Climate Change and Variability: Producers' Perceptions and Determinants of Adaptation Strategies in Rice Farming in Chitwan, Nepal.

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Hari Prasad Regmi

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Dedication

This thesis is dedicated to my family.

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Abstract

Nepalese agriculture is highly vulnerable to climate change. Rice is the most important cereal crop (as a staple food) in terms of area cultivated each year in Nepal. This study analyzes rice producers' perceptions of climate change, its impacts on rice farming, and factors influencing the adoption of adaptation strategies of the producers. The analysis of survey data of 359 rice-producing households in the South-Central Terai region of Nepal indicated that rice producers perceived changes in local weather patterns as compared to the recent past. Trend analysis (1981-2018) of weather data (temperature and rainfall) from a local meteorological station strongly supports producers' perceptions. Results revealed that producers are adopting a number of adaptation strategies to reduce the impacts of climate change in rice farming, they were adjustment in crop calendar (72.9%), varietal selection (64.9%), investment in improved irrigation (60.7%), adoption of integrated pest management (22.1%), and adoption of direct-seeded rice (15.6%). Results indicated that 76.6% of producers were adopting at least one adaptation strategy, and 10% of producers were adopting all those five strategies. Lack of adequate information, limited technical know-how, and credit constraints were major factors that impede adaptation to climate change. A multivariate probit model (MVP) and an ordered probit model (OPM) were used to examine factors influencing the rate of adoption of adaptation strategies and to estimate drivers of the intensity of adoption, respectively. Results of a multivariate probit model revealed complementarities among adaptation strategies indicating their adoption is inter-related. This result has important policy implication that enhancement of one strategy can have spillover effects on other strategies. Results revealed that human capital formation through education, literacy programs, formal and informal training help in making better farming decisions, increase awareness about the impacts of climate change, and can further enhance adoption of adaptation strategies on rice farming. Results of the intensity of adoption indicated that male-headed household, education, awareness about climate change, use of Extension, training, and information are significant to improve intensity of adoption.

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Acronyms

AGDP	Agricultural Gross Domestic Product
CBS	Central Bureau of Statistics
DADO	District Agricultural Development Office
DHM	Department of Hydrology and Meteorology
DSR	Direct Seeded Rice
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
HA	Hectares
HH	Household
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
KG	Kilogram
MT	Metric Tons
MOAD	Ministry of Agricultural Development
MOF	Ministry of Finance
MOFE	Ministry of Forest and Environment
NAPA	National Adaptation Program of Action
NARC	Nepal Agriculture Research Council
NOAA	National Oceanic and Atmospheric Administration
NRS	Nepali Rupees
UNFCC	United Nation Framework Convention on Climate Change

CHAPTER I. INTRODUCTION

According to the Intergovernmental Panel on Climate Change (IPCC, 2007; IPCC, 2019), climate change is one of the greatest challenges to agricultural production and food-security in many regions around the world. Climate change refers to the long-term variation of the climate (the average weather condition; specifically, rainfall, temperature, and wind) that persists for an extended period of time (IPCC, 2007). Weather refers to short-term changes in the atmosphere at a point of time and at a specific place (NOAA, 2020). In other words, the day-to-day conditions of the atmosphere, for example, temperature, rainfall, humidity, wind speed, etc. Climate change affects multiple sectors/regions around the world. Trends of extreme weather events such as abrupt temperature changes, drought, intense rainfall, floods, storms, etc. are increasing over time and impacts on natural and human systems are already observed worldwide (IPCC, 2019). The likely impact of climate change and variability differs across communities. However, due to the limited adaptive capacity, smallholder producers in developing countries are highly vulnerable to the impacts of climate change and variability (Morton, 2007; Kurukulasuriya and Rosenthal, 2013).

Many studies have projected warmer temperatures in Nepal in the future. For example, McSweeney et al., (2010) suggest that the mean annual temperature will likely increase by 1.8^0C by the year 2030 and 2.8^0C by the year 2060, above the observed mean of 14.4^0C for the period 1970 to 1999. Similarly, the Ministry of Forests and Environment (MoFE, 2019) forecasted that by 2030 and 2050, the mean annual temperature will likely increase by 1.07^0C and 1.82^0C, respectively, above the mean for 1981 to 2010. The average annual precipitation has decreased by 1.3 mm/year from 1971 to 2014 (DHM, 2017). The Food and Agricultural Organization (FAO, 2014) reported more intense rainfall during the rainy season and projected that by 2050, annual rainfall will decrease in the range of 20 mm to 100 mm. Occurrences of both erratic rainfall events and frequent and prolonged dry spells have increased over the years (Malla 2008; DHM 2017).

According to Nepal's Ministry of Finance (MoF, 2018), agriculture represents 27.6% of Nepal's gross domestic product (GDP). Rice is the leading crop grown in terms of area (more than 50% of total cultivated area each year) and production (Ministry of Agricultural Development, MoAD, 2015). Rice has high economic and social value as the most preferred staple food and contributes a significant share (20%) to the country's total agricultural domestic product (AGDP) (MoAD, 2015). Due to the greater preference for rice consumption as a staple food, the annual demand has increased by 10% (Dhungel and Acharya, 2017). To meet increasing demand, imports of rice have exceeded a monetary value of US$ 300 million in 2018 (822,642 Metric Ton), an annual increase of 29% than the previous year (Department of Customs, 2019). However, compared to other major rice-producing countries whose average rice yield is 7-8 metric tons/hectare (FAO, 2020), rice yield in Nepal is relatively low, at 3.76 metric tons/hectare (National Planning Commission, Nepal, 2020). Long-term variation in climatic parameters (primarily rainfall and temperature) and frequent occurrence of extreme weather events - such as drought and floods - affect soil-water-plant relationships and ultimately result in reduced yield. Rainfall variability, increasing dry spells, late onset of monsoon and increasing temperatures have increased the vulnerability of the monsoon-dependent rice production system in Nepal (Karna 2014; MoF, 2014). In Nepal, only 18% of total cultivable land is under irrigation throughout the year and nearly 46% of the land under cultivation is primarily dependent on monsoon (natural rainfall) for irrigation (MoF, 2018; Ministry of Energy, Water Resources, and Irrigation, 2018). The spatial and temporal distribution of rainfall has a significant influence on rice acreage. More than 50,000 hectares (123,552.7 acres) of rice acreage were affected by variability in the rainfall in 2013-14 and about 127,000 hectares (313,823.8 acres) of agricultural land were affected by natural disasters in 2017/18 (MoF, 2014; MoF, 2018). FAO (2014) reported that about 90% of crop losses in Nepal were associated with weather-related events.

Developing and disseminating appropriate adaptation measures are of critical importance in increasing yield and reducing the vulnerability of rice production to climate variability. Adaptation is contextual and time-specific, and it varies with the available resources and capacity of the producers (Deressa et al., 2009). Smallholder farmers seek to adjust their farm management practices by adopting some adaptation strategies. These strategies are primarily based on producers' conventional knowledge and beliefs of perceived changes and variability (Leclère et al., 2013). A better understanding of producer practices, beliefs, and their knowledge of climate change issues are vital for designing appropriate and compatible adaptation measures (Patino and Gauthier, 2009). There is abundant literature focused on macro-level (global, national, or regional) climate change adaptation that was published in recent years (Challinor et al., 2014). Most of the previous studies at the farm and household level adaptation strategies are focused on studying factors influencing adoption of adaptation strategies in isolation (Abid et al., 2015; Bryan et al., 2013; Teklewold et al., 2013; and Mertz et al., 2009). However, analyzing the adoption behavior without examining potential interdependence among the practices might overestimate or underestimate the influence of exogenous factors on the choice of adaptation practices. Furthermore, as indicated by Kurukulasuriya and Rosenthal (2013), the right mix of adaptation strategies are crucial to improve farm productivity and reduce negative impacts of climate change. Analyzing the patterns of adoption, examining the potential interdependence of adoption of adaptation strategies, and assessing the intensity of adoption may provide additional insights into the factors that enable effective and sustainable adaptation strategies.

The objectives of the study are:

- To understand rice producer perceptions of climate change and variability in Chitwan.
- To understand Chitwan rice producer perceptions of the effects of variability on rice production and to identify the preferred adaptation strategies of these producers; and
- To identify the socio-economic and institutional factors influencing the adoption of adaptation strategies of rice producers in Chitwan.

Implications of the study

Rice farming in Terai region of Nepal has been negatively affected in terms of acreage, production and yield due to climate change (Karna, 2014; Khanal, 2018; Gumma et al., 2011). Few studies have examined factors that influence Nepal rice producer’s decision to adapt to climate change. Further investigation is needed to determine factors that drive rice producer’s coping strategies to address adverse effects of climate change. This study will use a sample of 359 rice producers to understand household and farm characteristics, understand producers’ perceptions of climate change, adaptation to climate change, producers’ risk attitudes, and access to Extension services, credit, subsidy, and information. To investigate factors influencing rice producers’ adaptation to climate change, a multivariate probit model is estimated. The results can be used to identify potential factors that enable or limit adoption of adaptation strategies, and whether these adaptation strategies are complementary or supplementary in nature. To examine the intensity of adoption, an ordered probit model is estimated. The results can be used to determine the probability of adoption of a single or multiple adaptation strategies. A comprehensive understanding of producers ongoing adaptation practices and drivers of adaptation enables designing effective and sustainable policy for rice production in Nepal.

The rest of the chapters are organized as follows: Chapter II includes the literature reviews of several studies about climate change and adaptation strategies. The conceptual framework of the study, survey data collection and methods are described in data and methods section in chapter III. Chapter IV includes results and discussions. Finally, in chapter V, we present summary and conclusions from this study.

CHAPTER II. LITERATURE REVIEW

This section contains a review of the literature focusing on climate change, impacts of climate change, adaptation practices and various factors that enable or limit adaptive capacity. Some of the terminology used in climate change studies are presented in Appendix B.

Smit and Wandel (2006) studied adaptation, adaptive capacity, and vulnerability at the community level and indicated that adaptations are integrated into the optimum resource management and sustainable development programs to reduce the vulnerabilities of communities to climate-induced risks. The participatory vulnerability assessments help to identify preferred adaptation measures that are feasible at the local/community level. This study also emphasized that adaptation can be viewed as a local or community level adjustment to respond to climate change within the constraints of socio-economic and political structures. In our study, we are interested in studying rice producers' adaptation to climate change at the local village level, these producers are faced with the constraints of income, small land holding and limited technical support.

Brooks et al., (2005) in their study examined indicators of vulnerability and adaptive capacity at the national level. The authors indicated that adaptive capacity is highly associated with issues of governance, education, and political rights of the people. This study also spells out that the effective adaptation measures will be jointly determined and promoted in consultation with community members and only after identification of vulnerability hotspots at the local/community level. In the scenario of increasing weather unpredictability, weak institutional support, and predominance of semi-literate and subsistence producers, identification and promotion of a farm-level adaptation measures in consultation with the local producers have a crucial importance for planning effective and sustainable adaptation measures in reducing the vulnerability to climate change.

Gallopin (2006) analyzed the interrelationships among the concepts of resilience (according to the IPCC (2007), resilience is the ability of a social or ecological system to absorb disturbances while retaining the same basic structures and ways of functioning), adaptive capacity, and vulnerability by socioecological system perspectives. This study suggests that there is no generally accepted interpretation of the relationship among these concepts. However, these are a different reflection of the general process of response to change within the linkages between open dynamical systems and the external environment. A broader understanding of the dynamic linkages among the concepts of resilience, adaptive capacity, and vulnerability enable us to better explore the potential factors influencing producers' adoption decision under the diverse socioeconomic conditions.

Dalziell and McManus (2004) studied resilience, vulnerability, and adaptive capacity to evaluate organizational resiliency to major hazard events. This study highlights that not all organizations are well-prepared for managing uncertainty and unexpected events. Organizations should be encouraged to become more resilient, especially in the private sector where resilience planning is not regulated. While the planning for organizational resiliency is still limited in both at the producer's institutions (groups/cooperatives) and in support services including Agricultural Extension, by strengthening and empowering producers' institutions to become more resilient, producers' adaptive capacity will be enhanced which will ultimately lead to a reduction in vulnerability to climate change.

A number of studies reported about the negative impacts of climate change in rice farming in Nepal and how producers overcame those challenges. Variability in the rainfall pattern resulted in 13% reduction in rice acreage in 2006 (Gumma et al., 2011). Navaya (2017) found a strong correlation between the occurrence of monsoon rainfall and rice yield over a period of 45 years (1971 to 2015). The timely onset of monsoon is critical to enhancing rice yield. Late-onset of monsoon, frequent and intense episodes of dry spells resulted in a reduced harvest of 11.2% in 2012/13 as compared to previous years (MoF, 2013).

Producers' perceptions of climatic unpredictability vary across regions (Below et al., 2012) and are largely related to short-term changes in local weather patterns (Mertz et al. 2009). Understanding producers' perceptions of climate change are an important factor to be considered before designing and implementing adaptation measures (Piya et al., 2012). Furthermore, this study indicated that producers' understanding of climate change is largely related to their micro-level livelihood strategies and is shaped by their crop-climate interaction. The adoption of recommended measurers may not take place as anticipated if adaptation policies and programs do not address producers' perceptions (Piya et al., 2012). A better understanding of local perspectives, producers existing knowledge, how local producers observed the changes in the climatic parameter, and how they perceived associated impacts due to those changes are important in shaping their adaptation measures (Deressa, et al., 2011; Patino and Gauthier, 2009).

Literature indicates that there are abundant studies of farmers’ perceptions of climate change and determinants of climate change adaptation strategies in Africa (Mulwa et al., 2017; Gadédjisso-Tossou, 2015; Tilahun and Bedemo, 2014; Tazeze et al., 2012; Gbetibouo, 2009; and Deressa et al., 2009). Gadédjisso-Tossou (2015) studied farmers' perceptions and adaptation to climate change in Togo and reported that farmers' perceptions of climate change and variability align with historical weather patterns. Farmers adapted to climate change and variability by adjusting their crop calendar, selecting suitable crop varieties, adjusting crop acreages, incorporating diversification strategies, and working off-farm. This study revealed that access to agricultural Extension, credit, weather information, education, and farming experience positively influence the adoption of multiple adaptation strategies.

Tilahun and Bedemo (2014), consistent with other studies in Africa, reported that better education, earning from off-farm income, access to crop and livestock Extension services, and availability of farm credit are more likely to influence the adoption of improved farming practices. About 47% of farmers did not adopt any practices due to a shortage of labor force, and nearly 32% of farmers face credit constraints to address climate change impacts.

Mulwa et al., (2017) assess determinants of smallholder farmers' adaptation behavior to climate-induced risks. Unlike most of the other studies, this study estimated the simultaneous influence of exogenous factors on the adoption of multiple adaptation strategies. The adoption of a single strategy may not minimize climate change impacts, and farmers may prefer to adopt multiple strategies. Access to credit and availability of weather information has a positive influence on the adoption of most of the strategies among Malawi farmers. Interestingly, this study reported that even in the case of being credit constrained, the availability of climate information positively influences producers to invest in improved farming technologies.

Deressa et al., (2009); Tazeze et al., (2012); and Gbetibouo (2009) studied climate change adaptation determinants of Ethiopian farmers. All three studies reported that climate change and variability have an adverse effect on agriculture and ultimately impact farmers' livelihoods. The use of diverse crop species and varieties, adjusting cropping patterns as well as crop calendars, soil and water conservation practices, and crop diversification are the common adaptation strategies among Ethiopian farmers. Consistent with other adaptation studies, educational empowerment, relaxing financial constraints, and access to support services including training and Extension have a positive influence on adaptation to climate change.

Aryal et al., (2018) identified factors influencing the adoption of multiple climate-smart farming practices and determinants of intensity of adoption in Bihar and Haryana, India. Results indicate that farmers adopt inter-related multiple climate-smart agricultural (CSA) practices. Also, market access, provision of farm credit, access to Extension and information are crucial in promoting CSA practices. This study also suggested policy and structural reforms to address issues of land fragmentation (possession of several non-contiguous land plots by a farming household, and often scattered) to promote widespread CSA adoption.

A study by Piya et al., (2013), on the marginalized, indigenous *Chepang* community in Chitwan, Nepal recommend creating awareness about climate change and variability through dissemination of weather and crop-production related information to enhance adoption of adaptation practices. Further, this study reported that the provision of skill enhancement training, easy access to collateral-free micro credit, and access to Extension services increased the likelihood of adoption. In an earlier study about factors influencing perceived changes in local climatic conditions among *Chepang* villagers in Nepal, Piya et al., (2012), reported that nearly one-third of the respondents' perceptions of the changes in weather patterns were in-line with the long-term climatic data. The study found that ownership of a radio and membership in farmer groups helps farmers to understand the changes in local weather patterns.

A study by Acharya, (2018) estimated acreage and yield function of crops in the context of changing climate and market conditions in Nepal and indicated that daily temperature variation during planting seasons affect acreage allocation for most of the crops including rice. It is likely that temperature variation coincides with the late-onset of monsoon and prolonged dry-period limits the decision-making ability of producers. Furthermore, frequent rainy days during growing seasons and farmer's literacy rates improves crop yields. Empirical estimation shows that a 10 percent decrease in the number of rainy days during the rice-growing season is likely to reduce yields by 4.8%. This result is consistent with other findings as drought is one of the limiting factors for crop yields, specifically for rainfed farming in Nepal. This study also suggests that investment in human capital development (education), development of climate-smart production technologies and drought-tolerant varieties, availability of reliable weather information, and market access increase farm profitability in the face of climate change and variability.

Karna (2014) estimate the impacts of climate variables on rice yield in Nepal and found that, with a 1^0C increase in day-time temperature during ripening stage, rice yield increases by 27 kilograms/hectare (0.54 bushels/acre) up to a threshold of 29.9^0C (85.82^0F). However, this study also indicated that if the day-time maximum temperature surpasses 29.9^0C, rice yields start to decline. Precipitation has a non-linear relationship in rice yield with a strong negative effect if rainfall occurs during late crop stages that are not beneficial for growth.

To summarize the literature on climate change, many studies have focused on climate change adaptation in recent years and emphasize an integrated approach to address the impacts of climate change. A majority of these studies indicated increasing vulnerability of the agricultural sector due to climate change, emphasized enhancing adaptive capacity of the farmers, and suggests the implementation of adaptive measures to enhance growth in the agricultural sector. Much of the earlier climate change adaptation research focused on the adoption of technology in isolation, however, producers usually adopt multiple strategies. The multiple adaptation strategies may be complimentary or supplementary in nature. Analyzing interdependence among multiple practices and identifying the factors influencing the adoption decision is crucial to plan effective and sustainable adaptation strategies. Furthermore, very few studies focused on examining intensity of adoption by measuring number of adaptation practices adopted. This study aims to fulfill these gaps by examining potential interdependence of adoption of multiple adaptation practices, analyzing patterns of adoption, and assessing the intensity of adoption.

CHAPTER III. DATA AND METHODS

This chapter contains multiple sub-sections. The conceptual framework of the study is described in the first sub-section and then data and methods including sample size, data collection procedure, local weather data (of Rampur, Chitwan), and empirical modelling are discussed in the following sub-sections.

3.1 Conceptual Framework

This study employs the adaptation framework following Smit et al., (1999) to conceptualize the adaptation and mitigation in the agricultural sector as shown in figure 1. The extent of vulnerability of the system (agriculture) depends on its exposure to risks and hazards of climate change impacts and the ability of the system to adapt. Perception is a cognitive process and can be influenced by several factors. Producers, who perceived and observed the impacts of climate change and variability, enter the decision-making process of adoption of adaptation practices.

The adoption of practices might be influenced by a number of exogenous factors. If producers decide to adapt to climate change, they adjust their farming practices to respond to the changes, which is also called autonomous adaptation, for example, adjustment of crop calendar for planting based on the onset of monsoon. However, depending on the extent of impacts, producers' adjustments may not be sufficient enough to address the impacts of climate change and variability. From a policy perspective, adaptation and mitigation are two important aspects to deal with climate change. Policy options on addressing the issues of mitigation through human interference are ongoing, however, studies projected to increase the impacts of climate change in the future. Thus, planned adaptation, for example adoption of improved varieties and adoption of Integrated Pest Management (IPM) practices (according to the IPCC (2007), is a response to deal with various climate change issues, it is a result of a deliberate policy decision to return to or maintain a desired state) is necessary to reduce the likely negative impacts of climate change and variability. The short-term impacts are related to the initial effects of the projected change in climate and can be dealt without considering adaptation, however, the long-term impacts are net impacts that might occurs (or observed) after adaptation.

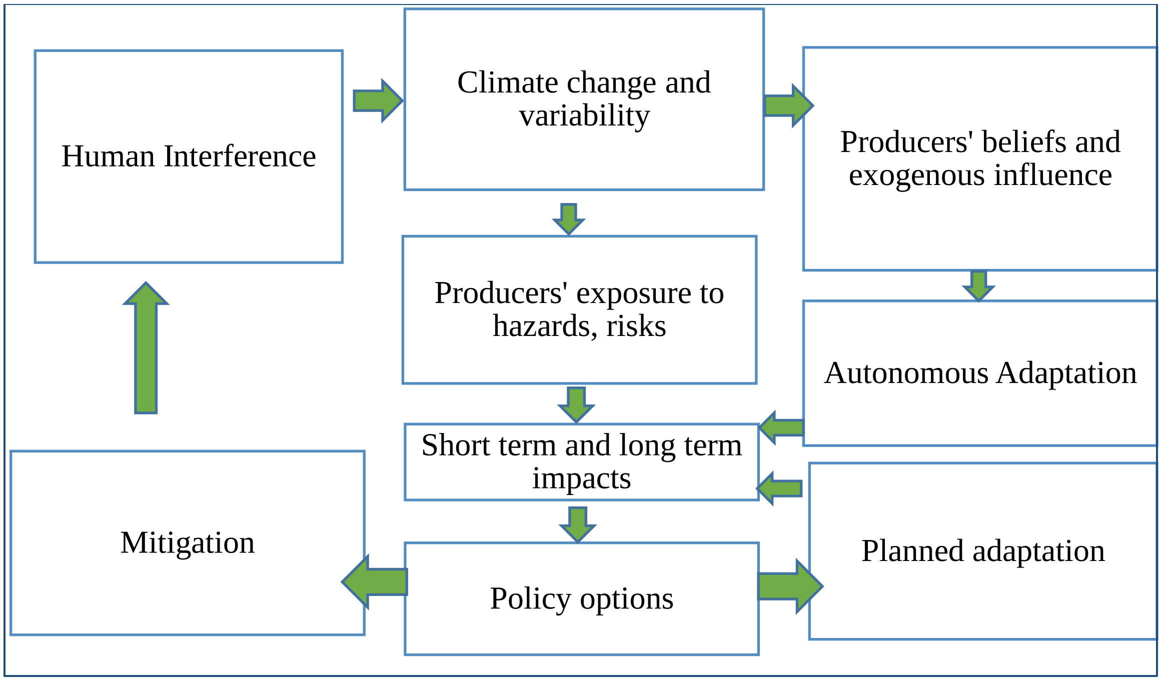

Figure 1: Conceptual framework

Source: Modified from Smit et al., (1999) Kurukulasuriya & Rosenthal (2013) reported the potential of an optimal mix of adaptation strategies to reduce the adverse impacts, as well as to enhance the beneficial impacts of climate change on farm productivity. Producers try to minimize the long-term negative impacts by adopting different adaptation strategies (both autonomous adaptation and planned adaptation). These strategies reduce producers' exposure to risk by minimizing the marginal effect of climate variability on farm productivity (Fisher-Vanden, 2011), which is considered to be within the general framework of utility or profit maximization. Furthermore, the utility of an economic agent is a latent variable and is not directly observable, but the actions of an economic agent can be observed through their choice to adopt particular strategies. An individual producer (as an economic agent) is more likely to adopt particular adaptation strategies if the producer perceives the benefit of adoption to be greater than non-adoption. Let U_j and U_0 represent the net benefit (latent variable) for producers with and without adoption respectively, then a producer decides to adopt j^{th} strategy (strategy may represent a set of practices) on his farm if U_j - $U_0 > 0$.

