**Original Research Article**

**Determinants of Farmers’ Preparedness and Adaptation Strategies to Climate Change; A Study of Smallholder Farmer of Kapurkot, Salyan Nepal**

 **ABSTRACT**

Smallholder farmers are highly vulnerable to climate change and require prioritized strategies to minimize the impacts. Challenges faced by smallholder farmers hinder the implementation of coping and adaptation strategies, limiting sustainable agriculture. This descriptive study was conducted in Kapurkot Rural Municipality, Salyan, Nepal aimed to investigate and understand how smallholder farmers view and react to climate change along with their primary adaptation practices to mitigate adverse effects. 170 households were surveyed using snowball sampling method and data were analyzed with MS Excel and SPSS version 23. Over 90% reported rising summer temperatures and decreased monsoon and winter rainfall. Between 1981 and 2022, a clear warming trend was observed in study area, with a greater increase in both maximum and minimum temperatures during winter compared to summer. Concurrently, a declining trend in average precipitation was noted, particularly during the monsoon season, reflecting growing climatic variability and potential implications for agriculture and water resources. Age, ethnicity, education, income, farm size, cooperative membership, and farmer group involvement significantly influenced adaptation strategies to climate change. The results indicate that increased droughts, crop failures, rising disease and insect infestations, and forest fires are major climate-related challenges. Farmers have adopted mixed cropping, adjusting sowing dates, mulching, increased use of fertilizers and pesticides, weather-based planning, temporary migration, and communal irrigation. Main barriers to adaptation were lack of knowledge about climate change, inadequate capital, lack of government support, poor access to credit and resistance to change. Therefore, we recommend future adaptation strategies should focus on improving climate change information access, increasing capital access, enhancing government support, expanding credit facilities, and addressing resistance to change.

**Keywords**: *Adaptation, Climate Change, Perception, Strategies, Vulnerable*

# INTRODUCTION

## Background

Climate change is the most pressing environmental issue of our time. It is primarily caused by the emission of greenhouse gases (GHGs). The Kyoto Protocol identifies six main greenhouse gases produced by human activities: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). The Intergovernmental Panel on Climate Change (IPCC) defines climate change as: “Climate change refers to a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It firmly asserts the undeniable existence of climate change, underscoring that human actions, including the combustion of fossil fuels and deforestation, have substantially raised the concentrations of greenhouse gases in the Earth's atmosphere.

Agriculture and livestock production has been a major part of Nepalese economy as more than 50.4% (CBS, 2021) of people are engaged in agriculture and it contributes 23.95 % of total GDP (CBS, 2021). The Global Hunger Index (GHI) of Nepal is 19.1 (GHI, 2022) which indicates the fundamental problem of food security, and the situation is more pronounced in the hilly and mountain region of Nepal.

Agriculture sector highly rely on weather conditions, is particularly susceptible to the impacts of climate change (Hasan et al., 2016).Climate change poses a major threat to agricultural productivity, leading to economic and physical vulnerabilities. Climate-influenced factors such as shifting rainfall patterns, rising temperatures, altered sowing and harvesting times, fluctuating water availability, growing occurrence of extreme weather events and changing site suitability expose a substantial influence on agriculture products (Shakoor et al., 2011).

These changes are expected to have far-reaching consequences, affecting food production, water resources, biodiversity, and livelihoods (Ahmad et al., 2011). In Nepal, where a large portion of the population resides in rural areas and relies heavily on agriculture as major source of living. The 2021/22 census reports the total number of farm population is 19,477,955 (67 per cent). Out of this population, 9,543,825 (49.1 per cent) are male and 9,904,130 (50.9 per cent) are female. The farm population accounts for 66.7 per cent of the total population of the country in 2021(CBS, 2021)

Amidst the growing threats from climate change, Nepal has designed and implemented multiple adaptation plans and policies (Gentle et al., 2018; Ranabhat et al., 2018; Khanal et al., 2019). Adaptation plans and policies like Climate Change Policy, National Adaptation Program of Action (NAPA), Local Adaptation Plans for Action (LAPA), reducing emissions from deforestation and forest degradation (REDD+), and Forest Policy have been formulated and implemented overtime (Tiwari et al., 2014; Ojha et al., 2016; Ranabhat et al., 2018).

## 1.2 Statement of problems

It is obvious that greenhouse gas emissions are still relatively low compared to many other countries. Nepal is one of the countries experiencing highly adverse impacts of climate change and is ranked fourth in the climate change vulnerability index (Eckstein et al., 2018). Climate-induced disasters (hailstorms, avalanches, wind storms, cold waves, floods, landslides and erratic rainfall events) have been frequently witnessed in Nepal in recent years (MoHA ,2019)

Indigenous peoples are among the poorest of the poor, they live in geographical regions and ecosystems that are most exposed to the impacts of cli­mate change, and they have high levels of exposure and vulnerability (Samuels et al., 2022). In Nepal, local farmers are unaware of scientific knowledge about climate change and its adaptation (Dulal 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. Smallholder farmers in developing countries are the worst affected by the adverse effect of climate change (Ndamani, 2016). Therefore, knowledge and perceptions of these smallholder groups are crucial in preparing farmers for the extreme weather conditions ahead (Ndamani, 2016). Agricultural policies and decisions should take into consideration experiences and empirical data from the local level to effectively address the challenges of climate change (Ndamani, 2016). The study will therefore aims to understand the knowledge and perceptions of these smallholder farmers and how best their views will be used to inform effective adaptation strategies.

## 1.3 Objectives of the study

Broad Objective:

* The study attempts to investigate and understand how smallholder farmers view and react to climate change, and to identify local adaptation strategies they practice.

Specific Objectives:

 -To draw perception of farmers regarding climate change.

 -To study the trend of climate change (temperature, precipitation) of Kapurkot.

-To study the determinants factors affecting adaption of climate change.

## 1. 4Limitations of the study

* This research is conducted from Salyan district, Kapurkot Rural Municipality. The restricted range of the sample may restrict how far findings may be applied.
* The initial data collection process encountered language barriers that hindered the surveyors and participants from fully capturing the perspectives and experiences of the study’s participants. This issue was subsequently resolved with the provision of accurate translation support facilitated by a local community guide.

# 2. LITERATURE REVIEW

## 2.1 Climate change and agriculture

The impact of climate change on agricultural productivity and crop yields will vary considerably across many regions and is likely to be small to moderate, which will probably result in a slight overall decrease of world cereal productivity (Aydinalp & Cresser, 2008). The most negative effects of climate change are predicted in resource poor countries, in dry land areas at lower latitudes and in arid and semi-arid areas. It has been reported that new combinations of plant diseases, weeds, insects and pests may emerge due to changes in temperature, rainfall patterns and the increase in CO2 levels which increase the risk of losses of crop output (Aydinalp & Cresser, 2008).Climate change affects seed germination rates, photosynthesis, and pollinator populations due to rising temperatures. Pollen grain expansion is restricted by heat stress during reproduction, which leads to insufficient release from the anther at dehiscence. Heat stress impairs plant development, particularly the growth and operation of the reproductive organs. In wheat, heat stress reduces yield. by about 40% overall, whereas in maize, it reduces production by 1.0 to 1.7% daily (Liliance & Charles, 2020).Climate changes directly or indirectly affect agricultural productivity through changing rainfall patterns, droughts, flooding, and the geographic dispersal of pests and diseases. Climate change threatens our ability to achieve global food security, poverty elimination, and environmental sustainability (FAO, 2022).Climate change has been responsible for a 21 % decline in global agricultural production since the 1960s, according to a new study cited by Science Daily (2021). This decline occurred despite major agricultural breakthroughs to feed the world's population.

