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Master thesis

Impact of climate change on agricultural production in Chitwan district, Nepal

Påvirkning av klimaendringer på jordbruksproduksjonen i Chitwan-området i Nepal

Master's in applied ecology

2022

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Abstract

This research was conducted in the Chitwan district of Nepal to determine the effect of climate change on agriculture. Climate change has affected agriculture worldwide. Nepal being an agricultural country is facing several problems due to ongoing climate change. Key factors affecting food production are temperature, rainfall, soil quality, and farmers' ability to adapt to the situation. Climate change has disturbed these parameters which are creating numerous problems in the agriculture sector of Nepal. This research is performed to determine the effects on the production but also the life of farmers, their economic situation, and their perceptions of what is going on.

The research involved a household survey to collect primary data that was then analyzed with the Chi-square test. 26% indicated that the rice planting season had changed to earlier, and 30 percent indicated that they should shift cultivation to later in the season. Harvest time is believed to be ahead of before according to 30 percent of farmers. A major problem has been identified in the rice crop, with 42.5 percent of farmers reporting that rice yields have declined compared to previous years. Further, the climate data are analyzed with the implementation of a regression model. Trend analysis of annual average maximum and minimum temperature shows a minute reduction of temperature (2000-2021) by 0.028° C and 0.0377° C respectively whereas the annual rainfall trend also shows a reduction by 21.75mm per year. Finally, the correlation model is accommodated to examine the relationship between the climate data and production statistics.

Climate change has directly affected the lives of farmers who depend on their crops for their livelihood. About 94% of farmers used pest management practices as an adaptation measure. Farmers report a growing problem of plant and insect diseases when using high-yielding crops. Despite these challenges, research has shown that farmers are willing to make changes in their practices to adapt to climate change. This shows that policymakers need to stay focused on climate change strategies and encourage research and development on these approaches.

Keywords: climate change, yield, adaptation

Norwegian abstract

Forskningen bak denne masteravhandlingen ble gjennomført i Chitwan-distriktet i Nepal og hadde som mål å undersøke effekten av klimaendringer på landbruket der. Klimaendringer har påvirket landbruket over hele verden. Nepal, som jordbruksland, står overfor flere problemer på grunn av de pågående endringene. Nøkkelfaktorer som påvirker matproduksjonen er temperatur, nedbør, jordkvalitet og bøndenes evne til å tilpasse seg til nye situasjoner. Klimaendringene har endret disse parameterne og det skaper mange problem for landbrukssektoren i Nepal. Forskningen er utført for å undersøke effektene av klimaendringer på produksjonen av mat, men også på bøndenes daglige liv; deres økonomi og deres tanker rundt de endringer som skjer. Forskningen involverte en undersøkelse av 80 hushold for å samle inn primærdata som deretter ble analysert med kjikvadratstester. 26 prosent av husholdene indikerte at risplantingssesongen hadde begynte tidligere, og 30 prosent antydet at de skulle endre dyrkingen til senere i sesongen. Innhøstingstiden antas å komme tidligere enn før ifølge 30 prosent av bøndene. Et stort problem ble identifisert i risproduksjonen, hvor 42,5 prosent av bøndene rapporterte at risavlingene har gått ned sammenlignet med tidligere år. Videre ble klimadata fra Chitwan-området analysert ved bruk av regresjonsanalyser, dette for å finne eventuelle trender de seneste 20 år. Gjennomsnittlig maksimum- og minimumstemperatur viste en årlig reduksjon på henholdsvis 0,028°C og 0,0377°C, mens den årlige nedbørstrenden viste en reduksjon med 21,75 mm per år men med stor variasjon fra år til år. Avslutningsvis er en korrelasjonsanalyser brukt for å undersøke sammenhengen mellom klimadata og produksjonsstatistikk. Klimaendringene har direkte påvirket livet til bønder som er avhengige av avlingene sine for å overleve. Omtrent 94 % av bøndene tok i bruk skadedyrbekjempelse som et tilpasningstiltak. Bønder rapporterte om økende problem med plante- og insektsykdommer ved bruk av vekster med høy avkastning. Til tross for disse utfordringene, har forskning vist at bøndene er villige til å gjøre endringer i sin praksis for å tilpasse seg klimaendringene. Dette viser at beslutningstakere må holde fokus på klimaendringsstrategier og oppmuntre til forskning og utvikling på disse områdene.

Nøkkelord: klimaendringer, avling, tilpasning

Table of Contents

1. Introduction

1.1 Background Context

Climate change is any alteration to the climate due to human or other factors. Climate change has become a worldwide issue as it is responsible for creating an impact on the environment, health, ecosystem, and evolution (Paudel, Acharya et al. 2014). The ecosystem is being affected due to the greenhouse effect from the high emission of carbon dioxide, nitrous oxide, and methane (Huttunen, Alm et al. 2003). Global temperature is rising, along with other changes in weather/climate (Karki, Mool et al. 2009). Many places have observed changes in rainfall, causing intense rainfall. Forest destruction, excessive use of fossil fuels, increasing unmanaged urbanization, and industrialization are the primary/vital causes of climate change in Nepal (Shrestha and Aryal 2011). Climate change is highly impacting Nepal despite its rich natural resources like rivers, rivulets, and forests. Most Nepalese are dependent on natural resources for their economy. Climate change is affecting Nepal badly compared to its size and its contribution to the emission of greenhouse gasses. Nepal's alms to global greenhouse gases emission = 0.025%. However, the warming rate here is higher than the average of the globe (Bhattarai and Conway 2010).

The geography of Nepal comprises hills, mountains, and plains which supports the diversity in the agricultural system. The variation in landforms makes the country vulnerable to several natural calamities such as soil erosion, flood, landslide, and landmass movement (Van der Geest 2018). The geography of Nepal has provided an opportunity for diversity and together with this, the country is timely facing unpredicted disaster. The change in climate results in untimely rainfall, heavy rainfall, monsoon rain, and persistent rise in temperature. Our whole agricultural food system is based on the topsoil which is affected by the rain. No rain or too much rain, even slight changes affect the soil pattern. Climate change has affected the water resources in Nepal which causes a serious impact on the agriculture sector (Chaulagain 2009). The maximum temperature rise annually in Nepal is 0.056°C (Karki, ul Hasson et al. 2020). This continuous change in temperature and disturbance in rainfall have a major impact on agriculture and the farmers who are dependent on their farms for their living. For Nepal, a gradual increase in temperature is estimated in the upcoming years (Karn 2014). The geographic formation of Nepal is rich in natural resources but makes it vulnerable to several natural disasters as well. Thus, the ongoing climatic change is likely to hugely affect water

resources that will decrease agricultural production and food security. The biodiversity is vulnerable to climate change and global warming. The Himalayas are seen as highly profound to the warming which is direct harm to the plains of Nepal. The heavy rainfall strikes with the snowmelts coming from the mountains (Pokhrel, Baral et al. 2013) . Nepal is predicted to have a disastrous impact due to climate change on agriculture which has been true so far as we get timely threatened by natural disasters. Climate change has disturbed agricultural production, biodiversity, and the life of farmers immensely (Devkota, Phuyal et al. 2018).

Nepal is a developing country. As much as 25% of the country's population lives under the line of poverty (Pokharel 2015). Being an agricultural country, agriculture is the dominant sector of Nepal. The agriculture sector in Nepal involves 75% of human resources and it supports 35% GDP of the nation (Adhikari 2015). People living in the rural parts of Nepal rely on agriculture for their livelihood. Maximum people in rural parts of Nepal are involved in agriculture. Climate change has challenged the national economy by disturbing the agriculture sector. Fluctuation in climatic conditions such as uneven rainfall, rise and fall in temperature, and untimely rainfall had adversely affected the production rate of several crops in Nepal (Pulhin, Shaw et al. 2010). About 85% of Nepal's population live in rural areas, which describes the vulnerabilities caused by the disturbance in the agricultural sector to the people involved in farming. The greatest impact is on the poor, and underprivileged population living in the country's rural area whose livelihood is dependent on agriculture (Tiwari, Rayamajhi et al. 2014). Climate change is a menace to Nepal due to the weather variability related to the rise in temperature and change in precipitation patterns. Nepal gets over 80% of precipitation in the season of monsoon (Shrestha, Wake et al. 2000). Various farming relies on the level of precipitation. Therefore, farmers are likely to suffer as they rely on natural rainfall for their cultivation.

1.2 Problem Statement

In Nepal, local farmers are unaware of scientific knowledge about climate change and its adaptation (Dulal, Brodnig et al. 2010). This makes it more vulnerable to the farmers in Nepal. Nepal has high potential in the agricultural sector. The geography of the county supports production at a higher rate. However, a lack of awareness is a barrier to the development of the agricultural sector of Nepal. Similarly, the poor financial capacity and instability of the government of Nepal is also a threat to the agricultural system in addition to climate change. We need to be aware and prepared for the natural challenges, for which several adaptation

measures are required. The agricultural ministry is not seen actively involved in the growth of the agricultural sector. Agriculture has the potential to increase the economy of the nation if every aspect is controlled and managed properly. Farmers have been introduced to technological innovation to adapt to climate change. However, the increase in challenges requires an update in the latest innovations to overcome the threat. Climate change can't be stopped eventually, but its impact on us can be controlled to some extent with proper awareness and adaptation to climate change (Adger, Huq et al. 2003). In Nepal, people living in rural parts lack literacy. The first and foremost initiation can be developing awareness and generating suitable ideas for adaption to the climatic changes. Nepal can be able to feed the whole nation with their only hard work if the appropriate system is applied to reduce the threat existing in the agricultural sector.

1.3 Aims and objectives

- To determine the effects of climate change in agriculture
- To understand the problems faced by locals of Chitwan due to the impact created by climate change, on agriculture
- To study the adaptation measures applied to agriculture to minimize the impact of climate change on the cultivation

2. Materials and Methods

2.1 Study area

Nepal is a small landlocked country in South Asia having an area of around 147,000km^2 and present between the latitude of 26^0 22'to 30^0 27' north and longitude 80^0 04' to 88^0 12' east. Nepal is listed as the fourth most vulnerable country in the world for climate change (Li, Lei et al. 2017). Rice, maize, and wheat are the most prestigious food crops in the country. 78% of Nepalese farmers harvest their cultivation for household consumption. Furthermore, about 60% of farmers are not able to meet their food requirements (Joshi, Maharjan et al. 2010). The agriculture sector plays important role in the welfare of Nepal since the country is highly dependent on its agricultural export for the economy (Tamang, Dhital et al. 2011).

The research is conducted in the Chitwan district of Nepal. Chitwan lies on the southwestern corner of Bagmati province. The district occupies an area of 2,238.39 km^2 and has a total population of 579984. It is in the subtropical inner Terai lowland of the south-central region of Nepal. The district has a tropical monsoon climate with high humidity throughout the year. People in Chitwan are small farmers. The focus of the research was Bharatpur Metropolitan which has a total of 433 square kilometers of area and is at an elevation of 208 m from sea level. Another study area is the Ikchyakamana rural municipality which has a total area of 166.67 square kilometers (Figure 1).

They produce main foods and cash crops like rice, wheat, maize, lentils, mustard, and other vegetables. The study is performed to determine the impacts on the agricultural condition of Chitwan and the people living within the territory. The objective/motto of this research is to monitor and evaluate the effect caused by climate change, and the response of farmers towards the current condition of agriculture.