In line with above mentioned theoretical concept, in our study, we assume that producers adopt both autonomous adaptation practices (adjustment of crop calendar) and planned adaptation practices (Variety, Improved Irrigation, Direct Seeded Rice, and Integrated Pest Management) to minimize the likely long-term impacts of climate change (reduction of farm productivity), if the net benefit (utility) of adoption is higher than non-adoption.

3.2 Description of Study Area and Sample Size

Nepal is a small landlocked country in South Asia with an area of 147,181 square kilometers (36.37 million acres). A map of Nepal is shown in figure 2. Geographically, Nepal is divided into mountain region (35% of the land area, divided into 16 districts), hilly region (42% of the land area, divided int 39 districts), and Terai/plains region (23% of the land area, divided into 20 districts). (The names of all the districts are listed in Appendix A - Table A.1). Each region has distinct agro-ecology and climatic conditions as shown in table 1. The mountain region's altitude ranges from 3,000 to 8,848 meters above sea level, is characterized by rugged mountains, and has mostly temperate climate. The hilly region (Mid-hills) has an altitude range of 300 to 3,000 meters above sea level and is characterized by mountains with small valleys. The hilly region has a sub-tropical to temperate climate, with few areas suitable for agriculture. The Terai or the plains region has an altitude range from 60 to 300 meters above sea level, has a tropical or sub-tropical climate (68^0F -77^0F), receives mean annual rainfall between 43.3 and 118.1 inches, and the soil is suitable for agriculture. The Terai region is the food basket of Nepal. Rice is one of the major cereal crops grown in the Terai region.

Nepal's mean annual temperature shows an increasing trend over the years (figure 3). The mean annual temperature of Nepal is 15^0C (59^0F). In Nepal, the minimum temperature varies spatially between -5^0C (23^0 F) and 20^0C (68^0F) in a year, and the maximum temperature varies spatially between 5^0C (41^0F) and 30^0C (86^0F) (DHM, 2017) in a year. Over the past 44 years (1971-2014), Nepal's annual maximum and minimum temperatures have increased by 0.056^0C/year and 0.002^0C/year, respectively (DHM, 2017). Nepal's average annual precipitation shows a decreasing trend over the years (figure 4). The average annual precipitation is 1,800 millimeters (70 inches) and more than 80% of the total precipitation is received during the monsoon period of June through September (DHM 2017; DHM 2018).

Figure 2: Map of Nepal highlighting the Chitwan district, the study area for this project

Table 1: Features of three major physiographic regions of Nepal

Features	Physiographic regions			
	Terai/Plain	Mid-hills	Mountains	Nepal
Area (%)	23%	42%	35%	100%
Altitude (Meters)	60-300	300-3,000	3,000-8,848	60-8,848
Climate zone	Tropical and Sub-tropical	Sub-tropical and temperate	Temperate and Arctic	Tropical to Arctic
Average annual Temperature (^{0}C)	20-25^{0}C (68-77^{0}F)	10-20^{0}C (50-68^{0}F)	<3-10^{0}C (37.4-50^{0}F)	15^{0}C (59^{0}F)
Average annual precipitation (mm)	1,100-3,000 (43.3-118.1 inches)	275-2,300 (10.8-90.5 inches)	150-200 (5.9-7.9 inches)	1,800 (70.8 inches)

Source: Shrestha et al., (2013); Central Bureau of Statistics (CBS, 2018a); and DHM, (2018)

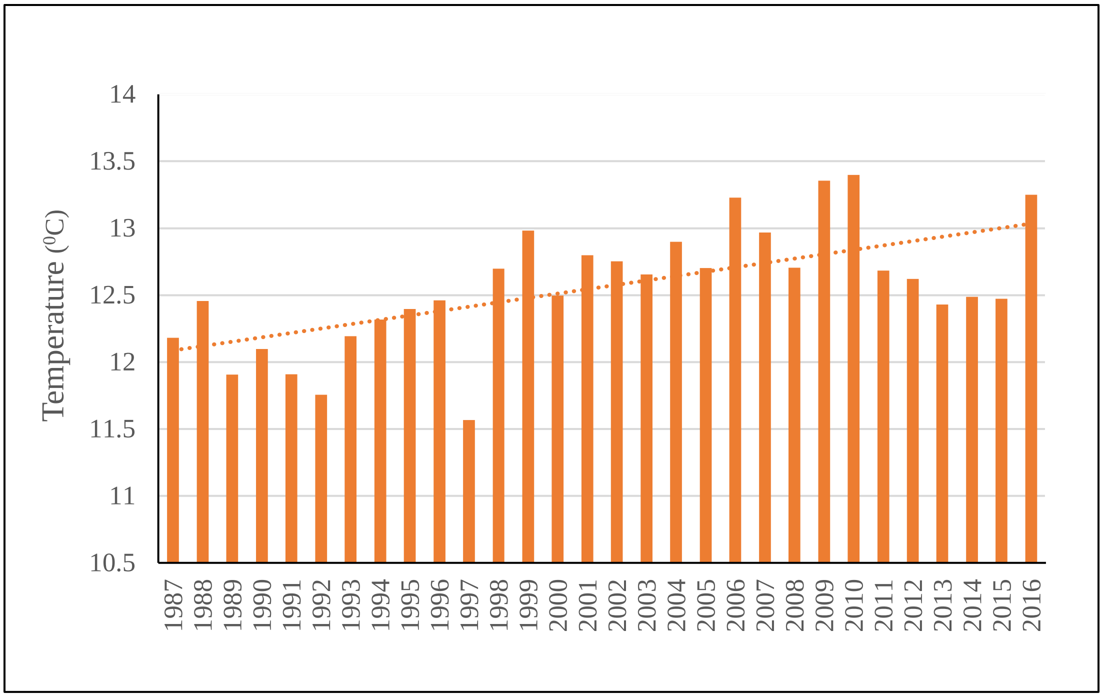

Figure 3: Average temperature trend of Nepal (1987-2016)
Source: World Bank Group, 2020

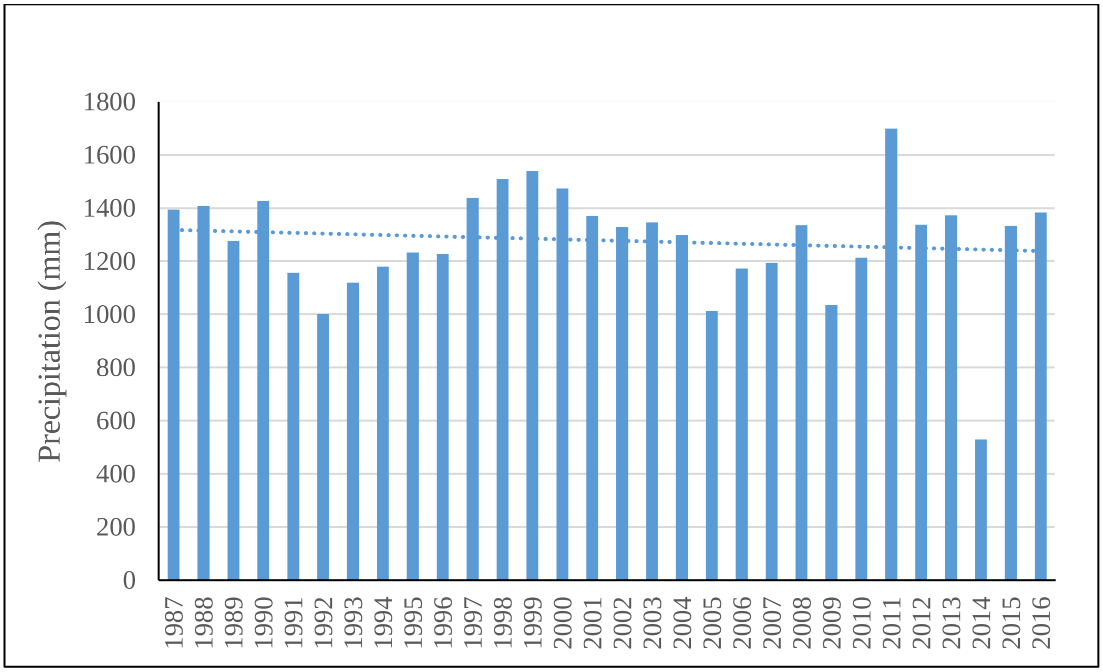

Figure 4: Average annual precipitation trend of Nepal (1987-2016)
Source: World Bank Group, 2020

The study area for this research is Chitwan district, located in the south-central Terai region of Nepal (Figure 2). Chitwan is one of the rice-producing districts of Nepal. According to the District Agricultural Development Office in Chitwan (DADO, 2017), rice is cultivated on approximately 33,900 hectares each year in Chitwan, which represents about 77% of the district's total arable land (44,291 hectares). A total of 132,462 households (HH) reside in the Chitwan district. Approximately 67% of which are involved in agricultural activities. Determination of sample size and sampling procedures are important aspects of the survey. This study used a sample size determination procedure as presented in equation 1 following Krejcie and Morgan (1970).

$$Sample\ size = \frac{\chi^2 NP\ (1-P)}{d^2\ (N-1) + \chi^2 P(1-P)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..(1)$$

$Where,$

$\chi^2 = Chi - square\ tabulated\ value\ at\ desired\ confidence\ level\ (we\ used\ 95\%)$

$N\ = Total\ population\ size$

$P\ = Population\ proportion$

$(assumed\ to\ be\ 0.5\ to\ provide\ the\ maximum\ sample\ size)$

$d\ = Degree\ of\ accuracy\ (5\%)$

Data were collected using a simple random sampling technique as shown in table 2. First, out of seven administrative units in Chitwan district, the largest administrative unit, *Bharatpur* was selected, which consists of a total of 69,035 households and 45,991 farming households (52.11% of the farming households in the district). Second, a consultation meeting was organized with agricultural Extension agents at District Agricultural Development Office (Agricultural Extension Office) to select rice producing local units. In consultation with the District

Agricultural Development Office, given our limited budget, we could only hire 4 enumerators for 5 days to cover three local units/villages - *Patiyani* (1,409 HHs in farming), *Jagatpur* (1,360 HHs in farming), and *Sharadanagar* (1,321 HHs in farming). In this three villages, rice is a major crop in terms of area cultivated each year. Third, using the population size (total number of farming households in three villages, altogether 4,090), the sample size was calculated to be 352 (95% confidence interval and 5% margin of error); altogether 359 rice producing households in three local units/villages (at least 100 households in each unit) were randomly interviewed in June 2019.

Table 2: Description of the sample size

District/Administrative Unit/Local unit	Number of households	Sample size (n=359)
District: Chitwan	88,246	-
Administrative Unit: Bharatpur	45,991	-
Local Unit/Village: Patiyani	1,409	117
Local Unit/Village: Jagatpur	1,360	115
Local Unit/Village: Sharadanagar	1,321	127

3.3 Description of Questionnaire and Procedure of Data collection

The questionnaire used is comprised of five sections (Appendix C). In section A, we collected data on household characteristics including age, literacy, education, farming experience; farm characteristics including farm size, rice yield, irrigation availability, membership in a farmer's group/cooperative, access to market; and sources of household income from crops, livestock, and off-farm income as well as the trend from income sources over the past five years.

In section B, we collected data on producers' perceptions of weather patterns in the past ten years including temperature, rainfall, occurrence of floods, dry periods, onset and retreat of monsoon, and water table fluctuations. We then collected data on impacts of these changes on rice production, including delays in transplantation, reduced irrigation, yield losses, and disease, pest and weed incidence.

In section C, we collected information on whether producers adopted climate change adaptation practices in rice farming including varietal management, improved irrigation practices, system of rice intensification, direct seeded rice, integrated pest management, changes in use of chemicals (fertilizer, pesticides, herbicides), adjustment of crop calendar, and farm diversification. Furthermore, we asked the producers the reasons for non-adoption if they did not adopt any adaptation practices.

In section D, we assessed risk attitudes of rice producers using a hypothetical lottery, wherein each producer would pick between a risky choice and a safe option. Consequently, each producer self identifies his or her risk tolerance.

Finally, in section E, we collected data on crop insurance, access to Extension services, participation in climate smart farming training, access to credit, sources of credit, access to subsidies, preferences for input subsidies and power availability (electricity and solar connection). Furthermore, data on access to different sources of information including access to internet, radio, television, and mobile applications were collected. The questionnaire was translated into the Nepali language for ease of understanding and to get an accurate response from rice producers.

Approval was obtained from the Institutional Review Board (IRB), The University of Tennessee, Knoxville for the survey questionnaire. In collaboration with Natural Resource Management Pvt. Ltd. Bharatpur, Chitwan, (a local organization working in agricultural research and rural development in Nepal), four undergraduate students of Agriculture and Forestry University were hired as enumerators to conduct the field survey. The enumerators spoke Nepali language, were aware of geographical conditions, familiar with local farming practices, and have prior experience conducting household surveys. The enumerators were trained and provided directions to fill the questionnaire before conducting the field survey. The enumerators started at the periphery of the village, selected farming households and progressed towards the center of the village. Individual producers were first asked for consent to participate, and then a face-to-face interview was conducted once they agreed. Twenty-four producers refused to participate in the survey (6.26 % of 383). Interview was done at producers' house or at a local gathering spot. Household head in a family was first approached to answer the survey, however, if they were unable to answer the survey, he/she was assisted by other family members. While some producers answered the survey in English, a majority of them answered the survey in Nepali. The enumerators used a motorcycle to travel to the survey area. On an average, each enumerator completed 10-12 surveys per day. On average, each interview took approximately 20 minutes. The enumerators were paid a flat fee of $20 per day (Approximately Nepali Rupees 2,000). At the end of each day, we had a group discussion with the enumerators on the successes and challenges, ideas to improve the data collection process and those ideas were implemented in the next day of data collection. Also, the data entered was verified and any discrepancies were rectified through a discussion. Our sample was fairly representative of these three villages. The average household size (5.59) and mean annual household income (Nepali Rupees 230,862) of the sampled household were slightly above the district average (4.38) and Nepali average (4.88). The literacy rate (65.54%) of our sampled households was comparable to the national average (65.9%) and 11.44% below the district average. The head of the households that were female (20.33%) were 13.36% below the district average and 5.37% below the national average as shown in table 3. Dependency ratio (49%) was lower than both the district average (61.53%) and the national average (75.56%). Average age of the sampled producers (46.30 years) was lower than the national average (66.6 years). Rice yield (4.13 MT/Ha) were higher than both the district average (3.40 MT/Ha) and the national average (3.6 MT/Ha). Slightly more than two-third (68.5%) of the sampled producers are a member of farmers' group/cooperatives, which is higher than both the district average (55.72%) and the national average (24.91%). Slightly more than half (54.3%) of the sampled household used Extension services, which is higher than the coverage of public Extension at the national average (15%). Socio-economic, demographic, and farm level data were not available at the local village level; so, we compared our sample with the district level data (Central Bureau of Statistics and District Agricultural Development Office) and at the national level data (Central Bureau of Statistics and Food and Agricultural Organization).

Data were analyzed using both descriptive and analytical statistical tools. The descriptive statistics of the data collected from survey are presented in the results and discussion chapter section 4.1.

Table 3: Sample average, district average and national average of selected indicators

Indicators	Mean (n = 359)	Chitwan Average[1,2]	Nepal Average[3,4]
Household size (members)	5.59	4.38	4.88
% Female headed Household	20.33%	33.69%	25.7%
% Literacy rate	65.54%	76.98%	65.9%
Dependency ratio (%)	49%	61.53%	75.56%
Average Age (Years)	46.30	-	66.6
Farm size (Hectares)	0.47 (1.15 acres)	0.46 (1.13 acres)	0.68 (1.68 acres)
Rice yield (MT/Ha)	4.13	3.40	3.76
Annual Income (Nepali Rupees)	230,862	169,070	113,740
Membership in group/cooperatives (%)	68.5%	55.72%	24.91%*
Extension coverage (%)	54.3%	-	15%

Source: [1]Central Bureau of Statistics (CBS) 2018b; [2]DADO, 2017; and [3]CBS, 2019; [4]FAO, 2010,

*National Planning Commission (NPC), Fifteenth Plan (2020) (Includes all cooperatives members)

3.4 Maximum and Minimum Temperature Trends at Rampur, Chitwan, Nepal

Secondary data on weather parameters (data from 1981 to 2018 of rainfall, maximum and minimum temperature at Rampur, Chitwan) were obtained from the Department of Hydrology and Meteorology (DHM) and used for estimating weather trends. An analysis of at least 30 years' data of climatic variables is recommended by the Intergovernmental Panel on Climate Change (IPCC, 2007) to study climate change and variability. The trend of the data indicated that minimum temperature, maximum temperature, and average temperature increased by 0.0406^0C ($P<0.000$), 0.0045^0C, and 0.0226^0C ($P<0.000$) per year, respectively as shown in figure 5. The trend of increase in average temperature was highly significant over the years (and increased by approximately 0.9^0C for 38 years since 1981 to 2018).

The linear trend analysis of maximum and minimum temperature during the growing season of rice (June-October) indicated that both maximum and minimum temperatures increased at the rate of 0.0131^0C /year ($P<0.10$) and 0.0094^0C /year, respectively as shown in figure 6. Karna (2014) reported that rice yield will be declining above the threshold of the daytime mean maximum temperature of 29.9^0C (85.82^0F) during the ripening stage. The daytime maximum temperature was higher than the critical threshold which is an indication of further decline in rice yield in the study area if an effective adaptation measures will not be employed.

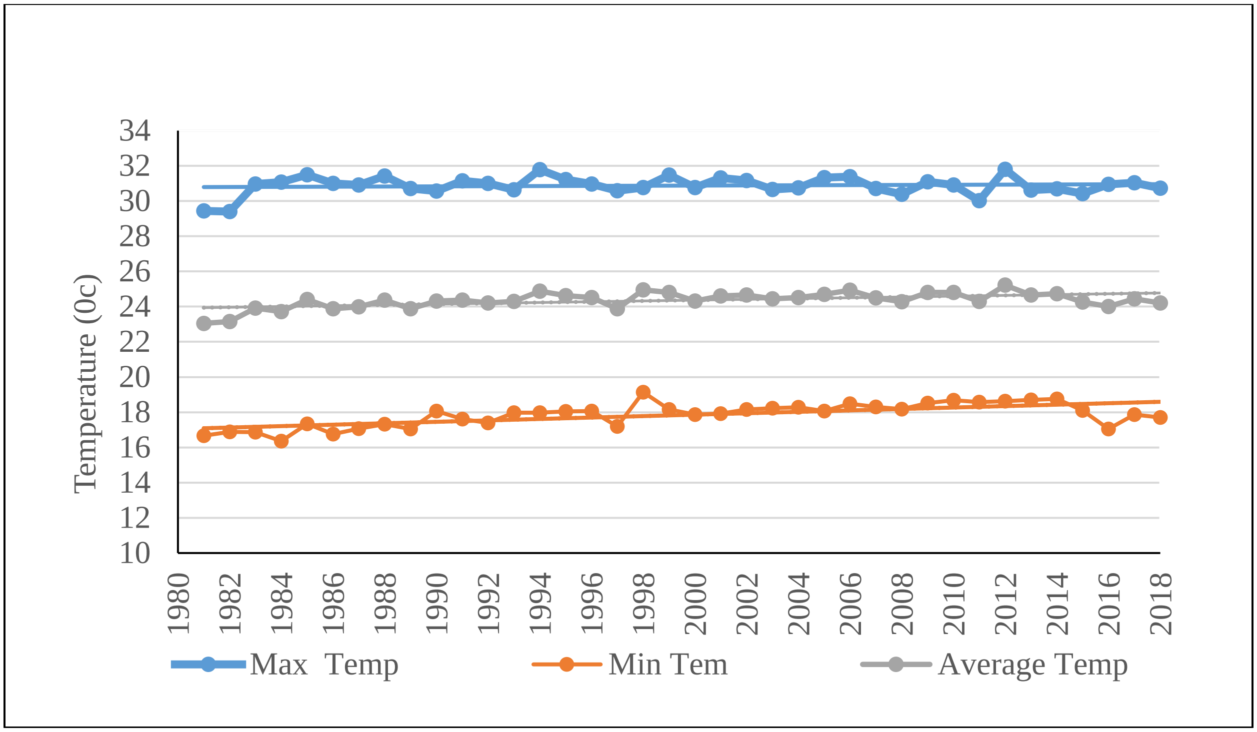

Figure 5: Trends of maximum, minimum, and average temperature at Rampur, Chitwan (1981-2018)

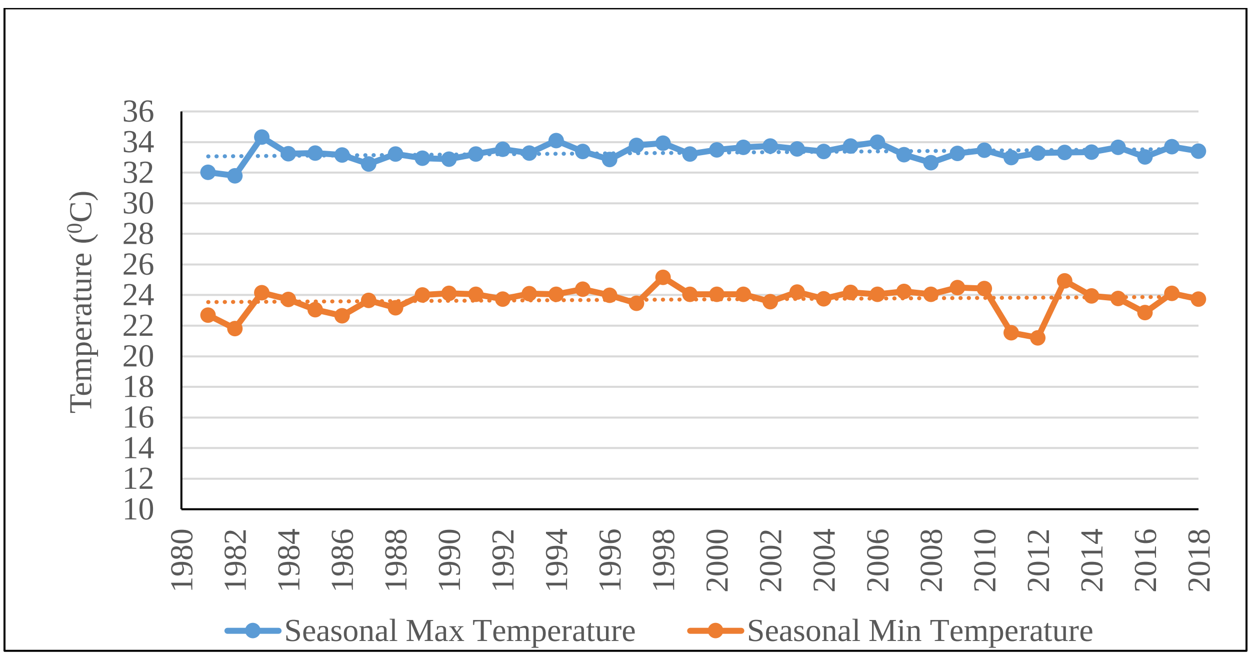

Figure 6: Trends of maximum and minimum temperature (Rice growing season) at Rampur, Chitwan (1981-2018)

3.5 Trends of Rainfall Data at Rampur, Chitwan (1989-2018)

The linear trend analysis of rainfall data indicated the irregular pattern of rainfall over the years. The total annual rainfall and seasonal rainfall (June-October) during the rice-growing season decreased by 6.54 mm (0.26 inches) per year and 7.59 mm (0.30 inches/year and approximately 227.7 mm, equivalent to 8.96 inches in 30-year period) per year as shown in figure 7.

