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Climate change and adaptive strategies for agriculture in Panchkhal Municipality

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Abstract

Climate change is a modern global crisis caused by human activities that emit greenhouse gases and alter the Earth's natural systems. It is now an undeniable global burning issue, affecting the complex relationship between the physical landscape, natural resources, and how communities adapt to the effects of climate change. Climate change brings many uncertainties to the livelihoods of farming communities that depend on weather and climate. The purpose of this paper is to examine the climate change and adaptive strategies of the farmers in Panchkhal Municipality using an explanatory mixed-methods research design. Primary data were collected from field observation, questionnaires, and interviews. Secondary data were collected from the Center Bureau of Statistics (CBS) and the Department of Hydrology and Meteorology (DHM). The finding shows the many impacts of climate change, such as hot waves, floods, landslides, droughts, increased diseases in agriculture production, and drying up water resources. Similarly, it shows that traditional adaptive strategies have been changing due to a decline in food crop production over the last two decades. Thus, strong policy efforts need to be prepared to mitigate the adverse impact of climate change on traditional farming methods.

Keywords: Climate change, impact, adaptive strategies, modern adaptation, indigenous, mitigation

Introduction

Climate change refers to changes in temperature and weather patterns over the long term. Such shifts can occur naturally due to changes in solar activity or large volcanic eruptions. Similarly, climate change is a significant change in average weather conditions over decades. Now, climate change has become a burning issue in developed and developing countries, including Nepal. According to the World Bank (2008) estimates, three out of four poor people in developing countries live in rural areas, and most of them depend directly or indirectly on

agriculture for their livelihoods. Climate change is the long-term trend that distinguishes it from natural weather variability.

Average surface temperatures today are about 1.1°C warmer than at the end of the 19th century (pre-industrial age). The overexploitation of natural resources and the expansion of industrial sectors into agricultural and forest land have led to an increase in greenhouse gas production in recent years, which has obviously increased the harmful effects of greenhouse gases (IPCC, 2014). However, since the 19th century, human activity has been a major contributor to climate change. Human activities are producing greenhouse gases that are warming the world the fastest in the last 2000 years (IPCC, 2013). The momentum to reduce emissions and decarbonize our lifestyles has gained major momentum since the United Nations Climate Change Conference (COP 21) on the Paris Agreement, which warned of limiting global warming to 1.5°C (UNFCCC, 2016). Countries and other partners will integrate and scale up recent agricultural innovation advances to improve resilience and climate protection, including smallholder farmers and agro ecology, by 2023. The Food and Agriculture Organization of the United Nations has announced for the first time that it is implementing a plan to reduce emissions from food and agricultural systems at COP 28, in line with the goal of keeping temperatures from rising above 1.5 degrees Celsius (UNFCCC, 2023). The temperature forecast for the end of the 21st century is 1.1–6.4 °C, compared to the second half of the 20th century, and based on the Special Report on Emissions (SRES) scenarios for greenhouse gas emissions (IPCC, 2000, 2007a). The rate of warming in Nepal accelerated significantly, reaching an average annual rate of 0.06 °C between 1971 and 1994 (DHM, 2017).

Many authors consider climate change to be the greatest threat to sustainable agricultural production due to increased drought, erratic rainfall, and low seasonal rainfall (Bhatt et al., 2014; Chapagai et al., 2019, & Adhikari et al., 2021). Changes in the average global temperature have varying effects across the planet. temperature, sea level change (average and extreme), water levels, rainfall and runoff, drought, wind patterns, food production, ecosystem health, species and animal distribution, and human health (IPCC, 2007b). The main causes of climate change are gases produced by burning fossil fuels, industrial agriculture, and other large industrial processes. When these gases are released into the atmosphere, they block heat from escaping the earth, causing the "greenhouse effect" that warms the earth. This rise may only be a few degrees, but as weather patterns become

uncontrollable, wildlife struggles to keep up. With a rapidly changing environment, these changes will have catastrophic consequences. The consequences of current climate change include intense droughts, water scarcity, severe fires, rising sea levels, floods, melting polar ice caps, devastating storms, and loss of biodiversity. The assessment report of the Intergovernmental Panel on Climate Change (IPCC) has predicted the adverse effects of climate change. Southeast Asia's agricultural sector will be affected mainly by increased droughts, torrential rains, and rising temperatures.

