technology \_ Adopted

Log-Lik Intercept Only:	-58.078	Log-Lik Full Model:	-32.756
D(216):	65.512	LR(13):	50.644
		Prob > LR:	0.000
McFadden's R2:	0.436	McFadden's Adj R2:	0.195
Maximum Likelihood R2:	0.198	Cragg & Uhler's R2:	0.498
McKelvey and Zavoina's R2:	0.513	Efron's R2:	0.439
Variance of y*:	6.757	Variance of error:	3.290
Count R2:	0.965	Adj Count R2:	0.500
AIC:	0.407	AIC*n:	93.512
BIC:	-1109.113	BIC':	20.051

#### Post-estimation test

Studies argued that cross-sectional data analysis involves two problems: The Cross-sectional data analysis, has two problems: heteroscedasticity in the error term and multicollinearity among explanatory variables. To cope with the problem of multicollinearity, the Variance inflation factor (VIF) Test was used. The VIF calculates how much multicollinearity in the model has inflated the variance of a regression coefficient. According to Williams (2016) a VIF score of less than 10 indicates that multicollinearity is not present. According to the results, the mean VIF is 2.86, indicating that the data set used for this analysis is free of multicollinearity. When the sizes of the observations differ significantly, heteroscedasticity occurs. The variability of one variable is not equal over the range of another variable that is expected, which is known as heteroscedasticity. Because the findings of the regression analysis will be wrecked if the heteroscedasticity is not identified, it is critical to do so. Outliers in the data set are indicated by the presence of heteroscedasticity in variables (Alih & Ong, 2015). We use a heteroscedasticity test to better understand our data collection. The outcome is displayed in a table. In the case of the hettest, the outcome for model is  $\text{prob} > \text{Chi}^2 = 0.0000$ , indicating the presence of heteroscedasticity. As a result, in our final regression analysis, we use a robust standard error test to solve the problem of heteroscedasticity in our dataset.

Table 4.20: Post-estimation Test

Variable	VIF	1/VIF
Firm Size	11.90	0.084043
Cultivated Area	11.82	0.84630
Age	1.45	0.691446
Change in Production	1.38	0.724709
Rainfall	1.38	0.727228
Farm Experience	1.28	0.782500
Maital Status	1.19	0.840170
Household Sz	1.18	0.846700
Land Fertility	1.16	0.861323
Sex	1.13	0.884626
Irrigation	1.12	0.892950
Adjustment	1.11	0.901904
Occupation	1.05	0.950191
Mean VIF	2.86	

#### Heteroskedasticity Test

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of Technology\_Adopted

chi2(1) = 130.18

Prob > chi2 = 0.0000

#### Final Result

The robustness tests have arisen in statistics as a response to the uncertainty that social scientists experience while defining empirical models. Robust standard error is a strategy for achieving unbiased OLS standard errors under heteroscedasticity, or it may be thought of as the actions carried out when executing tasks and solutions.

*Table 4.21: Final Regression Result*

Iteration 0: log pseudolikelihood = -58.077954  
 Iteration 1: log pseudolikelihood = -56.847951  
 Iteration 2: log pseudolikelihood = -42.963091  
 Iteration 3: log pseudolikelihood = -38.497935  
 Iteration 4: log pseudolikelihood = -33.452751  
 Iteration 5: log pseudolikelihood = -32.773434  
 Iteration 6: log pseudolikelihood = -32.756049  
 Iteration 7: log pseudolikelihood = -32.755969  
 Iteration 8: log pseudolikelihood = -32.755969

Logistic regression	Number of obs = 230
	Wald chi2(13) = 41.42
	Prob > chi2 = 0.0001
Log pseudolikelihood = -32.755969	Pseudo R2 = 0.4360