The seasonal rainfall (June to September) is highly critical for the monsoon-based rice farming in Nepal. June and July precipitation are critical for transplantations and rice seedling growth The analysis of the last 20 years of rainfall data (1999-2018) showed that average monthly rainfall in June, July, and August was higher for the 1999-2008 period than 2009-2018 as shown in figure 8. However, September rainfall (starting of rice harvesting season) was higher for 2009-2018 than 1998-2006. Late onset of monsoon and less amount of June-August rainfall resulted in delayed rice transplanting (delayed by a week to a month) than the typical rice transplantation date of 29th June (*Asar* 15 on Lunar calendar is the typical rice planting day in Nepal also called National Rice Day).

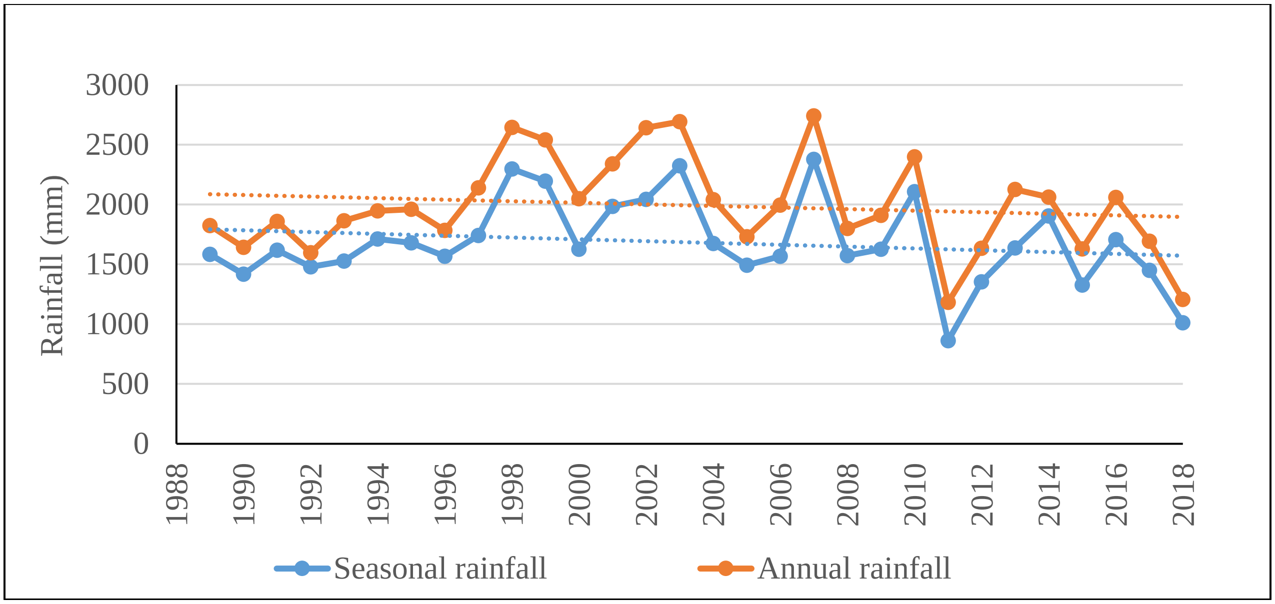

Figure 7: Trends of annual and seasonal (June-September) rainfall at Rampur, Chitwan (1989-2018)

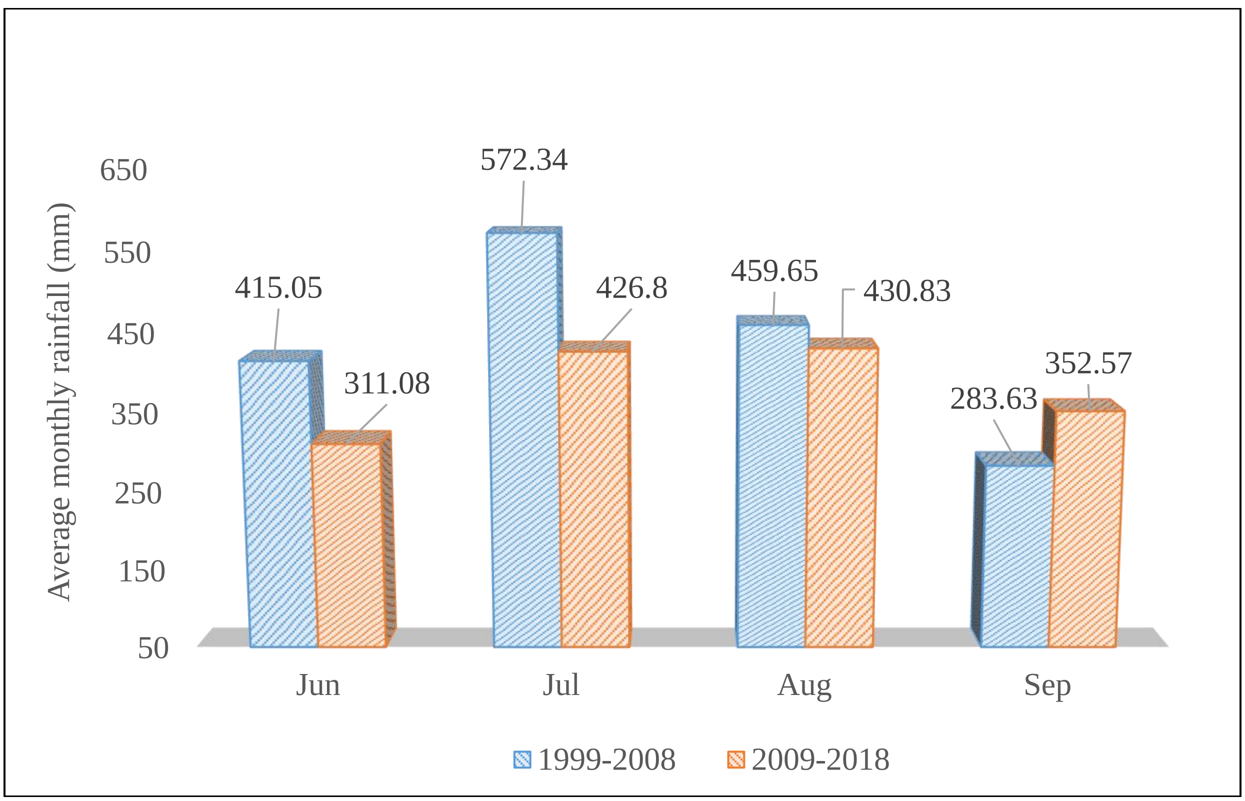

Figure 8: Seasonal (June-September) rainfall during two time periods (1999-2008; 2009-2018) at Rampur, Chitwan.

3.6 Calculation of Severity Index

Producers' perceptions of the severity of the adverse effects of changes in future weather events (changes in rainfall patterns, occurrence of dry period, occurrence of floods, depth to ground water table, and temperature) were measured by calculating a Severity Index (SI). The SI can be useful in planning of effective adaptation measures to address effects of future weather events in rice farming. The SI was calculated using Mazid and McCaffer's (1996) method, which is presented in equation 2.

$$SI = \sum_{i=1}^{4} a_i \, x_i \; / n \sum_{i=1}^{4} x_i \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, a_0 , a_1 , a_2 , a_3 , a_4 represents the response frequencies (of severity of adverse effects of changes in future weather events such as changes in rainfall patterns, occurrence of dry period, occurrence of floods, water-depth, and temperature) on a 5-point Likert scale $x_0 = 1, \; x_1 = 2, x_2 = 3, x_3 = 4, x_4 = 5$ and n = total number of respondents in a 5-point Likert scale. Then we used following criterion to analyze the severity index.

$x_0 = Strongly\ disagree, 0.00 \leq SI < 12.5$

$x_1 = Slightly\ disagree, 12.5 \leq SI < 37.5$

$x_2 = Neutral, 37.5 \leq SI < 62.5$

$x_3 = Slightly\ agree, 62.5 \leq SI < 87.5$

$x_4 = Strongly\ agree, 87.5 \leq SI \leq 100$

3.7 Empirical Model

Hypotheses

We used severity index and patterns of adoption to analyze our first two objectives; i.e., to understand producers' perceptions of climate change, to understand producers' perceptions of effects of climate variability on rice production, and to identify preferred adaptation strategies employed by rice producers

The first hypothesis is that there is a significant difference in perceptions about climate change and there is difference in rice production between adopters (adopting at least one adaptation practice) and non-adopters (if not adopting any adaptation practices). We compare the group means of adopters and non-adopters and use a t-test to determine whether the difference is significant or not.

H_0: There is no difference in perceptions about climate change and no difference in rice production between adopters and non-adopters.

H_1: There is difference in perceptions about climate change and difference in rice production between adopters and non-adopters.

Second, we hypothesize that producers' decisions on adoption are influenced by their household, demographic, socio-economic, financial, and institutional factors which aligns with objective 3 of this study (to identify the socio-economic and institutional factors influencing the adoption of adaptation strategies of rice producers in Chitwan). Thus, we will test a hypothesis that adoption of adaptation strategies is influenced by household, farm, socio-economic, financial, and institutional factors. We used a multivariate probit model to test this hypothesis.

H_0: Adoption of adaptation strategies is not influenced by demographic, socio-economic, financial, and institutional factors.

H_1: Adoption of adaptation strategies is influenced by demographic, socio-economic, financial, and institutional factors.

3.7.1 Multivariate Probit Model

A multivariate probit model was used to examine factors influencing adaptive capacity of the producers. The use of a linear regression model leads to biased and inefficient estimates in the case of binary outcomes or qualitative response variables (Greene, 2000). Thus, the discrete nature of producers' adoption response requires the use of a limited dependent variable model. Univariate models like logit and probit are common models to study a binary response (Gadédjisso -Tossou, 2015; Wooldridge, 2015). Univariate models assume that each adaptation strategy is independent and fail to capture the relationships between different adaptation strategies. Indeed, the adoption of each adaptation choice might be influenced differently by a set of explanatory variables, but the univariate model fails to capture such information (Piya et al., 2013).

Multinominal logit (MNL) and Multivariate probit (MVP) are best suited for dependent variables with multiple categories (Gbetibouo 2009; Gadédjisso-Tossou 2015). Studies by Addisu et al., (2016); Tazeze et al., (2012); Deressa et al., (2009); and Gbetibouo (2009) used a multinominal logit model to estimate the influence of household, socioeconomic, and institutional factors for adoption of different adaptation strategies. A major limitation of the multinominal logit model is that it assumes the choices are mutually exclusive, however a single producer can adopt/use more than one practice simultaneously or a combination of practices making explaining the influence of an explanatory variable to each practice is often difficult.

Thus, if the independence of irrelevant alternatives (IIA) assumption does not hold, the parameter estimates of MNL are biased because the error terms of each of the strategies are not correlated (Wooldridge, 2002; Kassie et al., 2013). Furthermore, the multinominal logit method also fails to account for potential correlation (complementary or competitiveness) among the different adaptation choices (Golob and Regan, 2002, Aryal et al., 2018).

A number of studies including Mulwa et al., (2017); Aryal et al., (2018), Nhemachena et al., (2014); Nhemachena and Hassan (2007); and Piya et al., (2013) used a multivariate probit model to study the influence of different factors on farm-level adaptation to climate change and variability. The computational difficulty is a drawback of the multivariate probit model. Depending upon the circumstances, producers can adopt a number of adaptation strategies, and a multivariate probit model helps to determine possible complements and substitutes among the choices. In our study, since there are binary dependent variables (multiple adaptation strategies), we used a multivariate probit model to study demographic, socio-economic, financial, and institutional factors influencing the adoption of multiple adaptation strategies in rice farming.

The general functional form of the multivariate probit model can be expressed as:

$$Y^*_{ij} = X'_{ij}\beta_j + \varepsilon_{ij} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (3)$$

Where, Y^*_{ij} is a latent variable representing the ith producer's $(i = 1, \dots \dots, N)$ utility derived from the adoption of the jth adaptation practice (categorical dependent variables; $j = 1, \dots \dots \dots, M$). X'_{ij} is a vector of explanatory variables, β_j are the unknown parameters, and ε_{ij} are random error components. The random error terms are distributed as a multivariate normal distribution with zero conditional mean and unitary variance; $\varepsilon_{ij} \sim N(0, \Omega)$, where, Ω is n x n covariance matrix. The covariance matrix is given by:

$$\Omega = \begin{bmatrix} 1 & \rho_{VI} & \rho_{VD} & \rho_{VP} & \rho_{VA} \\ \rho_{IV} & 1 & \rho_{ID} & \rho_{IP} & \rho_{IA} \\ \rho_{DV} & \rho_{DI} & 1 & \rho_{DP} & \rho_{DA} \\ \rho_{PV} & \rho_{PI} & \rho_{PD} & 1 & \rho_{PA} \\ \rho_{AV} & \rho_{AI} & \rho_{AD} & \rho_{AP} & 1 \end{bmatrix} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

The off-diagonal elements in the covariance matrix represents the correlation (unobserved) among the error terms of multiple adaptation practices. If the off-diagonal elements in the above matrix are non-zero, it allows for correlation across the error terms and justifies the use of a multivariate probit model instead of a univariate probit model. The unknown parameters are estimated using simulated maximum likelihood approach in multivariate probit model (Chib and Greenberg, 1998).

In our study, the ith producer $(i = 1 \dots \dots N)$ is more likely to adopt the jth practice (which denotes choice of practices: Variety (V), Irrigation (I), Direct Seeded Rice also called DSR (D), Integrated Pest Management also called IPM (P), and Adjustment in crop calendar (A), if the benefit of adoption (U_j) is higher than the benefit of non-adoption (U_0) (Lin et al., 2005; Mulwa et al., 2017, and Aryal et al., 2018). The net benefit that a producer derives from adoption $(Y^*{}_{ij})$ is a latent variable and is determined by the observed characteristics of the producer (explanatory variables X_{ij}: which includes household and demographic characteristics, farm characteristics, climate related factors, and institutional factors as presented in table 4) and unobserved characteristics (error term; ε_{ij}).

$$Y^*{}_{ij} = X'{}_{ij}\beta_j + \varepsilon_{ij} \quad (j = V, I, D, P, and \text{ A}) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (5)$$

The unobserved preferences in equation five is translated into observed binary outcome equation (Y_{ij}) using an indicator function as follows:

$$Y_{ij} = 1 \; if \; Y^*{}_{ij} > 0$$

$$= 0 \; if \; Y^*{}_{ij} \leq 0$$

$$(j = V, I, D, P, and\ A) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . . (6)$$

For each adaptation practice ($j = 1, \ldots \ldots, 5$), the equations of the multivariate probit model can be expressed as:

$$Y_{i1} = X'_{i1}\beta_1 + \varepsilon_{i1} \ (Variety) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (7)$$

$$Y_{i2} = X'_{i2}\beta_2 + \varepsilon_{i2} \ (Irrigation) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (8)$$

$$Y_{i3} = X'_{i3}\beta_3 + \varepsilon_{i3} \ (DSR) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (9)$$

$$Y_{i4} = X'_{i4}\beta_4 + \varepsilon_{i4} \ (IPM) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (10)$$

$$Y_{i5} = X'_{i5}\beta_5 + \varepsilon_{i5} \ (Adjustment) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (11)$$

The Multivariate Probit Model (MVP) is estimated by using simulated maximum likelihood estimation developed by Cappellari and Jenkins (2003) in STATA.

Selection of Variables Used in Econometric Modelling

(A) Selection of Dependent Variables

The selection of dependent variables (adaptation practices in rice farming) are based on National Adaptation Program of Action (NAPA) report (Ministry of Environment, 2010) and an in-depth review of literature. NAPA was developed and implemented by the government of Nepal in 2010 to reduce the impacts of climate change. Agriculture is one of the prioritized sectors in NAPA. NAPA mentions the number of adaptation strategies in the agricultural sector including the selection of drought-tolerant and short-duration varieties, investment in improved irrigation, and use of local plant extract and bio-pesticides for pest management (MOE, 2010). A number of studies mentioned the selection of crop variety, investing in water collection and improved irrigation, adjustment of crop planting date, integrated pest management, and livelihood diversification as important adaptation strategies to climate change and variability (Manandhar et al., 2011; Piya et al., 2013; Bigg et al., 2013). A study by Khanal et al., (2018) reported that the selection of varieties, improved irrigation, direct-seeded rice, fertilizer management, and adjustment in timing of farm operation are all major adaptation strategies adopted by rice farmers. Selection of varieties (drought tolerant and short duration), investment in irrigation structure, and direct seeding are important factors affecting rice yield in the context of variability in rainfall patterns. Integrated pest management strategies if adopted build crop resiliency by using pest tolerant and disease varieties which will in turn reduce the incidence of pest and diseases which are otherwise likely to be higher due to climate change. Changes in sowing time according to the onset of monsoon helps crop establishment and reduce crop-mortality due to lack of moisture in early crop-stages. Based on an in-depth review of the literature and NAPA report, our study focuses on analyzing the following five ongoing adaptation practices adopted by rice producers as dependent variables. They are: Variety (Growing drought tolerance, short duration, and disease/pest tolerance varieties); Irrigation (Investment in new canal/well and power backup systems, maintenance of existing irrigation systems; DSR (Adoption of direct seeding practice); IPM (Adopting Integrated Pest Management Practices); and planting Adjustments (Adjustment in crop calendar). Each of these adaptation practices are discussed in detail in results and discussions section 4.4.

(B) Selection of Explanatory Variables

The selection of explanatory variables influencing the adoption of adaptation strategies is based on an in-depth review of relevant literature. Many empirical studies enable us to select explanatory variables. We used 14 explanatory variables in our model with assumptions that, out of many factors, these are some of the important factors influencing the decision to adopt. The explanatory variables with an expected sign are presented in table 4 and each of these variables are discussed in detail in results and discussions section 4.1 under the heading descriptive statistics from survey. Household and farm-level characteristics are important factors that influence farmers' decisions to adopt adaptation strategies. Household characteristics like, gender of the household head, household size, years of farming, and education status are key determinants of adoption (Ali & Erenstein, 2017; Mulwa et al., 2017). We expect that gender of the head of the household might have a positive or a negative influence on the decision to adopt. Thus, we have no a priori expectations regarding the sign of the estimated coefficient. Consistent with the findings of Deressa et al., (2009), we expect that greater educational attainment of the household head implies better access to information on improved farming practices, and, thus, greater likelihood of adaption. A dependency ratio, which is the total number of dependent family members divided by total number of economically active members in the household, is used as a proxy for household labor availability. A family having a higher number of economically active family members has a greater labor force to adopt additional labor-intensive farming practices (Deressa et al., 2009). More experienced producers are expected to be more likely to adopt adaptation strategies. We expect that households whose member/s have migrated (for employment abroad) can influence the adoption decision in either way (positive and negative) depending upon income supplements from remittance. As noted by Hassan and Nhemachena (2008); Ali & Erenstein, (2017); Mulwa et al., (2017) and Nhemachena et al., (2014), we expect that higher household income has a positive influence on adoption. The farm characteristics, such as size of farm and number of parcels, are important factors influencing the adoption of adaptation practices (Mulwa et al., 2017; Nhemachena et al., 2014). We expect that producers having multiple plots and those who sold rice in the market in addition to self-consumption are more likely to adopt adaptation practices. Perceptions of producers, whether they perceived climate change and variability is another important factor and we expect that producers are adopting adaptation practices if they perceived changes in local weather patterns. Consistent with the previous studies by Deressa et al., (2009); Piya et al., (2013); and Abdulai and Huffman, (2014), we expect that access to weather information, better training and Extension services, and membership in farmers' co-operatives positively influence producers' decisions to adapt. It is generally assumed that if producers have access to weather information and are aware of the negative impacts of climate change, their likelihood of adoption will be higher.

Table 4: Descriptions and expected sign of explanatory variables used in econometric model

Variables	Descriptions	Exp. Sign
a. Household and Demographic characteristics		
Gender	=1 If female headed household, 0 otherwise	+/-
Dependency ratio	Household dependency ratio	-
Migrated	=1, If household member migrated, 0 otherwise	+/-
Education	Education year of household head	+
Farming years	Years of farming	+
Income	Nepali Rs. (000)	+
b. Farm characteristics		
Rice plots	Number of rice parcels	+
Rice sold	=1, If sold rice, 0 otherwise	+
Rice acreage	Hectares	+/-
c. Climate related factors		
Climate	=1 If perceived changes in weather pattern, 0 otherwise	+
d. Institutional factors		
Membership	=1, If member of farmers' institution, 0 otherwise	+
Extension	=1, If used extension services, 0 otherwise	+
Training	=1, If received training, 0 otherwise	+
Information	=1, If access to information, 0 otherwise	+

A multivariate probit (MVP) model provides the likelihood of adoption of particular practices and explains interrelatedness of practices but fails to differentiate between producers adopting single practices and adopting multiple practices. So, we used an ordered probit model to examine the factors influencing intensity of adoption.

3.7.2 Ordered Probit Model

Assessing the intensity of adoption is an important aspect of studying the producer's behavior. Estimating farm area under each practice is a good measure to study the intensity of adoption, however, due to complexities in assessing fragmentation of farm area under each practice, we used an ordered probit model to estimate the intensity of adoption by using the number of practices adopted as a dependent variable (Teklewold et al., 2013). The number of practices adopted were treated as a count variable and generally analyzed using a Poisson regression with an assumption of equal probability of occurrence (Wollni et al., 2010). However, the likelihood of adoption of first practices might differ from the likelihood of adopting a second, third, fourth, and so on practice with an assumption that producers gained some experience and were exposed to information about particular practices (Teklewold et al., 2013). Thus, the number of practices adopted were treated as an ordinal variable.