## 2.2 Climate change adaptation strategies

Farmer’s behavior adapted to climate change refers to how farmers commit acts for adjusting or changing their farming activities to minimize the negative or to optimize the positive impact of climate change (Tripathi & Mishra, 2017; Füssel, 2007). Adaptation is intangible intrinsic properties of farmer households that actually depends on many specific factors (Rurinda et al., 2014; Vervoort et al., 2014). This adaptation can be either anticipatory or reactive strategy over time (Smit & Wandel, 2006). The strategy was categorized as spontaneity if the farmer took this strategy passively without anticipating and planning as response climate change. Contrarily, if the adaptation strategy arises as planning and anticipation against the effect of climate change so that such adaptations were categorized as a planned adaptation. Climate change adaptation research at the farm level will provide an understanding of specific adaptation strategies and their impacts (Below et al., 2012). Adaptation seems to be the most efficient and friendly way for farmers to reduce the negative impacts of climate change (Fussel et al., 2006). This can be done by the smallholder farmers themselves taking adaptation actions in response to climate change or by governments implementing policies aimed at promoting appropriate and effective adaptation measures. The socioeconomic makeup of communities affects their ability to adapt. An effective strategy for coping with climatic changes and challenges, especially unpredictability and extremes, is to increase adaptive capacity. Adaptation to climate change can significantly lessen many of the negative consequences of climate change and increase its positive effects, but at an expense and with residual damage (Burton et al., 2018).

## 2.3 **Climate change impact on small-scale farmers**

 The Government of Nepal classifies the rural farm population into three groups—small commercial farmers (1-5ha), subsistence farmers (0.5-1ha), and landless/near landless farmers (<0.5 ha) (Government of Nepal, 2016). Smallholder farmers are one of the most vulnerable groups to climate change, yet efforts to support farmer adaptation are hindered by the lack of information on how they are experiencing and responding to climate change. More information is needed on how different types of smallholder farmers vary in their perceptions and responses to climate change, and how to tailor adaptation programs to different smallholder farmer contexts. (Harve et al., 2018). The threats to smallholder livelihoods caused by climatic events and other challenges, such as infectious illnesses, nutritional deficits, the depletion of natural resources, and unstable land tenure issues, negatively impact small-scale farming (Cohn et al., 2017). Globally, there are an estimated 475 million smallholder farmers cultivating less than 2 ha of land (Lowder et al., 2016). Smallholder farmers are highly vulnerable to climate change because most depend on rain-fed agriculture, cultivate marginal areas, and lack access to technical or financial support that could help them invest in more climate-resilient agriculture (Morton, 2007; Holland et al., 2017; Donatti et al., 2018). The impacts of climate change on smallholder agriculture are likely to intensify in future years, as climate models project rising temperatures, more erratic rainfall, and potential increase in the intensity and/or frequency of extreme weather events (Magrin et al., 2007; Imbach et al., 2017).

# 3. MATERIALS AND METHODS

## 3.1 Study Area

Kapurkot Rural Municipality of Salyan district was selected, which is located at
28°14'55.9" N to 82°21'41.3" E at average elevation of 1401 meters in Karnali Province. It comprises of 6 wards with total area 119.21 sq. kilometer. The total population of study area is 17,526 (CBS,2021).

Figure 1: Map of Kapurkot Rural Municipality

## 3.2 Methods

Different sources and techniques were used for the collection of necessary data. Both primary and secondary data were collected and analyzed in the study.

### 3.2.1 Primary source of data

The primary data was collected through face-to-face interviews with farmers in the study area, utilizing a semi-structured questionnaire. The validation of data was done by Key informant interview (KII) and a focused group discussions. These methods helped to identify adaptation strategies that are currently in use or could be suitable for the region.

### 3.2.2 Secondary Source of data

Secondary data were collected from articles, reports, journals, websites and various institutions and organizations like Central Bureau of Statistics (CBS) and Department of Hydrology & Meteorology (DHM).

## 3.3 Sample size, sampling procedure and selection of respondent

The study was conducted in all wards of Kapurkot Rural Municipality of Salyan district. A total of 170 respondents were selected using snowball sampling method. The sample size was calculated by using Cochran’s formula and got sample size of 170 with confidence level of 95% and margin of error 7.5%.

## 3.4 Survey design and collection of data

A field survey interview schedule was prepared to collect primary information from farmers. Simple random sampling method was used to carry out the field survey. Pre- testing of interview schedule was done by administering design interview schedule to few local farmers of study area. The final interview schedule was prepared by taking due consideration of suggestion obtained during pre- testing.

### Data analysis techniques

Data collected through household surveys via mWater Surveyor is cleaned, coded, and compiled, then entered into SPSS to create a clear database. The processed data is analyzed using SPSS 23 version and MS Excel, with the choice of software depending on convenience. Microsoft Excel is used for producing descriptive statistics in the form of bar-diagram, pie charts, trend lines etc. People’s perception, seasonal trends and variability in observed rainfall and temperature collected from Department of Hydrology and Meteorology (DHM) were analyzed. The trend analysis of temperature and precipitation involved collecting historical data, organizing it in Excel, and visualizing trends through line charts with added trend lines. Contingency tables and χ² tests us used to assess the relationship between preparedness and climate perceptions, while binary logit regression is used to identify factors affecting adaptation strategies.

#  4. RESULTS AND DISCUSSION

## 4.1 Socio economic characteristics

The results of the survey, as presented in Table 2, indicated that the majority of respondents were aged between 35 and 60 years, categorizing them as adults. Of the total participants, 60.58% were female, while 39.41% were male. In terms of family structure, 87% of the respondents lived in nuclear families, with only 13% belonging to joint families. This finding is consistent with the study by Rai (2023), which highlights a significant shift towards nuclear families in Nepal, with 70% of families being small nuclear units and 30% retaining the larger joint family system. The survey analysis further revealed that agriculture was the primary source of livelihood for 84% of the respondents, followed by remittances (7%), business (4%), and service sector employment (5%). This demonstrates that the economy of the Kapurkot area is heavily dependent on agriculture.

The literacy levels of the participants were assessed based on six categories: illiterate (those not involved in formal education), literate (those who can read and write through informal education), primary education, lower secondary education, secondary education, and intermediate education. The largest group of participants (28.23%) was literate without formal schooling, followed by those with primary education (24.70%), lower secondary education (13.52%), secondary education (11.76%), and intermediate education (8.23%). Additionally, 13.56% of the respondents were illiterate.