Drought causes crop failure in rain-fed areas, while heavy rains reduce crop yields due to crop damage (MoNREC, 2016). According to recent reports, nearly 90% of crop losses in Nepal are caused by weather and climate events, rising temperatures, and climatic disasters such as excessive rainfall, drought, and related floods. Climate change will cause a combined loss of around 10–30% in crop production, livestock, and fisheries. Low yields and production lead to reduced food availability and access, food insecurity, and poverty. Food insecurity and poverty affect the full realization of the right to food. Crop variety diversification, crop and crop rotation, selection of the best seeds to change agricultural soil characteristics, change of planting time, use of chemical fertilizers, promotion of mixed cropping systems, and investment to reduce livestock diseases are some of the adaptation measures practiced by farmers (Aase & Chapagain 2017; CBS 2017).

Adaptation plans and policies such as the Climate Change Policy, National Adaptation Program (NAPA), Local Adaptation Plan for Action (LAPA), Reducing Emissions from Deforestation and Forest Degradation (REDD+), and Forest Policy have been formulated and implemented over time (Tiwari et al., 2014; Ojha et al., 2016, & Ranabhat et al., 2018). Sustainable forest management has emerged as a promising adaptation strategy in Nepal. Many of these programs have brought about notable changes in climate change adaptation at the local level. But there are some critics who argue that Nepal`s adaptation strategies are often reactive and unplanned, leading to ineffective adaptation and poor adaptation outcomes due to a lack of resources, options, and knowledge about adaptation, technology, economic structures, and a lack of integration of institutions at multiple adaptation levels. (Bhatta et al., 2015; Adhikari et al., 2021 & Ranabhat et al., 2018). Local communities developed adaptation strategies based on environmental, social, cultural, and economic conditions. Khatiwada (2014; 2019) focuses on cultivation,

agroforestry, conversion of flat terraces to irrigated flat terraces (*khet bari*), and selective change of cropping calendar. He claimed that this change is being practiced in the hilly areas of eastern Nepal with the continuation of tolerant seeds and versatile farming.

Preliminary field observation data show that local communities in Panchkhal Municipality are also promoting the continuation and modification of their adaptation strategies (Shresha, 2020; 2022). In this context, this article aims to describe the perceived impacts of climate change on livelihoods and agricultural activities in hilly areas and examine the adaptation strategies used in Panchkhal Municipality.

Methods and materials of Data Collection

Study area

The study area is in Panchkhal Municipality, ward number 01 of Kavrepalanchok district. When it was established, it included Panchkhal, Baluwa, Anaikot, Sahitghar Bhagwati, Hoxebazar, Devbhoomi 2017, Kharelthok, and Koshidekha Village Development Committees in 2017 (Urban Water Supply and Sanitation Project, 2018)

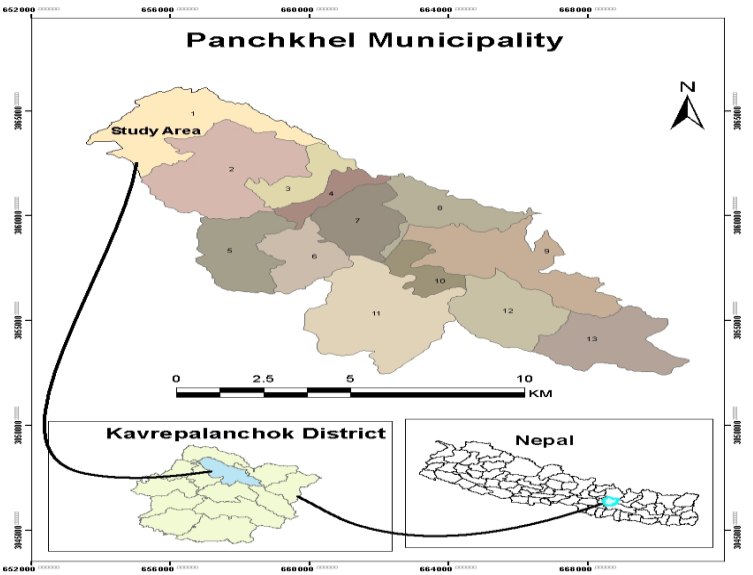

Fig. 1: Location map of study area

It lies between 27°39'N and 85°37'E. Panchkhal Municipality shows that it has been inhabited by different caste communities for a long time. The Panchkhal Municipality has several types of vegetation that include sub-tropical vegetative covers. This is a linear municipality in the center of the valley. The town is at the junction of Araniko Highway and Tamaghat-Thuloparsel Road, partly covered in black. The Panchkhal Valley is about 45 km from Kathmandu and is well connected by road and transport. A range of hills separates the Dhulikhel Valley to the west and the Dolalghat Valley to the east. Vegetable production has become