Techology	Robust				
Adopted	Coef.	Std. Err.	Z	P> z	95% Conf. Interval
Age	-.0119563	.0271577	-0.44	0.660	-.0651844 - .0412718
Sex	1.514583	.7082486	2.14	0.032	.126441 - 2.902725
Marital Status	2.276479	.7399538	3.08	0.002	.826196 - 3.726762
Household size	.1870006	.26837	0.70	0.486	-.3389949 - .712996
Farm size	.0360852	.0390515	0.92	0.355	-.0404543 - .1126246
Occupation	-.8140836	.7701858	-1.06	0.291	-2.32362 - .6954528
Farm Experience	-.0350975	.0273402	-1.28	0.199	-.0886834 - .0184884
Land Fertility	.6106465	.6852628	0.89	0.373	-.7324439 - 1.953737
Cultivated Area	-.0201456	.0186306	-1.08	0.280	-.056661 - .0163697
Irrigation Access	.5665731	.8521562	0.66	0.506	-1.103622 - 2.236769
Rainfall	-.2893024	.8247723	-0.35	0.726	-1.905826 - 1.327222
Change in Prod.	2.122419	.769882	2.76	0.006	.6134778 - 3.63136
Adjustment	3.546176	.7003824	5.06	0.000	2.173451 - 4.9189
Constant	-4.418071	2.083222	-2.12	0.034	-8.501111 - .3350314



the change in the likelihood of outcomes. In above table there are four significant variables namely, sex, marital status, change in production and adjustment beneficial having p-value less than 5%. This study finds when change in production is increased by 1 %, then the odds of being increment in technology adopted increases by a factor of 8.35 %. Similarly, if there is increase in adjustment beneficial of farmers, the odds of managing technology adopted increase by 34.68 %. Again, increase in married or unmarried respondents, the odds of managing the informal sector increases by 9.74 %. Lastly, it was found that if male farmers increase for paddy production then the odds of managing the technology adopted by farmers' increases by 4.547 %.

#### **4.5 Discussion**

The area of Kapilvastu district, Lumbini province, Nepal is second most important district for paddy production in Nepal. Purposive sampling Technique method is used to describe the impact of climate change in paddy production of Kapilvastu district. This study used both primary data as calculated by researcher in field visit and secondary data from Department of Hydrology and Metrology and CBS from 1980/81 – 2019/20 of Kapilvastu district. Sample size population for the study is 138 household however primary data collected from 231 household from questionnaire. And secondary data were used to under descriptive method. This study analyses the impact of climate change in paddy production for about 40 years. Age, sex, household size, farm size, land fertility, cultivated area, irrigation facilities, rainfall, seeds quality technology adaptation were used to analyze the study.

About 78% male and 22% female are engaged in paddy production considering major occupation. Almost about the age between 40-50 years were found involving in paddy production. It was found that about 97% farmers who are involved in the production of paddy are sole farmers. And about 5% get access for irrigation rests are based on monsoon. Farmers were facing the problems like shortage of quality seed, fertilizer not in time and under necessary quantity, lack of water in canals at the time of Chaite paddy production and over water at the time of Barkhe paddy production etc. however, the paddy production is increasing through numbers of farmers and land used seems decreasing. The household which have larger family members or joint family are found majority involving in paddy production. Most of the farmers are using traditional pattern of farming. Still most of the farmers are not practicing

commercial farming however cultivating in small own small area. Almost all farmers are not cultivating chaite paddy due to problems of irrigation but mostly produced Barkhe paddy depending on monsoon. Recently all farmers feel temperatures is changing years to years it has been extremely hot. Sometime heavy rainfall destroyed paddy and sometime extremely hot dried the plants. The technologies adaptation used by farmers as to reduce the effects of climate change by changing crop varies. Multiple crop farming used by 218 household and used modern methods to raised production and productivity. Some farmer's changes planting time with climate change. Farmers in group maintain irrigation facilities by controlling work publicly and standing as watch dog to protect paddy from publicly leaving wild cows.

The result shows a significant positive relationship of rainfall to the paddy production in the Kapilvastu district. Since the contribution of paddy production is large to GDP and in term of farmers engaged. Nepal's economic growth primarily depends upon the average rainfall as Kapilvastu district witness more rainfall, possibility of higher economic growth in the district. Paddy products are found based on quality of seeds, fertility of land, access of irrigation facility etc. As agricultural production is to increase irrigation facilities must provide to cultivated land of Kapilvastu district.