Regarding ethnicity, the majority of respondents (42.94%) belonged to the indigenous Janajati community, specifically the Magar group, followed by Chhetri (38.82%), Dalit (14.70%), Dasnami/Sanyasi (2.45%), and Brahmin (1.17%). The landholding status of the respondents revealed that 87% owned less than 10 ropanis of private land, while 13% held between 10 and 20 ropanis, indicating that the region is largely dominated by small-scale farmers. Furthermore, income analysis showed that 31.76% of respondents earned between NPR 200,000 and 300,000 annually from on-farm activities, while 7.02% earned between NPR 50,000 and 100,000, 32.94% earned between NPR 100,000 and 200,000, and 28.23% earned more than NPR 300,000. This highlights the economic diversity in the area, with a significant proportion engaged in small-scale agriculture.

Figure 2: Socio economic characteristics of the study area Kapurkot,Salyan

## 4.2 Perception of the farming communities on the climate change

### 4.2.1 Awareness of the respondent regarding climate change

In the survey, about 53 percent of the participant said that they have heard about climate change and have a basic idea about the concept, while 47 percent said they are unaware of this term and phenomenon. These result is similar to the perceptions reported in studies in other parts of Nepal(eg., Adhikari et al., 2022)

Figure 3: Pie chart representing knowledge about Climate change

Table 1: Chi Square test gender and Source of knowledge about climate change

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Gender | Knowledge on Climate Change | Total | p-value | χ2-Value |
| Yes | No |
| Male | 49(54.4) | 18(22.5) | 67(39.4) | 0.000 | 18.099\*\*\* |
| Female | 41(45.6) | 62(77.5) | 103(60.6) |

Note: \*p < 0.05, \*\*p < 0.01, \*\*\*p < 0.001 (levels of statistical significance)

A chi-square statistical test 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:

H0: There is no considerable relationship between gender and the source of knowledge.

H1: There is some relationship between gender and source of knowledge

The chi-square test was performed to assess the relationship between gender and knowledge about climate change. The calculated chi-square value was 18.099, while the tabulated value for 1 degree of freedom (df) and a significance level (α) of 0.05 is 3.841. Since the calculated value (18.099) is greater than the critical value (3.841), the null hypothesis is rejected.

Since **p < 0.001**, we conclude that there is a highly significant relationship between gender and knowledge of climate change, with males being more likely to report knowledge of the subject compared to females.

## 4.2.2 Source of knowledge in the study area

During the field survey, more than 50 per cent of the farmers shared their familiarity with climate change. They were aware of this phenomenon and process through some direct and some indirect sources. The majority of the farmers (74 percent) reported gaining knowledge about climate change from media platforms, primarily radio. 9 per cent cited social media platforms, 8 percent television, and 3 percent attributed their awareness to school and friends. Additionally, 4 percent mentioned that local-level programs and discussions contributed to their understanding, reflecting some degree of localization of the climate change issue in rural areas, although the percentage is quite low. Similarly, a minimal portion (2 percent) of farmers said they became aware through newspapers.

### 4.2.3 Intuition & feeling regarding the change in local climate

The pie chart illustrates the feeling about climate change where respondent responded feeling of sadness (45 %), and fear (32%). A relatively smaller proportion was expressed as confused (9%), while 11% responded no feeling. Very few responded as powerless (2%) and showed disbelief ( 1%) towards climate change. The result demonstrated the negative emotions associated with climate change as in the article by (Clayton et al., 2020).

 Figure 4: Pie chart representing feeling about Climate change

### 4.2.4. Incidences/consequences of climate change

 The table 1 shows that  **cent percent**  of respondents view **increased droughts and crop failure** as the most critical issue, followed closely by **crop diseases and insect infestations (91%)** and **forest fires (84%).** Lesser concerns include **community fires (10%**), **postharvest loss** (**7%)**, and the **extinction of crops** **(4%).**

Table 2 :Consequences of climate change

|  |  |  |  |
| --- | --- | --- | --- |
| S.N | Consequences | Responses | Percentage(%) |
| 1. | Increased droughts and crop failure | 170 | 100 |
| 2. | Forest fires | 143 | 84 |
| 3. | Crop disease and insect infestations | 154 | 91 |
| 4. | Fire in community | 17 | 10 |
| 5. | Extinction of some crops and crop varieties | 7 | 4 |
| 6. | Postharvest loss | 12 | 7 |

## 4.3 Perception on climate change variability

All respondents reported that they had experienced variability in summer temperature observed by 97.1% increase in summer temperature where as reported to be decreased by 2.9 %. As per the surveying outcome, 45 % of the respondent believe that increase in winter temperature whereas, 20 % of believe decrease in winter temperature and 34 % responded no change in winter temperature. They also reported that the monsoon rainfall had decreased by 90.6 %, increased by 8.2% and few responded reported no change 1.2% (Figure 6). Similarly, all most all 98 % responded decreased in winter rainfall whereas only 2% of the respondents have perceived that no change in quantity of winter rainfall (Figure 6). Our results agreed with the result reported by the study indicated that climate change, particularly increase in mean and maximum temperature and decrease in rainfall greatly influence the experiences and perceptions of the local people regarding climate change and related events. (Dhungana et al., 2018).

Figure 5: Bar graph representing people’s perception on temperature

Figure 6: Bar graph representing people’s perception on rainfall

The perceived changes were further evaluated with trends in the observed data for the same climatic parameters. As shown in figure 5 and 6, local people’s perception in terms of changes in seasonal precipitation, temperature in summer and winter season corresponds well with the trends in the observed data. Thus it can be summarized that the rainfall in terms of magnitude is decreasing. Further it can be summed from fig 5 that both maximum and minimum temperature of summer and winter are increasing this implies that the Kapurkot region is being warmer and warmer every year.

Using trends in the observed data for the same meteorological factors, the perceived changes were further assessed. Local people' perceptions of variations in summer and winter temperatures and seasonal precipitation, as depicted in figures 5 and 6, closely match the patterns in the data that was collected. Consequently, it can be concluded that the amount of rainfall is getting less. The data presented in Figure 5 further suggests that the summer and winter maximum and minimum temperatures are rising, indicating an ongoing trend of increasing temperatures in the Kapurkot region.

## 4.4. Trend analysis of temperature in Salyan

## 4.4.1 Average maximum temperature for summer month

Figure 7: Average maximum temperature for summer months at Salyan Bazar Meteorological Station during the period of 1981-2022.

The observed data represents that the average maximum temperature for summer month has shown fluctuation from starting year to the end. The trend line suggest that the average maximum temperature increases by approximately 0.0029° each year, starting from a base of around 27.072°C in the first year. Here R2 value is 0.001 which is extremely low which indicate the relationship between years and average maximum temperature is very weak, meaning there isn't a clear upward or downward trend. In summary, the graph suggests a very slight increase in average maximum temperature over the years.

### 4.4.2 Average maximum temperature for winter month

Figure 8: Average maximum temperature for winter months at Salyan Bazar Meteorological Station during the period of 1981-2022.