The functional form of an ordered probit model can be expressed as

$$Y^{**}{}_i = X'_i\beta + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Where, $Y^{**}{}_i$ represents a latent variable (utility of adoption of ith producers' $(i = 1, \ldots\ldots, N)$) indicating adoption of *j* number of practices (j represents the total number of adaptation practices adopted; $(j = 0, \ldots\ldots, J)$), X'_i is a vector of explanatory variables as presented in table 4, β is a vector of parameters to be estimated and ε_i is unobservable error (normally distributed; zero mean and unitary variance). Producers' decide to adopt more than one practice (additional practices) if utility gained from adoption is higher than non-adoption. The latent variable ($Y^{**}{}_i$) is unobserved and it is related to the observed level of intensity of adoption (Y_i) as follows:

$$Y = 0 \; if \; Y^{**}{}_i \leq 0$$

$$Y = 1 \; if \; 0 < Y^{**}{}_i \leq \alpha_1$$

$$Y = 2 \; if \; \alpha_1 < Y^{**}{}_i \leq \alpha_2$$

$$Y = 3 \; if \; \alpha_2 < Y^{**}{}_i \leq \alpha_3$$

$$Y_i = j \; if \; \alpha_{j-1} < Y^{**}{}_i \leq \alpha_j \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (13)$$

Where α_j are the threshold parameters (cutoffs) to be estimated through maximum likelihood estimation, and the probability of each outcome can be estimated as follows:

$$P(Y = 0|X) = (-X'{}_i\beta)$$

$$P(Y = 1|X) = \Phi\,(\alpha_1 - X'{}_i\beta) - \Phi\,(-X'{}_i\beta)$$

$$P(Y = 2|X) = \Phi\,(\alpha_2 - X'{}_i\beta) - \Phi\,(\alpha_1 - X'{}_i\beta)$$

$$P(Y = 3|X) = \Phi\,(\alpha_3 - X'{}_i\beta) - \Phi\,(\alpha_2 - X'{}_i\beta)$$

.

$$P(Y_i = j|X) = 1 - \Phi\left(\alpha_{j-1} - X'{}_i\beta\right)$$

Where, P is the probability and Φ is the standard normal cumulative distribution function (cdf). The results of multivariate probit model and ordered probit model are presented in results and discussion sections 4.6 and 4.7, respectively.

Assumptions of the study

1. Producers are adopting multiple adaptation strategies to minimize the impact of climate changes on their farm income.

2. The household characteristics, farm characteristics, climate-related factors and institutional factors are the major factors influencing the adoption of adaptation strategies. The number of practices adopted were treated as count variable and analyzed using a Poisson regression with an assumption of equal probability of occurrence in estimating ordered probit model.

CHAPTER IV. RESULTS AND DISCUSSIONS

The descriptive statistics from survey, severity index, results from analysis including, patterns of adoption, estimates of multivariate probit model, and ordered probit model are discussed in this section.

4.1 Descriptive Statistics from Survey

Table 5 presents statistics of producers' household, socioeconomic and farm characteristics.

a. Household Demographic and Socio-economic Characteristics

- **Gender:** Among survey respondents, most of the head of households (79.67%) were predominantly male and rest (20.33%) were female in the study area. The head of the household has an important role and influence in the decision-making process. The decision to adopt an improved practice is influenced by the training received by the individual, awareness, skills, and educational background of the individual.
- **Age**: The age of the sampled producers (head of the household) ranged from 21 to 80 years. The average age of the producers was 46.30 years. Household head was first approached to answer the survey, however, if they were unable to answer the survey, he/she was assisted by other family members.
- **Household Size, Economically Active Members and Dependency Ratio**: Average household size was found to be 5.59 in the study area, which is higher than the average of Chitwan district (4.38). The household size ranged from a minimum of two to a maximum of 15 members per household. Economically active family members are those who are in the age group between 16 and 60 years. All others are considered (children below 16 years and adults above 60 years) as dependent members. The survey indicated that the number of economically active household members ranged from 1 to 12. The

average number of economically active members per household was found to be 4.04. The economically active member only captures the number of active workforce available to work both on the farm and off-farm whereas dependency ratio captures the relative economic burden of dependent members in the household on the active workforce. Dependency ratio number of dependent family members/number of economically active family members was calculated as a proxy to estimate the farm labor availability in the household, and the average dependency ratio was 0.49, indicating 49% of the population were dependent on economically active members in the sampled households.

- **Education:** The number of literate family members ranged from 0 to 10, with an average of 3.66 literate members per household. The formal education years of household head ranged from 0 to 18, with an average of 7.92 years. The literacy rate in the study area was found to be 65.54%.
- **Farming Experience:** The experience of farmer in rice production ranged from 4 to 62 years, and average years of farming experience was 26.01. Based on their field experience, the producers' preferred particular strategies to be most suited for their farm.

Table 5: Summary statistics of producers' household, socio-economic, and farm characteristics (n=359)

Variables	Minimum	Maximum	Mean	Standard deviation
Gender of the household head (Female=1)	0	1	0.20	0.40
Age of the household head (Years)	21	80	46.30	10.14
Household size (No.)	2	15	5.59	1.73
Economically active members (No.)	1	12	4.04	1.42
Dependency ratio	0	6	0.49	0.65
Out-Migration for employment (Yes=1)	0	1	0.45	0.49
Literate members (No.)	0	10	3.66	1.50
Years of education of the household head	0	18	7.92	4.12
Years of farming of the household head	4	62	26.01	10.81
Nearest market distance (Kilometers)	0.50	20	6.36	6.49
Rice plots (No.)	1	5	1.65	0.79
Rice acreage (Hectares)	0.06	3	0.46	0.30
Rice harvest (Metric Ton)	0.20	15	1.92	1.32
Rice yield (Metric Ton/Hectares)	1.50	6.25	4.13	0.72
Membership in farmers' institution (Yes=1)	0	1	0.68	0.46
Household income (1,000 Nepali Rupees) *	0	1,250	230.86	162.39
Perceived climate change (Yes=1)	0	1	0.76	0.42
Use of Extension Services (Yes=1)	0	1	0.54	0.49
Participate in training (Yes=1)	0	1	0.44	0.50
Use of credit (Yes=1)	0	1	0.55	0.49
Access to subsidy (Yes=1)	0	1	0.49	0.50
Access to information (Yes=1)	0	1	0.54	0.49

* 1 USD = Approximately 110 Nepali Rupees (in 2019)

- **Out-Migration:** Out-migration status of the household members for employment were also collected as part of the survey. The migration status of the household members to other countries reduces the availability of labor force in farming activities. Out of the 359 sampled households, 45.9% of households had at least one member who migrated to another country for employment. During the household survey, respondents reported that a majority of the younger adults were migrating to the Middle-East and Gulf countries mainly to work as unskilled labor.
- **Income:** Household income is one of the key variables influencing the selection of a particular adaptation strategy. The average annual household income was NRs. 230,862 (equivalent to $2,098.70). The household income ranged from NRs. 0 to NRs. 1,250,000 (equivalent to $ 0 to $11,363.63).

The Nepalese farming system is characterized by an integrated farming system that includes diverse practices. Rearing livestock, growing multiple crops including cereals, fruits, vegetables, migrating household members for employment, and seasonal labor workers are common in farming households in Nepal. The survey revealed that off-farm sources (job, business, remittance) contribute a major share of household income (46.14%) followed by livestock/livestock products (24.59%), crops-excluding rice (15.31%), and income from rice (13.08%) as presented in figure 9. Relative trends of income sources over the past five years was assessed and presented in figure 10. A majority of the producers (51.53%) reported a declining trend of income from rice production, however, income from livestock and off-farm employment were increasing in 60.17% and 73.54% of households. A majority of the farmers (54.32%) reported no change in income from production of other crops (except rice). Out of a total of 359 households, only 78.5 % of households sold rice in the market, and the remaining 22.5% of household farm mainly for self-consumption. Overall, the share of income from rice production is low and shows a declining trend, producers are still involved in rice production which indicates that the value of rice production is greater than that of rice's contribution to aggregate household income.

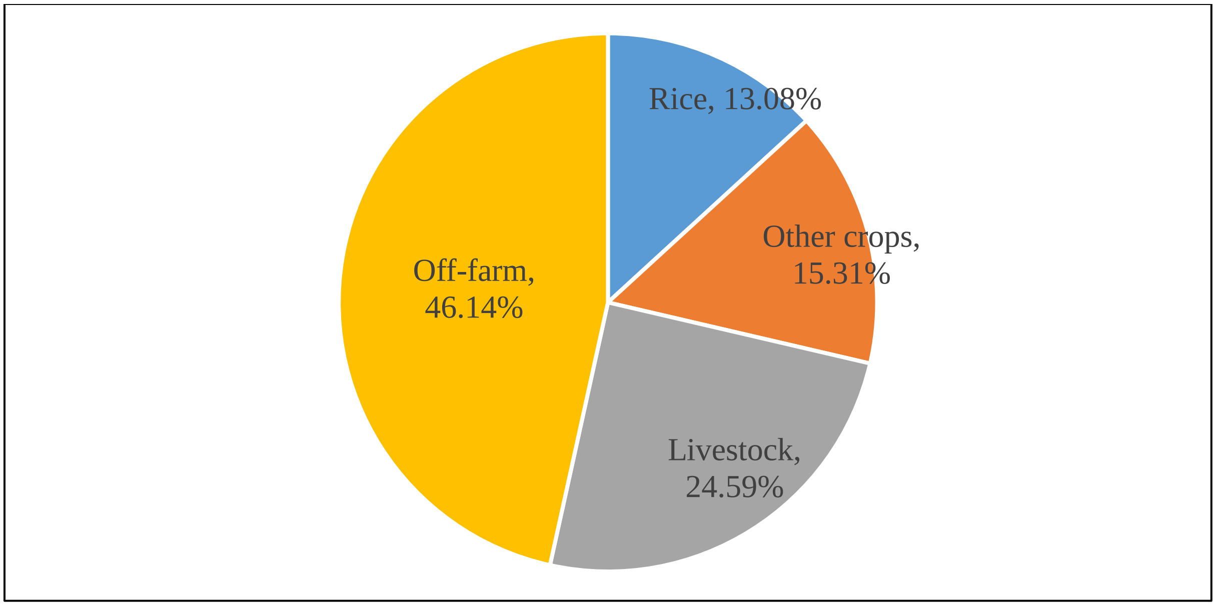

Figure 9: Share of household income from different sources (n=359)

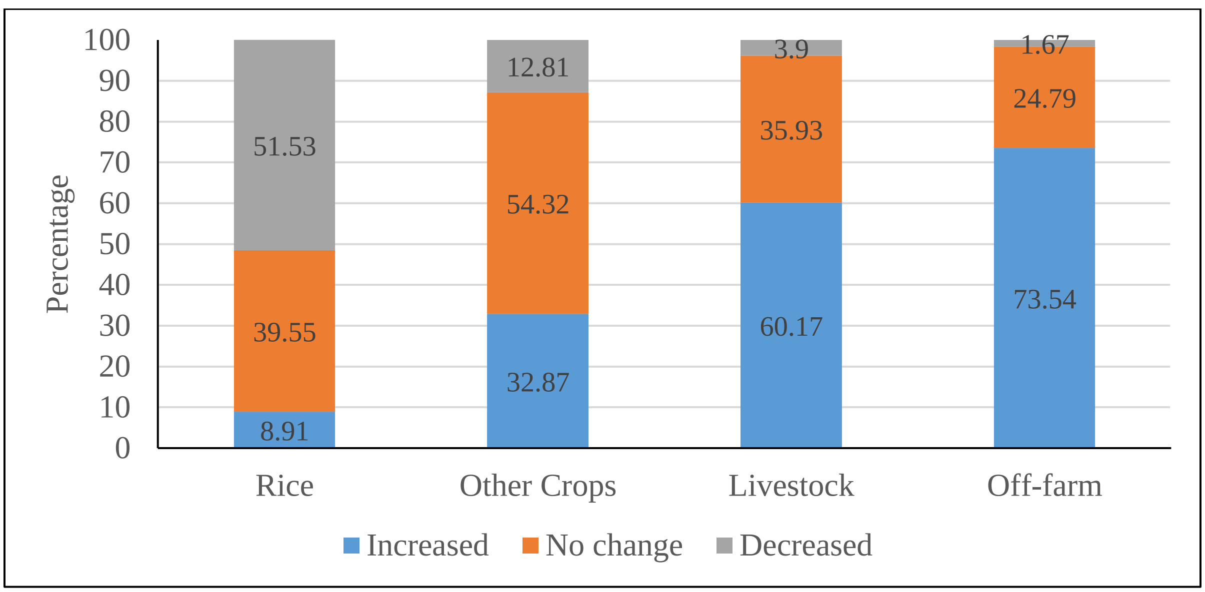

Figure 10: Overall trends of income sources in past 5 years (n=359)

b. Farm Characteristics (Number of Rice Plots, Rice Acreage and Yield)

The number of plots ranged from 1 to 5 per household. The average number of rice plots per household were 1.65. The rice acreage ranged from 0.066 hectares to 3 hectares per household. Similarly, the harvest of rice ranged from 0.2 Metric tons to 15 Metric tons (1 Metric ton = 1,000 Kg = 10 Quintal) per household. The mean rice harvest was 1.92 Metric tons per household.

c. Membership in Farmers' Institution

We collected information on whether the producers belonged to a farmers' institution or a cooperative. Out of 359 sampled households, 68.5% of producers (246) were members of a farmer group or a cooperative.

d. Producers' Perceptions of Climate Change and Variability

In our study, producers' perceptions were assessed through their response to whether they had perceived any changes in local weather patterns in the past ten years. The results indicate that out of 359 producers, 76.6% of producers' perceived changes in local weather patterns 23.4% producers did not perceive changes in local weather patterns in the past ten years.

A majority of producers perceived the increase in both average summer (86.9%) and average winter (61.9%) temperature, indicating that on an average, summers were getting relatively hotter and winters were getting relatively warmer, as compared to the past. The trend analysis of long-term temperature data (1981-2018) from Rampur, Chitwan strongly supports the farmers' perceptions of hotter summer and relatively warmer winter compared to past years. Most of the producers perceived an increased intensity of rainfall (80.8%), however, 51.09% of producers perceived a decreased frequency of rainfall. A majority of producers perceived an increase in both duration (71.38%) and frequency (56.52%) of dry periods. These results are consistent with the findings of Gurung and Bhandari (2009). They reported drought and erratic rainfall as an indicator for climate change and variability in Chitwan district. Occurrence of intense rainfall in a short period of time has a multitude of negative effects on monsoon-based irrigation systems including physical damage of crops, soil erosion, and occurrence of flash floods. Almost all producers perceived both increased weather unpredictability (99.64%) and occurrences of hailstorms (97.83%). Increased weather unpredictability affects the calendar of farm operations and the occurrence of hail/storms resulted in physical crop damage. Timely onset of monsoon is a crucial factor for good harvest in monsoon-based irrigation system. A majority of producers reported late onset of monsoon (86.23%). Late onset of monsoon is one of the critical factors for declining rice production by delaying planting dates, shortening growth stages, and poor crop establishments. Analysis of rainfall trends strongly supports the producers' perceptions of the occurrence of irregular rainfall patterns during the rice-growing season. A majority of the producers (86.23%) also reported that groundwater table was depleting, which has two consequences. First, it becomes difficult to irrigate crops due to less water availability and it also increases the cost of irrigation through pumps. Another concern is that as weather becomes more unpredictable and the monsoon season is delayed as in recent years, over-extraction of groundwater may lead to a further decline in the water table, and it endangers the sustainability of groundwater resources. The linear trend analysis of long-term precipitation data (1989-2018) obtained from Department of Hydrology and Meteorology for Rampur, Chitwan supports the farmers' perceptions of irregular rainfall patterns during the rice-growing season over the years. Gurung and Bhandari (2009) also reported drought and erratic rainfall as an indicator for climate change and variability in Chitwan district. Details of producers' perceptions of weather parameters/events are presented in figure 11

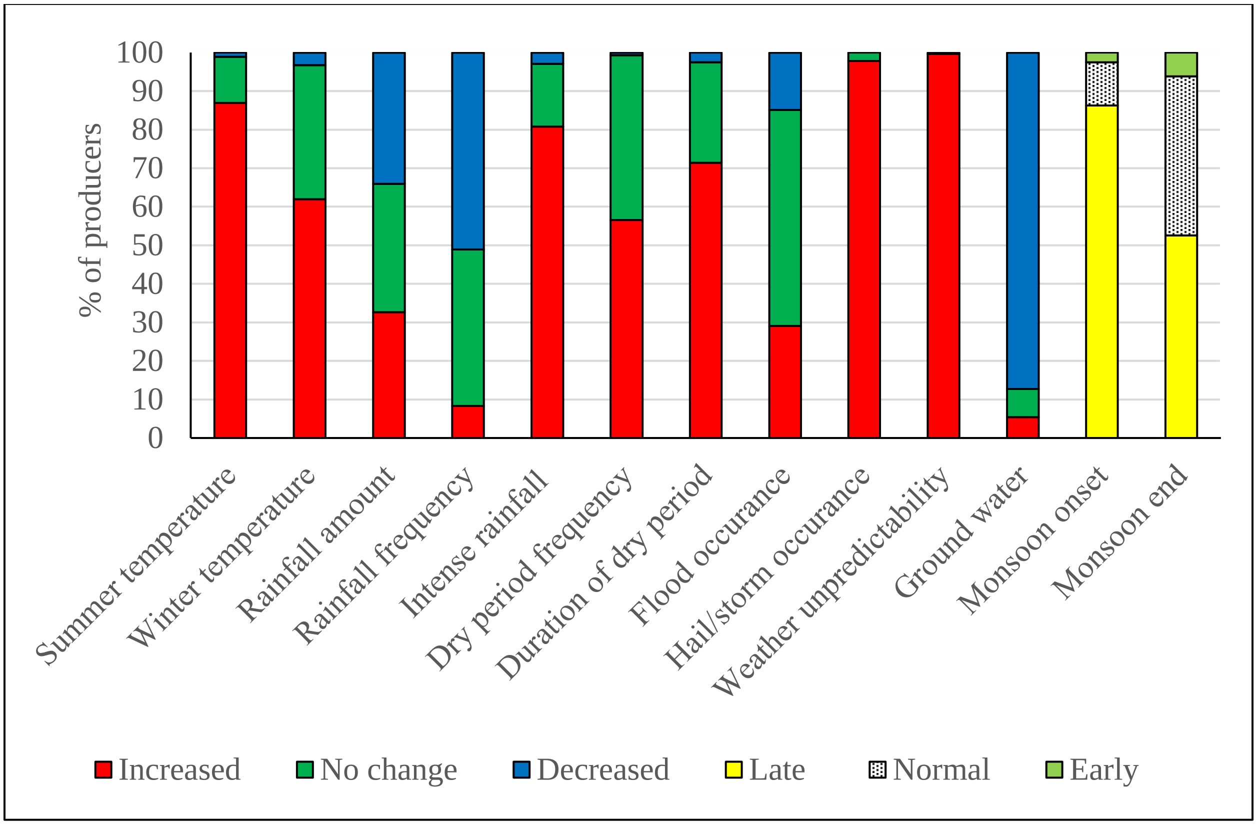

Figure 11: Producers' perceptions of changes in local weather parameters/events in the past 10 years (n=275)

e. Use of Extension and Training

The use of Extension services was assessed by asking respondents whether they had visited an Extension office or if Extension worker had visited their farm. Slightly more than half (54.3%) of sampled households (195) had used Extension services. Producers were also asked whether they had participated in any kind of climate change adaptation related trainings, and their responses were collected. Some governmental organizations and private institutions organized training related to agriculture and climate change adaptation. Out of a total of 359 sampled households, an average of 44% of households (158) had participated in climate change related training. Producers were also asked what kind of training they preferred to enhance adaptation to climate change as an open-ended question, and the producers answered about training related to improved production practices, access and use of weather-related information, and climate-smart agricultural practices. In the household survey and informal discussion with producers, it was identified that producers indicated an interest to increase access to Extension services and participation on climate change adaptation training.

f. Use of Credit and Subsidy

It was quite difficult and challenging to collect precise information on access to credit. In our study, access to credit refers to the ease with which producers can obtain the finances required for farming at a reasonable interest rate. Out of the 359 sampled households, on average, 55.9% households (201) had used credit for farming. The sources of farm credit are presented in table 6. Very few households (10.02%) reported that they do not need credit to invest in their farming activities. The survey results revealed that microfinancing (saving groups/cooperatives) was the major source of credit (84.57%), followed by borrowing from friends/relatives (15.92%), banks (13.93%), and moneylenders (10.44%) The producers may have used multiple sources to finance farming activities and hence the total may add up to more than 100%. A total of 44.02% of producers (158) did not used credit for farming. Out of the 158 producers, 74.68% of producers reported that they had not used credit due to high interest payments, followed by no need of credit (22.78%) and very few producers (2.53%) replied that taking credit was a burdensome process. In the household survey, producers reported that interest rate charges by money lenders were quite high, the minimum interest rate was 24% and a maximum of 48%, and occasionally it could be as high as 60%. In addition, there are a number of subsidized farm loan schemes offered through the government and private commercial banks, however, not many smallholder producers utilize them. They preferred microfinance groups and cooperatives because of ease of access, faster approval, low interest rate (usually 12% or less per annum), availability at the village level, no collateral requirements (in most cases), and a less burdensome process of application and reporting to access credit. Overall, it was noted that the formation of farmer groups and cooperatives, mobilization of their saving funds, and micro-financial institutions at the village level are milestones for access to credit service.

Table 6: Sources of farm credit for rice production (n=201)

Particulars	Number of producers	Percentage of producers*
Microfinance	170	84.57
Bank	28	13.93
Friends/relatives	32	15.92
Moneylenders	21	10.44

*percentage not equal to 100 due to multiple answers.

Nepalese agriculture is characterized by the dominance of smallholder farmers and traditional farming practices. Provision of subsidies in farming is one of the prioritized programs of the Government of Nepal since the early nineties. Producers were also asked to indicate three most preferred subsidies among variety (drought tolerant and short duration), irrigation, farm machinery and tools, fertilizers, and subsidized farm loans. Out of 359 households, nearly half of the households (49.8%) had access to subsidies (i.e., that could obtain subsidies) in rice farming (179 producers). The survey results revealed that subsidies for irrigation scheme (53.48%) was the most preferred, followed by farm machinery and tools (23.67%), and crop variety (16.15%) in first priority. In second priority, farm machinery and tools (49.86%) was most preferred, followed by irrigation (23.95), and variety (15.87%). In third priority, chemical fertilizers (56.55%) was most preferred, followed by variety (17.82%), and farm machinery and tools (9.49%) as presented in figure 12.