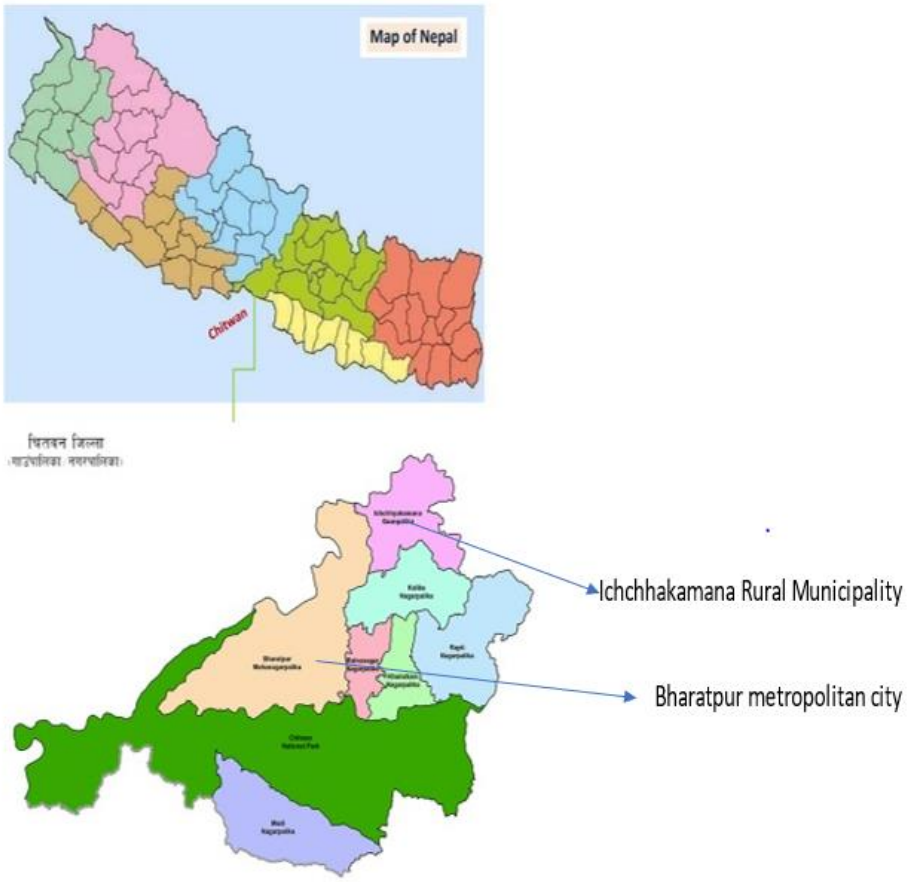


Figure 1: Map of Nepal and map of Chitwan showing study areas (source: commons.wikimedia.org).

2.2 Data Collection Techniques

2.2.1 Primary data collection

Primary data was collected by conducting programs in the village areas of Ikchyakamana rural municipality and the Bharatpur Metropolitan of Chitwan, from the farmers and the authorized communities working in the district. Several questionnaires were completed at Agriculture and Forestry University in Rampur to collect data from the students studying on this topic. The data was collected from the farmers from different economic backgrounds, educational backgrounds, and ages. The questions were prepared to cover as many aspects as possible. The aged people were asked about the change they have observed in the agricultural system in the district because of the climate change and the evolution of adaptation procedures applied to the

community. Several ethnic groups are included in the research. We collected data visiting the farmers working on the land and conducted a program to gather people to extract data.

2.2.1.1 Direct survey

We visited every house in the community of Ikchyakamana, and Bharatpur which are highly engaged in agriculture. We conducted a field visit with the prepared questions and carried out questions and answers. We included every age group and gender in the survey to get diverse perspectives and information. We went from house to house for 4 days day and re-visited the missed places the next day. The survey was concerned with finding out the cultivation rate, amount of rainfall, fluctuation in temperature, the pattern of temperature, drought, change in water supply, and their impact on cultivation (see Appendix 3). We covered 80 houses and 80 people through the field visit.

2.2.1.2 Program

We conducted a program to gather people and conducted informative sessions regarding innovative approaches to be adapted for minimizing the impact of climate change in agriculture. We collected data to be informed about people's awareness of adaptive measures. We asked people about the information we provided on the session and if they were previously aware of them. It helped us to analyze their level of literacy and awareness towards the impact of climate change.

2.2.1.3 The survey in Agriculture University

We developed questions to survey at Agriculture and Forestry University in Rampur. 50 students and professors were present on our survey, and they answered the queries related to their field of study. We collected information about the scenario of climate change and its effect. The prediction and estimated future impacts were also discussed by the students. The teachers and professors in the university also assisted in the data collection process.

2.2.2 Secondary data collection

Various sources were used to gain information to integrate them with primary data and generate meaningful results. Several journals, articles, and book knowledge were used as the secondary source of data collection. Similarly, online journals and articles were also helpful in finding relevant data. The data were taken from the annual reports generated by the organizations

working on climate change and agriculture, such as the National agriculture research council (NARC), the Central Bureau of Statistics (CBS), and Community Based Organizations (CBO). The data from secondary sources were taken from meteorological forecasting division, Kathmandu to evaluate the changes and adaptation measures in agriculture (see appendix 1). The data related to productivity and production of food and cash crops were obtained from the Agriculture Department Chitwan during the research. (see appendix 2).

2.3 Data Analysis

The research was majorly focused on the locals of the Bharatpur and Ikchyakamana region of the Chitwan district. The survey and interviews were carried out by prior discussion with the farming communities and the local agricultural universities along with local agricultural officials. Through the help of the farming communities along with the professors of the Agriculture and Forestry University in Rampur the cropping calendar of the Chitwan district was prepared. The major data and information about the agricultural changes in the Bharatpur and Ikchyakamana municipalities were taken from the District Agriculture Development Office (DADO), Chitwan. The secondary data were also collected from various online sources that were related to the temperature, precipitation, and so on about the Chitwan district in general.

The primary data were collected from the form survey carried out by visiting the farming communities of the Bharatpur metropolitan and Ikchyakamana rural municipality of Chitwan district on the field. All the obtained data were then placed/coded in the MS Excel sheet and the information required for the analysis of our research was then analyzed. All the measurements are taken in terms of the SI unit. The data analysis process used both the qualitative as well as quantitative methods as suitable.

All the qualitative information that was collected from the survey forms, like the knowledge related to climate change, agroecology, the effect of climate change on temperature, rainfall, drought, flood, landslide, change in the cropping pattern, use of fertilizers, herbicides, amount/rate of pest infestation, and so on were analyzed qualitatively and described. Other quantitative models of descriptive and analytical analysis were employed for understanding the age group, gender, economic status, occupational patterns, landholding information, etc. All the quantitative analyses were performed by using the MS Excel tool. To compare some categorical variables, the statistical measure of the Chi-Square (χ^2) test is also implemented in

the data analysis/evaluation phase. The chi square test was calculated using chi square test calculator and using Excel. Regression analysis was done and the obtained R square and p-value were interpretated. Similarly, correlation coefficient was also calculated to see the relationship between study variables. The changes in the trend of precipitation, landslides, and temperature were performed by analytical analysis. The data from meteorological office was kept in Excel sheet and analyzed using simple linear equation. Other statistical tools used in the data analysis process were mean and, in some cases, standard deviation.

3. Results

3.1 Socio-economic and demographic background

The study area was taken in the Chitwan district, and the survey tried to include the respondents from different socio-economic and demographic backgrounds. The sample size of 80 was divided equally into two locations: Bharatpur metropolitan city and Ikchyakamana rural municipality. The total respondents included 41 (51.25 per cent) male participants and 39 (48.75 per cent) female participants. The age group of the participants was also almost equally divided. The highest age group of the respondent was 22 which were of the range 41 – 50 years. And the least participation of 18 was from the age group of >50.

The literacy of the participants was measured based on the five different categories: illiterate (meaning they have not been associated with the formal education, Primary, Secondary level, Higher Secondary level, and graduation as shown in Table 1. Maximum of the participants had passed the secondary level (37.5%) and higher secondary level (31.25%) education. Only 4 (5%) of the 80 participants were graduates.

The chi-square test was performed to estimate the relation between gender and education level. H_0: There is no relevant relationship between the two study variables gender and education level. H_1: There is some significant relationship between the two study variables: gender and education level. On calculation, the chi-square value was obtained to be 3.27. And the degree of freedom for the obtained value table is = 4. From the chi-square distribution table, the chi-square ($\chi 2$) value for the degree of freedom 4, and 0.05 level of significance = 9.488. Since the calculated value of the chi-square is less than the tabulated value, the null hypothesis is accepted and reject the alternative hypothesis. The conclusion being there is no significant relationship among the two study variables gender and education level. The survey results showed that the family was mostly nuclear and the mean of family members from the data of 80 respondents was 6.375 as shown in table 2.

Table 1. Distribution of respondents 'age group and education level'

	Male	**Female**	**Total**
Age group			
<30	7	13	**20**

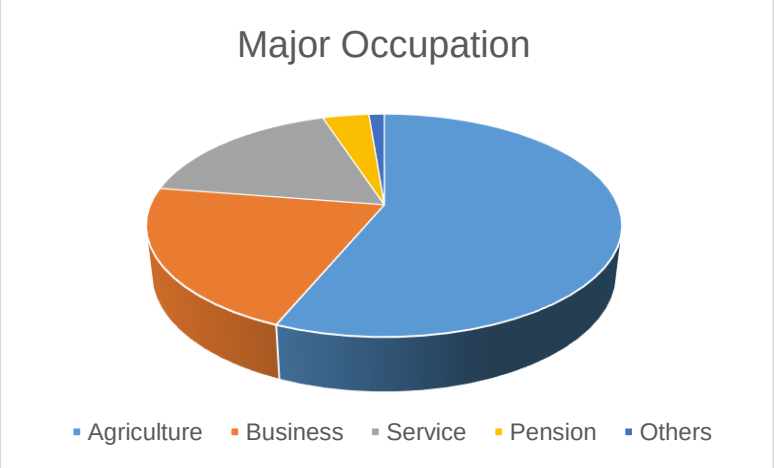
30-40	11	11	**22**
41-50	8	12	**20**
>51	15	3	**18**
Educational level			
Illiterate	4	7	**11**
Primary	5	5	**10**
Secondary	19	11	**30**
Higher Secondary	11	14	**25**
Graduation	2	2	**4**
Total	**41**	**39**	**80**

Table 2: Family member's statistics

	Mean	Standard Deviation
Number of family members	6.375	5.75

3.2 Households, land holdings, religion, and occupational characteristics

The survey respondents were majorly from the Hindu religion, about 80 per cent, followed by 10 per cent of the Christian, 7.5 per cent of Muslims, and 2.5 per cent Kirati. The chi-square test was performed to identify the association between religion and gender. H_0: There is not any significant relationship between gender and religion. H_1: There is some significant relationship between gender and religion. The calculated X^2 value was 0.01244. While the tabulated X^2(degree of freedom (df) = 3, level of significance (α) = 0.05) = 7.815. The tabulated value of chi-square is higher than the calculated value, therefore there is no significant relationship between the gender and the religion of the respondent in the study area, and we accept the null hypothesis (Table3).



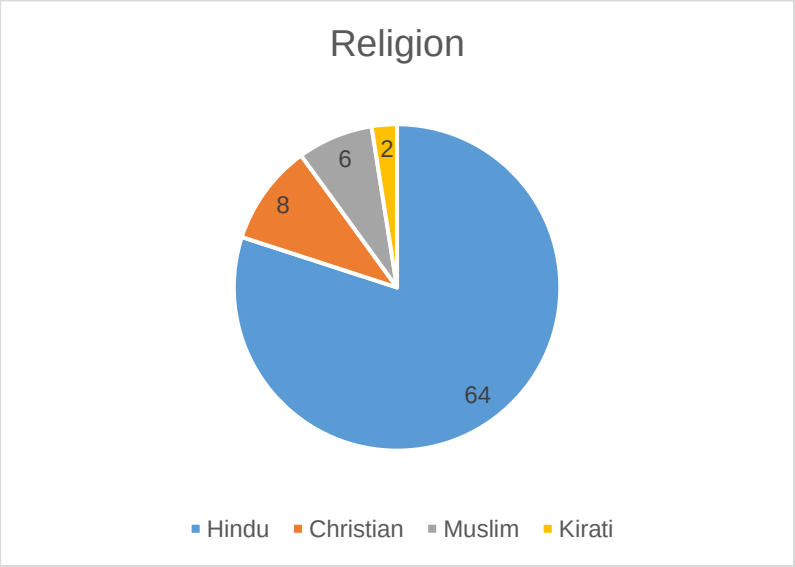


Figure 2: Religion and occupation of respondents

The landholdings results show that the maximum (50 per cent) farmers have land in the range of 0.5 – 1 ha in the area followed by the (40 per cent) <0.5 ha area. Only 10 per cent of respondents were having landholdings of >1 Ha (Figure 3).

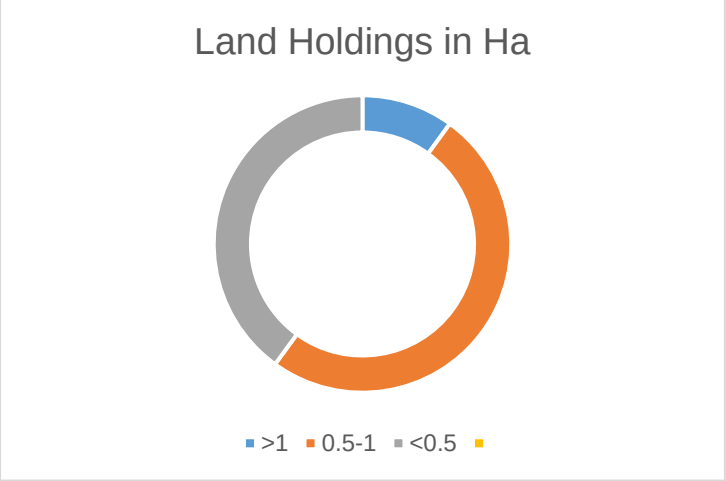


Figure 3. Landholding distribution

Table 3. Religion based on gender

Religion	Male	Female	Total
Hindu	33	31	**64**
Christian	4	4	**8**
Muslim	3	3	**6**
Kirati	1	1	**2**
Total	**41**	**39**	**80**

The occupation wise study of the survey showed that most of the families had agriculture as the main occupation (56.25 per cent), followed by business (21.25 per cent), and Service (17.5 per cent). 66.67 per cent of the agriculture occupation is contributed by the Ikchyakamana respondents and only 33.33 per cent is accompanied by the respondents of the Bharatpur metropolitan city (Figure 2).