The observed data represents that the average maximum temperature for winter month which has shown fluctuation from starting year to the end. The trend line suggest that the average maximum temperature increases by approximately 0.0479° each year, starting from a base of around 18.506°C in the first year. From the regression analysis, we got a R2 = 0.1085. This implies that the regression line explains 10% 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 90% of the variation.

### 4.4.3 Average minimum temperature for summer month

Figure 9: Average minimum temperature for summer months at Salyan Bazar Meteorological Station during the period of 1981-2022.

The observed data represents that the average minimum temperature for summer month which has considerable fluctuation from starting year to the end. The trend line suggest that the average minimum temperature increases by approximately 0.011° each year, starting from a base of around 19.025°C in the first year. This positive slope indicates a gradual warming trend over the 42-year period. From the regression analysis, we got a R2 = 0.1775. This indicate that only 17.75% of the variation in the average minimum temperature is explained by the year-to-year progression. This means most of the variation in the data is not explained by the model, so there are other issues explaining 90% of the variation.

### 4.4.4. Average Minimum Temperature for winter Month

 Figure 10: Average minimum temperature for winter months at Salyan Bazar Meteorological Station during the period of 1981-2022.

The observed data represents that the average minimum temperature for winter month which has considerable fluctuation from starting year to the end. The trend line suggest that the average minimum temperature increases by approximately 0.0205°C each year, starting from a base of around 6.79°C in the first year. This positive slope indicates a gradual warming trend over the 42-year period. The minimum lower temperature has reached to less than 5.62°C and the minimum highest temperature has been recorded to more than 10°C temperature, in Salyan Bazar. From the regression analysis, we got a R2 = 0.0781. This indicates that only 7.8% of the variation in the average minimum temperature is explained by the year-to-year progression. This means most of the variation in the data is not explained by the model, so there are other issues explaining 92.2% of the variation.

## 4.5 Trend analysis of precipitation in Salyan

### 4.5.1 Average precipitation for monsoon season

 Figure 11: Average Precipitation for Monsoon months at Salyan Bazar Meteorological Station during the period of 1981-2022

From the figure above we can see that the slope is negative, which represents the line is going down. This slope value shows that the annual monsoon precipitation decreases by 1.80 mm every year.. The annual monsoon maximum precipitation was 1220.3 mm in 2000 AD whereas the minimum rainfall was only 449.4 mm in 2012. R² of 0.01980 means that only **1.98% of the variance** in average monsoon precipitation can be explained by the change in years from 1981 to 2022. The study conducted by Khatiwada et al. (2015) aligns with our findings, as they observed that the average precipitation in the Karnali basin is decreasing by 4.36 mm per year. This result corresponds with our trend analysis and the local population's perception of declining monsoon rainfall.

### 4.5.2. Average precipitation for winter season

Figure 12: Average Precipitation for winter months at Salyan Bazar Meteorological Station during the period of 1981-2022.

From the figure above we can see that the slope is negative, which represents the line is going down. This slope value shows that the annual winter precipitation decreases by 0.2152mm every year. The annual winter maximum precipitation was 247.3 mm in 2019 AD whereas the minimum rainfall was only 13 mm in 2001. The **R² value of 0.0019** is very close to zero, meaning that only 0.19% of the variation in winter precipitation is explained by the year from 1981 to 2022**.**

## 4.6. Adaptation strategies adopted by farmers to climate change in Kapurkot

Farmers are practicing various adaptation strategies to overcome the effect of the climate risks in crop production.

### 4.6.1. Crop management strategies practiced by farmers.

Crop management strategies practiced by farmers to mitigate the effect of climate change are shown in (Table 3). The majority of farmers often engaged in mixed cropping using leguminous crops (wheat + chickpea/masuro, or maize + broad bean/cowpea) rank I. Since the majority of farmers rely on rainfall for agricultural cultivation, they often adjust the dates of crop planting (rank II) in accordance with rainfall. According to research, 157 farmers (92.35%) used crop diversity as a primary strategy. This was followed by an increase in the use of pesticides and synthetic chemical fertilizers (IV). Very few farmers showed their preferences for adopting Drought tolerant varieties and is ranked (V) The main cause of this was a lack of knowledge and availability of drought-tolerant cereal and vegetable crop varieties. Similar finding was observed in study conducted (D. Adhikari et al., 2021) where 12 per cent of the participants reported that they have changed planting and harvesting time of the crops. Due to the change in rainfall pattern, they claimed that they faced slight change in planting and harvesting season and therefore had to adjust their planting and harvesting time. Similarly, 8 per cent of the farmers adopted chemical fertilizers and insecticides due to lower productivity and increase in pest infestation.

Table 3. Crop management strategies practiced by farmers in Kapurkot

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S.N | Crop Management | Responses | Percentage (%) | Rank |
| 1. | Alternation of Sowing date | 158 | 92.94 | II |
| 2. | Drought Stress tolerant varieties | 22 | 12.94 | V |
| 3. | Mixed Cropping | 167 | 98.23 | I |
| 4. | Crop Diversification | 157 | 92.35 | III |
| 5. | Increased chemical fertilizer & pesticide use | 136 | 80 | IV |

### 4.6.2. Water management strategies practiced by farmers.

Farmers practiced different water management strategies during dry spell days. Mulching (rank I) was practiced by majority farmers as shown in (Table 4). Farmers use drip/sprinkle irrigation for minimum water use (Rank II) for irrigating crop in the fields. Farmers gave least preference for rain water harvesting (III) due to decreasing rainfall intensity and duration. These result support the finding of Rajbhandari (2024) who discovered that 86% of farmers employed adaptation strategies such as mulching and drip irrigation, addressing issues arising from increased hot days, prolonged droughts, and shifting rainfall patterns

Table 4: Water management strategies practiced by farmers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S.N |  Water management | Frequency | Percentage (%) | Rank |
| 1. | Rain water Harvesting | 21 | 12.35 | III |
| 2. | Drip/sprinkle irrigation | 90 | 52.94 | II |
| 3. | Mulching | 140 | 82.35 | I |

### 4.6.3 Adoption of new technologies as strategies practiced by farmers.

The data highlights the adoption of new technologies for climate adaptation, with **weather forecasting** being the most widely used strategy (47.64%), followed by **protected structures like polyhouses** (22.94%). **Raising new livestock breeds** (14.70%) and **cold storage** (9.41%) are less commonly adopted. These findings suggest that while innovative technologies are being integrated, more accessible and cost-effective options like weather forecasting are preferred over infrastructure-heavy solutions.