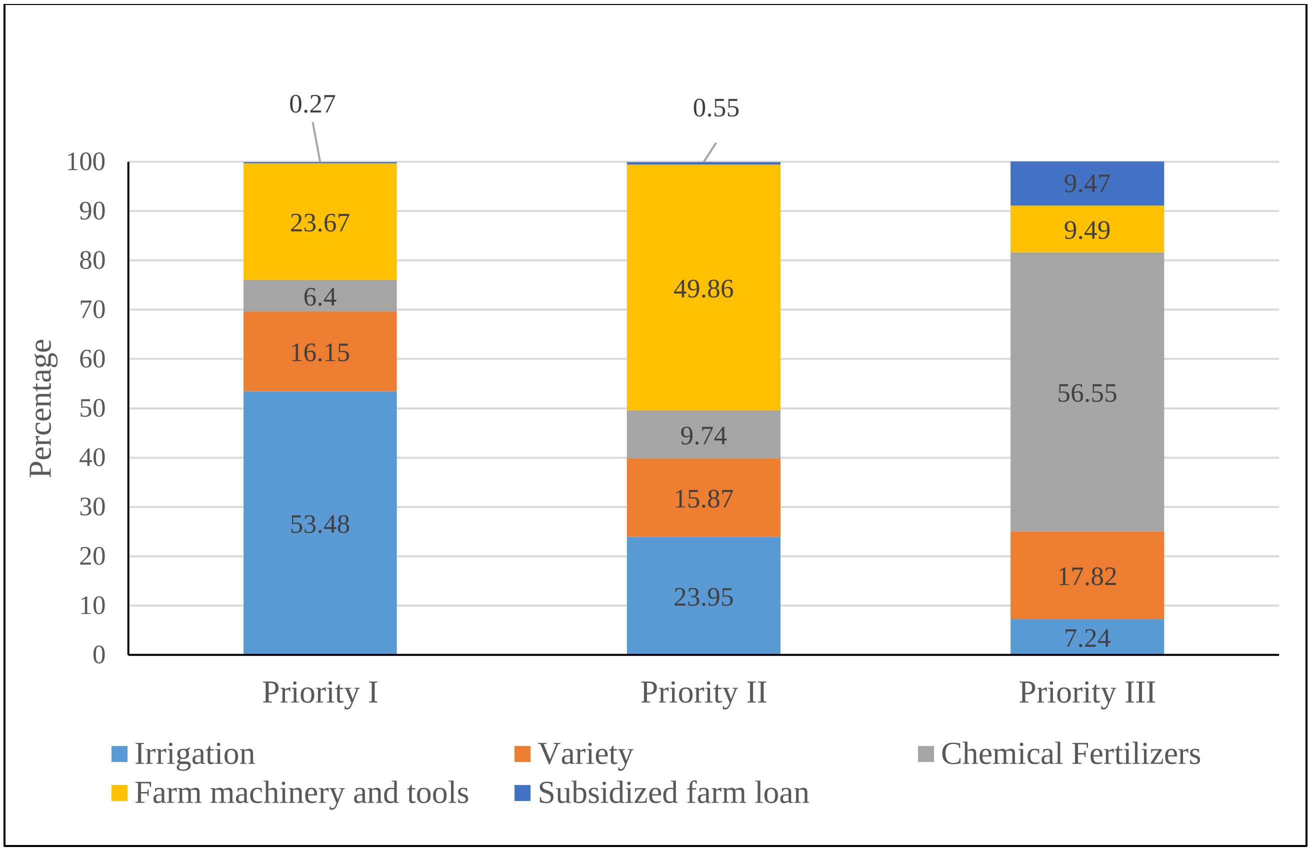

Figure 12: Producers' preferences for subsidies (n=359)

g. Access to Weather and Adaptation Information

Access to weather information is not only important for how producers perceive climate change, but also to how they adapt to reduce the negative impacts of all those changes. A majority of the producers (73.25%) had Television (TV)/FM radio (at least either TV or FM radio or both), and 27.85% of producers had internet connection as presented in table 7. Slightly more than one third (35.65%) of producers had received text messages regarding weather and agricultural related information, and about 25.34% of producers used mobile apps for getting weather and agricultural related information. In addition, producers' preferences for use of information sources were collected (by asking which information source you prefer to use mostly) and found that a majority of the producers preferred FM radio (96.65%), followed by TV (95.82%), Extension publications (67.40%), mobile application (29.80%), internet (8.91%), and agro-advisory (5.01%). The producers preferred multiple information sources and hence the total may add up to more than 100%. The preference of producers for FM radio, TV, and Extension publication might be due to low cost and readily available nature as compared to the use of internet and mobile applications which are relatively expensive in Nepal.

Table 7: Various sources to access weather and adaptation related information (n=359)

Sources	Number of Producers	Percentage of Producers*
TV/FM radio	263	73.25
Internet	100	27.85
Text message	128	35.65
Mobile apps	91	25.34
Producers’ preference for information sources (n=359)		
Sources	Number of Producers	Percentage of Producers*
FM radio	347	96.65
TV	344	95.82
Mobile apps	107	29.80
Internet search	32	8.91
Agro-advisory	18	5.01
Extension publication	242	67.40

*percentage not equal to 100 due to multiple answers.

4.2 Severity Index

A severity index (SI) was calculated to study producers' perceptions of the severity of adverse effects of potential changes in future weather-related events on rice production. The SI values ranges from 0 to 100. A low SI value indicates relatively less severity of adverse effect of weather-related events on rice production and a high SI value indicates relatively higher degree of severity of adverse effect of weather-related events on rice production. The SI values of adverse effects of change in future rainfall patterns, change in occurrence of dry periods, changes in occurrence of flood, change in water depth, and change in temperature were 88.25%, 86.41%, 66.46%, 62.12%, and 67.58%, respectively as shown in table 8. The highest SI values (of change in future rainfall patterns and change in occurrences of dry periods) indicates that producers are concerned with the availability of irrigation water in rice field Furthermore, canal water flow is largely determined by the frequency and amount of monsoon. Indeed, prolonged dry spells and insufficient canal/groundwater availability is detrimental for rice growth and yield. Computation of SI values indicate that a majority of the producers perceive that rice farming will be affected in the future due to changes in weather-related parameters.

Table 8: Calculation of severity index (SI) of producers' perceptions of adverse effect of changes in future weather-related parameters (n=359)

Weather related parameters		Strongly Disagree	Slightly Disagree	Neutral	Slightly agree	Strongly agree	SI	
		1	2	3	4	5	Value	%
Change in rainfall pattern	%	0.56	2.51	1.39	46.24	49.3	4.41	88.25
Change in occurrence of dry period	%	0.00	1.11	8.36	47.91	42.62	4.32	86.41
Change in occurrences of floods	%	10.58	13.09	32.59	20.89	22.84	3.32	66.46
Change in water-depth	%	12.26	8.36	49.58	16.16	13.65	3.11	62.12
Change in temperature	%	4.18	4.74	49.58	32.03	9.47	3.38	67.58

4.3 Producers’ Perceptions of Impacts of Climate Change in Rice Farming

Producers answered the question on perceived adverse climate change impacts on rice production as presented in figure 13. Producers over the past three years dealt with a delay in monsoon during planting time. Out of 359 producers, a majority of producers faced difficulties in transplanting seedlings (77.94%) and a reduced/shortage of irrigation water in rice fields (68.52%). Nearly two-fifth of the producers (40.66 %) reported loss of crop due to water stagnation/flooding and 29.54% of producers reported loss of crop due to rainfall during harvesting period. Concurrent to the untimely monsoon, producers also perceived an increase in incidence of disease/pests (95.26%) and weeds (93.03%) in rice fields.

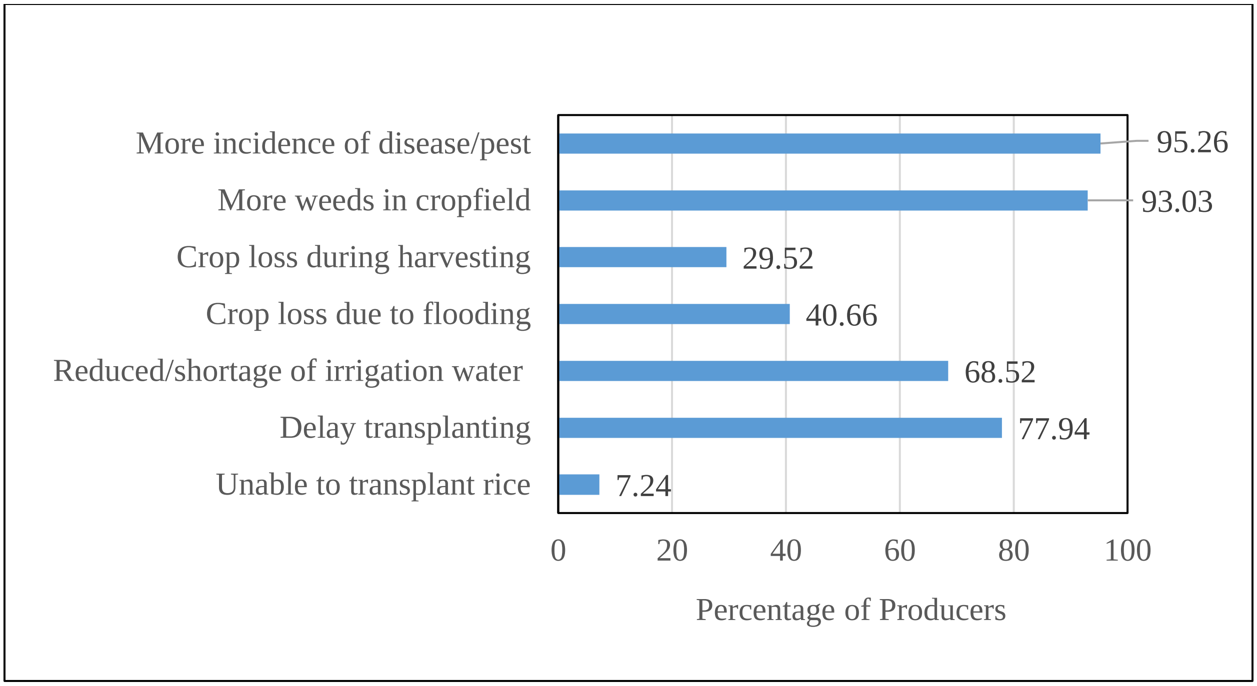

Figure 13: Producers’ perceptions of impacts of climate change and variability in rice farming (n= 359)

A majority of producers (78.27%) reported that less than 25% of rice yield decline due to climate change. 21.45% of producers reported 25-50% of yield decline, and a single producer reported a greater than 50% yield decline.

4.4 Adaptation to Climate Change and Variability in the Study Area

A. Selection of Varieties

Rice producers' in the study area were found growing drought-tolerant, short duration, and disease as well as pest tolerant varieties. Out of 359 households, only 64.90% (233) of households adopted varietal management. During the household survey, producers reported that they replaced traditional, long-duration rice varieties: *Aapjhutte, Anadi, Dhudhraj, Gurdi, and Mansara*. They also replaced *Mansuli* due to higher disease infestation. Improved varieties including *Hardinath, Sukkhadhan-2, Sukkhadhan-4, and Ramdhan as well as hybrid varieties* such as *Garima, Gorakhanath, and Loknath* were the most popular varieties found in the study area. Furthermore, these are relatively short duration varieties, and can have better yield potential, than traditional varieties even in reduced irrigation, except for *Ramdhan*. In the case of adequate rainfall conditions, producers preferred *Ramdhan* because of its superior taste of the grain and increased tolerance to disease and pests.

B. Improved Irrigation

Information about investing in improved irrigation and adoption of water conservation measures was collected. Out of 359 households, 60.7% (218) of households invested in water infrastructure and water conservation. Producers invested in new irrigation infrastructure like digging new wells, buying electric motors to pump water, cleaning and maintenance of existing wells, and canals for better water flow. In a few areas, producers reported that they constructed deep tube wells under joint investment with neighboring producers. They shared their views that joint investment is highly useful in reducing irrigation costs. The neighbors followed a rotational schedule to irrigate their crops. In some areas, producers also conserve water in lowlands (Wetland- also called *Ghol* in Nepali). They constructed earthen structure as a barrier to surface run-off and the accumulated water was utilized by pumping it for irrigation. In addition, information on access of electricity connection to pump water and suitability of solar panel as an alternative to electricity connection was collected. It was found that 78.55% of producers' rice fields have access to electricity, and 95.82% of producers reported that installing solar panels will be more beneficial than running electric motors since electric power shortages are a common occurrence. During discussions, producers preferred subsidized solar panels as most of them faced a low voltage in power supply that prevented them from running electric motors during summer months when demand for electricity is typically higher.

C. Direct Seeded Rice (DSR)

In our study, out of 359 producers, only 15.60% (56) of producers adopted DSR. Producers can adopt DSR irrespective of the availability of water for land preparation and may not depend on onset of monsoon. However, as indicated by Joshi et al., (2013), during the household survey, producers shared their views that weed management is challenging in DSR Furthermore, disease and pest incidence were also higher in DSR compared to transplanted rice. The major benefits they realized by using DSR was that they do not need to wait for the onset of monsoon, it requires less labor, and producers can harvest early. Early harvest compared to transplanted rice provides enough time for land preparation, particularly for vegetable growers.

D. Integrated Pest Management (IPM)

Integrated pest management (IPM) strategies were initiated in Nepal in late nineties with technical support of Food and Agricultural Organization (FAO) after an outbreak of Brown Plant

Hopper (BPH) in rice in Chitwan district (FAO, 2011). Then, IPM was extended to other districts and other crops through farmers field school (FFS) approach. In our study, out of 359 producers, only 22.56% (81) of producers adopted IPM practices. During the discussion with producers, it was identified that those producers who have concerns about soil fertility and crop/human health adopted IPM practices. During the field survey, producers also reported that they were reluctant to apply pesticides in their plots, however when neighbors applied pesticides, producers applied pesticides in their own field to prevent likely crop damage.

E. Adjustment in Crop Calendar

Out of 359 producers, 72.98% (262) of producers adjusted their planting time. Based on the timing of onset of monsoon, producers adjusted their crop calendar. Despite investing in new irrigation schemes, there may not be enough surface water and ground water recharge to meet the water requirements for rice planting if there is late onset of monsoon and less rainfall. Furthermore, during the survey, producers shared their views that the seedling mortality rate is quite high if they transplant without adequate moisture in the soil. Producers also recalled that they transplanted older aged seedlings during late monsoon years (>30 days). Transplanting older aged seedlings may resulted in poor crop establishment, and disease-pest infestations might be higher in such plots.

4.5 Analyzing Patterns of Adoption

Producers employed many practices based on their existing knowledge, farming experience, and influence of exogenous factors. Identifying producers' preferred adaptation practice and combination of practices are important to formulate appropriate long-term adaptation strategies. Studying adoption patterns of best management practices (Lambert et al., 2014) and estimating probabilities of adoption of sustainable agricultural practices (Teklewold et al., 2013) helps in identifying producers preferred combination of practices (bundle of practices). Out of a total of

359 households, 76.60% of households adopt at least one adaptation strategy. Among all five adaptation strategies (Variety (n =233), Irrigation (n= 218), DSR (n=56), IPM (n=81), and Adjustment (n=262)), adjustment in crop calendar (72.98%) was the most common, and direct-seeded rice (15.60%) was the least common strategy employed by rice producers. The reason behind the higher level of adoption of adjustment in crop calendar might be due to the relatively low cost in terms of efforts and ease of implementation. A potential 32 combination of practices (2^5 =32) are possible as shown in table 9. (The percentage of producers who exclusively adopted single practice or a group of practices are presented in Appendix A - Table A.2).

If the producers adopted two practices; variety and planting adjustment (62.40%) were the most commonly adopted practices whereas DSR and IPM (10.86%) were the least commonly adopted practices.

If the producers adopted three practices; variety, irrigation, and planting adjustment (55.99%) were the most commonly adopted practices whereas irrigation, DSR, and IPM (10.03%) were the least commonly adopted practices.

Furthermore, if the producers adopted four practices; variety, irrigation, IPM, and planting adjustment (21.45%) were the most commonly adopted practices whereas variety, irrigation, DSR, and IPM (10.03%); and irrigation, DSR, IPM, and planting adjustments (10.03%) were the least commonly adopted practices.

Analyzing patterns of adoption indicate that only 10.03% of producers adopted all five practices. Overall, variety and planting adjustments (62.40%); variety and irrigation, (57.38%); and variety, irrigation, and planting adjustments (55.99%) were the most commonly adopted practices among all possible combinations. The selection of varieties, investment in improved irrigation, and adjustment in crop calendars are important strategies to reduce the negative impacts of climate change. Adoption of variety and planting adjustments is not surprising, as growing short-duration variety requires the adjustment of transplantation timing based on the onset of monsoon. The adoption of variety and irrigation could be because the adoption of improved and short-duration varieties requires assured irrigation facilities. Furthermore, variety and availability of irrigation water are the most important inputs in rice farming, once producers planted an improved variety, along with other management practices, without assured irrigation, yield cannot be enhanced. Thus, producers were motivated to invest in both practices. The analysis of patterns of adoption indicates that producers tend to adopt more than one practices rather than adopting single practices, and it appeared reasonable, as rice farming requires adoption of multiple practices to get maximum yield.

The results indicate that 23.40% of producers had not adopted any practices. The reasons for non-adoption of adaptation strategies were elicited by asking why the producers did not adopt any practices. The results indicate that Lack of relevant information and inadequate technical know-how are the major reasons for not taking up all the adaptation practices except investment in improved irrigation. Unable to invest in water infrastructure (59.6%) is the main reason for not adopting improved irrigation. The reasons for non-adoption are presented in figure 14. Improved education and providing technical training to producers may improve adoption of most of these adaptation practices.

Table 9: Patterns of adoption of adaptation practices

Combination of adaptation practices	Mean (n=359)	Std. Dev.
Single practice		
Adjustment (ADJ)	0.7298	0.4447
Variety (VAR)	0.6490	0.4779
Irrigation (IRR)	0.6072	0.4890
IPM	0.2213	0.4186
DSR	0.1560	0.3634
Two practices		
VAR+ADJ	0.6240	0.4851
VAR+IRR	0.5738	0.4952
VAR+IPM	0.2256	0.4186
IPM+ADJ	0.2256	0.4186
IRR+IPM	0.2145	0.4110
IRR+ADJ	0.1822	0.4939
DSR+ADJ	0.1560	0.3634
VAR+DSR	0.1504	0.3580
IRR+DSR	0.1309	0.3378
DSR+IPM	0.1086	0.3116
Three practices		
VAR+IRR+ADJ	0.5599	0.4971
VAR+IPM+ADJ	0.2256	0.4186
VAR+IRR+IPM	0.2145	0.4110
IRR+IPM+ADJ	0.2145	0.4110
VAR+DSR+ADJ	0.1504	0.3580
VAR+IRR+DSR	0.1309	0.3378
IRR+DSR+ADJ	0.1309	0.3378
VAR+DSR+IPM	0.1086	0.3116
DSR+IPM+ADJ	0.1086	0.3116
IRR+DSR+IPM	0.1003	0.3008
Four practices		
VAR+IRR+IPM+ADJ	0.2145	0.4110
VAR+IRR+DSR+ADJ	0.1309	0.3378
VAR+DSR+IPM+ADJ	0.1086	0.3116
IRR+DSR+IPM+ADJ	0.1003	0.3008
VAR+IRR+DSR+IPM	0.1003	0.3008
All five practices (VAR+IRR+DSR+IPM+ADJ)	0.1003	0.3008
No Adopter	0.2340	0.4240

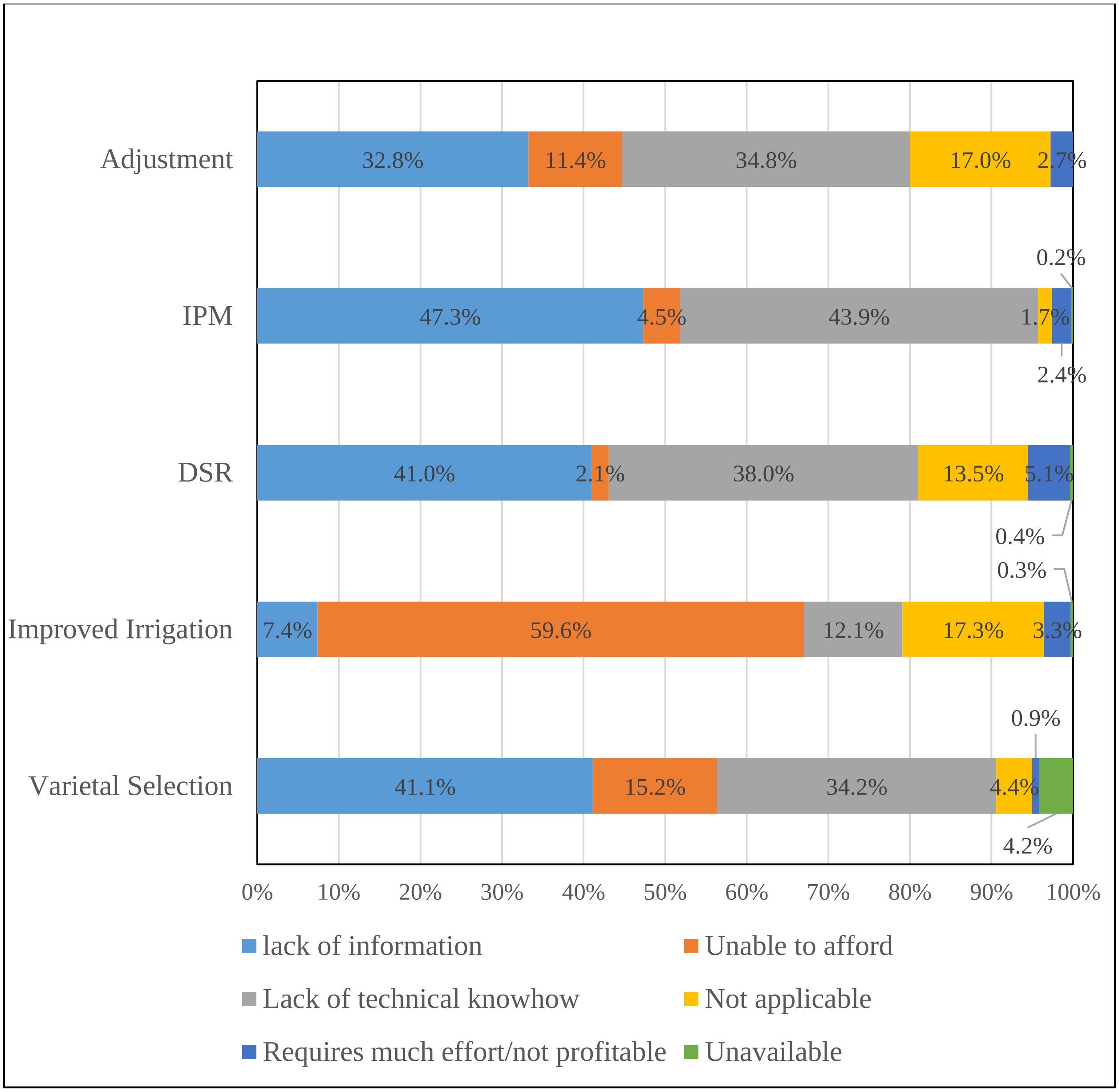

Figure 14: Reasons for non-adoption of adaptation strategies (n=84)

4.6 Household and Socio-economic Characteristics of Adopters and Non-Adopters

We categorized the producers as adopter if they adopted at least one adaptation strategies and non-adopters otherwise. Group means of adopters and non-adopters including mean differences are presented in table 10. The adopters tend to be male headed household and non-adopters tend to be female headed households. There are significant differences between adopters and non-adopters in having number of economically active family members, dependency ratio, and years of education. Years of education and number of economically active family members are high in adopter households and dependency ratio were high in non-adopter households. The difference of average rice yield between adopters and non-adopters is 227 Kilogram/hectares and it is statistically significant. Furthermore, Adopters have significantly larger rice acreage and higher household income. There are significant differences between adopters and non-adopters in rearing livestock and selling rice to market. In addition, there are significant differences between adopters and non-adopters in perceiving climate change and variability, membership in farmer institutions, access to Extension, training, credit, subsidies, and information, which indicates that majority of adopters access those services.