very popular in many areas of Nepal, especially around major roads. Panchkhal Municipality is a very popular municipality for producing vegetables, which are sold at high prices in Kathmandu as well as other nearby cities. Agriculture is the main source of income. Some people are engaged in small-scale cottage industries. Livestock increases national income, while trade and remittances are other sources of income for local people (Central Statistics Office, 2012; Panchkhal Municipal Office, 2018). Settlements were scattered, except for linear accumulation in the market area. It has a police station, a military barracks, five commercial and development banks, four financial institutions (savings and credit), four cooperatives, seven money transfer agencies, one club youth, a post office, a telecommunications office from Nepal, and dozens of agricultural veterinarians (Dahal, 2018).

Data collection

A mixed-methods approach (Teddlie &Tashakkori 2003, & Gentle et al. 2018) was used to collect background information for this study. The household survey was conducted using simple random sampling. This study uses a mixed-methods research design that adopts quantitative and qualitative methods. Data collection is really beneficial, especially when it comes to respondents' experiences, perceptions, and opinions. Primary and secondary data sources were used in this article. The household survey was conducted using simple random sampling. There are a total of 856 households in Ward No. 1 in Panchkhal Municipality. From the total population, a sample was conducted among 269 households, representative of all population categories.

The primary sources were conducted through a household survey and key informant interviews. Key informant interviews (KII) were conducted with seven key informants, including elders, local leaders, teachers, social workers, local government officials, and non-governmental organizations (NGOs), to explore the impacts of climate change and adaptation measures. Similarly, secondary sources of data were collected through DHM and CBS (2068 and 2078).

Data analysis

Quantitative data and qualitative information obtained from the field study were analyzed separately. Quantitative data collected from household surveys were analyzed using Statistical Package for Social Sciences (SPSS) version 20 and coded, categorized, and fed into the computer for further analysis. I used Likert scales and closed-ended questions to determine people's perceptions of climate change impacts and adaptation strategies adopted by farmers. Quantitative data was

analyzed through frequency, descriptive analysis. Similarly, qualitative data were collected through key informant interviews and thematic analysis.

Results and Discussion

The current status of agriculture and climate change

Nepal is considered a low-income country, with a GDP per capita of 689.5 USD in 2015 (WB 2017). In 1975, Nepal's agricultural sector accounted for 65 percent of the country's gross domestic product (Mishra, 2023). Agriculture is the mainstay of the economy and the traditional way of life of the people, contributing nearly one-third of the GDP and providing employment to 74 percent of the economically active population. The export of agricultural products is the main source of income for the country. However, production of staple crops (such as rice and maize) is not sufficient to meet domestic demand, explaining the country's high rate of staple crop imports. The slow growth of the agricultural sector in recent years has been attributed to the high dependence of agricultural activities on weather, inadequate irrigation facilities, and the availability of agricultural inputs (especially seeds and fertilizers) and the increasing trend of abandonment (NPC, 2017).

Agriculture is predominantly small-scale farming with an area of less than two hectares (ha), accounting for about 76 percent of the country's arable land (CBS, 2013). Climate change is caused by changes in solar energy, temperature, and precipitation due to greenhouse gas emissions from fuel combustion, deforestation, urbanization, and industrialization (Upreti, 1999). Climate change is expected to have a negative impact on the agricultural sector of developing countries, with large losses and adaptation costs. In its Sixth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) announced that the average global temperature has increased by 1.10°C over the past decade (2011–2020), compared to an estimated increase of 1.30°C to 5.0°C. This is consistent with low and very high emissions scenarios by the end of the century (IPCC, 2021).