3.3 Social characteristics and knowledge acquirement in the study area

The survey also included the questionnaire to understand the social status of the respondents in the study area. The participants from Ikchyakamana were found to be heavily engaged in social positions compared to those of the Bharatpur metropolitan city. 35 per cent of the respondents from the Bharatpur area were not associated with any social positions, while 50

per cent of those from the Ikchyakamana were found to have some social positions. Regarding the organizational involvement, both the study area was lacking behind, as only 26.25 per cent of the total participants were involved in some sort of organizations like NYC, Mahila Samuha, Local Farmers Group, LEO, etc. Also, there was poor participation among the individuals of the study area in the farmer knowledge exchange programs (only 21.25 per cent participation). The result also showed that there was very minimum assistance reached to the farmers of Ikchyakamana rural municipality after the COVID. But there was a good awareness among the farmers of the study area regarding the insurance on agricultural land and production as 43.75 per cent had done some sort of insurance like General/Basic insurance, Crop, and agricultural insurance, as well as farm property and equipment related agricultural insurance, crop insurance, etc. (Table 4).

Table 4: Institutional and social characteristics of respondents in the study area

Variables	**Bharatpur (n=40)**	**Ikchyakamana (n=40)**	**Total (n=80)**
Social Position			
Yes	14	20	34
No	26	20	46
Organizational Involvement			
Yes	10	11	21
No	30	29	59
Farmer Knowledge exchange			
Yes	8	9	17
No	32	31	63
COVID assistance from the state			
Yes	14	5	19
No	26	35	61
Insurance on land and production			
Yes	13	22	35
No	27	18	45

3.4 Perception of the farming communities on the climate change

3.4.1 Awareness of the respondent regarding climate change and agroecology

In the survey, about 65 per cent of the participants said that they have heard about climate change and have a basic idea about the concept, while 35 per cent said they are unaware of this term and phenomenon. And 72 per cent said they have heard and are familiar with the term

agroecology as they have heard about it from the agricultural departments and organizations, however, 28 per cent were unaware of this aspect of agriculture (Figure 4).

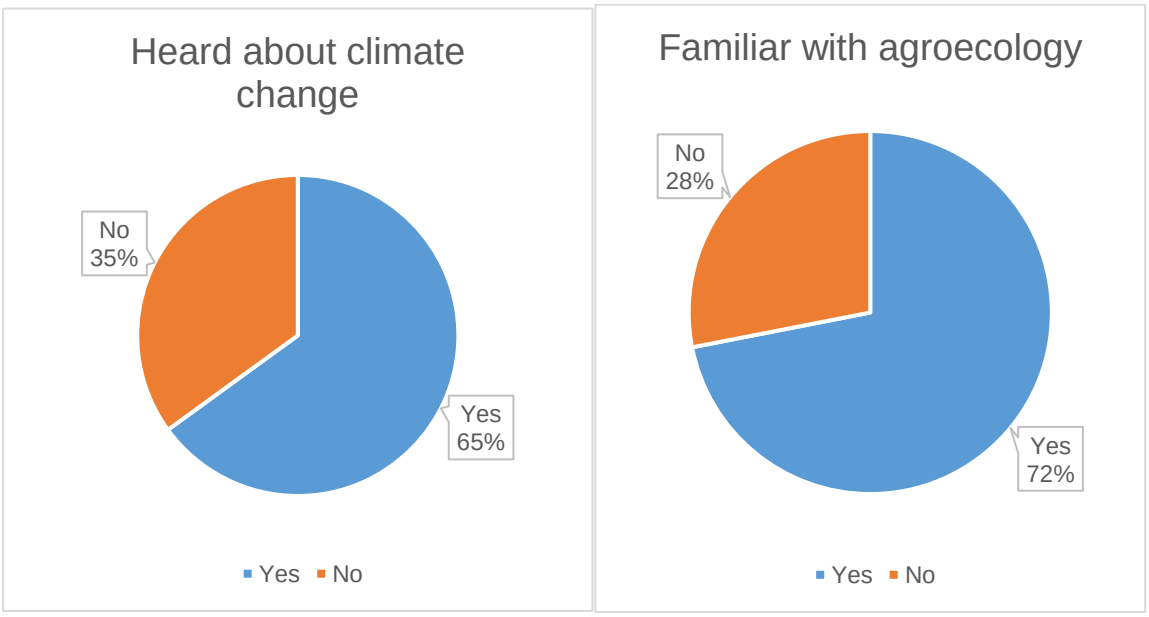


Figure 4. Awareness of respondents regarding climate change and agroecology.

3.4.2 Source of knowledge in the study area

During the field survey, most of the farmers shared their familiarity with climate change as well as agroecology. They were aware of this phenomenon and process through some direct and some indirect sources. Most of the farmers (around 44 per cent) suggested that they were gaining knowledge on climate change from media platforms, like TV, radio, newspapers, etc. This knowledge source was closely followed by self-experience, as many of the farmers have been working for more than 10 years, and they are getting to see the shuttle as well as huge changes in the environment. Around 14 per cent of the participants suggested that they were made aware of climate change by the social organizations. A minimal portion of 5 per cent of farmers said that they were yet unaware of this phenomenon of climate change (figure 5).

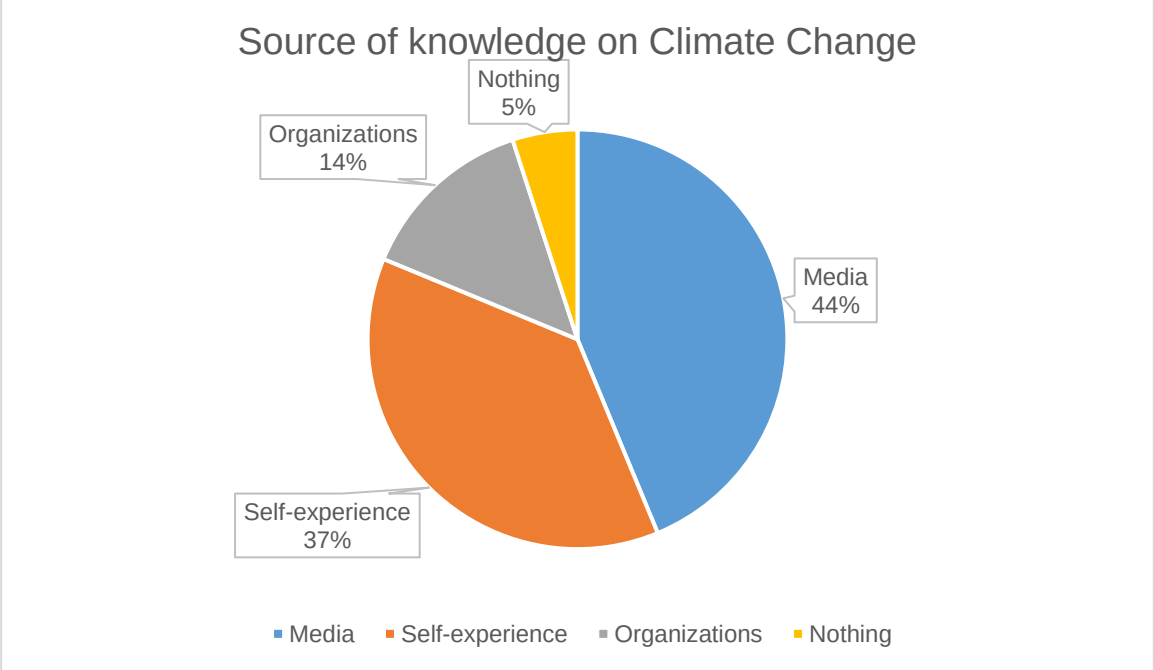


Figure 5. Source of knowledge on Climate Change

Table 5: Chi-Square test, gender, and knowledge on climate change

Source	Male	Female	Total
Media	16	19	**35**
Self-experience	18	12	**30**
Organizations	4	7	**11**
No idea	3	1	**4**
Total	**41**	**39**	**80**

A chi-square statistical test was also performed to analyze the effect of gender on the source of knowledge and information in the study area. For this the hypothesis was set as:

H_0: There is no considerable relationship between gender and the source of knowledge.

H_1: There is some relationship between gender and source of knowledge.

The expected and obtained values were calculated and the chi-square value for the available data was obtained to be 3.228. While the tabulated value for the degree of freedom (df) =3, and level of significance (α) 0.05 is found to be 7.815. Therefore, the null hypothesis is accepted as the value obtained from the chi-square distribution table is greater than the calculated chi-square value. The relation could not be established between gender and the source of information in the study area.

3.4.3 Intuition, feeling, and experience regarding the change in local climate

The weather has been a major factor that has been fluctuating since the last decade, various aspects of agriculture have been directly and indirectly influenced by climatic conditions. The participants of the survey were asked to classify their perception regarding the temperature, rainfall, drought, flood, and landslide.

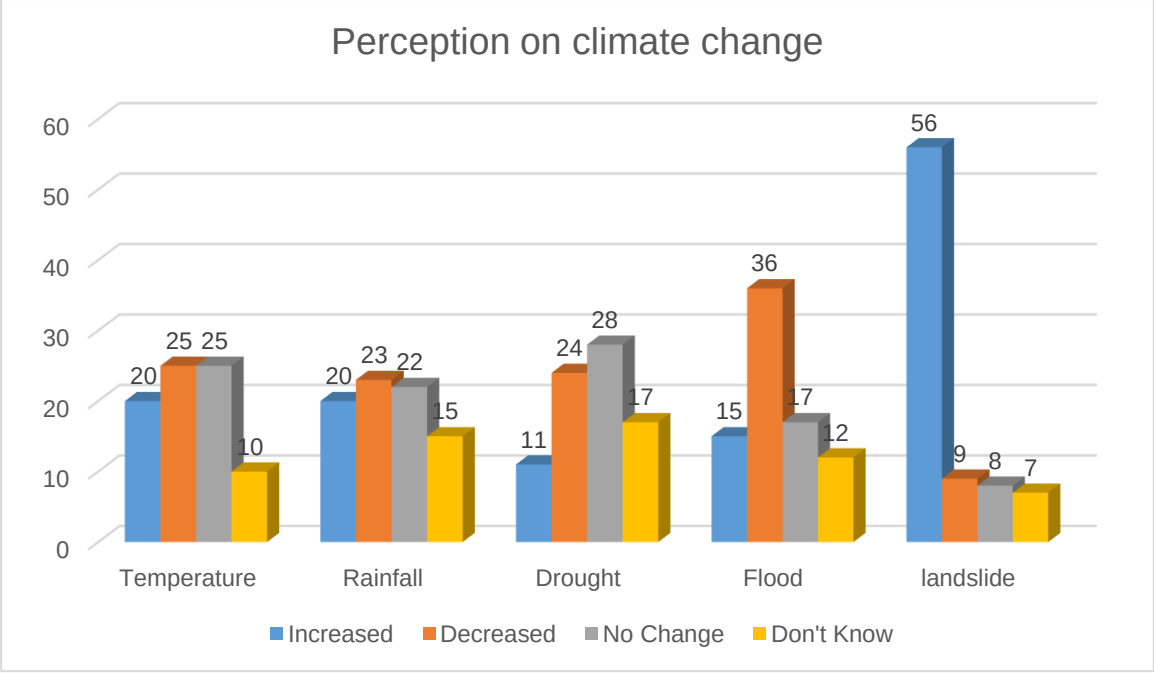


Figure 6. Bar graph of perception on climate change

Maximum (25 each) participants suggested they have seen a decrease and no change in the temperature in the past 10 or more years since they have started agriculture. While 25 per cent of them felt that there was an increase in the temperature than in the past and the 12.5 per cent

could not sense the variations. Similarly, 28.75 per cent of participants felt that there was a decrease in the rainfall and 27.55 per cent felt no change in the precipitation quantity compared to the past. About the drought, many respondents felt no such change compared to the past (about 35 per cent), while 13.75 per cent of the respondents felt the increase in drought. Likewise, a maximum number of participants (45 per cent) observed a decrease in the flood compared to the past. This is due to various artificial management taken to control the hazards of the flood, especially in the rainy season. However, the largest number of the participants, which is around 70 per cent observed a significant increase in the landslide-related problems (Figure 6).