Thus paddy production of Kapilvastu district is based on monsoon. If there is drought, it has not only creates problems in paddy production however effect climate one side other side farmer cannot cope the problems due to lack of electricity. So, to increase paddy production in the district, local seeds, irrigation facilities, fertilizers must provide to farmer in on time.

The impact of climate change in paddy production of Kapilvastu district varies from place to place and time to time. The impact of climate change may be positive or negative, farmers can be cope with technological adaptation. Since the climate change is a global issue, farmers must emphasize on adaptation measure rather than mitigation. The farmers must minimize cost bearing climate change to keep paddy production higher.

## CHAPTER 5: SUMMARY & CONCLUSION

This study conducts a comprehensive examination of climate change's impact on paddy production in Kapilvastu District, Nepal. It investigates socio-economic aspects, land ownership, and climate perceptions over 39 years, using secondary and primary data. Despite a reduction in production area, paddy yield rises, influenced by variable temperature and rainfall. Farmers acknowledge climate change effects, adopting alternative farming. Barkhey paddy exhibits resilience compared to Chaitey. The study underscores the importance of tailored solutions, advanced methods, and improved irrigation. Farmers aged 40-50 need targeted support. Recommendations include heightened awareness, soil testing, and addressing specific challenges faced by Chaitey paddy farmers.

### 5.1 Summary

Agriculture is the most important part of the Nepalese economy. As a result, the development of the agricultural sector is critical for the growth of the national economy. Paddy is also one of the most grown agricultural crops of Nepal. However, agriculture is directly dependent on weather condition (Le, 2016). Thus, climate change is creating various negative effects on paddy production as well as other agricultural activities. Thus, Malla (2008) already warned that it was already high time for Nepalese agriculture sector to start adapting to climate change issues and find the way for its mitigation.

The objective of the study was to analyze the impacts of climate change on paddy production whereas, some of the specific objectives are: To measure the effect of climate change on paddy production in Kapilvastu district, to analyze the trend, pattern and composition of effect of climate change, analyze technologies adopted by the farmers to cope with the effect of climate change related to hazards on paddy production and their effectiveness. In order to carry our study forward various literatures were reviewed that provides background as well as validation for the study. Further, detail review on agriculture products, paddy production, climate change and effect of climate change on paddy production were made. Also, the research gap due to which this study was thought to be carried forward was portrayed.

The area for this study is Kapilvastu district of Nepal. It is located in Lumbini province of Nepal. As terai region of Nepal is considered as grain basket of the

nation, Kapilvastu one of the crop growing area of terai region is chosen for the study. Purposive sampling technique is used in the study. This study used both time series and field-based data in order to complete the study. The time series analysis is based on data from 1981/1982 to 2019/2020 of Kapilvastu district. Likewise, population for this study is all the paddy farmers of Kapilvastu district. The Primary data were collected using a questionnaire survey. Also, secondary data were used to gather various information related to the study. The information was gathered through a standardized questionnaire. Both descriptive and inferential statistics is used for the analysis of the study.

This study examines effect on paddy production due to climate change using agro meteorological data for 39 years. Paddy production area, year, rainfall, minimum and maximum temperature were obtained and analyzed in this study. The study shows that 78% male are engaged in paddy production and 32.03% of all those paddy farmers who are engaged in paddy production are in between age of 40-50. Likewise, 96% are married. 97% paddy farmer's claims that they are only engaged in farming considering it as their main occupation. Majority of farmers have resided in the study area for more than 20 years. In the similar context the study depicted that 25.54% are engaged in farming since 10-20 years. Irrigation facility plays crucial role while cultivating any agricultural products. This study tried to examine paddy cultivation of Chaitey paddy and Barkhey Paddy which revealed that 5% gets access for irrigation of Chaitey paddy whereas, 95.67% gets access to irrigation facility for Barkhey paddy. Similarly, Barkhey farmers (89.61%) also responded that they have 80-100% cultivable land under irrigation facility. However, only 0.43% Chaitey farmers responded that their 20-40% cultivable land is under irrigation facility. From those who responded they get proper irrigation facility among Chaitey paddy farmer majority (58.33%) are accessing irrigation facility from canal, followed by tube well (25%) and Rain water (16.67%). Likewise, Barkhey Paddy farmers (71.94%) also stated that they access irrigation facility from canal, followed by rain water (23.98%) and tube-well (8%).