Table 10: Characteristics of Adopters and non-Adopters (mean comparison)

Variables	Adopters (n= 275)		Non-Adopters (n=84)		
	Mean	SE	Mean	SE	Difference
Gender of HHs head (Female=1)	0.127	0.020	0.452	0.050	-0.325***
Age of HHs head (Years)	46.250	0.600	46.32	1.120	-0.070
Economically active members (No.)	4.140	0.080	3.710	0.130	0.430**
Dependency ratio	0.443	0.030	0.667	0.080	-0.224**
Out-Migration (Yes=1)	0.461	0.300	0.452	0.540	0.009
Education years of HHs head	9.116	0.210	4.035	0.340	5.081***
Literate family member (No.)	3.970	0.080	2.666	0.110	1.304
Farming years of HHs head	26.509	0.640	24.392	1.200	2.117
Rice plots (No.)	1.683	0.040	1.571	0.090	0.112
Rice sold (Yes =1)	0.840	0.020	0.607	0.050	0.233***
Yield (MT/Hectare)	4.190	0.040	3.963	0.080	0.227**
Rice acreage (Hectare)	0.486	0.010	0.403	0.040	0.083*
Livestock (Yes=1)	0.956	0.010	0.583	0.050	0.373***
Membership (Yes=1)	0.807	0.020	0.285	0.040	0.522***
Income (000, NRS.)	239.88	10.480	201.300	12.310	38.580**
Perceived climate change (Yes=1)	0.920	0.010	0.261	0.040	0.659***
Use of Extension Services (Yes=1)	0.665	0.020	0.142	0.030	0.523***
Training (Yes=1)	0.552	0.030	0.071	0.020	0.481***
Use of credit (Yes=1)	0.680	0.020	0.166	0.040	0.514***
Access to subsidy (Yes=1)	0.629	0.020	0.071	0.020	0.558***
Access to information (Yes=1)	0.687	0.020	0.083	0.030	0.604***

4.7 Determinants of Adaptation Strategies

The Wald test (Wald chi^2, $\chi^2(70) = 471.92$; Prob > $\chi^2 = 0.000$) was highly significant and rejected the null hypothesis that all regression coefficients in MVP are jointly equal to zero and showing that the model fits the data well. The assumptions of possibilities of interdependence (complements or supplements) among adaptation practices were tested by using pair-wise correlation coefficients across the residuals of multivariate probit model and presented in table 11. (The results of independent probit model of five adaptation strategies and ten bivariate probit estimates of adopting two adaptation practices are presented in Appendix A - Table A.3, and Appendix A - Table A.4, respectively). Furthermore, the likelihood ratio test (χ^2 (10) =96.63, Prob >χ^2 = 0.000) rejected the null hypothesis that the covariance of the residuals of the multivariate probit model equations were equal to zero. Out of ten pairs, eight pairs of residuals were positively correlated and statistically significant, indicating that adaptation strategies were adopted together. All five practices were found complementary to each other. Varietal selection has significant positive correlation with improved irrigation, IPM, and adjustment. This might be because once producers decided to invest in improved irrigation, they also anticipate better harvest by using improved and hybrid seed varieties. The positive relationship between variety and IPM may be due to that once producers decided to adopt IPM practices, they are also concerned with the use of disease/pest tolerant rice varieties. The adjustment of crop calendar is dependent upon onset of monsoon and the positive relationship between variety and adjustments might be due to the use of short duration variety in case of late onset of monsoon. Irrigation has significant positive correlation with IPM and adjustment of crop calendar. The positive relationship between irrigation and IPM may be due to that once producers invested in improved irrigation, they are also concerned with protecting crop health, soil quality, and environment by implementing IPM practices. Contrary to our expectation, irrigation and adjustments are positively related. This might be due to the fact that even though producers invested in improved irrigation practices, unless there is enough monsoon rainfall, they were compelled to adjust their crop calendar because the submerged rice system is highly water-intensive for land preparation (puddling). DSR, IPM, and adjustment of crop calendar were significantly correlated with each other. The positive relationship between DSR and IPM is plausible because the weed incidence is relatively higher in DSR plots, and weeds can be a host of several insects and disease pest. Thus, producers have adopted both practices together. The positive relationship between DSR and adjustment of crop calendar might be related with good initial crop establishment. Although DSR does not require puddling operation, producers may be concerned with good seed germination, establishment and initial vigor of the seedlings, which eventually requires adequate soil moisture. Multicollinearity of explanatory variables were tested by calculating a condition index value (Belsley, 1991). When the value of the condition index is less than 30, there is no issue of multicollinearity. Our test results suggest no multicollinearity.

Table 11: Pairwise correlation coefficients across adaptation practices

Adaptation strategies	Coefficients	Standard error	P-value
Variety (ρ_v) X Irrigation(ρ_I)	0.464***	0.119	0.000
Variety (ρ_v) X DSR(ρ_D)	0.168	0.198	0.395
Variety (ρ_v) X IPM (ρp)	0.468*	0.255	0.067
Variety (ρ_v) X Adjustment (ρ_A)	0.533***	0.114	0.000
Irrigation (ρ_I) X DSR (ρ_D)	0.102	0.123	0.407
Irrigation (ρ_I) X IPM (ρp)	0.315*	0.126	0.013
Irrigation (ρ_I) X Adjustment (ρ_A)	0.558***	0.080	0.000
DSR (ρ_D) X IPM (ρp)	0.706***	0.077	0.000
DSR (ρ_D) Adjustment (ρ_A)	0.380***	0.098	0.000
IPM (ρp) X Adjustment (ρ_A)	0.622***	0.141	0.000

Likelihood ratio test of $\rho_{VI} = \rho_{VD} = \rho_{VP} = \rho_{VA} = \rho_{ID} = \rho_{IP} = \rho_{IA} = \rho_{DP} = \rho_{DA} = \rho_{PA} = \chi^2$ (10) = 96.63, Prob > χ^2 = 0.000; ***, ** and * refers to significant at 1%, 5%, and 10 % levels respectively.

The results of the multivariate probit model are presented in table 12. The direction of influence is as expected for most of the explanatory variables with a few exceptions. The adoption of variety is significantly more likely to be influenced by years of education, participation in training, access to information and use of Extension services. Imparting knowledge and skills through education, training, and access to information influence producers to use improved varieties, which are less affected by climate-induced risks. Furthermore, producers who sell rice in the market are more likely to adopt varietal selection, as they are positively motivated by earning a higher income by selling rice in the market. Adoption of high-yielding variety is significantly more likely to be influenced by number of plots available. Producers grow a combination of varieties in multiple plots instead of single variety. Producers who accurately perceived the changes in local weather patterns were more likely to adopt varietal selection. Furthermore, migrated households are significantly less likely to adopt varietal selection; this might be due to two reasons: first, due to lack of sufficient labor availability and second, due to less dependence on rice farming as household income is supplemented from remittances by migrated family members.

Table 12: Parameter estimates of the multivariate probit model

Explanatory variables	Variety		Improved Irrigation		Direct Seeded Rice		Integrated pest Management		Adjustment	
	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE
Gender	-0.158	0.291	-0.239	0.197	-0.310	0.265	0.434*	0.247	-0.396*	0.204
Dependency ratio	-0.156	0.147	-0.134	0.111	0.237*	0.133	0.267**	0.118	0.102	0.134
Out-migration	-0.460*	0.2246	-0.125	0.170	0.165	0.186	-0.004	0.180	0.355**	0.169
Education year	0.131***	0.036	0.110***	0.027	0.043	0.029	0.060**	0.030	0.076**	0.030
Farming year	0.004	0.010	0.020**	0.009	-0.021***	0.009	-0.006	0.008	-0.003	0.008
Rice plot	0.239*	0.188	0.026	0.138	-0.041	0.127	0.060	0.120	0.069	0.123
Rice sold	0.850***	0.269	0.394*	0.229	-0.391	0.303	0.505	0.280	-0.133	0.254
Rice area	-0.571*	0.391	-0.345	0.357	0.604*	0.332	-0.950**	0.374	0.202	0.324
Membership	-0.121	0.304	0.586**	0.243	0.251	0.362	1.264***	0.418	0.061	0.240
Income	0.000	0.001	0.001*	0.000	0.001*	0.000	0.000	0.001	0.00	0.000
Climate	0.685**	0.286	0.771***	0.241	0.641*	0.374	0.874**	0.422	1.136***	0.224
Extension	0.819***	0.269	0.422**	0.189	0.355*	0.209	0.460**	0.205	0.761***	0.210
Training	1.618***	0.467	0.375*	0.194	0.223	0.196	0.132	0.191	0.146	0.224
Information	0.932**	0.302	-0.095	0.266	0.642**	0.265	0.637**	0.249	0.265	0.221
Constant	-2.453***	0.540	-2.721***	0.444	-2.767***	0.485	-4.178***	0.708	-1.639***	0.395

Wald chi², $\chi^2(70) = 471.92$; Prob > $\chi^2 = 0.000$;
Log-likelihood = -516.18.

***, **, and * refers to significant at 1%, 5%, and 10 % levels respectively.

Years of education, years of farming, use of Extension services, training, and perceptions of climate variability are significantly more likely to influence the decision to adopt improved irrigation practices. Gaining more knowledge and awareness through education, training and learning from farming activities encouraged producers to invest in improved irrigation practices to increase rice yield. Similarly, if producers perceived variability in local weather patterns over the years, they decided to invest in irrigation to reduce yield losses due to climate-induced risk. Rice selling household are more likely to adopt varietal selection. Furthermore, household income and membership in farmer's cooperatives positively influenced their decision to adopt improved irrigation practices. Being a member of a farmer cooperative helps to pool available individual resources and also strengthen their voice to influence governmental and developmental policies benefitting the agricultural sector.

The adoption of DSR is significantly influenced by the dependency ratio and rice area, which is somewhat expected due to the apparent labor shortage and large farm size. DSR requires less labor force as compared to transplanted rice cultivation. Households with more dependent members has less labor availability. Furthermore, large rice area requires more water in addition to the higher labor force for transplanting and producers preferred DSR under such conditions. If producers perceived the changes in local weather pattern over the years, they are more likely to adopt DSR. Similarly, household income, access to information, and use of Extension services have a positive influence, as hypothesized. However, farming experience is less likely to influence the decision to adopt DSR contrary to our expectation. This might be because farmers with more years of experience are relatively older and older farmers are reluctant to adopt new practices like DSR.

Female headed households are more likely to adopt IPM practices than male headed household. The adoption of IPM practices is significantly more likely to be influenced by years of education, membership in farmer's cooperatives, perceptions of climate change, access to information and use of Extension. Educated farmers are more conscious about eco-friendly practices of disease and pest management in rice field. IPM practices were initially taught in farmer groups/cooperatives through Extension agents or local IPM facilitators and then adopted on individual farms. Being a member of farmer's group/cooperative, producers can share their knowledge and innovative ideas among each other, which might be an influencing factor for the adoption of IPM practices. Producers who perceived changes in local weather patterns positively influence adoption of IPM, this might be due to that producers took IPM as one of the viable practices to reduce increasing disease pest attacks in context to climate change and variability. The large farm owners are less likely to adopt IPM practices, because adoption of IPM practices in larger areas requires more organic fertilizers /bio-pesticides. In addition, large farm owners are more concerned with income rather than use of environment friendly practices. Contrary to our expectation, a higher dependency ratio is more likely to influence adoption of IPM practices; the results found in study area were quite surprising.

Adjustment in crop calendar is positively influenced by years of education, perceptions of changes in local weather patterns, and use of Extension services. Educated producers can better visualize the effects of changing weather patterns and adjust their crop calendar accordingly. The use of Extension services might motivate producers to better understand farming practices and calendar of farm operations. As expected, the direction of influence of migration is negative to adjust crop calendar. Furthermore, the decision to adjust crop calendar is less likely to be influenced by female-headed households.

4.8 Factors Influencing Intensity of Adoption

Producers' adopted multiple practices in the study area, however, the intensity of adoption varies. We used an ordered probit model to estimate factors influencing the intensity of adoption. The results of ordered probit model are presented in table 13. The Likelihood ratio chi-squared statistics for the ordered probit model is 319.01, is highly significant (Prob > χ^2 = 0.000), and rejected the null hypothesis, indicating that joint test of all slope coefficients is equal to zero. Results revealed that female-headed households have a significant negative effect on the intensity of adoption. Education years of household head and household income have significant positive effects on the adoption of most of the adaptation strategies. Likewise, other explanatory variables producers' perceptions of climate change, membership of producers' groups/cooperatives, Extension, training, and information have significant positive effects on the intensity of adoption.

Due to the complexities in explaining the direct effect of each explanatory variable on the intensity of adoption, we estimate the marginal effects of each explanatory variable on the intensity of adoption (Aryal et al., 2018; Teklewold et al., 2013). The marginal effects of explanatory variables revealed interesting results on a different level of intensity of adoption. Compared to the male-headed household, the likelihood of adopting three, four, and five adaptation practices will be lower by 6.6%, 3.6%, and 1.2%, respectively than a female-headed household. Each additional year of education of household head increases the likelihood of adopting three, four, and five adaptation strategies by 1.6%, 1.1%, and 0.4%, respectively. Interestingly, producers' perceptions of changes in local weather patterns have a significant, positive influence on the intensity of adoption, more clearly, if producers perceived the variability in local weather patterns, the likelihood of adopting three, four, and five adaption strategies increases by 23.7%, 9.9%, and 3.2% respectively. The use of agricultural Extension services enhances the adoption of a greater number of adaptation strategies. Specifically, the likelihood of adopting three, four, and five strategies increase by 12.0%, 7.8%, and 2.9% respectively with to the use of agricultural Extension services. Access to training has a significant positive influence on the intensity of adoption. The likelihood of adopting three, four, and five strategies increases by 7.7%, 5.6%, and 2.1% respectively with access to training. Access to information about weather and improved agricultural practices enhances the adoption of multiple strategies. The likelihood of adoption of three, four, and five strategies increases by 10.3%, 6.7%, and 2.5% respectively with access to information. Overall, consistent with the findings of Aryal et al., (2018), the magnitude of the effect of explanatory variables reduces as the level of intensity increases, indicating that adoption of a greater number of adaptation strategies reduced with the increasing availability of alternatives to producers.

Table 13: Parameter estimates and marginal effects of ordered probit model

Explanatory Variables	Coef.	Std.Err.	Marginal effects Prob(Y=0|X)	Prob(Y=1|X)	Prob(Y=2|X)	Prob(Y=3|X)	Prob(Y=4|X)	Prob(Y=5|X)
Gender	-0.294*	0.150	0.042*	0.052*	0.020**	-0.066*	-0.036**	-0.012*
Dependency ratio	0.060	0.085	-0.007	-0.010	-0.004	0.012	0.008	0.003
Out-migration	-0.042	0.120	0.005	0.007	0.003	-0.008	-0.005	-0.002
Education year	0.082***	0.021	-0.010***	-0.014***	-0.006***	0.016***	0.011***	0.004***
Farming year	0.001	0.005	-0.000	-0.000	-0.000	0.000	0.000	0.000
Rice plot	0.111	0.086	-0.014	-0.019	-0.009	0.022	0.015	0.005
Rice sold	0.206	0.166	-0.028	-0.036	-0.015	0.045	0.026	0.009
Rice area	-0.269	0.213	0.034	0.047	0.022	-0.054	-0.036	-0.013
Membership	0.410**	0.178	-0.059**	-0.072**	-0.028**	0.090**	0.051**	0.017**
Income	0.001**	0.000	0.0001**	-0.000**	-0.000**	0.000**	0.000**	0.000**
Climate	0.961***	0.186	-0.178***	-0.153***	-0.037***	0.237***	0.099***	0.032***
Extension	0.595***	0.148	-0.080***	-0.103***	-0.044***	0.120***	0.078***	0.029***
Training	0.407***	0.144	-0.050***	-0.070***	-0.033**	0.077***	0.056***	0.021**
Information	0.509***	0.162	-0.068***	-0.088***	-0.038***	0.103***	0.067***	0.025**

Log-likelihood ratio $\chi^2(24) = 319.01$; Prob > $\chi^2 = 0.000$.
Number of observations = 359.
Log-likelihood = -434.87.

***, **, and * refers to significant at 1%, 5%, and 10 % levels respectively.

CHAPTER V. SUMMARY AND CONCLUSIONS

This chapter contains summary and conclusions, policy implications, limitation of the study and future research areas.

(A) Summary and Conclusions

This study examined the producers' perceptions of climate change and variability (objective 1), its impact on rice farming, producers' preferred adaptation measures, and drivers of the adaptation based on primary data collected from 359 households survey in the Chitwan district of Nepal. Results revealed that producers perceived the changes in local weather patterns as compared to the past decades in terms of late onset of the monsoon, prolonged dry period, deepening groundwater depth, increasing average temperature, and increasing weather unpredictability. The trend analysis of the local weather data strongly supports the producers' perceptions of relatively hotter summer and warmer winter. Although, the average annual temperature increased at the slow rate of 0.0226^{0}C, the increased weather unpredictability and late onset of monsoon is detrimental to the monsoon-based rice farming in Chitwan.

Producers reported that increased incidence of disease/pest, weeds, and delaying transplantation are the major impacts associated with climate change and are responsible for reduction in rice yield. (objective 2). Furthermore, producers believed that the change in rainfall patterns and change in occurrence of dry period have major adverse effects on rice farming in the future. Producers are adopting a number of adaption practices to adapt to climate change. This study analyzed the five ongoing adaptation strategies in rice farming. The adjustment in crop calendar (72.99%) was the most adopted strategy followed by varietal adoption (64.9%), investment in improved irrigation (60.7), IPM (22.56%), and DSR (15.6%). Results indicate that about 23% of producers did not adopt any adaptation strategies and only 10.03 % of producers adopted all five strategies. The results indicate that variety and adjustment; variety and irrigation;

and variety, irrigation, and adjustment tend to be the most adopted combinations in the study area. There is a significant difference in household, farm, and socio-economic characteristics between adopters and non-adopters. The average rice yield for adopters was 227 Kg/ha higher than that of non-adopters. Thus, along with the planned adaptation, agricultural policies and programs should focus on Extension and promotion of ongoing adaptation strategies.

The results of multivariate probit model show the complementarities between the adaptation practices, indicating the inter-dependence of adoption of adaptation practices. This result has important policy implications that enhancement of one practice can have spillover effects on other practices. The study reveals the key drivers of the adoption of adaptation practices and the intensity of adoption (objective 3). Lack of adequate information, limited technical know-how, and credit constraints are major factors that impede adaptation to climate change. Furthermore, households with out-migrating family members are less likely to adapt to climate change. This might be due to the shortage of agricultural labor, which indicates the need for mechanization and dissemination of less labor-intensive farming practices. The finding reveals that education, awareness about climate change, use of Extension services, and access to information are the major factors that enhances likelihood of adoption of multiple adaptation strategies. However, the average years of education of the household head is below the secondary school level (less than 8 years). This result highlights the benefit of better access to education to enhance the uptake of multiple adaptation practices. Results of the intensity of adoption revealed that male headed household, education, higher income, awareness about climate change, use of Extension, training and information are more likely to adopt a greater number of e adaptation strategies. Overall, a majority of demographic, socio-economic, financial, and institutional factors have influenced the adoption of adaptation practices, thereby rejecting the second hypothesis.

(B) Policy Implications

Based on the finding of this study, following policy options are suggested:

- Based on the results from identifying factors influencing adaptation strategies and intensity of adoption, it suggested that human capital formation through education, literacy programs, formal and informal training help in making a better farming decision, and increase awareness about the impacts of climate change on rice farming.
- Based on the results from the intensity of adoption, it is suggested that effective Extension and training services will enhance adoption of three or more adaptation practices.
- Although DSR practice is an effective climate change adaptation strategy in rice production, only 15.6 % producers adopted this practice. Extension and outreach programs can demonstrate DSR practice including weed management practices to improve widespread adoption. Furthermore, agronomists could develop disease as well as pest-resistant varieties that can be used in conjunction with DSR practice.
- Although IPM practices were introduced in Nepal in late 1990's, only 22.13% producers adopted IPM practices in rice production. Through effective Extension and outreach programs, adoption of IPM practices can be improved among rice producers.
- More than two-thirds of producers are a member of farmers' group/cooperatives, which can enhance peer-to- peer learning experiences about adaptation strategies and transfer of technical skills.

- The survey results suggest irrigation infrastructure, farm equipment, and fertilizer are the most-preferred subsidies among rice producers. It is suggested that government should prioritize providing subsidies in these three areas in rice production.
- TV and FM radio programs were accessible to 73.25% of producers, and more than 95% of producers preferred them for obtaining information. More programs on improved farming practices, weather-related information and raising awareness about climate change will be instrumental in improving adaptation practices.

Overall, the results of this study have meaningful policy insights to the country like Nepal, which are in the stage of implementing different plans and programs to combat the negative impacts of climate change. To develop the planned adaptation strategies, policy institutions should consider producers' ongoing adaptation practices, learn from existing practices, investing in factors that enables adaptation, and wide-scale promotion of adaptation practices to reduce the vulnerability of climate change and variability in rice farming.

(C) Limitations of the Study and Future Research Areas

There are possibilities of recall bias in this study because the data was collected through household survey and producers answered by recalling. Furthermore, due to the budgetary and time constraints, this study is limited to the three locality (village) within Chitwan district of Nepal and focused on determinants of adaptation practices, however, in-depth research including the cost-benefit analysis of multiple adaptation practice on multiple scales and in different agro-ecological locations with larger sample size would be suggested. Due to the lack of complete socioeconomic data at the village level, we cannot extrapolate our results beyond our study area.

Additional research should focus on the societal and environmental impacts of adaptation strategies. For example, investment in increased extraction of groundwater may question the sustainability of the water resources. Modeling of yield and climatic variables to quantify the economic losses from climate change and estimating producers' willingness to adopt (and cost-share) multiple practices through choice experiments in different climate scenario will be the other research areas for designing planned, long-term adaptation strategies. Assessment of the producer's risks attitudes and its implications on rice yield would also be a future research area.