Table 5: Adoption of new technologies as strategies practiced by farmers.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S.N | Adaptation Strategies | Responses | Percentage (%) | Rank |
| 1. | Follow weather forecasting | 81 | 47.64 | I |
| 2. | Protected structure(Polyhouse) | 39 | 22.94 | II |
| 3. | Cold Storage | 16 | 9.41 | IV |
| 4. | Raised new type of livestock | 25 | 14.70 | III |

### 4.6.4. Off farm adaptation strategies practiced by farmers

The data highlights the most common off-farm adaptation strategies employed by respondents to cope with challenges. Temporary migration is the most popular, with 76.47% of respondents opting for this strategy, followed by engaging in local business and handicrafts at 65.29%. Government subsidies and bank credit are also significant, chosen by 42.94% and 42.35% of respondents, respectively. Less common strategies include permanent migration (8.23%) and livestock insurance (7.64%), while crop insurance is the least utilized at only 2.35%. The low adoption of crop (2.35%) and livestock insurance (7.64%) in Nepal is due to factors like limited awareness, high premiums, and distrust in the insurance process, including delays in claim settlements. These barriers make insurance less appealing compared to more accessible strategies like migration and local businesses. This finding is supported by Thapa and Adhikari (2018), who reported that agricultural insurance penetration in Nepal is only 1.10%, the lowest among Asian countries. Migration does not represent the first adaptive response to climate change. It is frequently viewed as a last resort when other adaption tactics fail to suit household needs. (Maharjan et al., 2020). Communities impacted by climate change may not always be able to migrate. (Adams, 2016; Melde et al., 2017). Lack of finance, necessary knowledge and skill, and also lack of social network at destination place are the important factors influencing migration decision

Table 6: Off farm adaptation strategies practiced by farmers.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S.N | Off Farm adaptation strategies | Responses | Percentage (%) | Rank |
| 1. | Temporary migration | 130 | 76.47 | I |
| 2. | Permanent migration | 14 | 8.23 | V |
| 3. | Local business & handicrafts | 111 | 65.29 | II |
| 4. | Crop insurance | 4 | 2.35 | VII |
| 5. | Government subsides | 73 | 42.94 | III |
| 6. | Bank Credit | 72 | 42.35 | IV |
| 7. | Livestock Insurance | 13 | 7.64 | VI |

### 4.6.5. Nature based solutions as strategies practiced by farmers

In the study of adaptation strategies, Crop-Livestock Integration emerged as the most favored nature-based solution, with 88.82% of respondents supporting it, indicating its high relevance and effectiveness in adaptation efforts. This was followed closely by Agroforestry and Contour Farming, with support percentages of 84.70% and 84.12%, respectively, highlighting their significant role in enhancing resilience. Bee Keeping and Home Gardening were less popular, with 55.29% and 37.06% support, reflecting their relatively lower perceived impact or feasibility. Bio Pesticides (Jholmal) received the least support at 32.94%, suggesting that while it may have benefits, it is less prioritized compared to other strategies.

Table 7: Nature based solutions as strategies practiced by farmers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S.N | Nature Based solutions | Responses | Percentage (%) | Rank |
| 1. | Agroforestry | 144 | 84.70 | II |
| 2. | Contour Farming | 143 | 84.117 | III |
| 3. | Crop-Livestock integration | 151 | 88.82 | I |
| 4. | Bio Pesticides(Jholmal) | 56 | 32.94 | VI |
| 5. | Bee keeping | 94 | 55.29 | IV |
| 6. | Home gardening | 63 | 37.058 | V |

### 4.6.6. Communal pooling strategy practiced by farmers

The survey results presented in Table 8 reveal a strong consensus among respondents regarding communal pooling adaptation strategies for climate change. Forest conservation emerged as the most widely endorsed strategy, with 98.2% of respondents recognizing its importance. Similarly, soil conservation was identified by 96.47% of participants as a crucial measure. Prevention of uncontrolled grazing was noted by 86.47% of respondents as a significant strategy, while soil erosion prevention programs were deemed essential by 97.05%. Additionally, local communities highlighted the preservation and restriction of grazing areas, with 95.29% of respondents considering this approach vital. Although less commonly practiced, communal irrigation was recognized by 58.2% of respondents as a relevant adaptation strategy. These findings underscore a broad agreement on several key strategies for communal pooling to address climate change, with forest and soil conservation being particularly emphasized.

Table 8: Communal pooling strategy practiced by farmers

|  |  |  |  |
| --- | --- | --- | --- |
| S.N | Communal Pooling strategy | Responses | Percentage (%) |
| 1. | Forest conservation | 168 | 98.82 |
| 2. | Soil conservation | 164 | 96.47 |
| 3. | Preventing uncontrolled grazing | 164 | 86.47 |
| 4. | Soil erosion prevention programs | 167 | 97.05 |
| 5. | Preservation and restrictions of grazing area | 162 | 95.29 |
| 6. | Communal irrigation | 99 | 58.23 |

## 4.7. Adoption of adaptation strategies

Binary logistic Regression was conducted to determine the influence of the 9 variable considered in the model. Table 9a and 9b presents the logistic estimates of the determinants of farmers’ adoption of an adaptation strategy to climate change. Among the nine independent variable seven variables were found significant that influences farmers adoption of climate change adaptation strategy. These are age, ethnicity, education, annual income, farm size, Cooperative membership and Farmers’ group membership.

Table 9a presents the model correctly predicts 79.3% of cases related to polyhouse cultivation. It is significantly influenced by factors such as cooperative membership, ethnicity, and farmer group membership. This suggests that farmers involved in cooperatives and farmer groups have improved access to technology and subsidies for tunnel construction and adoption. The table revealed that engagement of farmer in farmers’ group had a significant at p<0.05(chi-square 26.32) positive impact on adoption of Integrated Pest Management (IPM) practice correctly predicted at 64.7%. Similarly, from the table, it is observed that crop rotation is affected by age at chi-square= 67.046, p<0.001. This indicates that farmers’ probability to adopt crop rotation strategy is influenced by age of farmer indicating that as age increases, the likelihood of adopting crop rotation decreases elders farmers may be more resistant to adopting new agricultural practices due to established routines and comfort with traditional methods. As people age, they often become less willing to experiment with new techniques, especially if they perceive risks involved.. Other factors like cooperative group membership also significantly influence adoption. The data suggests that cooperative group members are less likely to adopt crop rotation (Exp(B) = 0.201). This could be due to cooperatives promoting other farming practices, having established crop management protocols that don’t emphasize rotation, or focusing on crop specialization rather than diversification.

The table 9a shows that forecast based preparedness is affected by annual income of household and farm size. This highlights the importance of economic capacity (income and farm size) in enhancing preparedness, suggesting that resource availability plays a critical role in how individuals respond to forecast-based recommendations.

The result also revealed that he adoption of crop-livestock integration is significantly influenced by **age and education, which implies** older farmers are more likely to adopt integration, while those with higher education are less likely, possibly favoring more modern practices. The odds of adopting crop-livestock integration increase by 7.1%. This suggests that older individuals are more likely to adopt this strategy, possibly due to their greater experience in farming.

The table showed that adoption of government subsidies as a strategy is significantly affected by **ethnicity and farmer group membership.** Different ethnic groups might have varying levels of access to information about subsidies, or face different levels of bureaucratic hurdles. Language barriers, cultural attitudes towards government support, or historical experiences with government programs can impact adoption rates. Members of farmer groups might rely on alternative forms of support or resource sharing within their groups, reducing their need or interest in government subsidies.