Table 6: Temperature and age group

Temperature	<30	30-40	41-50	>50	Total
Increased	8	5	3	4	**20**
Decreased	6	7	7	5	**25**
No Change	3	7	9	6	**25**
Don't Know	3	3	1	3	**10**
Total	**19**	**22**	**20**	**19**	**80**

The statistical analysis of the relation between the perception of temperature and the age group of the respondents was performed by using the chi-square test. The initial hypothesis setup was:

H_0: There is no relation between the perception of the temperature variation and the age group.

H_1: There is a significant relationship between the perception of the temperature change and the age group of the respondents. From the statistical calculation we obtained:

Chi-Square value Calculated = 7.754624Chi-Square value Tabulated = (degree of freedom = 9, level of significance = 0.005) = 16.919. The Chi-Square value tabulated is more than the Chi-Square calculated value, therefore, the null hypothesis is accepted, and there is no relation among the study variables (Table 6).

The statistical analysis of the relation between the perception of rainfall and the age group of the respondents was performed by using the chi-square test. The initial hypothesis setup was:

H_0: There is no relation between the perception of the rainfall variation and the age group.

H_1: There is a significant relationship between the perception of the rainfall change and the age group of the respondents. From the statistical calculation we obtained:

Chi-Square value Calculated = 6.998539

Chi-Square value Tabulated = (degree of freedom = 9, level of significance = 0.05) = 16.919.

The Chi-Square value tabulated is higher than the Chi-Square calculated value, therefore, the null hypothesis is accepted, and there is no relation among the perception on rainfall and age group (Table 7).

Table 7: Rainfall and age group

Rainfall	<30	30-40	41-50	>50	Total
Increased	4	8	4	4	20
Decreased	4	5	9	5	23
No Change	8	5	3	6	22
Don't Know	4	4	4	3	15
Total	20	22	20	18	80

3.5 Impact on production due to climate change

Due to climate change, the major crops yield has been affected in many locations. Chitwan being one of the largest rice-yielding areas, the survey intended to understand the changes in the timings and the yield of rice crops in the study area. 26.25% of the respondents informed that the rice planting time has been shifted earlier in comparison to the past, and 30 per cent informed that they must shift the rice planting time to the latter half of the season (Table 8).

Table 8: Impact of climate change on cropping pattern

Cropping pattern	Comparing before 10 years and now		
	Earlier than before	Late than before	same
1. Rice planting time	21	24	35
2. Harvesting time	24	21	35

The harvesting time is believed to be earlier than before according to 30 per cent of the farmers. The major issue was seen in the rice yield, where 42.5 per cent of farmers informed that rice yield has lowered compared to the past years (Table 9).

Table 9: Impact of climate change on rice yield

	Comparing before 10 years and now		
	High	Low	same
Rice yield	15	34	31

3.6 Climate Change mitigation farming practices

Along with climate change, different mitigating practices are being deployed by the farmers. The majority (93.75 per cent) of the respondents were practicing pest management, followed by 86.25 per cent of the respondents who were practicing minimum tillage mitigation. Other methods used by the farmers of the study area were like plant cover and using green manure (Table 10).

Table 10: Climate change mitigating practices

Mitigating practices	Relation on rice farming and climate change adoption	Bharatpur farmers	Ikchyakamana Farmers	Total
Minimum tillage practice	**Yes**	32	37	69
	No	8	3	11
Planting of the cover crops	**Yes**	23	25	48
	No	17	15	32
Green manure practice	**Yes**	34	30	64
	No	6	10	16
Trying to incorporate the crop residues	**Yes**	28	30	58
	No	12	10	22
Practicing pest management	**Yes**	40	35	75
	No	0	5	5

3.7 Local climatic condition (Weather stats, 2022)

3.7.1 Trend analysis of Temperature in Chitwan

Maximum annual average temperature

The figure 7 below is the trend analysis of average maximum air temperature in Chitwan. The graph shows that the average maximum air temperature in recent time has been decreased. From the above linear equation, we see slope is negative which represents the line is going down, its decreasing that means every year average temperature goes down by 0.0288°C. But, when we see figure, in 2000 the average max temperature was 30.74 degree Celsius, while in 2006 the average max temp was 31.38 degree Celsius which was the highest average maximum temperature of last 20 years.

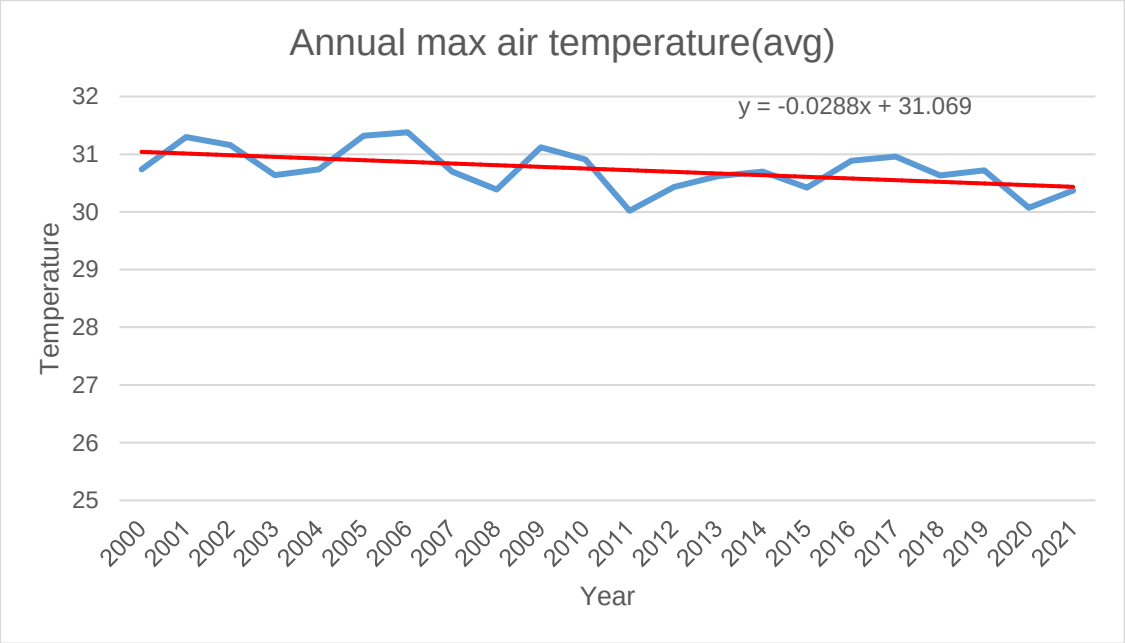


Figure 7. Trend analysis of annual maximum average air temperature in Chitwan for 2000-2021(Data source: Meteorological Forecasting Division, Kathmandu)

From the regression analysis, we got a R square value = 0.25. This implies that the regression line explains 25% of the variation in the annual maximum average temperature per year. This means most of the variation in the data is not explained by the model, so there are other issues explaining 75% of the variation. Also, we got a p-value = 0.0177 for the slope of the regression line, which shows that there is a statistically significant decrease in max. average temperature per year.

Average maximum temperature of 5 years period

I zoomed in on a five-year period from 2015 to 2019 to illustrate some of the variation. From figure 8, we can see that the slope is positive, and the average annual temperature was increased annually by 0.034°C over these five years. The average annual temperature was recorded 30.42 °C in 2015. In 2017 the temperature increases sharply to about 31 °C. From the regression analysis, R square value was 0.06, which means the model accounts for 6% of the variation. This means most of the variation in the data is not explained by the regression model. Similarly, p value obtained was 0.68, which implies the result is not statistically significant.

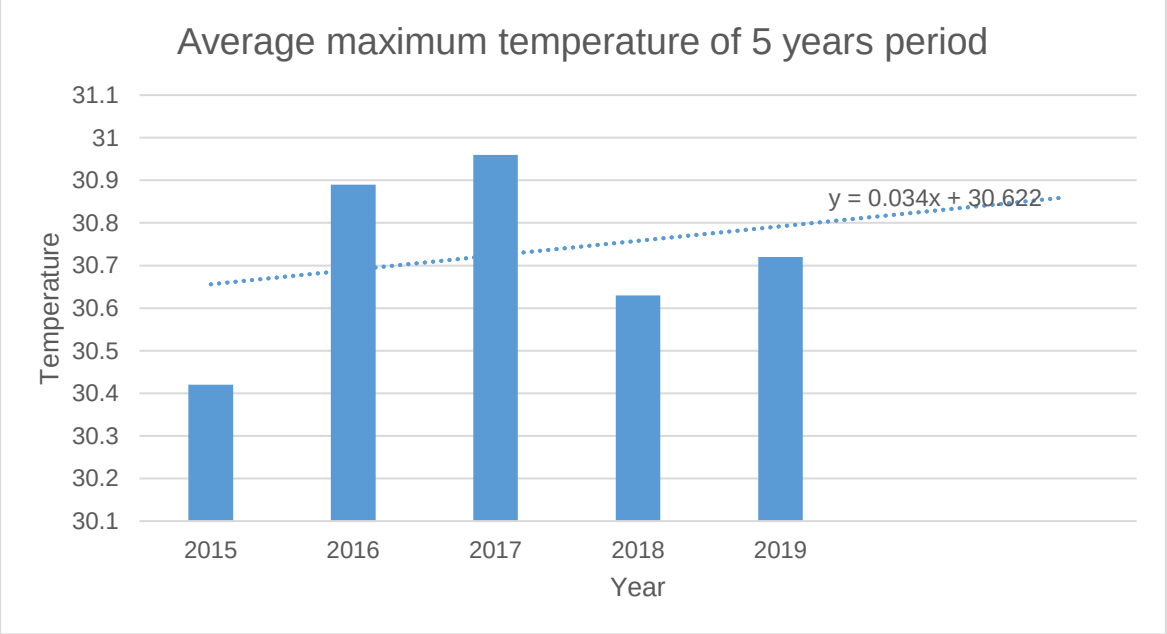


Figure 8. Trend analysis of annual maximum average air temperature in Chitwan for 2015 to 2019 (data source: Meteorological Forecasting Division, Kathmandu)

Minimum annual average temperature

From linear equation on the below figure, we see the slope is negative, which represents the line is going down, its decreasing which means average minimum temperature decreases by 0.0377 °C every year. But when we see the year wise average minimum temperature values, The highest average minimum temperature was found about 19 °C in 2010 and lowest average minimum temperature was about 14 °C in 2012, which was the lowest average minimum temperature of last 20 years (Figure 9).

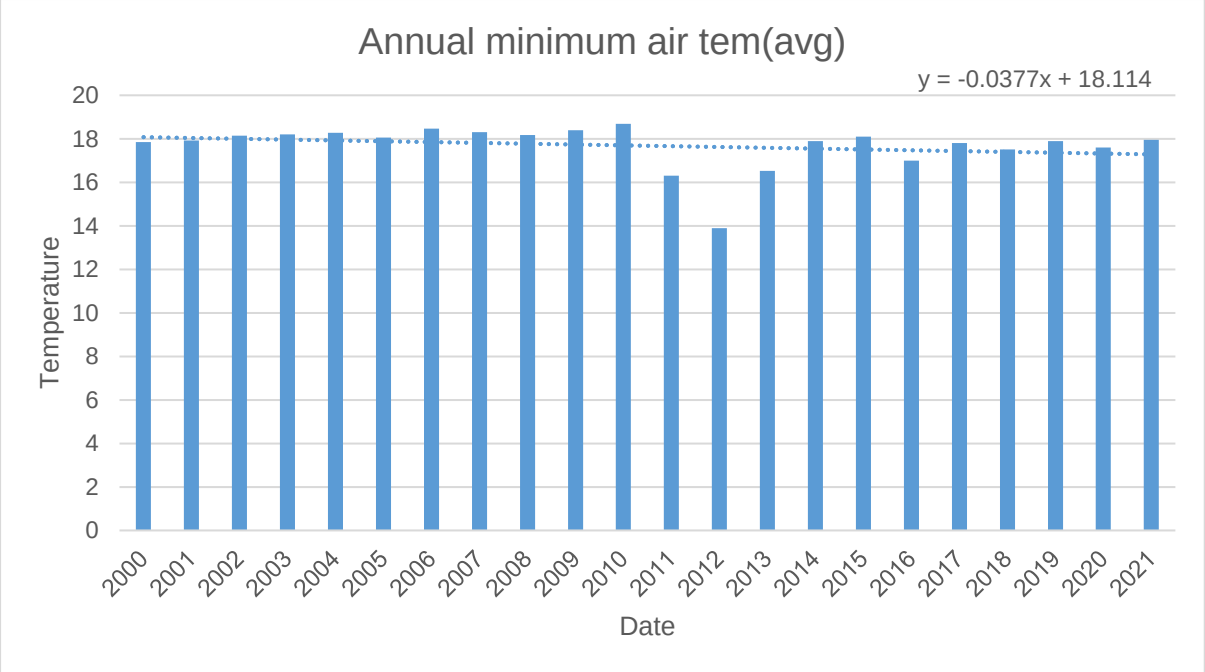


Figure 9. Trend analysis of annual minimum average air temperature in Chitwan for 2000-2021(data source: meteorological forecasting division, Kathmandu)

From regression analysis, the value of R square calculated was 0.05 and p value was 0.28. This means that the suggested regression line accounts for 5% of the variation for the annual average minimum temperature. Most of the variation (95% is not explained by the model. The p value implies that the result is not statistically significant.