While asking about the fertility of their land 61.53% farmers who cultivate Chaitey paddy thinks their land is fertile, 7.69% thinks their land is neutral and 30.76% thinks that their land is very fertile. On the same hand, 51.08% farmers who cultivate Barkhey paddy thinks their land is fertile, 44.15% thinks their land is very fertile and

only 2.59% thinks their land is neutral. The study finds that 92.85% of Chaitey paddy farmers own their own land and cultivate paddy in their own land and 7.14% use both own and leased land for cultivation of paddy. Similarly, 90.70% Barkhey paddy farmers own their own land which is used for cultivation. 3.98% use leased land for cultivating paddy and 5.30% use both own and leased land for cultivating paddy.

On a similar note, 78.57% Chaitey paddy farmers stated that they have understanding regarding climate change variability and change. Likewise, 97.40% Barkhey paddy farmers stated that they have understanding regarding climate change variability and change. 78.57% stated that they feel temperature has changed since last 15 years according to Chaitey paddy farmers. Similarly, 96.10% Barkhey paddy farmers perceive that they feel temperature has been changed since last 15 years. 78.57% Chaitey paddy farmers believe that they have witnessed change in rainfall pattern over last 15 years. On the other hand, among Barkhey paddy farmer's majority (45.88%) perceives change in timing of rainfall whereas, only 4.32% feels decrease in rainfall.

According to 78.57% Chaitey paddy farmers and 95.23% Barkhey paddy, climate change has affected paddy production to certain extent. Among all the respondents taken in the study, 78.57% Chaitey paddy farmers agreed that they have taken different adaptation measures in rice farming to reduce the effect of climate change and 93.07% Barkhey paddy agreed that they have taken different adaptation measures in rice farming to reduce the effect of climate change. Some of the major adaptation techniques used by farmers as to reduce the effect of climate change are; change crop varieties, build water harvesting scheme, implementation of soil conservation scheme and so on. However, changing crop varieties are majorly adopted by both Chaitey paddy farmers.

The study also showed that from the year 2010-2020 the land used as production area seems to be decreased drastically. The study shows that paddy yield seems to be increasing year after year recently. As the temperature plays crucial role in paddy yield temperature pattern seems to be fluctuating. Maximum temperature seems to be more fluctuating than minimum temperature. Rainfall also seems to be fluctuated the rainfall seems to be drastically decreased in the year 2005 and further it seems to be decreased in the year 2020 as well. The mean paddy yield and rainfall is 2254.576

kg/ha and 1305.974 mm respectively. The minimum temperature observed during the time is 22.78 degree Celsius whereas the maximum is 37.2 degree Celsius. Likewise, the standard deviation for the rainfall is 330.77 whereas, for paddy yield is 569.57.

## **5.2 Conclusion**

The study concluded with following impacts of climate change on paddy production in Kapilvastu district:

- Most of the farmers of Kapilvastu are aware regarding the climate change, its measure and adaptation strategies. The irrigation facility seems to be accessible and land is found to be fertile for Barkhe paddy due to availability of water compared to Chaitey Paddy in Kapilvastu district.
- Almost all the farmers having their own land for farm purpose have made farmer easier for farming activities. Surprisingly paddy production has increased with the change in climate. This might be because of changing seeds in the shift of rainfall pattern or unpattern rainfall.
- Paddy yield seems to be increasing recently. As the temperature plays crucial role in paddy yield temperature pattern seems to be fluctuating. Maximum temperature seems to be more fluctuating than minimum temperature.
- Rainfall also seems to be fluctuating as in the year 2005 and 2010 rainfall drastically decreased which make falls in paddy productions as well.
- The study revealed that rise in maximum temperature would decrease the paddy yield. Farmer believes that the pattern of temperature and rainfall have changed over past 15 years. Farmers are aware that such conditions occurred due to change in climate and its condition. Further, they believe that this might continue and they should be well prepared for the scenario.
- Due to the climatic change situation farmers have started to choose alternate methods or farm techniques where they have started changing crop as major tactics. Some of the major alternative measures were found to be changing crop varieties, building water harvesting scheme, implement soil conservation scheme, diversification of livestock types and varieties, changing planting dates, irrigation and so on. Also, around 8,694,550 is expensed by farmers as adaptation and diversification measure to tackle climate change.