Furthermore, adoption of adaptation strategies bio pesticide (Jholmal) and home gardening revealed that the model is statistically significant overall, suggesting that the predictors combined have an impact on the outcome. However, none of the individual variables show statistically significant effects

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| IndependentVariables | Polyhouse farming | Integrated Pest Management | Crop Rotation | Forecast-Based Preparedness |
| Age | 0.994(-0.006) | 1.011(0.011) | 0.841(-0.174)\*\*\* | 1.021(0.021) |
| Gender | 0.743(-0.297) | 0.689(-0.372) | 1.023(0.023) | 0.632(-0.459) |
| Ethnicity | 0.307(-1.182)\*\* | 0.496(-0.702) | 1.037(0.036) | 0.991(-0.009) |
| Education | 1.676(0.516) | 0.900(-0.106) | 2.961(1.086) | 1.168(0.155) |
| Family Size | 0.860(-0.151) | 0.901(-0.104) | 0.998(-0.002) | 1.203(0.185) |
| Annual Income | 0.754(-0.282) | 767756650.274(20.459) | 0.770(-0.261) | 5.441(1.694)\* |
| Farm Size | 1.088(0.084) | 1.611(0.477) | 0.534(-0.627) | 4.015(1.390)\* |
| Cooperative Membership | 0.316(-1.153)\* | 0.903(-0.102) | 0.201(-1.606)\*\* | 1.418(0.349) |
| Farmers’s Group  | 0.336(-1.091)\* | 0.436(-0.831)\* | 3.109(1.134) | 0.966(-0.035) |
| Intercept | 70.201(4.251)\*\*\* | 2.276(0.822) | 211.308(5.353) | 0.048(-3.026) |
| Model Chi-Square | 24.827\*\* | 26.362\*\* | 67.046\*\*\* | 21.502\* |
| Degree of Freedom | 9 | 9 | 9 | 9 |
| -2 log Likelihood | 155.321 | 207.399 | 108.491 | 213.580 |
| Negelkerke pseudo R2  | 0.208 | 0.192 | 0.506 | 0.159  |
| % correctly Predicted | 79.3 | 64.7 | 84.1 | 65.9 |

Table 9a: Factors influencing adaptation strategies

Note: Figure in parenthesis are logit coefficient.\*p<0.05, \*\*p<0.01, \*\*\*p<0.001

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| IndependentVariables | Crop Livestock Integration | Government Subsidy | Jholmal | Homegardening |
| Age | 1.071(0.068)\*\* | 1.013(0.013) | 1.00(.00) | 1.021(0.021) |
| Gender | 1.273(0.241) | 0.766(-0.267) | 0.787(-0.239) | 0.913(-0.092) |
| Ethnicity | 1.543(0.434) | 0.464(-0.768)\* | 0.668(-0.403) | 0.805(-0.216) |
| Education | 0.155(-1.863)\* | 1.778(0.575) | 1.554(0.441) | 0.520(-0.654) |
| Family Size | 0.990(-0.010) | 1.349(0.299) | 0.893(-0.113) | 1.058(0.057) |
| Annual Income | 1.997(0.692) | 1.462(0.401) | 325007962.5(19.599) | 803970284.3(20.505) |
| Farm Size | 0.633(-0.457) | 1.349(0.299) | 2.277(0.823) | 1.264(0.234) |
| Cooperative Membership | 4.919(1.593) | 0.567(-0.568) | 0.528(-0.639) | 0.708(-0.346) |
| Farmers’s Group  | 0.590(-0.527) | 0.374(-0.984)\* | 0.474(-0.746) | 0.724(-0.324) |
| Intercept | 0.005(-5.215) | 3.933(1.369) | 4.438(1.490) | 0.879-0.129) |
| Model Chi-Square | 19.732\* | 26.637\*\* | 26.569\*\* | 16.984\* |
| Degree of Freedom | 9 | 9 | 9 | 9 |
| -2 log Likelihood | 103.419 | 205.633 | 187.300 | 203.406 |
| Negelkerke pseudo R2  | 0.213 | 0.195 | 0.203 | 0.132 |
| % correctly Predicted | 88.2 | 66.5 | 66.7 | 67.5 |

Table 9b: Factors influencing adaptation strategies

Note: Figure in parenthesis are logit coefficient.\**P*<.05,\*\**P*<.01, \*\*\**P<*.001

## 4.8. Association between independent variable and adoption of adaptation strategies

Table 10a: Chi-square test of association between cooperative membership and adoption of polyhouse farming

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Cooperativemembership | Polyhouse farming | Total | p-value | χ2-Value |
| Yes | No |
| Yes | 33(86.8) | 77(58.8) | 110(65.1) | 0.001 | 10.209\*\* |
| No | 5(31.2) | 54(41.2) | 59(34.9) |

The Chi-square test result showed that there is a significant association between cooperative membership and adoption of polyhouse farming (p=0.001, χ2= 10.209). Farmers with cooperative membership are more likely to adopt polyhouse farming compared to non-members.

Table 10b: Chi-square test of association between Farmers’ group membership and adoption of Integrated Pest Management

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Farmers’groupmembership | Integrated Pest Management | Total | p-value | χ2-Value |
| Yes | No |
| Yes |  56(73.7) | 49(52.1) | 105(61.8) | 0.004 | 8.269\*\* |
| No | 20(26.3) | 45(47.9) | 65(38.2) |

The Chi-square test result showed that there is a significant association between farmers’ group membership and adoption of integrated pest management practices(p=0.004, χ2=8.269).Farmers with membership in Farmers’ group are more likely to adopt IPM practices .This may be due to access to information, accessibility to training and motivation among farmers. This finding is consistent with the study by Balasha (2019) which highlights a farmers' group membership significantly enhances the adoption of Integrated Pest Management among small-scale vegetable farmers in Lubumbashi, DR .

Table 10c: Chi-square test of association between annual income and forecast based preparedness

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Annual Income | Forecast Based Preparedness | Total | p-value | χ2-Value |
| Yes | No |
| Low | 2(2.5) | 10(11.1) | 12(7.1) | 0.029 | 4.787\* |
| High | 78(97.5) | 80(88.9) | 168(92.9) |

The Chi-square test result showed that there is a significant association between annual income and weather forecast-based preparedness ***(P<* 0.029, χ² = 4.787**). This implies that those with greater incomes could have easier access to resources and knowledge, allowing them to more effectively plan for weather-related catastrophes. The results of this cross-sectional study imply that families may handle preparedness items differently, as evidenced by the differences in the direction of the relationships between household socioeconomic variables and resource- and action-based preparedness. Similar results were found by Zamboni & Martin (2020), indicating a direct correlation between preparedness capacity and income level.

Table 10d: Chi-square test of association between crop-livestock integration and age

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Age  | Crop-livestock integration | Total | p-value | χ2-Value |
| Yes | No |
| Young(<35 years) |  60(40) | 5(25) | 65(38.2) | 0.010  | 9.274\* |
| Adult(35-60 years) | 78(52) | 9(45.0) | 87(51.2) |
| Elderly( >60 years) | 12(8) | 6(30) | 18(10.6) |  |  |

The Chi-square test shows a significant link between age and crop-livestock integration, with a p-value of 0.010 and a χ² value of 9.274. This indicates that younger and adult farmers are more likely to adopt crop-livestock integration, suggesting that age affects the willingness to embrace new farming practices.