Monsoon climate

From the below bar graph (Figure 10), we can clearly see the average monsoon temperature decreased every year, and in average by 0.0298 °C per year. But when we see the temperature of 2000 from graph it was found about 34.10 °C. Highest monsoon temperature recorded was 34.84 °C in 2019. But the monsoon temperature of last 2 years was decreased as compared to 2019. From the regression analysis, the obtained R square value was 0.13. This illustrates that the linear regression line accounts for 13% of the variation. This means most of the variation is not explained by the model. And the p-value obtained was 0.093, which shows the result is not statistically significant.

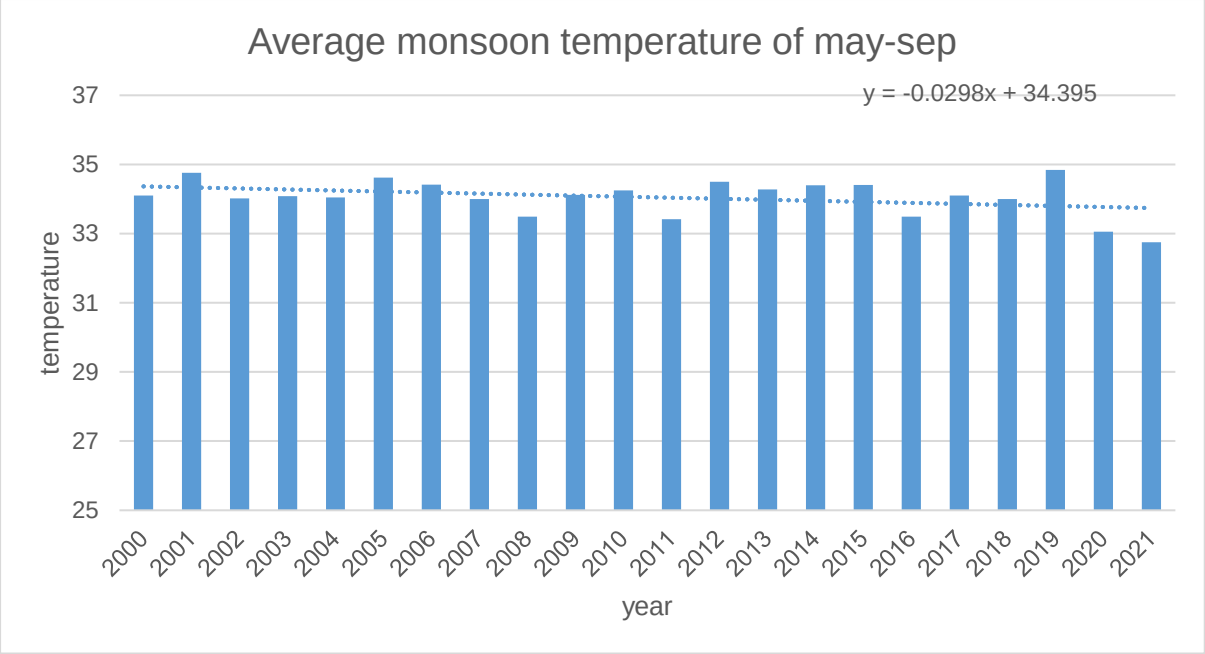


Figure 10. Trend analysis of average yearly monsoon temperature of Chitwan for 2000 to 2021 (data source: meteorological forecasting division, Kathmandu)

3.7.2 Precipitation trend analysis

From the figure below we can see that the slope is negative, which represents the line is going down. This slope value shows that the annual precipitation decreases by 21.752 mm every year. But when we see the graph, the rainfall is fluctuated over the last 20 years. The annual maximum precipitation was 3165 mm in 2020 whereas the minimum rainfall was only 1184 mm in 2011. Annual rainfall of 2018 was 1206mm, after that the rainfall increased sharply to highest peak of 20 years of 3165 mm in 2020 (Figure 11).

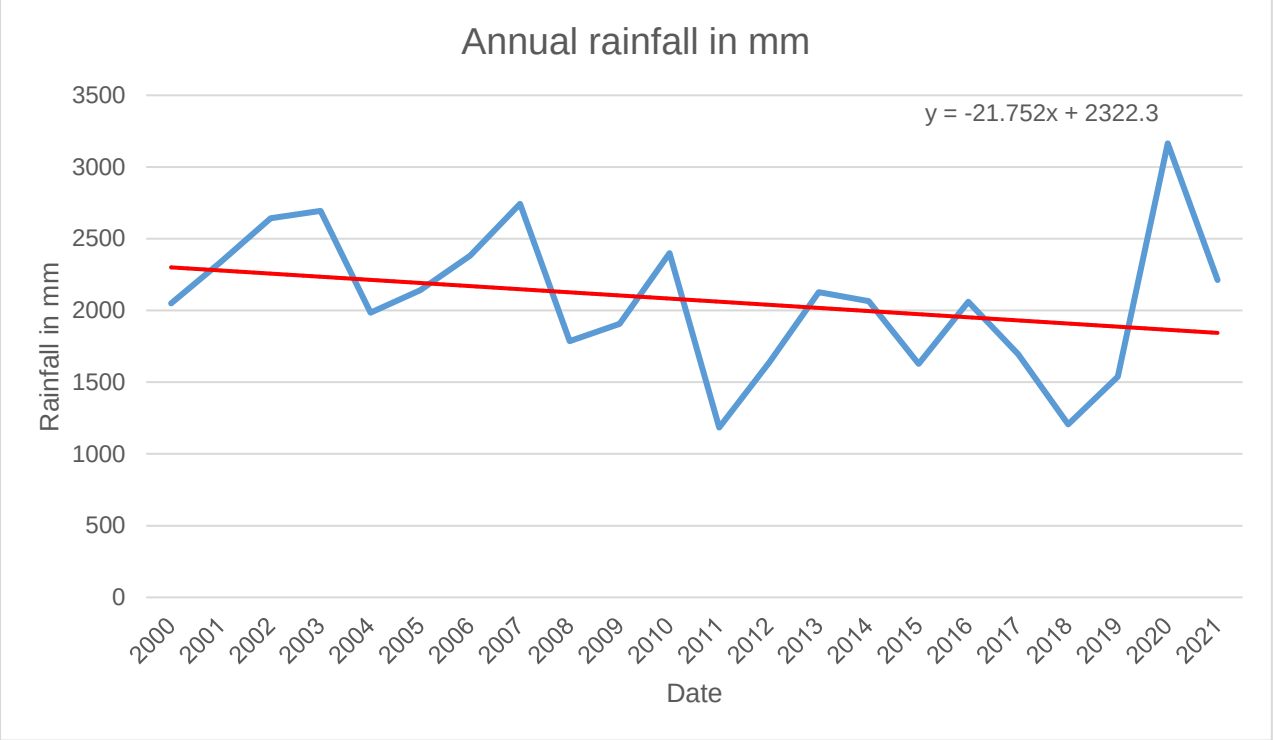


Figure 11. Annual rainfall of Chitwan district (data source: meteorological forecasting division, Kathmandu)

From regression analysis, R square and p – value obtained were 0.081 and 0.19 respectively. This means the only 8.1% of the variation is explained by the model and p value which is higher than 0.05 implies that the result is not statistically significant.

Average Yearly Precipitation of rainy season (June to September)

The graph below shows that the mean precipitation of rainy season decreased over 20 years (2000-2021). There has been high variation in precipitation in between 2010 to 2021. Maximum rainfall observed was 670.5 mm in 2020 whereas the minimum rainfall recorded was only 215mm in 2021 (figure 12).

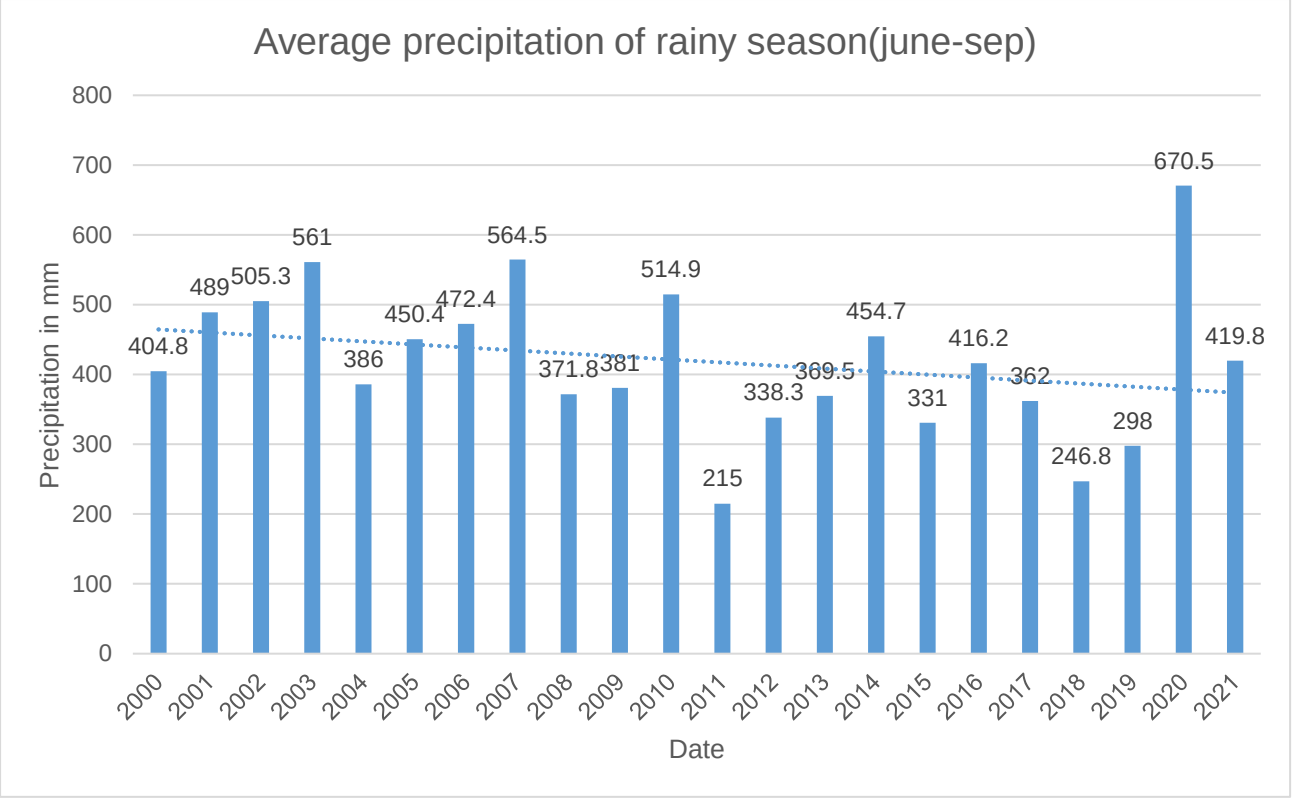


Figure 12. Average monsoon rainfall of Chitwan district (data source: meteorological forecasting division, Kathmandu)

From the regression analysis, R square value obtained was 0.068, which implies average monsoon rainfall and year regression model accounts for only 6.8% of the variation. Similarly, the p-value obtained was 0.24, that shows that the result is not statistically significant.

3.8 Statistical description of different variables on wheat, paddy, and maize production

From the figure 12 we can see the greatest area included in paddy production was 29655 Hectare in 2011/2012. Similarly, the largest area involved in maize production was 10000 hectares in 2011/2012, while the maximum area involved in wheat production was 8750 hectares in 2011/2012 and 2012/2013.