Sources of information about climate change

Weather information is important for preparedness for agricultural activities. Radio and TV have become the most important sources of information. Internet devices have increased access to weather information. The sources of weather information have made it easier to do agricultural work (table- 1).

Table 1: Sources of information about climate change

Sources	No. of responses (n=269)	Percent
Radio/TV	190	70.6
Experience	148	55.0
Internet	124	46.1
News paper	63	23.3
Book	24	8.9
Neighbor	21	7.8

Source: Field study, 2020

Table 1 shows the sources of information about climate change. The majority (70.6%) of the farmers has used radio and TV, followed by 55.0 percent with experience, and a few (7.8%) farmers have used neighbors as a source of climate change. In this way, farmers use two or more sources of information about climate change. But now the use of internet is gradually increasing in the sources of climate change.

Impact of climate change

There are many types of climate change effects in my study area. Flood, landslide, hot wave, drought are the main effects of the climate change in Panchkhal Municipality. This affect is mainly affecting in the agricultural production. In this context, scientific studies on the impact of climate variability and vulnerability on agriculture, especially on production, have not yet been identified. Due to climate change, it is vulnerable to disasters such as flash floods, GLOF in mountains, snowmelt, droughts, and floods in lowlands. Climate change is causing extreme weather events such as heat waves, higher temperatures, and longer periods of heat, threatening human health and forest fires.

Changes in rainfall patterns are making floods more frequent and severe, causing widespread destruction to homes, infrastructure, and farmland. Heavy rainfall and soil erosion can destabilize slopes, accelerate landslides, and trigger dangerous mass movements that threaten communities and infrastructure. In addition, droughts are becoming more persistent and destructive, which can pose significant challenges to areas dependent on water supply, agricultural productivity, and ecosystems (table- 2).

Table 2: Impact of climate change

	Statement	No. of responses	Percent
Hot wave	Yes	129	48.0
	No	115	42.8
	Undecided	25	9.2
Flood	Yes	263	97.8
	No	6	2.2
Landslide	Yes	227	84.4
	No	42	15.6
Drought	Yes	163	60.6
	No	106	39.4
	Total	269	100.0

Source: Field study, 2020

Table 2 shows the impact of climate change in the study area**.** The majority (48.0%) of the farmers have been informed about the hot wave, and a few (9.2%) of the farmers are undecided about it. Similarly, the majority (97.8%) of the farmers are affected by floods, 84.4% have been affected by landslides, and 60.6 percent by drought. It is clear that the majority of farmers are affected by climate change. Therefore, the government should implement effective strategies for the mitigation of climate change. Otherwise, it becomes a crisis in agriculture production.

Participated in training

Climate change has significant impacts on agriculture, and it is important to provide farmers with the knowledge and skills to improve and study resilient agriculture. Basic Agricultural Training: Acquires knowledge through a high school of general agricultural education and/or any training program specialized in certain subjects (especially horticulture, horticulture, viticulture, forestry, fisheries, veterinary science, agricultural technology, and related subjects). A completed agricultural apprenticeship program is considered basic training. Full agricultural training: any continuous training equivalent to at least two years of full-time training after the end of compulsory education and completion at an agricultural college, university, or other institution of higher education in agriculture, horticulture, forestry, fisheries, veterinary science, agricultural technology, or a related subject in table -3.

Table 3: Participants in Training

Statement	**Response**	**Percent**
Participated	154	57.2
Not participated	115	42.8
Total	269	100.0

Source: Field study, 2020

Table 3 shows the participants in agriculture training. The majority (57.2%) of the respondents participated in the agriculture training, followed by 48.2 percent who did not participate in the agriculture training.

It is clear that less than half of the farmers have received agricultural training. Among the farmers who have received training, it shows that only a few farmers have applied the agricultural training in practice.

New diseases appeared in livestock and crops.

A variety of bacterial, viral, and parasitic infections cause significant economic losses to agriculture production in worldwide. From the perspective of food security in Nepal, pest invasion of crops is also a problem. According to the climate survey conducted by the Central Bureau of Statistics in 2017, 60.25 percent of households observed the emergence of new plant diseases, and 66.09 percent observed the emergence of new insects or pests in their crops (Smith, 2019). The new diseases that appeared in livestock and crops are presented in table- 4.