- The study finally concludes that adoption in technology would aid in increment in agriculture production. Technology would be beneficial for coping with the risks of climate change.
- Analyzing the results and the knowledge assimilated from this study, recommendations are made to kept forward for the consideration of concerned people, organization and policy makers which includes making farmer's aware about the advanced methods adopted to overcome climate change issues, access to irrigation facility, soil testing mechanism, and bridging the manpower gap as this study unleashed majority of paddy farmers are of age group 40-50.
- This study revealed that Chaitey paddy farmers' are in more problem them Barkhe paddy farmers' thus farmers along with the concern authorities should initiate and run programs that would help in solving the issue being faced by Chaitey paddy farmers so that they could get proper access to all the facilities that eases them in production of the paddy.

### **5.3 Recommendations**

The empirical study findings from descriptive analysis, following recommendation are presented for agricultural planning and research in the paddy production.

- This study finds that paddy production in Kapilvastu district is vulnerable to the impacts of climatic change. Farmers need support to cope with the climatic induced problems in paddy production.
- Farmers needs supports in technology to cultivate land throughout the year.
- This study found farmers are producing paddy with traditional practices. They need support for adoption of modern technologies to adapt to the climate change.

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# A P P E N D I C E S

## QUESTIONNAIRE

Namaste Sir/Madam,

My name is Keshab Sharma, a M.Phil. Student of Economics at Tribhuvan University, Nepal doing a research on “**Impact of climate change on Paddy production of Kapilvastu District, Nepal**”. The major objective of this study is to analyze the impact of climate change on paddy production. For that purpose, Banganga Municipality of Kapilvastu district, Lumbini Province is selected as area of study thus, your area has also been selected. Therefore, it is important to obtain information from Paddy farmers/ paddy farming HH of this area. You have been randomly selected and we would be grateful if you could kindly participate in our survey. Your participation is completely voluntary and you have the right NOT to participate in this survey at all or stop participation at any point in time during the survey. This information is being collected for academic purposes only, and there are no personal benefits or risks to your participation. It is possible that some of the questions asked, are of a sensitive nature, but please note that your name will not be recorded in the questionnaire, and any details related to your privacy will be kept confidential.

May I have your permission to undertake this interview?

Yes = Proceed with interview

No = Thank the person and look for next respondent

### **Part A: General Information**

Name of Respondent:	Sex: a. Male b. Female c. Others
Age: .....	Contact No. :
Municipality:	Ward No. :
Is respondent household head? a. Yes b. No	Marital Status: a. Single b. Married
Occupation of Household Head:	Total Family members:
How long have you lived in this community?	
What are the farm experiences of household head? (Year of experience of farming of respondent):	

### Part B: Land Ownership and Utilization

S.N.	Questions	Chaite Paddy	Barkhe Paddy
Q.1	What is the size of your land?		
Q.2	What is the area under cultivation?		
Q.3	What is the area under paddy cultivation?		
Q.4	Does your land have access to irrigation facility?	01 = Yes 02 = No	01 = Yes 02 No
Q.5	If yes, what is the source of irrigation?	01 = Tube-well 02 = Canal 03 = Rain water 04 = Other .....	01 = Tube-well 02 = Canal 03= Rain water 04 Other .....
Q.6	What percent of your total cultivable land is under irrigation?	.....%	.....%
Q.7	What is your perception about the fertility level of your land?	01 = Very fertile 03 = Neutral 05 =Very infertile	02 = Fertile 04 = Infertile 06 = Don't know
Q.8	What is the type of land ownership?	01 = Own 03 = Both (Specify).....	02 = Leased 04 = Others