Further examination of the data in figure 12, reveals that the minimum area engaged in paddy cultivation was 26005 hectares in 2019/20, while the minimum area involved in wheat production was 5055 hectares in 2018/19. Similarly, the minimum area involved in the production of maize was in 2012/13 which was recorded to be 3490 Hectare.

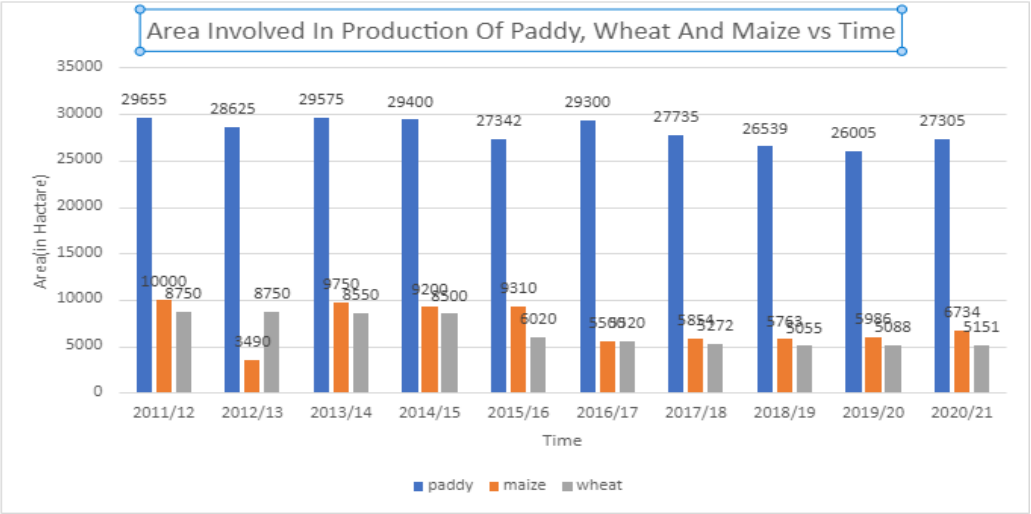


Figure 12. Total cultivated area of major crops in hectares (data source: District agriculture development office, Chitwan)

On further analysis of the graph in figure 13, it becomes clear that the maximum production of paddy was in 2016/17 which was recorded to be 108996 Metric Tonnes. Similarly, maximum production of wheat was in 2014/15 which was recorded to be 30500 Metric Tonnes and the maximum production of maize was in 2011/12 which was recorded to be 30000 Metric Tonnes.

On further analysis of the data presented in figure 13, it becomes clear that the minimum production of paddy was in 2015/16 which was recorded to be 92925 Metric Tonnes. Similarly, minimum production of wheat was in 2019/20 which was recorded to be 19360 Metric Tonnes and the minimum production of maize was in 2012/13 which was recorded to be 10500 Metric Tons.

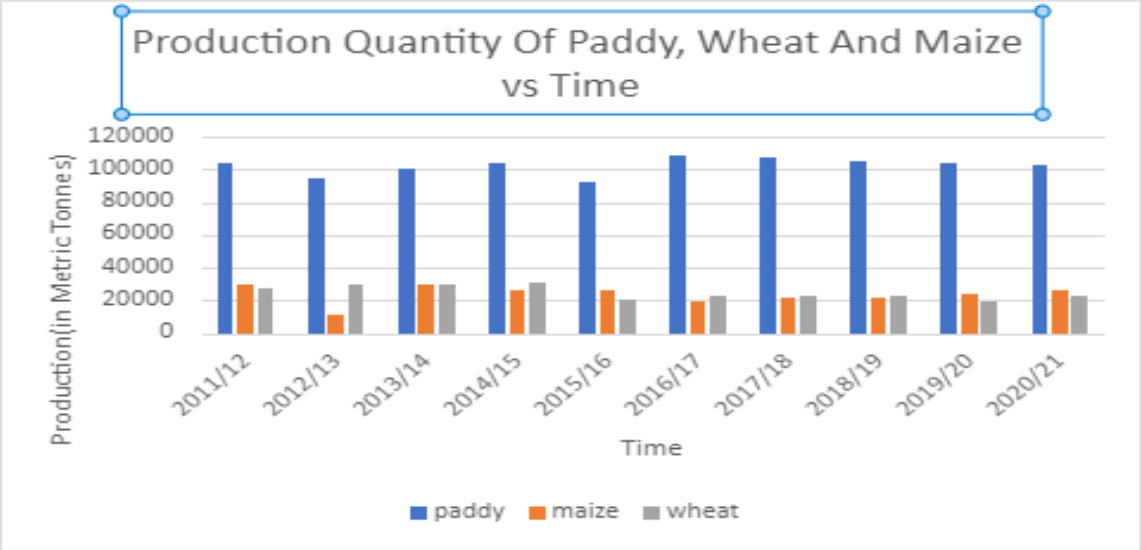


Figure 13: Total yields of paddy, maize, and wheat in metric tonnes (data source: district agriculture development office, Chitwan)

The data presented in figure 3.9.3 depicts the year wise yield of maize, paddy, and wheat. Viewing the graph, the maximum yield of maize was in the year 2019/20 which was recorded to be 4 Metric Tonnes per Hectare and the maximum yield of paddy was in the year 2019/20 which was recorded to be 4 Metric Tonnes per Hectare. Similarly, the maximum yield of wheat was in the year 2018/19 which was recorded to be 4.59 Metric Tonnes per Hectare.

Data presented in figure 14, makes it clear that the minimum yield of maize was in 2015/16 which was recorded to be 2.81 Metric Tonnes per Hectare, the minimum yield of wheat was in 2011/12 which was recorded to be 3.1 Metric Tonnes per Hectare and the minimum yield of paddy was in 2012/13 which was recorded to be 3.31 Metric Tonnes per Hectare.

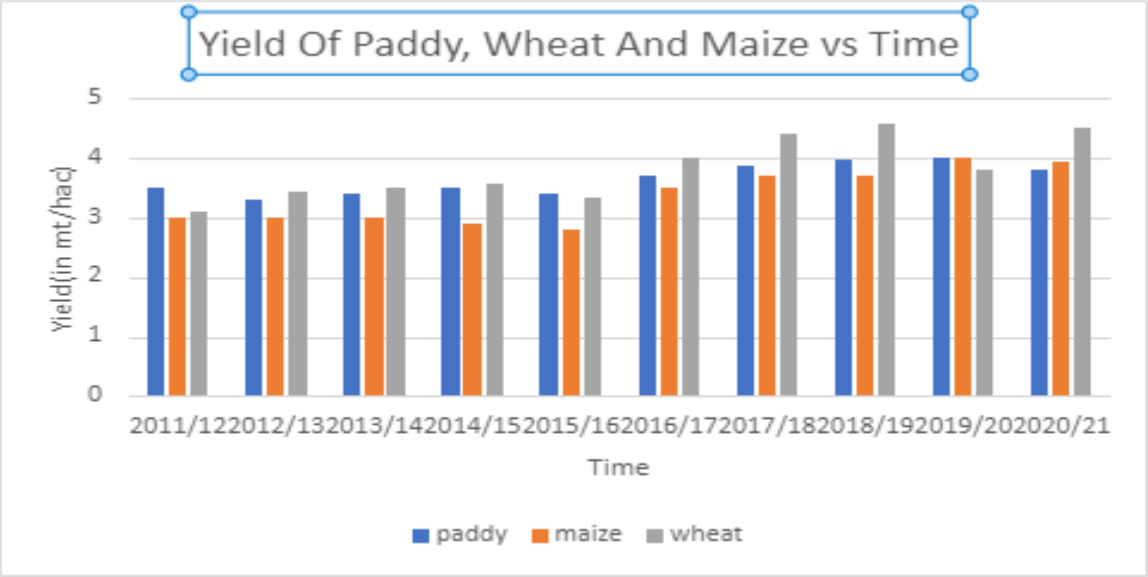


Figure 14. Year-wise data representation of yield of paddy, wheat, and maize in mt/hac (data source: district agriculture development office, Chitwan)

3.8.1 Correlation between Production vs Temperature, and rainfall

The correlation coefficients (r) of temperature vs rice, temperature vs maize, and temperature vs wheat were 0.40, - 0.30, - 0.16, respectively. This implies that the rice production and average annual temperature are moderately related Whereas temperature vs maize and wheat production shows weak negative correlation.

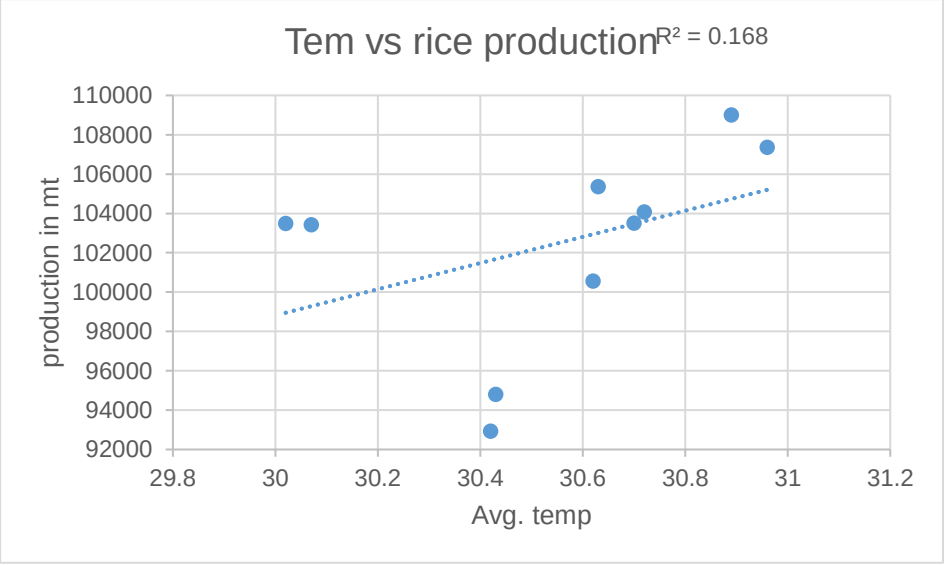


Figure 15. Correlation between Temperature and rice Production (data source: Meteorological forecasting division, Kathmandu, and district agriculture office Chitwan)

Similarly, the correlation coefficient of rainfall vs rice production, rainfall vs maize production and rainfall vs wheat production were found 0.085,0.15,0.063. This implies very weak positive correlation between rainfall and all three crops.

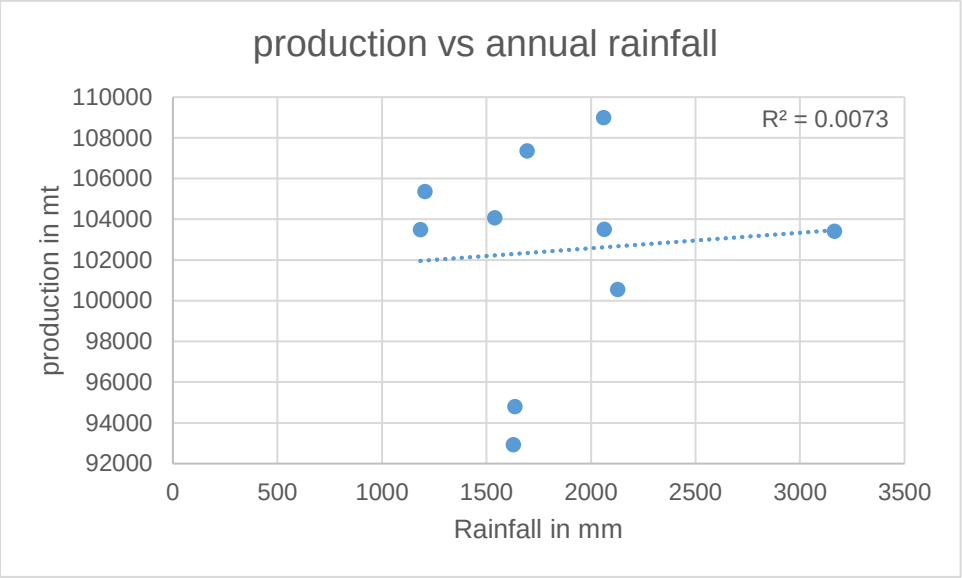


Figure 16. Correlation between Temperature and rice Production (data source: Meteorological forecasting division, Kathmandu, and district agriculture office Chitwan

3.9 Climate change impact on different variables

Most of the respondents said the crop diseases increased extremely over the years and many farmers reported that the yield has decreased to great extent due to climate change. Climate change has also resulted in making soil less suitable for cultivation and prolonged harvesting period to great extent according to the farmers.