## 4.9 Barriers to adaptations

The survey identifies several major obstacles to effective climate change adaptation among respondents. The most significant barrier, with a high scale value of 161.4, is limited access to climate change information, indicating that insufficient knowledge hampers adaptation efforts. Financial constraints are also critical, with a scale value of 121 highlighting that many farming communities find adaptive measures too costly or lack the necessary capital. Government support, with a scale value of 111, is the third-ranked obstacle, suggesting that inadequate governmental assistance limits adaptation capabilities. Additionally, the lack of access to credit, with a scale value of 85.2, exacerbates financial challenges. Resistance to change, ranked fourth with a scale value of 48.2, reflects hesitancy in adopting new practices, while the compatibility of adaptation strategies with social norms and values, with a scale value of 47.20, underscores the importance of aligning strategies with cultural expectations. Overall, addressing these barriers requires improving information access, providing financial support, and ensuring that adaptation strategies are both culturally acceptable and supported by government policies.

The finding is supported by Fadina and Barjolle (2018) and Ndamani and Watanabe (2015), who identified institutional constraints, limited access to capital, insufficient climate information, and inconsistent extension services as major barriers to effective climate adaptation strategies for farmers.

Table 11: Barriers to Adaptation to Climate Change

|  |  |  |
| --- | --- | --- |
| Problem | Scale Value | Rank |
| Limited access to information and knowledge | 161.4 | I |
| Inadequate Capital | 121 | II |
| Resistance to change | 48.2 | V |
| Incompatibility with social norms and values | 47.2 | VI |
| No access to credit | 85.2 | IV |
| Lack of government support | 111 | III |

# 5. CONCLUSION

These results demonstrates that the impacts of climate change are increasing rapidly but the preparedness of farmer for adapting changing climate scenario is not sufficient for coping with these changes. The policies and plans did not effectively address the needs and voices of farmers. Therefore, we suggest that local governments involve farmers actively in municipal policy planning and implementation. The ASDP project, launched jointly by MOALD and IFAD to promote offseason vegetable production, implemented effective early preparedness strategies. Similarly, the PMAMP project also demonstrated strong climate change adaptation strategies, highlighting the crucial roles of both government and non-government organizations in facilitating adaptation efforts. Farmers excel in nature-based adaptation strategies but lag in implementing technological structural adaptations. Additionally, to be effective and achieve better results, adaptation strategies need to combine environmental, cultural, and economic aspects. It's also important to blend farmers’ traditional knowledge with modern technology to ensure sustainable and long-lasting outcomes.

**Ethical Approval Certificate**

This study does not require approval from an ethics committee.