### Part C: Perception of Climate Change and Adaptation Methods

S.N.	Questions	Chaite Paddy	Barkhe Paddy
Q.9	Do you perceive climate variability and change?	01 = Yes 02 = No	01 = Yes 02 = No
Q.10*	Have you noticed any changes in temperature over the last 15 years?	01 = Yes 02 = No If No, Please go to Q. 12	01 = Yes 02 = No If No, Please go to Q. 12
Q. 11	If yes, what has happened to the number of hot days over the last 15 years?	01 = Increased 02 = Declined 03 = More extreme 04 = Less extreme	01 = Increased 02 = Declined 03 = More extreme 04 = Less extreme
Q.12*	Have you noticed any changes in rainfall pattern over the last 15 years?	01 = Yes 02 = No If No, Please go to Q. 14	01 = Yes 02 = No If No, Please go to Q. 14
Q.13	If yes, what has happened to the number of rainfall days over the last 15 years?	01 = Increased 02 = Declined 03 = Change in timing of rains 04 = Decrease in rains and change in timing 05 = Change in frequency of droughts/floods	01 = Increased 02 = Declined 03 = Change in timing of rains 04 = Decrease in rains and change in timing 05 = Change in frequency of droughts/floods

Q.14*	Do you think there is change in paddy production due to climate change?	01 = Yes 02 = No If No, Please go to Q. 17	01 = Yes 02 = No If No, Please go to Q. 17
Q.15	What is the main impact of these changes on rice production?	01 = Increase in production 02 = Decrease in production 03 = Don't know 04 = Other (specify) .....	01 = Increase in production 02 = Decrease in production 03 = Don't know 04 = Other (specify) .....
Q.16	What percentage of total production increases/ loss is incurred for rice production?	.....%	.....%
Q.17*	Have you taken any adaptation measures in your rice farming practices in order to reduce the impact of climate change?	01 = Yes 02 = No If No, please end the survey	01 = Yes 02 = No If No, please end the survey

Q. 18. Please mentioned that whether the given adaptation options are available or not?

S. N.	Climate Change Adaptation	Please tick the available adaptation options	
		Chaite Paddy	Barkhe Paddy
1	Change crop varieties		
2	Build water harvesting schemes		
3	Implement soil conservation scheme		
4	Diversification of crop types and varieties		
5	Diversification of livestock types and varieties		
6	Changing planting dates		
7	Changing size of land under cultivation		
8	Irrigation		
9	Reduce number of livestock		
10	Diversify from farming to non-farming activity		
11	Others (specify) .....		

**Part-D: Climate Change Adaptation and Diversification**

Q. 19. Please mentioned that whether you employed any of the following climate change impact adaptation strategies in your farm?

S. N.	Climate Change Adaptation	Please tick that you have applied			
		Chaite Paddy	Total Cost Incurred (in NRs.)	Barkhe Paddy	Total Cost Incurred (in NRs.)
1	Change crop varieties				
2	Build water harvesting schemes				
3	Implement soil conservation scheme				
4	Diversification of crop types and varieties				
5	Diversification of livestock types and varieties				
6	Changing planting dates				
7	Changing size of land under cultivation				
8	Irrigation				
9	Reduce number of livestock				
10	Diversify from farming to non-farming activity				
11	Others (specify) .....				
	Is such adjustment (s) beneficial or harmful?	01 = Beneficial 02 = Harmful		01 = Beneficial 02 = Harmful	
	If beneficial, how...	.....		.....	
	If harmful, why...	.....		.....	

**Thank you !**

## List of Photographs

Snapshots of researchers collecting information by visiting each ward and farmers in the field of Banganga Municipality, Kapilbastu district, Nepal.







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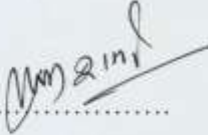
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# IMPACTS OF CLIMATE CHANGE ON PADDY PRODUCTION I...

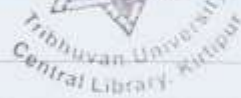
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