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Appendix A: Table A.1 List of districts of Nepal

(A) Mountain Region	(B) Hilly Region		(C) Terai Region
1. Taplejung	1. Pachthar	21. Kaski	1. Jhapa
2. Sankhuwasabha	2. Ilam	22. Syangja	2. Morang
3. Solukhumbu	3. Terhathum	23. Parbat	3. Sunsari
4. Dolakha	4. Dhankuta	24. Baglung	4. Saptari
5. Sindhupalchowk	5. Bhojpur	25. Palpa	5. Siraha
6. Rasuwa	6. Khotang	26. Gulmi	6. Dhanusha
7. Manang	7. Okhaldhunga	27. Myagdi	7. Mahottari
8. Mustang	8. Udayapur	28. Pyuthan	8. Sarlahi
9. Dolpa	9. Ramechhap	29. Argakhachi	9. Rautahat
10. Mugu	10. Sindhuli	30. Rolpa	10. Bara
11. Jumla	11. Makwanpur	31. Rukum	11. Parsa
12. Kalikot	12. Kathmandu	32. Salyan	12. Chitwan
13. Humla	13. Bhaktapur	33. Jajarkot	13. Nawalparasi
14. Bajhang	14. Lalitpur	34. Surkhet	14. Rupandehi
15. Bajura	15. Nuwakot	35. Dailekh	15. Kapilbastu
16. Darchula	16. Dhading	36. Achham	16. Dang
	17. Kavre	37. Doti	17. Banke
	18. Gorkha	38. Dadeldhura	18. Bardia
	19. Tanahun	39. Baitadi	19. Kailali
	20. Lamjung		20. Kanchanpur

Appendix A: Table A.2 List of practices exclusively adopted by percentage of rice producers

Adaptation Practices	Percentage of Producers (n=359)
Variety (VAR)	1.11
Irrigation (IRR)	1.11
DSR	0.00
IPM	0.00
Adjustment (ADJ)	7.80
VAR+IRR	1.39
VAR+DSR	0.00
VAR+IPM	0.00
VAR+ADJ	4.18
IRR+IPM	0.00
IRR+ADJ	2.23
IRR+DSR	0.00
DSR+IPM	0.00
DSR+ADJ	0.56
IPM+ADJ	0.00
VAR+IRR+DSR	0.00
VAR+IRR+IPM	0.00
VAR+IRR+ADJ	31.48
VAR+DSR+IPM	0.00
VAR+DSR+ADJ	1.11
VAR+IPM+ADJ	0.28
IRR+DSR+IPM	0.00
IRR+DSR+ADJ	0.00
IRR+IPM+ADJ	0.00
DSR+IPM+ADJ	0.00
VAR+IRR+DSR+IPM	0.00
VAR+IRR+IPM+ADJ	11.42
VAR+DSR+IPM+ADJ	0.84
VAR+IRR+DSR+ADJ	3.06
IRR+DSR+IPM+ADJ	0.00
All adopter	10.03
No adopter	23.40
Total	100.00

Appendix A: Table A.3 Parameter estimates of probit models of five independent adaptation strategies

Models	*(1)*		*(2)*		*(3)*		*(4)*		*(5)*	
	Variety		Improved Irrigation		Direct Seeded Rice		Integrated pest Management		Adjustment	
Explanatory variables	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE
Gender	-0.327	0.301	-0.297	0.197	-0.384	0.296	0.342	0.245	-0.560***	0.199
Dependency ratio	-0.173	0.151	-0.131	0.110	0.243*	0.128	0.294**	0.121	0.145	0.159
Out-migration	-0.538*	0.267	-0.161	0.169	0.175	0.187	-0.053	0.177	0.301	0.186
Education year	0.115***	0.041	0.120***	0.027	0.038	0.030	0.060*	0.031	0.088***	0.032
Farming year	0.003	0.011	0.022**	0.009	-0.020**	0.009	-0.000	0.008	-0.000	0.009
Rice plot	0.272	0.195	0.056	0.141	-0.047	0.129	0.092	0.121	0.151	0.142
Rice sold	0.837***	0.289	0.393	0.239	-0.395	0.302	0.502*	0.302	-0.102	0.246
Rice area	-0.749**	0.378	-0.398	0.332	0.690**	0.326	-1.015***	0.389	0.066	0.313
Membership	-0.198	0.332	0.603**	0.239	0.299	0.356	1.263***	0.448	0.049	0.256
Income	0.000	0.000	0.001**	0.000	0.001*	0.000	0.000	0.000	0.001	0.000
Climate	0.638**	0.308	0.620**	0.242	0.661	0.407	0.882*	0.497	1.099***	0.217
Extension	0.866***	0.284	0.416**	0.191	0.363	0.230	0.484**	0.217	0.751***	0.206
Training	2.218***	0.511	0.411**	0.198	0.159	0.205	0.132	0.198	0.223	0.221
Information	1.194***	0.352	-0.097	0.259	0.623**	0.285	0.627**	0.249	0.226	0.228
Constant	-2.426***	0.582	-2.752***	0.447	-2.803***	0.507	-4.349***	0.745	-1.789***	0.440
	n = 233		*n = 218*		*n = 56*		*n = 81*		*n = 262*	

***, **, and * refers to significant at 1%, 5%, and 10 % levels respectively.

Appendix A: Table A.4 Parameter estimates of bivariate probit model of adopting two adaptation strategies

Models	*(1)*		*(2)*		*(3)*		*(4)*		*(5)*	
Explanatory Variables	VAR * IRR		VAR * DSR		VAR * IPM		VAR * ADJ		IRR * DSR	
	VAR	IRR	VAR	DSR	VAR	IPM	VAR	ADJ	IRR	DSR
Gender	-0.123	-0.330*	-0.391	-0.349	-0.332	0.364	-0.107	-0.571***	-0.298	0.390
Dependency ratio	-0.210	-0.133	-0.112	0.257*	-0.098	0.314**	-0.219	0.118	-0.130	0.244*
Out-migration	-0.498*	-0.168	-0.497**	0.183	-0.546**	-0.034	-0.438*	0.273	-0.164	0.171
Education year	0.125***	0.119***	0.111***	0.038	0.116***	0.060*	0.135***	0.088***	0.120***	0.038
Farming year	0.003	0.022**	0.006	-0.021**	0.003	-0.001	0.005	-0.000	0.022**	-0.020**
Rice plot	0.108	0.062	0.275	-0.053	0.214	0.088	0.348*	0.132	0.057	-0.045
Rice sold	0.829***	0.390	0.801***	-0.402	0.866***	0.497	0.896***	-0.138	0.394*	-0.394
Rice area	-0.520	-0.403	-0.814	0.762**	-0.676*	-1.006***	-0.608	0.093	-0.406	0.690**
Membership	-0.093	0.632***	0.165	0.350	0.189	1.207***	0.101	0.127	0.606**	0.289
Income	0.000	0.001**	0.000	0.001*	0.000	0.000	0.000	0.001	0.001**	0.000*
Climate	0.649**	0.634***	0.696**	0.547	0.600*	0.865	0.741***	1.087***	0.619**	0.659
Extension	0.861***	0.389**	0.856***	0.354	0.765***	0.478**	0.856***	0.728***	0.418**	0.364
Training	1.898***	0.421**	2.184***	0.155	2.255***	0.130	1.628***	0.237	0.410**	0.163
Information	1.078***	-0.104	1.206***	0.626**	1.248***	0.606**	0.784***	0.181	-0.099	0.621**
Constant	-2.161***	-2.770***	-2.404***	-2.741***	-2.379***	-4.292***	-2.680***	-1.738***	-2.756***	-2.796***
Rho	*0.763****		*0.999***		*0.998*		*0.758****		*0.038*	
	χ^2 (1) = 15.458		χ^2 (1) = 5.045		χ^2(1) = 0.793		χ^2(1) = 25.77		χ^2(1) = 0.085	
	Prob > χ^2 = 0.000		Prob > χ^2 = 0.0247		Prob > χ^2 = 0.373		Prob > χ^2 = 0.000		Prob > χ^2 = 0.770	

***, **, and * refers to significant at 1%, 5%, and 10 % levels respectively.

Appendix A-Table A.4: Parameter estimates of bivariate probit model of adopting two adaptation strategies (contd.)

Models	*(6)*		*(7)*		*(8)*		*(9)*		*(10)*	
Explanatory Variables	IRR * IPM		IRR * ADJ		DSR * IPM		DSR * ADJ		IPM * ADJ	
	IRR	IPM	IRR	ADJ	DSR	IPM	DSR	ADJ	IPM	ADJ
Gender	-0.278	0.257	-0.321	-0.493**	-0.322	0.355	-0.434	-0.578***	0.269	-0.549***
Dependency ratio	-0.134	0.302**	-0.110	0.115	0.235*	0.259**	0.251*	0.118	0.366**	0.153
Out-migration	-0.164	-0.078	-0.154	0.304*	0.136	-0.073	0.169	0.253	-0.049	0.270
Education year	0.120***	0.061**	0.113***	0.082***	0.040	0.061*	0.038	0.086***	0.056*	0.088***
Farming year	0.022**	-0.000	0.022**	-0.000	-0.018**	-0.002	-0.021**	-0.000	-0.001	-0.001
Rice plot	0.044	0.115	0.048	0.098	-0.045	0.085	-0.038	0.154	0.063	0.134
Rice sold	0.403*	0.503*	0.320	-0.119	-0.373	0.525*	-0.375	-0.084	0.459	-0.114
Rice area	-0.398	-0.979***	-0.399	0.056	0.629**	-0.913**	0.704*	0.045	-1.072***	0.125
Membership	0.585**	1.200***	0.624***	0.115	0.300	1.306***	0.327	0.023	1.297***	0.056
Income	0.001**	-0.000	0.001**	0.001*	0.000*	0.000	0.001*	0.000	0.000	0.000
Climate	0.638***	0.591	0.692***	1.055***	0.587	0.861*	0.589	1.129***	0.780	1.104***
Extension	0.415**	0.508**	0.426**	0.747***	0.368*	0.483**	0.361	0.767***	0.511**	0.766***
Training	0.390*	0.206	0.397**	0.162	0.161	0.107	0.224	0.202	0.200	0.186
Information	-0.082	0.600**	-0.105	0.270	0.629**	0.626**	0.595**	0.219	0.631**	0.218
Constant	-2.740***	-4.061***	-2.742***	-1.672***	-2.764***	-4.324***	-2.785***	-1.746***	-4.204***	-1.741***
Rho	*0.432****		*0.663****		*0.737****		*0.978***		*0.999*	
	χ^2 (1) = 8.915		χ^2 (1) = 27.899		χ^2(1) = 35.125		χ^2(1) = 5.076		χ^2(1) = 0.242	
	Prob > χ^2 = 0.0028		Prob > χ^2 = 0.000		Prob > χ^2 = 0.000		Prob > χ^2 = 0.024		Prob > χ^2 = 0.622	

***, **, and * refers to significant at 1%, 5%, and 10 % levels respectively.

Appendix B: A few climate change related terminologies

Climate change

According to Intergovernmental Panel on Climate Change (IPCC, 2007), climate change refers to the long-term variation of the climate (the average weather condition; specifically, rainfall, temperature, and wind) that persists for an extended period, generally decades or longer. Further, IPCC also mentions that climate change refers to any changes in climate over time due to either natural variability or because of human activity.

Climate change impacts

Impacts of climate change refer to the effects of climate change on the natural and human systems (IPCC, 2007). IPCC defines mainly two types of climate change impacts, potential impacts, and residual impacts. Those impacts that occur without considering adaptation are called potential impacts and impacts observed after adaptation are referred to as residual impacts.

Adaptation

Climate change adaptation refers to adjustment in natural, socioeconomic or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Anticipatory, autonomous, and planned adaptation are three major types of adaptations, among many others. Anticipatory adaptation is also called proactive adaptation. Generally, proactive adaptation takes place before impacts are observed. Autonomous adaptation is also called spontaneous adaptation. This type of adaptation is generally triggered by the ecological change or by market /welfare changes in human systems without conscious response to climatic stimuli. Planned adaptation is response strategies to deal with various climate change issues, it is a result of a deliberate policy decision to return to or maintain a desired state (IPCC, 2007).

Adaptive capacity

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007).

Mitigation

Mitigation is the human intervention to reduce the sources or enhances the sinks of greenhouse gases (IPCC, 2007).

Vulnerability

The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007).

Resilience

The ability of a social or ecological system to absorbs disturbances while retaining the same basic structures and ways of functioning, the capacity for self-organization and capacity to adapt to stress and the change (IPCC, 2007). The community can resist, absorb, and recover from the effects of hazards in a timely and efficient manner, preserving or restoring its essential basic structures, functions, and identity.

Appendix C. Survey questionnaire

Nepal: Survey of Rice Producers on Climate Change and Adaptation Strategies

Namaskar! My name is________ I am working on a research project for University of Tennessee, US. I would like to ask you a few questions about rice production practices. This is a voluntary survey and your responses will be kept confidential. Information you provide will help inform how rice producers have adopted to climate variability in Nepal. Would you like to take 15 minutes to participate in this study?

YES: Continue **No:** Thank you and have a great day **Interview No:** ☐ **Location:** _______________

Name: __________________ **Age:** ____ **Gender:** M F **Ethnicity:** ☐ Brahmin/Chettri ☐ Janajati ☐ Dalit

Section A: Household (HH), Farm and General Information

1	Head of Household	M F		7	No. of rice plots (parcels)			13	Sources of irrigation a. Kulo/Canal water	
2	No. of total household members			8	Irrigated (low land) ....Unit				b. Canal+ Ground water pumping (both)	
	a. No. of members-16 to 60 years				Unirrigated(upland)...............Unit			14	a. Member of farmer group/cooperative	Y N
3	No. of literate family members			9	Rice area in last year.............Unit				b. Are you involve in group/cooperative farming through Pocket/Blocks/Zone?	
4	No of members migrated abroad			10	Rice harvest last year............Unit			15	Distance of frequently/mostly visited market for agricultural input/output (KM)	
5	Education years of household head			11	Rice quantity sold last year ....Unit					
6	Household head years of farming			12	Do you rear livestock	Y N		16	Is rice farming is profitable to you	Y N

17. Share of different sources to annual income (last year)	Share % (Total 100%)	18. What is the overall trend of income sources in past 5 years? *(Tick one)*		
Sources of income		Increasing trend	Not changed	Decreasing trend
i). Sale of rice and rice straw	.........................%	☐	☐	☐
ii.) Sale of other crops	.........................%	☐	☐	☐
iii). If you rear livestock, sale of livestock/livestock products	.........................%	☐	☐	☐
iv). Others off-farm (business/job/remittance etc.)	.........................%	☐	☐	☐

Section B: Producers' Perceptions on Climate Change/Variability and Impact on Rice Production

19. Have you noticed any changes in local weather patterns in past 10 years? ***(Circle one).*** **Y N If Yes, ask 20**

20. Perception on current weather patterns as compared to past 10 years ***(Tick one)***

Weather parameters	Increased	Not Changed	Decreased	Don't know
a. Average summer temperature	☐	☐	☐	☐
b. Average winter temperature	☐	☐	☐	☐
c. Amount of rainfall (in average)	☐	☐	☐	☐
d. Frequency of rainfall	☐	☐	☐	☐
e. Intensity of rainfall	☐	☐	☐	☐
f. Frequency of dry period	☐	☐	☐	☐
g. Duration of dry period	Long ☐	No change ☐	Short ☐	☐
h. Occurrences of floods	☐	☐	☐	☐
i. Occurrences of Hail/Storms	☐	☐	☐	☐
j. Unpredictability of weather	☐	☐	☐	☐
k. Ground water table	☐	☐	☐	☐
l. Onset of monsoon	Early ☐	Normal ☐	Late ☐	☐
m. End of monsoon	Early ☐	Normal ☐	Late ☐	☐

1

21. Do you have any adverse impact of these changes on your rice farming in past 3 years? Y N. If yes, what are the impacts of above changes?

Impacts of above changes on rice farming	*(select all apply)*
a. Unable to transplant rice	☐
b. Delaying transplantation of rice	☐
c. Reduced/shortage of irrigation water	☐
d. Crop loss by flooding/water- logging	☐
e. Loss during harvesting	☐
f. More weeds in rice field	☐
g. Increased incidence of disease/pest in rice field	☐

22. In average, in last 3 years, due to these changes,	
a. Approx. % of rice area affected	< 25 % ☐ 25-50% ☐ >50% ☐
b. Approx. % of rice yield decline.	< 25 % ☐ 25-50% ☐ >50% ☐
c. Approx.% of loss of net income from rice	< 25 % ☐ 25-50% ☐ >50% ☐

23. Please indicate your level of agreement on following statements

In the future, do you believe ..... (a.....e).........	Strongly agree	Slightly agree	Neutral	Slightly disagree	Strongly disagree
a. Changes in temperature will have adverse effect on your rice yield	☐	☐	☐	☐	☐
b. Changes in rainfall pattern will have adverse effect on your rice yield	☐	☐	☐	☐	☐
c. changes in occurrence of dry period will have adverse effect on your rice yield	☐	☐	☐	☐	☐
d. changes in occurrences of floods will have adverse effect on your rice yield	☐	☐	☐	☐	☐
e. Change in water table will have adverse effect on your rice yield	☐	☐	☐	☐	☐

Section C: Adaptation to Climate Change and Variability

24. Have you adopted these practices in rice farming within past 3 years? *(Circle only adopted practices, not all)*		25. If not, why not you adopt these practices? *(Select all that apply)* Lack of information about practices	I can't afford it	Lack of technical knowhow	Not applicable to my farm	Require too much efforts/ Not profitable	Others/Not available
(A) Varietal management							
Growing drought tolerance varieties	Y N	☐	☐	☐	☐	☐	☐
Growing short-duration varieties	Y N	☐	☐	☐	☐	☐	☐
Growing disease/pest tolerance varieties	Y N	☐	☐	☐	☐	☐	☐
(B) Investment in improved irrigation							
Constructing new well/canal, water-harvest	Y N	☐	☐	☐	☐	☐	☐
Investing on power backup-generator/solar for pumping water	Y N	☐	☐	☐	☐	☐	☐
Changing frequency of irrigation	Y N	☐	☐	☐	☐	☐	☐
(C) Using of Direct Seeded Rice (DSR)	Y N	☐	☐	☐	☐	☐	☐
(D) Using of SRI (System of Rice Intensification)	Y N	☐	☐	☐	☐	☐	☐
(E) Adjusting crop calendar (planting/sowing date)							
Late transplanting by no. of days	Y N	☐	☐	☐	☐	☐	☐
Late harvest by no. of days........................	Y N	☐	☐	☐	☐	☐	☐
Changing crop rotation/cropping pattern	Y N	☐	☐	☐	☐	☐	☐
(F) Changing dose/frequency of chemicals		☐	☐	☐	☐	☐	☐
IPM (Integrated pest management)	Y N	☐	☐	☐	☐	☐	☐
Changing dose/frequency of pesticides	Y N	☐	☐	☐	☐	☐	☐
Changing dose/frequency of chemical fertilizer	Y N	☐	☐	☐	☐	☐	☐
Changing dose/frequency of organic manure	Y N	☐	☐	☐	☐	☐	☐
(G) Diversification							
Reducing rice area and switch to other crops	Y N	☐	☐	☐	☐	☐	☐
Diversify to livestock (Cattle/Poultry/Goat)	Y N	☐	☐	☐	☐	☐	☐
(H) Others (If any, specify)							

Section D: Producers' Risk Attitudes

26. Let's play a hypothetical lottery game: Which options do you choose? Answer all questions from 1 to 8.

Question No.	1	2	3	4	5	6	7	8
Option A; You got safely (100% sure)	Rs. 100	Rs. 75	Rs. 60	Rs. 50	Rs. 40	Rs. 30	Rs. 20	Rs. 10
Option B; 50: 50 % chance of Rs. 100 or 0	100 or 0	100 or 0	100 or 0	100 or 0	100 or 0	100 or 0	100 or 0	100 or 0
Which option do you choose? *(circle one)*	A or B	A or B	A or B	A or B	A or B	A or B	A or B	A or B

27. How you describe your risk tolerance level? *(Tick one).* ☐ Low ☐ medium (somewhat) ☐ high

Section E: Access to Extension services, Credit, Subsidy and Information

Insurance	28. a. Do you know/aware about rice crop insurance?	Y N	
	b. Do you have rice crop insurance within last 3 years?	Y N	c. If not, Why not?( ) High premium ( ) Burdensome process ( ) Unaware about benefit/cost ( ) Others, specify..................................
Extension	29. Did you visit extension office or extension agent visit your farm in last year?	Y N	
Training	30. a.Did you receive/attend climate smart farming related training in last 3 years?	Y N	b. What kind of training you prefer to enhance adaptation? Explain. ....
	c. If not, are you willing to receive such training?	Y N	....
Credit	31.a. Did you take loan for farming?	Y N	b. If yes, Sources; ( ) Bank ( ) Microfinance (group/cooperatives) ( ) Money lenders ( ) Friends/Family members
	c. If not, Why not? ( ) No need ( ) High interest ( ) Burdensome process		
Subsidy	32.a. Do you have access to any subsidy in rice farming?	Y N	b.Please put your preference of subsidy to build resilience against climate variability *(Select top 3)* ( ) Variety (drought tolerance/short duration/disease pest) ( ) Irrigation canal/well construction/water-pump/solar/electricity ( ) Farm machinery/tools ( ) Fertilizers and pesticides (both chemical/organic)
Power	33.a Do you have continuous electricity for irrigation?	Y N	b.Do you have solar power connection to run water pump? Y N
Information	34.a. Do you have access to internet?	Y N	b. Do you listen/watch ag and weather program in TV/Radio?
	c. Are you updated with weather forecast/adaptation related information?	Y N	
	d. Do you receive text message alert regarding adaptation/weather related information?	Y N	e. How is accuracy/reliability of such information? ( )Low ( )Medium ( )High
	f. Are you using any mobile apps for varietal/ technological/weather related information?	Y N	g.How useful of such information in adopting to climate variability? ( )Very useful ( )Somewhat useful ( )Not useful at all
	h. Do you use such information in farm decision?	Y N	If yes, for what purpose? ....
	i. For weather and adaptation related information, which information sources you use mostly? *(Select top 4)* ( ) FM radio ( ) Toll free phone numbers ( ) TV ( ) Internet search ( ) Mobile apps ( ) Announcements from Agricultural office/NARC/DHM ( ) Agro- advisory ( ) Published extension materials/ Newspaper		

j. Please indicate your level of agreement on: I have adequate access to..... (i...v)......	Strongly agree	Slightly agree	Neutral	Slightly disagree	Strongly disagree
i) Information on past weather trends	☐	☐	☐	☐	☐
ii) Information on weather forecasts	☐	☐	☐	☐	☐
iii) Information on climate smart farming practice	☐	☐	☐	☐	☐
iv)Varietal information	☐	☐	☐	☐	☐
v) Price and marketing information	☐	☐	☐	☐	☐

Is there anything else you wish to share/add related to rice farming..?

Thank you for your time and patience.

Good luck!!!

All information collected here is part of a University of Tennessee research project and is completely voluntary. All information will be kept strictly confidential. If you have questions about this survey, please contact Sreedhar Upendram at (865)-974-7410 or UTK IRB staff at (865)-974-7697.