Table 4: New diseases in livestock and crops

Statement	No. of responses	Percent
Yes	103	38.3
No	166	61.7
Total	269	100.0

Source: Field study, 2020

Table 4 shows the emerging diseases in livestock and crops in the study area. The majority (61.7%) of farmers did not perceive new diseases in livestock and crops, and few farmers (38.3%) saw them in agriculture. This means that few farmers have realized that new diseases in livestock and crops have emerged due to climate change in agriculture. The supported of the following statements:

> *Five years ago, a kind of disease appeared in paddy. This dried up the rice paddy. Even the agricultural experts could not identify what disease it was. As a result, rice production was damaged. Thus, due to climate change, new diseases have appeared in new environments. Some diseases are easily identifiable, while others are not. Such diseases destroy crops and animals and cause financial loss.*

It has been shown that new diseases have appeared in agricultural crops due to climate change. Farmers have suffered huge financial losses. For this, agricultural experts should arrange modern laboratories to diagnose and solve diseases in time. Because of this, the financial loss to farmers is reduced.

Migrant farmers in the study area

By 2050, approximately 1.3 million people will be forced to flee their homes in Nepal due to climate change. Compared to the period 2006–2020, he has

increased more than three times. Current global efforts and targets keep us on track for 2.1°C to 3.3°C of warming (Sherpa & Bastakot, 2021). The Intergovernmental Panel on Climate Change (IPCC) reported that natural disasters and environmental change are major drivers of migration (IPCC, 2014). Farmers have migrated due to the fact that this ward is far away from the central area of Panchkhal Municipality and there is no arable soil, in addition to the lack of development infrastructure (table- 5).

Table 5: Migrant farmers

Statement	No. of responses	Percent
Yes	96	35.7
No	173	64.3
Total	269	100.0

Source: Field study, 2020

Table 5 shows the migration in the study area. Majority (64.3%) of farmers did not migrate and few farmers (35.7%) migrated due to climate change. This means that due to climate change, people have migrated to the wards and fertile lands of this municipality where infrastructure is developed, and few farmers have migrated.

Agriculture Adaptive strategies

Adaptation strategies in agriculture of Panchkhal Municipality include various techniques and practices designed to mitigate the effects of climate change. These methods are promoting drought-tolerant crops, introducing efficient irrigation systems, implementing agroforestry practices, and developing crop varieties that can withstand extreme climatic conditions. The objectives of these strategies are to promote sustainable agricultural practices that increase resilience to environmental challenges, conserve biodiversity and ensure food security. Agricultural adaptation strategies commonly used by farmers include developing drought-resistant crop varieties, crop diversification, changing cropping patterns and planting calendars, conserving soil moisture through appropriate tillage practices, improving irrigation efficiency, and planting and agroforestry (Akinnagbe & Irohibe, 2014). This article also focuses on agricultural adaptation strategies for climate change impacts in Panchkal Municipality. They developed three possible strategies for him: reducing the risk of loss, developing the ability to cope with inevitable losses, and taking advantage of new opportunities. Household responses to adaptation strategies are summarized in table -6.

Table 6: Agricultural adaptive strategies of the study area

Statements	Frequency		Percentage	
	Yes	No	Yes	No
Indigenous farming	63	206	23.4	76.6
Modern farming	111	158	41.3	58.7
Changed crop species	161	108	59.9	40.1
Changed planting date	179	90	66.5	33.5
Commercial farming	184	85	68.4	31.6
Tunnel farming	145	124	53.9	46.1
Organic farming	158	111	58.7	41.3
Unseasonal farming	138	131	51.3	48.7

Source: Field study, 2020

Table 6 shows the adaptation strategies of the farmer in the study area. The majority (66.5%) of the farmers has changed planting date; followed by 59.9 percent changed crop species and few 23.4 percent farmers have adopted the indigenous farming.

It is clear that the farmers have changed their farming methods and seed varieties to adapt to climate change. As a result, in addition to using hybrid seeds instead of local and indigenous seeds, chemical fertilizers and pesticides are being used more in agriculture.

One of the farmers supported by the following statements:

20 years ago I used to grow food crops for home consumption on 5 ropani land. Gradually, I started to grow food crops as well as cash crops, especially potatoes and some vegetables. But now I only use less food crops and now, I have converted most of the land from traditional farming to commercial farming. Now I am also cultivating vegetables inside the tunnel for the market. Compared to rice cultivation, alternative agriculture has increased income and employment. But agriculture uses high-yield seeds, chemical fertilizers, and pesticides to increase production.