**ACRONYMS/ ABBREVIATIONS**

% Percentage

C Celsius

CC Climate Change

DHM Department of Hydrology and Meteorology

F Frequency

CBS Central Bureau of Statistics

KII Key Informant Interview

FGD Focus Group Discussion

HH Household

IPCC Intergovernmental Panel on Climate Change

Mm Millimeter

SPSS Statistical Package for Social Science

χ2 test Chi square Test

IPM Integrated Pest Management

ASDP Agriculture Sector Development Program

PMAMP Prime Minister Agriculture Modernization Program

IFAD International Fund For Agriculture Development

MOALD Ministry of Agriculture and Livestock Development

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**REFERENCES**

1. Adams, H. (2016). Why populations persist: mobility, place attachment and climate change. *Population and Environment, 37,* 429-448. <https://link.springer.com/article/10.1007/s11111-015-0246-3>.
2. Adhikari, D., Prasai, R., Lamichhane, S., Gautam, D., Sharma, S., & Acharya, S. (2021). Climate Change Impacts and Adaptation Strategies in Trans-Himalaya Region of Nepal. *Journal of Forest and Livelihood*, *20*(1), 16–30. <https://www.researchgate.net/publication/359278776>.
3. Adhikari, S., Rawal, S., & Thapa, S. (2022). Assessment of Status of Climate Change and Determinants of People’s Awareness to Climate-Smart Agriculture: A Case of Sarlahi District, Nepal. *Advances in Agriculture*, *2022*. <https://doi.org/10.1155/2022/1556407>.
4. Ahmad, J., Alam, D., & Haseen, M. S. (2011). Impact of climate change on agriculture and food security in India. *International Journal of Agriculture and Environment Biotechnology, 4*(2), 129-137. <https://doi.org/10.5958/j.2230-732X.4.2.020>.
5. Aydinalp, C., & Cresser, M. S. (2008). The effects of global climate change on agriculture. *American-Eurasian Journal of Agricultural & Environmental Sciences*, *3*(5), 672-676.
6. Balasha, A. M. (2019). Drivers of Adoption of Integrated Pest Management among Small-scale Vegetable Farmers in Lubumbashi, DR Congo. *American Journal of Rural Development*, *7*(2), 53-59.
7. Smit, B., & Pilifosova, O. (2003). Adaptation to climate change in the context of sustainable development and equity. *Sustainable Development*, *8*(9), 9.
8. Clayton, S. (2020). Climate anxiety: Psychological responses to climate change. *Journal of Anxiety Disorders, 74*, 102263. <https://doi.org/10.1016/j.janxdis.2020.102263>.
9. CBS (2021). National Sample Census of Agriculture 2021/22.Kathmandu, Nepal, Central Bureau of Statistics. <https://agricensusnepal.gov.np>.
10. Cohn, A. S., Newton, P., Gil, J. D., Kuhl, L., Samberg, L., Ricciardi, V., Manly, J. R., & Northrop, S. (2017). Smallholder agriculture and climate change. *Annual Review of Environment and Resources, 42*, 347-375. <https://doi.org/10.1146/annurev-environ-102016-060946>.
11. Donatti, C. I., Harvey, C. A., Martínez-Rodríguez, M. R., Vignola, R., & Rodriguez, C. M. (2018). Vulnerability of smallholder farmers to climate change in Central America and Mexico: Current knowledge and research gaps. *Climate and Development, 10(1),* 10-26. <https://doi.org/10.1080/17565529.2018.1442796>.
12. Dulal, H. B., Brodnig, G., Thakur, H. K., & Green-Onoriose, C. (2010). Do the poor have what they need to adapt to climate change? A case study of Nepal*. Local Environment, 15(7)*, 621-635. <https://doi.org/10.1080/13549839.2010.498814>.
13. E., Van Etten, J., Allan, R., Hemming, D., Stone, R., Hannah, L., & Donatti, C. I. (2017). Climate change, ecosystems and smallholder agriculture: An introduction to the special issue. *Climatic Change, 145*(1-2), 1-10. <https://doi.org/10.1007/s10584-017-1920-5>.
14. Imbach, P., Beardsley, M., Bouroncle, C. *et al.* Climate change, ecosystems and smallholder agriculture in Central America: an introduction to the special issue. *Climatic Change* **141**, 1–12 (2017). <https://doi.org/10.1007/s10584-017-1920-5>.
15. Eckstein, D., Hutfils, M. L., & Winges, M. (2018). *Global climate risk index 2019: Who suffers most from extreme weather events?* Germanwatch. <http://www.germanwatch.org/en/cri>.
16. Fadina, R., & Barjolle, D. (2018). Farmers' adaptation strategies to climate change and their implications in the Zou department of South Benin. *Environments*, *5*(1), 1-17. https://doi.org/10.3390/environments5010015.
17. Gentle, P., & Maraseni, T. N. (2012). Climate change, poverty and livelihoods: Adaptation practices by rural mountain communities in Nepal. *Environmental Science & Policy, 21*, 24-34. <https://doi.org/10.1016/j.envsci.2012.04.006>.
18. Government of Nepal. (2016). *Agriculture development strategy (ADS)*. Ministry of Agricultural Development.
19. Holland, M. B., Shamer, S. Z., Imbach, P., Zamora, J. C., Medellín, C., Leguía, E., Donatti, C. I., Martínez-Rodríguez, M. R., & Harvey, C. A. (2017). Mapping agriculture and adaptive capacity: Applying expert knowledge at the landscape scale. *Climatic Change, 141(1),* 227-241. <https://doi.org/10.1007/s10584-016-1810-2>.
20. Hasan, M. M., Sarker, M. A. R., & Gow, J. (2016). Assessment of climate change impacts on Aman and Boro rice yields in Bangladesh. *Climate Change Economics, 7*(3), Article 1650008. <https://doi.org/10.1142/S2010007816500080>.
21. Intergovernmental Panel on Climate Change (IPCC). (2021). *Climate change 2021: The physical science basis. Contribution of working group I to the sixth assessment report of the Intergovernmental Panel on Climate Change* (V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, & B. Zhou, Eds.). Cambridge University Press.
22. Khanal, Pragya & Wagle, Bishnu & Upadhaya, Suraj & Ghimire, Prayash & Acharya, Suman. (2019). Perceived Climate Change Impacts and Adaptation Strategy of Indigenous Community (Chepangs) in Rural Mid-hills of Nepal. *Forestry: Journal of Institute of Forestry, Nepal. 16*. 48-61. 10.3126/forestry.v16i0.28353.
23. **Khatiwada, K., Panthi, J., & Shrestha, M. (2015).** Hydro-climatic trends in Karnali River Basin of Nepal Himalaya. <https://doi.org/10.13140/2.1.1387.5526>.
24. Lowder, S. K., Skoet, J., & Raney, T. (2016). The number, size, and distribution of farms, smallholder farms, and family farms worldwide. *World Development, 87,* 16-29. <https://doi.org/10.1016/j.worlddev.2015.10.041>.
25. Maharjan, A., de Campos, R. S., Singh, C., Das, S., Srinivas, A., Bhuiyan, M. R. A., ... & Vincent, K. (2020). Migration and household adaptation in climate-sensitive hotspots in South Asia. *Current Climate Change Reports*, *6*, 1-16. <https://doi.org/10.1007/s40641-020-00153-z>.
26. Melde, S., Gemenne, F., Blocher, J., Laczko, F., & Vigil, S. (2017). *Making Mobility Work for Adaptation to Environmental Changes-Results from the MECLEP global research*. IOM, Geneva. <https://www.researchgate.net/publication/315744534>.
27. Ministry of Home Affairs (MoHA). (2019). *Nepal disaster report 2019*. Ministry of Home Affairs, Government of Nepal.
28. Morton, J. F. (2007). The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the National Academy of Sciences, 104(50*), 19680-19685. <https://doi.org/10.1073/pnas.0701855104>.
29. Ndamani, F., & Watanabe, T. (2015). Farmers' perceptions about adaptation practices to climate change and barriers to adaptation: A micro-level study in Ghana. *Water*, *7*(9), 4593-4604. <https://doi.org/10.3390/w7094593>.
30. Ndamani, F. (2016). Climate change perceptions and adaptation in agriculture: A study of rural Ghana (Master’s thesis, Wageningen University, Netherlands). <http://hdl.handle.net/10173/1388>.
31. Ngoune, L. T., & Shelton, C. M. (2020). Factors affecting yield of crops. In Amanullah (Ed.), *Agronomy - Climate change and food security (pp. 1-16).* IntechOpen. <https://doi.org/10.5772/intechopen.90672>.
32. Ojha, H. R., Ghimire, S., Pain, A., Nightingale, A., Khatri, D. B., & Dhungana, H. (2016). Policy without politics: Technocratic control of climate change adaptation policy making in Nepal. *Climate Policy, 16*(4), 415-433. <https://doi.org/10.1080/14693062.2015.1047060>.
33. Ranabhat, S., Ghate, R., Bhatta, L. D., Agrawal, N. K., & Tankha, S. (2018). Policy coherence and interplay between climate change adaptation policies and the forestry sector in Nepal. *Environmental Management, 61*(6), 968-980. <https://doi.org/10.1007/s00267-018-1022-1>.
34. Rajbhandari, B. (2024). *Farmers’ perception and adaptation towards climate change on vegetable farming in Kathmandu district.* [*https://www.researchgate.net/publication/385631837*](https://www.researchgate.net/publication/385631837)*.*
35. Rai, D. (2023). Changes of family structure in Nepal. *DMC Journal*, *8*(7), 73–79. <https://doi.org/10.3126/dmcj.v8i7.62432>.
36. Samuels, M. I., Masubelele, M. L., Cupido, C. F., Swarts, M. B. V., Foster, J., Dewet, G., & Lynes, L. S. (2022). Climate vulnerability and risks to an indigenous community in the arid zone of South Africa. *Journal of Arid Environments, 199*, 104718. https://doi.org/10.1016/j.jaridenv.2022.104718.
37. *Climate change cut global farming productivity 21% since 1960s*. (2021, April 21). ScienceDaily. <https://www.sciencedaily.com/releases/2021/04/210401112554.htm>
38. Shakoor, U., Saboor, A., Ali, I., & Mohsin, A. Q. (2011). Impact of climate change on agriculture: Empirical evidence from arid region. *Pakistan Journal of Agricultural Sciences, 48*(4), 327–333.
39. Thapa, P., & Adhikari, A. (2018). Importance, scope, and status of agriculture insurance in Nepal. *Journal of Agricultural Economics and Rural Development, 4(1*), 365–371. <https://www.semanticscholar.org/paper/Importance%2C-Scope-and-Status-of-Agriculture-in-Thapa-Adhikari/18612eee94b8005d763b35f8dcf51e3851f90656>.
40. Tiwari, K. R., Rayamajhi, S., Pokharel, R. K., & Balla, M. K. (2014). Does Nepal’s climate change adaptation policy and practices address poor and vulnerable communities? *Journal of Policy & Globalization, 23*, 28-34. <https://doi.org/10.7176/JPG/23-03>.
41. Whitmarsh, L. (2011). Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. *Global Environmental Change, 21*(2), 690-700. <https://doi.org/10.1016/j.gloenvcha.2011.01.016>.