Questionnaire translated into Nepali language

मौसम, जलवायुमा फेरबदल: किसानहरुको धारणा र धानखेतीमा यसको असर एवं अनुकूलन सम्बन्धी घरधुरी सर्भेक्षण प्रश्नावली

नमस्ते मेरो नाम..............................हो । म अमेरिकाको टेनिसी विश्वविद्यालयको एउटा अनुसन्धान कार्यको लागि स्थानीयवासीहरुसँग मौसम सम्बन्धि फेरबदल र यसले धानखेतीमा पारेको असर सम्बन्धि केही प्रश्न सोध्न आएको छु र तपाईको उत्तरहरु गोप्य राखिनेछन् । सबै प्रश्नहरु छलफल गर्न जम्मा जम्मी १५ मिनेट लाग्न सक्छ । तपाई राजी हुनुहुन्छ ? **छु** : Continue **छैन,** धन्यवाद हजुरको दिन शुभ रहोस् । **Interview No:** ☐ स्थान : ______________

तपाइको नाम: ______________ तपाइको उमेर: _____ लिंग: M F तपाइ आफुलाइ कुन जाती मान्नुहुन्छ? ☐ ब्राम्हण/क्षेत्री ☐ जनजाती ☐ दलित

Section A: घरपरिवार र खेतीपाती सम्बन्धि साधारण प्रश्नहरु

1	तपाइको घरमूली महिला वा पुरुष को हुनुहुन्छ?	M F	7	तपाइले हाल कतिवटा कित्ता (प्लट) मा धानखेती गर्नुभएको छ ?		13	सिंचाइको स्रोत के हो ? a. कुलो/नहरको पानी	
2	तपाइको एकैपरिवारमा कतिजना बस्नुहुन्छ?		8	तपाइको कुलो, नहरको पानी लाग्ने कति जग्गा छ (सिंचित जग्गा) ?			b. कुलो/नहरको पानी + बोरिंग (जमिनमुनिको पानी)	
	a.तपाइको एकै परिवारमा 16-60 वर्षउमेरका कतिजना सदस्य हुनुहुन्छ?			तपाइको नहरको पानी नलाग्ने कति जग्गा छ ? (असिंचित आकाशको भर)		14	a. तपाइ कुनै किसान समूह, सहकारीको सदस्य हुनुहुन्छ?	Y N
3	तपाइको परिवारमा साधारण लेखपढ गर्न सक्ने कतिजना सदस्य हुनुहुन्छ ?		9	गतवर्ष कति जग्गामा धान लगाउनुभएको थियो ?			b. तपाइ कुनै समूह, सहकारीमार्फत सामुहिक खेतीमा संलग्न हुनुहुन्छ?(Pocket, Block, Zone)	Y N
4	कुनै सदस्य वैदेशिक रोजगारमा जानुभएको छ?		10	गतवर्ष कति धान फलाउनुभयो?		15	तपाइले धेरैजसो कृषिसामाग्रीको किनबेच गर्ने (मल, बीउ, विषादि,औजार, उत्पादन) बजार कति टाढा छ?(किमी)	
5	घरमूलीको शैक्षिक योग्यता कति छ ? (वर्षमा)		11	गतवर्ष कति जति धान बेच्नुभयो ?				
6	घरमूलीले धानखेती गर्नुभएको कतिवर्ष भयो ?		12	तपाइले गाइवस्तु पाल्नुभएको छ ?	Y N	16	तपाइको विचारमा धानखेती नाफामूखी छ ?	Y N

17. गतवर्ष विभिन्न शीर्षकबाट प्राप्त अनुमानित वार्षिक आम्दानीको अंश (प्रतिशतमा)	a. Share (अंश) %	b. यी आम्दानीका स्रोतहरुको विगत ५ वर्षको trend ? *(Tick one)*		
आम्दानीका स्रोतहरु	(Total 100%)	बढ्दो (Increasing trend)	Not changed (उस्तै उस्तै छ)	घट्दो(Decreasing trend)
i). धान वा पराल बेचबिखनबाट प्राप्त आम्दानी	..................%	☐	☐	☐
ii.) धानबाहेक अन्य सबै बालीनाली बेचबिखनबाट प्राप्त आम्दानी	..................%	☐	☐	☐
iii). गाइवस्तु पाल्नुभएको छ भने तिनको वा तिनका उत्पादनहरुको बिक्रीबाट प्राप्त आम्दानी	..................%	☐	☐	☐
iv). खेतीपातीबाहेक अन्य स्रोतबाट प्राप्त आम्दानी (जागीर, वैदेशिक रोजगार, व्यवसाय)	..................%	☐	☐	☐

18. सबै स्रोतहरुबाट प्राप्तहुने तपाइको गतवर्षको वार्षिक अनुमानित आम्दानी (रु लाख वा हजारमा) (..)

Section B: धान खेती गर्ने किसानको मौसम फेरबदल सम्बन्धी धारणा र धानखेतीमा यसले पारेका प्रभावहरु सम्बन्धी प्रश्नहरु

19. विगत १० वर्षको तुलनामा स्थानीय मौसमको अवस्थामा केही परिवर्तनहरु देख्नुभएको वा महशुस गर्नुभएको छ?*(Circle one).* Y N If Yes, ask 20

20. विगत १० वर्षको तुलनामा, मौसमका अवस्थाहरु, सुचकहरु	बढेको	उस्तै हो (खासै परिवर्तन छैन)	घटेको	थाहा छैन
a. गर्मीयामको औसत तापक्रम (पहिलेका वर्षहरुको तुलनामा गर्मी हुने दिनहरु)	☐	☐	☐	☐
b. जाडोयामको औसत तापक्रम (पहिलेका वर्षहरुको तुलनामा जाडो हुने दिनहरु)	☐	☐	☐	☐
c. पहिलेका वर्षहरुको तुलनामा आकाशबाटपर्ने पानीको मात्रा	☐	☐	☐	☐
d. पहिलेका वर्षहरुको तुलनामा आकाशबाट पानी पर्ने दिनहरु	☐	☐	☐	☐
e. पहिलेका वर्षहरुको तुलनामा मुसलधारे पानी पर्ने दिनहरु	☐	☐	☐	☐
f. पहिलेका वर्षहरुको तुलनामा सुख्खा /खडेरीको संख्याहरु	☐	☐	☐	☐
g. पहिलेका वर्षहरुको तुलनामा सुख्खा / खडेरीको अवधि	लामो ☐	उस्तै हो ☐	छोटो ☐	☐
h. पहिलेका वर्षहरुको तुलनामा बाढी, भेलका संख्याहरु	☐	☐	☐	☐
i. पहिलेका वर्षहरुको तुलनामा हावाहुरी, असिना, चट्याङ	☐	☐	☐	☐
j. पहिलेका वर्षहरुको तुलनामा मौसमको अनिश्चितता	☐	☐	☐	☐
k. पहिलेका वर्षहरुको तुलनामा जमिनमुनीको पानीको सतह	☐	☐	☐	☐
l. पहिलेका वर्षहरुको तुलनामा पानी पर्ने/वर्षाको शुरु हुने समय	छिटो ☐	उस्तै हो ☐	ढीलो ☐	☐
m. पहिलेका वर्षहरुको तुलनामा पानी/वर्षाको अन्त्य हुने समय	छिटो ☐	उस्तै हो ☐	ढीलो ☐	☐

21. विगत ३ वर्षमा माथि उल्लेखित मौसमका अवस्थाहरुले तपाइको धानखेतीमा केही असर पारेको छ ? Y N यदि छ भने (Y) ती असरहरु के के हौलान ?

धानखेतीमा पुर्‍याएका असरहरु	(select all apply)
a. धान रोपाइ गर्न नसकेको, नपाइएको	☐
b. धान रोपाइ गर्न कठिनाइ भएको, ढीलो भएको	☐
c. धानखेतीमा सिचाइको लागी पानीको अभाव भएको	☐
d. बाढीले धानबाली नोक्सान भएको, धेरै पानी जमेर क्षति भएको	☐
e. धान काट्ने बेलामा पानी परेर नोक्सान भएको	☐
f. धानखेतमा धेरै झारपात आएर उत्पादनमा नोक्सानी पुर्‍याएको	☐
g. धानखेतमा धेरै रोगकीरा लागेर उत्पादनमा रोगकीराले धेरै क्षति गरेको	☐

22. In average, in last 3 years, due to these changes, औसतमा सम्पुर्णमा विगत ३ वर्षमा :	
a. ती कारणहरुले गर्दा धानबालीको अनुमानित कति % क्षेत्रफलमा असर पुगेको होला?	< 25 % ☐ 25-50% ☐ >50% ☐
b. ती असरले गर्दा धानको उत्पादकत्वमा अनुमानित कति % ले कमी भयो होला ?	< 25 % ☐ 25-50% ☐ >50% ☐
c. ती असरले गर्दा धानबाली बाट प्राप्त हुने खुद आम्दानीमा अनुमानित कति %.ले कमी भयो होला ?	< 25 % ☐ 25-50% ☐ >50% ☐

23 तलका भनाइ/वाक्यहरुमा आफ्नो सहमती वा असहमती राख्नुहोला ।

भोलिका दिनहरुमा तपाइको विचारमा	पूर्ण सहमती	अति अति सहमती	तटस्थ	पूर्ण असहमती	अति अति असहमती
a. पानीपर्ने मात्रामा देखिएको परिवर्तनले मेरो धानउत्पादनमा प्रतिकूल असर पार्नसक्छ ।	☐	☐	☐	☐	☐
b. सुख्खा, खडेरीपर्ने समयमा आएको परिवर्तनले मेरो धानउत्पादनमा प्रतिकूल असर पार्नसक्छ ।	☐	☐	☐	☐	☐
c. बाढी, पानीजम्ने अवस्थामा आएको परिवर्तनले मेरो धानउत्पादनमा प्रतिकूल असर पार्नसक्छ ।	☐	☐	☐	☐	☐
d. जमिनमुनिको पानीको सतहमा आएको परिवर्तनले मेरो धानउत्पादनमा प्रतिकूल असर पार्नसक्छ	☐	☐	☐	☐	☐
e. तापक्रम, तातोपनामा आएको परिवर्तनले मेरो धानउत्पादनमा प्रतिकूल असर पार्नसक्छ ।	☐	☐	☐	☐	☐

Section C: मौसमको फेरबदल र धानखेतीमा यसको अनुकूलन सम्बन्धी प्रश्नहरु

24. विगत ३ वर्षमा धानखेतीमा तपाइले तलका कुनै पद्धतिहरु वा तरिकाहरु प्रयोग गर्नुभएको छ? (Have you adopted these practices in rice farming within past 3 years?) *(Circle only adopted practices, not all)*		25. यदि यी तरिकाहरु, पद्धतिहरु प्रयोग गर्नुभएको छैन भने किन प्रयोग नगर्नुभएको हो ? *(Select all that apply)*					
		यो तरिका पद्धति को बारेमा नबाइ थाहानै नभएकोले	यो तरिका मा मैले लगानी गर्न नसकेर	यो तरिकाको बारेमा नबाइ प्राविधिक जानकारी नभएकोले	यो तरिका मेरो क्षेत्रमा उपयुक्त नहुने भएर	यो तरिका प्रयोग गर्न धेरै मेहेनत गर्नुपर्ने र खासै फाइदाजनक नभएर	अन्य कारण (केही भए)
(A) Varietal management							
सुख्खा, खडेरी सहनसक्ने जातको धानहरु लगाउनुभएको छ ?	Y N	☐	☐	☐	☐	☐	☐
छिटो पाक्ने जातको धानहरु लगाउनुभएको छ ?	Y N	☐	☐	☐	☐	☐	☐
रोगकीरा कम लाग्ने जातको धानहरु लगाउनुभएको छ ?	Y N	☐	☐	☐	☐	☐	☐
(B) Investment in improved irrigation							
नयाँ नहर,कुलो बनाउने, पानी सञ्चयगर्ने कार्यमा लगानी गर्नुभएकोछ?	Y N	☐	☐	☐	☐	☐	☐
पानी तान्ने नयाँ मोटर, नयाँ पम्पमा लगानी गर्नुभएको छ ?	Y N	☐	☐	☐	☐	☐	☐
धानखेतमा पानी लगाउने संख्या, तालिकामा परिवर्तन गर्नुभएको छ ?	Y N	☐	☐	☐	☐	☐	☐
(C)DirectSeeded Rice(DSR) जस्ता धानखेती गर्नुभएको छ?	Y N	☐	☐	☐	☐	☐	☐
(D) SRI पद्धति गर्नुभएको छ ?	Y N	☐	☐	☐	☐	☐	☐
(E) धानको रोपाइ गर्ने वा लगाउने, समयमा परिवर्तन गर्नुभएको छ?	Y N						
ढीलो रोपाइ गर्नुभएको छ भने औसत समयभन्दा कति दिनजति ढिलो ?		☐	☐	☐	☐	☐	☐
ढीलो धान काट्ने गर्नुभएको छ भने औसत समयभन्दा कति दिन ढिलो ?		☐	☐	☐	☐	☐	☐
धनखेतमा बाली चक्र वा बाली प्रणालीमा केही परिवर्तन गर्नुभएको छ ?	Y N	☐	☐	☐	☐	☐	☐
(F) Changing dose/frequency of chemicals		☐	☐	☐	☐	☐	☐
IPM पद्धति अपनाउनुभएको छ ?	Y N	☐	☐	☐	☐	☐	☐
पहिलेभन्दा विषादि प्रयोगमा परिवर्तन ल्याउनुभएको छ ? कमी धेरै	Y N	☐	☐	☐	☐	☐	☐
पहिलेभन्दा रासायनिकमलको प्रयोगमा परिवर्तन ल्याउनुभएकोछ? कमी धेरै	Y N	☐	☐	☐	☐	☐	☐
पहिलेभन्दा जैविकमलको प्रयोगमा परिवर्तन ल्याउनुभएको छ? कमी धेरै	Y N	☐	☐	☐	☐	☐	☐
(G) Diversification							
धानखेती गर्ने जग्गा कमी गरेर अरु बालीहरु लगाउनुभएको छ ?	Y N	☐	☐	☐	☐	☐	☐
धानखेती छोडेर पशुपंक्षीपालन, वा अन्य रोजगारीतर्फ लाग्नुभएको छ?	Y N	☐	☐	☐	☐	☐	☐
(H) अन्य (केही भए, खुलाउनुहोस)							

Section D: किसानको जोखिम वहन गर्ने धारणा सम्बन्धी प्रश्नहरु

26. एउटा काल्पनिक खेल खेलौ : तपाइ कुन Option रोज्नुहुन्छ A or B, सबै प्रश्नको उत्तर दिनुहोला । प्रश्न No. 1 to 8

प्रश्न No.	1	2	3	4	5	6	7	8
Option A; बिना risk मा रकम पाउनुहुन्छ (100% sure)	Rs100	Rs. 75	Rs. 60	Rs. 50	Rs. 40	Rs. 30	Rs. 20	Rs. 10
Option B; Rs.100 वा 0 पाउने आधा-आधा chance (50: 50 %)	100 or 0	100 or 0	100 or 0	100 or 0	100 or 0	100 or 0	100 or 0	100 or 0
तपाइ कुन Option रोज्नुहुन्छ ? A or B *(circle one)*	A or B	A or B	A or B	A or B	A or B	A or B	A or B	A or B

27. तपाइलाइ आफ्नो जोखिम वहन गर्ने क्षमता (Risk tolerance level) कतिको छ जस्तो लाग्छ ?
☐ Low - म खासै जोखिम (Risk) लिन्न ।
☐ Medium- अलिअलि ठीकठीके जोखिम (Risk)उठाउछु / लिन्छु
☐ High- म धेरै नै जोखिम (Risk) उठाउछु / लिन्छु

Section E: किसानको कृषि प्रसार, तालिम कृषि ऋण, कृषि सूचनामा पहुच सम्बन्धी प्रश्नहरु

बालीबीमा	28. a. तपाइलाइ धान बाली बीमाको बारेमा थाहा छ ?	Y N	
	b. तपाइले धान बालीको बीमा गर्नुभएको छ?	Y N	c. यदि छैन भने, किन नगर्नुभएको?( ) प्रिमियम रकम धेरै तिर्नुपर्ने भएकोले ( ) भाग्भाटिको प्रकृयाले गर्दा नगरेको ( ) बीमाको फाइदा,घाटाको बारे पर्याप्त जानकारी नभएर ( ) अन्य कारण.................................
कृषि प्रसार	29. तपाइ गतवर्ष कृषि विकास कार्यालय वा सेवा केन्द्रमा जानुभयो वा ती कार्यालयका कोही प्रसार कर्मचारीहरु तपाइको घर खेतबारीमा आएका छन ?	Y N	
तालिम	30.a. विगत ३ वर्षमा तपाइले जलवायु मैत्री खेती पद्धति, तरिकाको बारेमा कुनै तालिम लिनुभएको छ ?	Y N	b. तपाइले कस्ता प्रकारका तालिम पाउनुभयो भने जलवायु परिवर्तनका असरहरुसंग अनुकूलन हुन सजिलो हुन्छ होला ? Explain..
	c. तपाइ त्यस्ता तालिमहरुमा भाग लिन चाहानुहुन्छ ?	Y N	
कृषि ऋण	31.a. तपाइले कृषिकार्य/धानखेतीको लागी loan (ऋण) लिनुभएको छ ?	Y N	b. यदि लिनुभएको छ भने, कहा बाट ?; ( ) Bank बाट ( ) समूह, सहकारी, लघुवित्तहरु बाट ( ) स्थानीय साहु, व्यापारीहरुबाट ( ) साथीभाइ, नातेदार, इष्टमित्रहरुबाट
	c. यदि लिनुभएको छैन भने किन नलिनुभएको?( ) Loan नचाहिएर ( ) ब्याजदर धेरै भएकोले ( ) भाग्भाटिको प्रकृयाले गर्दा		
अनुदान	32 a. तपाइले धानखेतीको लागी कुनै अनुदान, राहतहरु पाउनुभएको छ?	Y N	b. जलवायु परिवर्तनको अनुकूलन क्षमता बढाउन कस्ता प्रकारको अनुदान चाहानुहुन्छ, रुचाउनुहुन्छ ? *(Select top 3)* ( ) उपयुक्त, हावापानी सुहाउदो रोगकीरा प्रतिरोधी जातहरुको उपलब्धता र त्यसमा छुट ( ) सिचाइ सम्वन्धि नहर, कुलो, र सिचाइको लागी विद्युत महसुलमा छुट ( ) धानखेतीको लागी चाहिने मल उपकरणहरुमा सहुलियत वा छुट ( ) रासायनिक तथा जैविक मलमा अनुदान तथा छुट ( ) धानखेतीको लागी सहुलियत वा बिना ब्याजको loan (ऋण) को उपलब्धता
विद्युत	33 तपाइको धानखेतमा सिचाइकोलागी पानीतान्न सजिलै विद्युतआपूर्ति छ?	Y N	धानखेतमा पानीतान्ने मोटर चलाउन सोलार प्यानल उपयुक्त होला ? Y N
कृषि र मौसम सम्बन्धी सूचना	34. a. तपाइको घरमा इन्टरनेट जडान गरिएको वा मलको पहुँच छ ?	Y N	b. तपाइको घरमा TV /Radioमा मौसम सम्वन्धि समाचार, कार्यक्रम हेर्नुहुन्छ ? Y N
	c. तपाइ कृषि मौसमसम्वन्धि सूचनाहरुमा जानकार वा update हुनुहुन्छ ?	Y N	
	d. तपाइले मोबाइलमा कृषि मौसम र अनुकूलन सम्वन्धि message हरु प्राप्त गर्नुहुन्छ?	Y N	e. विभिन्न स्रोतबाट आउने त्यस्ता मौसम सम्वन्धि सूचनाहरु तपाइलाइ कतिको विश्वसनीय र भरपर्दो लाग्छन? ( ) धेरै भरपर्दो र विश्वसनीय ( )ठीकठीके ( )खासै विश्वास लाग्दैन
	f. कृषि प्रविधि र मौसमसंग सम्वन्धित कुनै मोबाइल एप्स हरु प्रयोग गर्नुभएको छ ?	Y N	g. मौसम र प्रविधिसंगसम्वन्धित यस्ता सूचनाहरु जलवायु परिवर्तन अनुकूलनकोलागी कतिको उपयोगी छन त ? ( ) अत्यन्तै उपयोगी ( )अलिअलि उपयोगी ( )उपयोगी छैनन
	h. यस्ता सूचनाहरु तपाइले खेतीपाती गर्दा कस्तो बेला के निर्णय गर्न प्रयोग गर्नुहुन्छ ? Explain		
	i. मौसम र खेती प्रविधि सम्वन्धि जानकारीको लागी कुन सूचनाका स्रोतहरु धेरै प्रयोग गर्नुहुन्छ, धेरै हेर्नुहुन्छ? *(Select top 4)* ( ) FM radio सुनेर ( ) TV हेरेर ( ) Mobile apps को प्रयोग गरेर ( ) Agro- advisory (कृषि मौसम सल्लाह सेवा बुलेटिन पढेर)	( ) Toll free phone numbers (पैसा नलाग्ने फोन नं. मा फोन गरेर) ( ) Internet मा खोजेर, हेरेर ( ) कृषि कार्यालय, मौसम विज्ञान विभाग, नार्क बाट प्राप्तहुने सूचनाहरु, सन्देशहरु सुनेर, पढेर ( ) प्रकाशित भएका कृषि सम्वन्धि पुस्तक, पत्रपत्रिका वा अन्य स्रोतहरुको प्रयोग गरेर	

j.तलका कुराहरुमा आफ्नो सहमती वा असहमती राख्नुहोला मेरो/मसंग....(i....V)...को उपयुक्त पहुच, थाहा वा उपलब्धता छ	पूर्ण सहमती	अलि अलि सहमती	तटस्थ	पूर्ण असहमती	अलि अलि असहमती
i) विगतको समयको मौसम सम्वन्धि तथ्यांक तथा Trends हरुमा	☐	☐	☐	☐	☐
ii) मौसमको पूर्वानुमान वा भविष्यवाणीमा	☐	☐	☐	☐	☐
iii) जलवायुमैत्री कृषि अनुकूलन तथा खेतीप्रविधि सम्वन्धि जानकारीमा	☐	☐	☐	☐	☐
iv) मौसम र हावापानी सुहाउदो जातहरुको बारेमा	☐	☐	☐	☐	☐
v) बजार, बजारीकरण र मूल्यसम्बन्धी सूचनाहरुमा	☐	☐	☐	☐	☐

धानखेती र यसमा जलवायुपरिवर्तनका असर सम्बन्धी तपाइको अन्य केही भन्नु छ ....?

तपाइको समय र सहयोग को लागी धन्यवाद   **Good luck!!!**

All information collected here is part of a University of Tennessee research project and is completely voluntary. All information will be kept strictly confidential. If you have questions about this survey, please contact Sreedhar Upendram at (865)-974-7410 or UTK IRB staff at (865)-974-7697.

VITA

Hari P Regmi is from a hill district Gorkha, Nepal. He completed his Bachelor and Master of Science in Agriculture at the Tribhuvan University, Nepal in 2008 and 2010, respectively. He worked as an Agricultural Extension Officer in the Ministry of Agricultural Development, Government of Nepal since 2010. He joined Department of Agricultural and Resource Economics at the University of Tennessee to pursue a master's degree in Agricultural Economics in fall 2018 and will graduate in Summer 2020. He will Join Purdue University for doctoral degree in Agricultural Economics in Fall 2020.