Table 11: Perception on the impact of environment variables

Environment variables	To no extent	To a little extent	To great extent	Extremely
Do you think the frequency of crop diseases has increased in recent years due to climate change?	5	17	22	36

Crop yields have decreased due to climate change. What is your perception of this?	4	15	31	30
Do you think climate change affects making the soil less suitable for cultivation?	7	10	37	26
By how long the harvesting of the crops has been prolonged due to climate change?	7	20	29	24

3.10 Local community adaptation practices in agriculture

10 to 20 years ago the agricultural practices in the Chitwan district were traditional and crop grown were also traditional (Dangol 2008). Farmyard manure and animal dung were used as fertilizers to increase the fertility of the cropland. Back in the day, there was no such practice of using chemical fertilizers, insecticides, and other technical factors to improve or protect the crops as well as cropland. Most of the respondents who participated in the survey were knowledgeable about climate change and agroecology, however, they weren't aware of the measures to be taken to tackle the issues created by this change. They were feeling that the climatic hazards and crop diseases were increasing in recent times as compared to the past years. Some farmers were trying to adopt chemical fertilizers, and other technical variables to improve their cultivation (Shelar, Singh et al. 2021). However, the effectiveness of the application is very poor, as the crop yield (rice majorly) was found to be not increased satisfactorily.

The primary source of irrigation in the study area is rainwater. The farmers in the study area shared that the rainfall in the last 20 years has been very unpredictable, and more so in recent years. The timing and the pattern of the rainfall have been fluctuating. The sowing of the seeds has been done after the rainfall occurs. It was observed that the variable temperature and rainfall patterns have forced the farmers to change their cropping system. In the last 5 years, the majority of the farmers are found to shift their rice-wheat-maize cropping system to the rice-vegetable-maize cropping system.

Also, the interview with the older farmers put forward an interesting fact that the change in rainfall pattern has made them switch their planting time of the major crop like rice. While the rice was planted around the end of Ashadh (later June) back in the 2000s, now the planting has been shifted to several weeks later to wait for the monsoon to have adequate water in the soil.

The major adoption of the new practices to tackle the problems formed by climate change are shown as follows:

Table 11: Technology/Practice adapted by Farmers

Types of problem	Adaptation practices
Loss in productivity	Changing sowing time
	Green Manure Practice, Trying to incorporate the crop residues, Use of more chemicalfertilizer, FYM/compost
Disease, insect pest attack	Practicing pest management, Consult with Agro-vet
No moisture(drought)	Sowing after rainfall Irrigation through canal
Weed infestation	Hand pulling
Decrease in the soil quality	Minimum tillage practice

Comparative Analysis of Monsoon, Production and shifting cultivation time

This section shows the effect of monsoon in the production of paddy, wheat, and maize. The data shows that the production increases with the increase of monsoon. According to the graph of monsoon, area, and production, it shows that the monsoon is high in 2020 than other years, and the area was less, but the production of paddy in the year 2020 is about 4.6 metric tonnes per hectare(wheat), 4 metric tonnes per hectare (maize) and 4 metric tonnes per hectare(paddy) which is more than that of previous years. The average precipitation of 2011 was only 98mm (lowest of last 20 years) but the area used in this year was highest (29655 hectare for paddy, 10000 hac for maize and 27125 hac for wheat). This shows that despite the less area, but due to the more rainfall, the production of paddy increased in 2020/2021. Here, the monsoon and

production of year 2011 and 2016 is also compared. According to the graph, the rate of monsoon in the year 2011 is less than the monsoon in the year 2016. The area in the year 2011 is more than that of year 2016. And the production of paddy is less in the year 2011, but the production of maize is high. This shows that the production of paddy increases with the increase of precipitation.

Many farmers said in the survey that the cultivation time has changed. From the rainfall data we get from meteorological forecasting division Kathmandu, we found that in the years 2013 and 2016 rainfall starts from early may, so they must shift their paddy cultivation time earlier. Similarly In 2011 rainfall starts on June(305mm) but in the July the monthly average rainfall was only 45mm which affects the paddy field badly. In 2009 and 2017 rainfall starts from July, as rice is transplanted normally in June, but at those years they must transplant rice seedlings later.

4. Discussion

The review was directed for concentrating on the impact of changing environment on the Chitwan area of Nepal. Recognized issues existing in the farming area of that region with its effect on the day-to-day existence of individuals living there were the driving elements. Nepal is an agricultural country, about 80 percent of Nepalese population is involved in agriculture for living (Tamang, Dhital et al. 2011). Rice, wheat, and maize are the main crops of Nepal. In Nepal rice plantation is mostly dependent on rain water , more than 80 percent precipitation occurs on monsoon so mainly rice is cultivated in monsoon (Malla 2008). So due to change in rainfall pattern over the last 20 years the yield rate is being affected badly.

From the study, 72% knew about agroecology, and the excess 28% had no clue about the term. Individuals had some awareness of environmental change and agroecology through a few associations working around there and farming divisions. The associations in Chitwan are locked in to elevate the information on neighborhood individuals to improve their living. Individuals in Chitwan knew about these peculiarities through a few immediate and roundabout sources. A large portion of the respondents (around 44%) proposed that they were acquiring information on environmental change from the media stages, like TV, radio, papers, and so on. This information source was firmly trailed by self-experience, as a significant number of the respondents have been working for over 10 years, and they are getting to consider the bus to be well as colossal changes in the climate. Around 14% of the members recommended that they were made mindful of environmental change by friendly associations. An insignificant part of 5% of farmers said that they were at this point ignorant about this peculiarity of environmental change.

Nepal's economy relies upon farming. Absolute area of Nepal is 147,181 square kilometers partitioned in mountains (35%), slopes (42%) and terai (23%). The Chitwan region has diversified landscapes from hills to terrain areas. A sum of 3091000ha region is developed for agribusiness, and it represents 38.15% of the total national output (GDP) (Adhikari 2015). The nation is powerless to fiascos, including streak flood, GLOF and dissolving snow in the mountains and dry seasons and immersion in the terai. The increasing temperature and emanation of CO2 somewhat is useful underway of major crops. The temperature was noticed lowest among the winter in December 2012, and it was 4 degrees, while the maximum was recorded in the April of 2010, and it was nearly 38.1 degrees (source: meteorological department, Kathmandu)

From the analysis of the graph, it was found that monsoon is very important to produce paddy. It was concluded that we can produce more paddy in less area if there is good rainfall and good rate of monsoon. The journal of topic Climate change and its impact on Nepalese agriculture by G. Malla has also presented that the production of paddy increase with the increase of monsoon which is similar to our result (Malla, 2008). The article on the topic of Climate Influence on Rice, Maize and Wheat Yields and Yield Variability in Nepal by Mahadev Prasad Poudel presents that excess rainfall decrease the production of maize and wheat (Poudel, Chen and Huang, 2014). And to produce more amount of wheat and maize, the area must be more. Our result also shows that the production of maize was less during the excess rainfall and less area of production. According to Reyes the suitable temperature for rice cultivation is between 25 to 35 °C (De los Reyes, Morsy et al. 2003). When we see the average maximum temperature of monsoon over the last 20 years, the temperature of Chitwan was found between 25 to 35 °C, from this also we can say that the temperature does not have much effect on the study area, also the most respondents feel decrease or no change in temperature which support our result. But it may differ in other parts of country because temperature was higher 40 degree in other region of the country(Shrestha, Gurung et al. 2018)

The information was gathered from the review posing inquiries about their assessment of vacillation in temperature, the amount of precipitation, flood, and dry spell. The size (25%) of the respondents recommended that they see a lessening and there has been no adjustment of temperature 10 years or more since they began cultivating. Albeit 25% of them felt that there was an expansion in temperature than previously, and 12.5 percent couldn't feel the variances. Also, 28.75 percent of members felt that there was a decline in precipitation and 27.55 percent felt that there was no adjustment of precipitation contrasted with the past time frame. Concerning the dry spell, most respondents didn't feel such a change contrasted with the past (around 35%), while 13.75 percent of respondents felt an expansion in dry season. Also, countless members (45%) saw an abatement in flooding contrasted with the past time frame. This is because of the administration of different measures taken to forestall flood risks, particularly during the stormy season. Nonetheless, the biggest number of members, 70%, saw a critical expansion in land-related issues.

The study area was dominated by Hindu (about (80%), and the main occupation of the respondents was agriculture (56%) followed by business (21%). 50 percent of the farmers hold the land area of 0.5 to 1 hectare. Due to climate change, large crop yields have been affected

in many areas. Chitwan is one of the largest farming areas, and the survey aims to understand the timing and yield of crops in the research area. According to (Devkota, Regmi et al. 2013) landslide is a major problem in Chitwan and in 2007 landslide killed 4 people, 70 household and agricultural lands were destroyed. Our result also showed that 70 % of the respondents said landslide had increased over the time.

To estimate the effect of changing climate over the years, variables such as wheat farming, paddy farming, maize farming, high temperature, low temperature, moderate temperature, and total rainfall were considered. The trend analysis of average maximum temperature, average minimum temperature, and average annual rainfall of Chitwan was found to be decreasing over the past 20 years as shown by negative slope value shown on the equation on the graph. The average maximum and minimum temperatures were found 31.38 ℃ and 4 ℃ respectively. Rainfall seems to be much less in Chitwan in comparison to other regions of Nepal. The annual maximum rainfall of Chitwan was found to be about 3165mm in 2020 and minimum annual rainfall was 1184mm in 2011. But average annual rainfall of Chitwan was only 98 mm in 2011(minimum over the last 20 years) and about 264mm in 2020(maximum of the last 20 years). The average annual rainfall of Nepal is 1397mm (Meteorological forecasting division, Kathmandu). This level of rainfall is very bad considering most farmers of this study area rely on rainfall sources for farming. Rainfall has been another major problem for Bharatpur and Ikchyakamana municipalities.

10 to 20 years ago agricultural practices in the Chitwan region were traditional and crop farming was also traditional. Farm manure and animal manure were used as fertilizers to increase the fertility of the crop area. At that time, there was no such thing as the use of chemical fertilizers, pesticides, and other technological know-how to improve or protect crops and the environment. Most of the respondents who participated in the study were aware of climate change and agroecology, however, they were unaware of the steps to be taken to address the problems caused by these changes. They felt that climate hazards and plant diseases were increasing in recent times compared with previous years. Some farmers were trying to use chemical fertilizers, and other technological innovations to improve their farming. However, the efficiency of the application was found to be very poor, as crop yields were found to have not been satisfactorily increased. The main source of irrigation for the study area is rainwater. Farmers in the study area have shown that the rainfall over the last 20 years was unexpected, and it is most prevalent in recent years. The timing and pattern of rainfall have been fluctuating.

Sowing seeds is done after the rains. It was noted that fluctuating temperatures and rainfall patterns forced farmers to change their planting methods. 5 years ago, most farmers were found to be shifting their rice-growing system to a rice-vegetable-maize planting system. Also, an interview with older farmers revealed the interesting fact that climate change has caused them to change their timing of planting a larger crop like rice. When the rice was planted in late Asar (later June) back in the 2000s, now planting has been changed a few weeks later to wait for the monsoon to have enough water in the soil.

Climate change is degrading the soil quality and creating unpredictable barriers to cultivation. It has directly affected the livelihood of farmers who are dependent on their cultivation for their living (Shrestha and Nepal 2016). Farmers are adapting to the changing condition by experimenting with the season and type of crops. Most farmers use hybrid varieties of crops that under the changing climatic conditions be the most used method of adaptation. Other adaptation measures can be our irrigation management, change in cropping pattern, diversification of food crops, and introduction of drought-resistant varieties (Manandhar, Vogt et al. 2011). Severe weather can be the result of climate change. Of Nepal's major grain crops, namely rice, maize, and wheat, the Nepal Agriculture Research Council (NARC) studied modelling models and found that rice and wheat yields grew below the natural carbon dioxide and 4 ° C temperatures. However, the maize yield is declining in the case of Terai (Shrestha, Raes et al. 2013).

5. Conclusion

Most of the farmers in the Chitwan area have seen current climate change concerning rainfall patterns, rainy season, rainfall intensity, precipitation, the onset of rainfall, increased weather risks, and summer temperature changes. Often, drought has resulted in a poor yield of crops. Floods cause damage and loss of vegetation in the field through the overgrowth, soil immersion, and pest infestation. In addition, floods also cause loss of human life, houses and affect livelihoods. This research was conducted to assess the impact of changing climate on grain production, farmers' perceptions of this issue, and strategies for tackling climate change.

We received a lot of information from this research. We can predict that the climatic condition will gradually become worse. Therefore, it is very necessary to adapt to this phenomenon change in agriculture. Climate change is affecting several sectors worldwide. Nepal contributing less to global warming is comparatively receiving more hazardous effects. This research was performed in a part of Nepal. It gave us a vision of the overall agricultural condition of the nation. Nepal has high potential in the agriculture sector due to its climate and landscape. It is the responsibility of the government to look after the condition of this sector and work for its betterment.

From the study we found that most of the respondents were aware of the term climate change and agroecology and the main source of knowledge on climate change was media stages like tv, newspaper, etc. Meteorological data showed that average maximum temperature was 31.84 °C in 2006 and average minimum temperature recorded was 13.9 degree °C in 2012. Maximum rainfall recorded was 3165mm in 2020 and minimum rainfall recorded was 1184mm in 2011. Regression analysis of average temperature vs year shows the result is statistically significant (p value =0.017) and R square (0.25) describes the 25% variation on the data. Correlation coefficient values shows that the rainfall and production were very weekly corelated, but temperature and rice production show moderate positive correlation and temp vs maize and wheat shows negative weak correlation.

Diseases and pests are the major problems of farmers. Farmers use insecticides and other chemicals to balance the soil which on other hand hurts the crops. Farmers are adopting different strategies on their own to find out the suitable condition for their farms. They are learning with experience. Nevertheless, there lies a necessity to promote local and indigenous adaptations. Farmers having local and traditional skills and resources follow such practices.

A change in climatic condition was affecting the crop rotation and normal cropping calendar as compared to the past by the farmers. Farmers have been using various adaptation strategies to cope with climate effects. The strategies used for adapting include planting trees, change in planting/cultivation dates, changing to irrigation-based farming, building irrigation channels, shifting to the cropping system, diversification of the crops. Despite having the will, most of the smallholder farmers are facing challenges related to financing, knowledge, and water sources.

Climate change is a worldwide issue, at the national level also it must be considered for the development of several sectors. In agriculture, it's very important to minimize the effects of climate change. It directly impacts the economy of the nation. Therefore, the government must be conscious of this problem and provide awareness to the citizens. The research centers must perform studies about the soil and plants and create ideas to cultivate them in the condition which is unsupported by the climate. A suitable adaptation measure must be suggested to the farmers to develop their field and generate maximum income through it.

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8. Appendixes

Appendix 1: Climate data of Chitwan District

Annual rainfall of Chitwan (data source: meteorological forecasting division, Kathmandu)

Date	Annual rainfall in mm
2000	2049.9
2001	2340.1
2002	2643.9
2003	2693.5
2004	1985
2005	2140
2006	2381
2007	2743
2008	1787
2009	1907
2010	2400
2011	1184
2012	1636
2013	2128
2014	2064
2015	1628
2016	2060
2017	1695
2018	1206
2019	1539
2020	3165
2021	2212

Average yearly maximum and minimum temperature of Chitwan of (2000 – 2021)

Data source: meteorological forecasting division, Kathmandu

Date	Annual max. air temperature (avg)	Date	Annual min. air temperature (avg)
2000	30.74	2000	17.85
2001	31.3	2001	17.92
2002	31.16	2002	18.15
2003	30.64	2003	18.2
2004	30.74	2004	18.27
2005	31.32	2005	18.05
2006	31.38	2006	18.47
2007	30.7	2007	18.31
2008	30.39	2008	18.17
2009	31.12	2009	18.4
2010	30.91	2010	18.69
2011	30.02	2011	16.31
2012	30.43	2012	13.9
2013	30.62	2013	16.53
2014	30.7	2014	17.9
2015	30.42	2015	18.1
2016	30.89	2016	17
2017	30.96	2017	17.8
2018	30.63	2018	17.51
2019	30.72	2019	17.89
2020	30.07	2020	17.6
2021	30.37	2021	17.95

Appendix 2: Production data of Chitwan District

Production data of main crops (data source: Department of agriculture, Chitwan)

Area in Hectare (Ha), Production in metric tonnes (Mt), Yield in mt/hac									
	Paddy			maize			wheat		
year	area	production	yield	area	production	yield	area	production	yield
2011/12	29655	103496	3.49	10000	30000	3	8750	27125	3.1
2012/13	28625	94800	3.31	3490	10500	3	8750	30125	3.44
2013/14	29575	100555	3.4	9750	29250	3	8550	29899	3.49
2014/15	29400	103500	3.5	9200	26700	2.9	8500	30500	3.58
2015/16	27342	92925	3.39	9310	26200	2.81	6020	20119	3.34
2016/17	29300	108996	3.72	5500	19250	3.5	5520	22119	4
2017/18	27735	107362	3.88	5854	21775	3.71	5272	23225	4.4
2018/19	26539	105360	3.97	5763	21381	3.71	5055	23199	4.59
2019/20	26005	104075	4	5986	24083	4	5088	19360	3.8
2020/21	27305	103416	3.79	6734	26544	3.94	5151	23248	4.51

Appendix 3: Household Survey Questionnaire

Section A – Information of the respondents

1. Date (dd/mm/y) …….
2. Country……
3. District……
4. Address: VDC/Municipality……, Ward No…….
5. Name of household head……
6. Name of Respondent…….
7. SEX……. (M = male, F= female)
8. Marital status……
9. Age (years): 1. <30 2. 30-40 3. 41-50 4. >50
10. Education Level: 1. Illiterate 2. Primary 3. Secondary 4. Higher-Secondary 5. Graduation
11. Years in farming…… (at least 10 years so we can get information of the past related to climate change)
12. Religion……. (Hindu, Christian, Muslims, Buddhist or Others)
13. Family type……. (Nuclear or Joint)
14. Total Family members…….
15. The language used in the interview…….

Section B – Socio-Demographic Information of Household

A. Family size, education

Total family Number	**Number of HH members**		**Total**	**No. of educated**
	Male	**Female**		
<30				
30-40				
40-50				
>51				
Total				

The main occupation of the family…… (1. Agriculture, 2. Business 3. service, 4. Pension, 5. Others

Section C- Land Holding status:

1. Do you have your land……? (Yes/No)

If yes, what type of land do you have…….

(a) Upland (Bari) (b) Lowland(khet) (c) both

Total land area (Land unit Kattha/ropani/bigha)

SN	Upland area	Lowland area	Total area
1.			

2. What type of agriculture do you practice?.....
   (a) Rainfed (b) Irrigation (c) both (d) others(specify)…….
3. Did you hire laborers on your farm?..... (a) YES (b) NO

If yes how many……., for how many months……

4. What type of livestock do you own?.....
   (a) Cattle (b) goat (c) sheep (d) pigs (e) others…….

Section D – Perception about climate change

1. Have you heard about climate change? ……
   (a) YES (b) NO
2. Are you familiar with the concept and principles of agroecology?
   a. YES, b. NO
3. How do you know about climate change? …….
   (a) Self-experience (b) Media (c) Organization (d) Others
4. Have you experienced the impact of climate change on your agricultural production?.....
   (a) YES (b) NO
5. Have you lost your agricultural land due to natural calamities (like a landslide, flood)?..... (a) YES (b) NO
6. Have you experienced a vast decrease in production over the last 10 years due to climatic variables?.....

(a) YES (b) NO

If yes, then which climatic variables responsible for this…….

7. Have you noticed any changes in weather over the last 10 years?

If you have noticed, then fill in the following table.

Weather	increased	decreased	No change	Don't Know
Temperature				
Rainfall				
Drought				
Flood				
landslide				

8. Have you made changes in your farming ways in response to climate change over the last 10 years?.....

(a) YES (b) NO

9. Are your agricultural yields have increased or decreased in the past 20 years?

(a) Increased

(b) Decreased

(c) Same

(d) Don't know

10. How adversely have the following mentioned climate change impacts have affected your agricultural crop production?

Topic	To no extent	To a little extent	To a great extent	Extremely
Do you think the frequency of crop diseases has increased in recent years due to climate change?				
Crop yields have decreased due to climate change. What is your perception of this?				
Do you think climate change affects making the soil less suitable for cultivation?				
By how long the harvesting of the crops has been prolonged due to climate change?				

Section E – Impact on agro production due to climate change

11. Have you had any experience with rice cropping patterns changing?

(a) YES (b) NO

If yes fill the table,

Cropping pattern	Comparing before 10 years and now		
	Earlier than before	Late than before	same
3. Rice planting time			
4. Harvesting time			

12. What has been your experience with rice yield?

	Comparing before 10 years and now		
	High	Low	same
Rice yield			

13. Have you experienced a change in planting/seeding time?

(a) YES (b) NO

If yes ……. (a) early sowing (b) late sowing (c) same

Section F - Climate change and adaptation

1. Have you practiced any methods to deal with this climate change?

(a) YES (b) NO

If yes what type of practices or methods……

2. How many times your farm has been affected by floods in the past 10 years?

(a) 0 (b) 1 (c) 2 (d) 3 (e) more than 3 times

3. Have you experienced soil erosion in the past 10 years?

(a) More (b) less (c) don't know

4. What techniques do you use to avoid soil erosion? .....
5.

Climate change mitigating farming practices (for rice yield)	Relation on rice farming and climate change adoption for agro-ecology support			
		Ikchyakamana farmers	Bharatpur Farmers	Total
Minimum tillage practice	Yes			
	No			
Planting of the cover crops	Yes			
	No			
Green Manure practice	Yes			
	No			
Trying to incorporate the crop residues	Yes			
	No			
Practicing pest management	Yes			
	No			

Section G - Fertilizers and pest control

1. Is your farm is affected by pests?..... (a) YES (b) NO
2. Do you use pesticides on your farm?..... (a) YES (b) NO
3. How do you preserve the soil fertility of your land?

(a) By fertilization (using Chemical, green manure, animal manure, etc)

(b) Crop rotation

(c) Intercropping

(d) Others

4. What kind of fertilizers are you using?

(a) Chemical fertilizers

(b) Organic fertilizers

(c) Both

(d) Others(specify)…….

5. How do you control weeds?

(a) Using herbicides

(b) Crop rotation

(c) Burning residues

(d) Grazing by animals

(e) Others(specify)……

6. Have you taken any training on controlling pests?..... (a) YES (b) NO

   If Yes (Specify)…….

7. What kind of experience do you have with disease insect infestations in rice fields?

Comparing before 10 years and now

Pest infestation	Higher than before	Lower than before	same	New pest/disease found

Section H – Agricultural production and effect on family feeding and finance (Food Security Condition/Status)

1. How many months has your household had enough food grain from its production?

   (a) 1-3 months (b) 1-6 months (c) 1- 9 months (d) 1-12 months

2. Did you or other members of your family ever eat less because you didn't have enough to eat?

(a) 1 time a week

(b) 1 time a month

(c) 1 time in 6 months

(d) 1 time in a year

(e) Never

		Amount (Rs)	
Farm income (last 12 months)	From crops		
	From livestock		

Income from off-farm	Business	
	services	
	other	

Household income

Household expenditures

Items	Monthly (Rs)
Food	
Health	
education	
others	

3. In the last 6 months, have you or anyone in your household received any assistance from the state (local or provincial or federal) as part of a COVID19 response, either food or cash?

(a) YES (b) NO

If yes

If it is cash, how much…… (In Rs)

If it is cereal food, how much……. (In KG)

4. Does your household currently have food stock?

(a) YES (b) NO

5. What will you do with your production?

(a) Only use for the house (b) sell to market (c) both

SECTION I - Social Capital

1. Do you have any social responsibility (social position) in your community?.....
   (a) YES (b) NO
2. Have you or any of your family members been involved in any organization?
   (a) YES (b) NO

If yes (specify)……

3. Have you participated in knowledge exchange with other farmers of your village or other villages?..... (a) YES (b) NO

If yes, what type of knowledge…….

4. How easy is it to access technical assistance for the agro-ecosystem and agro-ecology based agriculture in your field?
   a. Easy
   b. Very difficult
5. Do you know about the agriculture insurance policy of Nepal?..... (a) YES (b) NO

6. Do you use media (Radio, TV, newspaper)? 1=yes, 0=No if yes specify,

	1-Daily	2-Occasionally	3-once a month	4- none
Radio				
TV				
others				

7. Have you done insurance on your agricultural land and production? ……. (a) YES (b) NO

   If yes, what type, specify…….

   Do you like to give any suggestions and comments on climate change and its impact on agricultural production?

……

……

Appendix 4: Photo from field visit, Chitwan District

Picture taken while asking survey question to local female farmer at her farm (ickhyakamana rural municipality)