Thus, it is clear that farmers used to cultivate only food grains, but now due to climate change, the water source is gradually drying up. Farmers have been attracted towards vegetable cultivation under cash crops that can be produced even with less water. Farmers have said that they are giving more income than food crops. In addition, communities in the study area implemented the following adaptation strategies.

Crop diversification: Growing different crops can help reduce the risks associated with climate change. Different crops have different tolerances to environmental stresses such as drought, heat, and excessive rainfall. Even if one crop fails due to adverse conditions, crop diversification ensures a certain level of productivity. Farmers are producing high value crops like ginger, cardamom, vegetables,

avocado, kiwi, orange and ginger. Most of the Panchkhal Municipality farmers are making huge profits by converting food crops into cash crops.

Agroforestry: Local farmers have integrated trees with crops and livestock provides many benefits. Local people have been encouraged to plant trees for commercial purposes.

The farmers have planted cardamom, avocado, orange, kiwi and trees to adapt to the effects of climate change. Lob Green Nepal non-governmental organization is providing training and distributing seedlings to farmers at free and low cost.

Utilization of Climate Resistance Crop Varieties: The local farmers select and use of crop varieties that are more resilient to climate stress, such as heat and drought tolerant crops, can improve agricultural resilience. For example, corn, root crops, and tunnel cultivation require significantly less irrigation (Water) compared to rice cultivation in this municipality.

Integrated Pest Management (IPM): An integrated pest management approach is a combination of practices and techniques to reduce crop losses due to pests and diseases while reducing reliance on pesticides. The main objective of this method is reducing dependence on chemical pesticides through biological control, crop rotation, and the use of resistant varieties for pest control. Lob Green Nepal non-governmental organization is helping farmers to produce and marketing of IPM agriculture in the Panchkhal Municipality.

Livestock Management Practice: Livestock rearing is the traditional adaptation strategies. In the context of the study, good livestock management techniques, such as adjusting feeding methods or changing breeds to adapt to changing climatic conditions, help maintain livestock productivity. In addition to the dairy industry in this municipality, it plays a big role in meeting the needs of Kathamandu valley, so livestock farming is also done with the farmers.

Water Conservation and Management: Local farmers report that most adaptation methods produce benefits. By implementing efficient irrigation techniques like drip irrigation, plastic ponds, rainwater harvesting and mulching, water is saved and its optimal use is ensured. A plan is being implemented to construct plastic ponds in the dry wards of this municipality, as well as to reconstruct the old water wells, to conserve and promote water, and to bring water from the Sunkoshi River through the lifting system.

Labour Migration: Labor migration is a form of adaptation strategy to balance household income. Most of the young generation migrates seasonally to Dhulikhel, Banepa, Kathmandu, Lalitpur and Bhaktapur for foreign employment as well as internal employment. They are sending remittances from migrants to adapt to the negative effects of climate change.

Livelihood diversification: Local farmers have worked to diversify their livelihoods to adapt to climate change. The introduction of both agricultural and non-agricultural activities has diversified livelihood options such as: Commercial crops, fruits and vegetables, poultry, livestock farming, and small-scale trade are adopted in this municipality.

Mixed cropping: A mixed cropping system involves growing two or more crops on the same field at the same time. This approach offers many advantages, especially in the context of climate change, as it increases resilience and adaptability. One of the farmers supported by the following statements:

> *Mixed farming is my main source of livelihood. I often grew food crops for home consumption, vegetables for the market, and livestock for dairy and meat. I believe this adaptation strategy increases our resilience to adverse conditions such as drought, erratic rainfall, and flooding. In this context, I have been promoting the continuity of agricultural practices since the past 20 years.*

It is clear from this that due to climate changes, farmers are gradually changing the agricultural crops that they have been adopting before. Especially, instead of food crops, many farmers have changed to cash crops. Most of the farmers in this municipality have adopted mixed farming system. Because by adopting such a farming system, even if one crop is destroyed, another crop will help.

Changed the working time due to the temperature and rainfall

Climate change is a matter of concern to the world. Climate change is a matter of concern to the world. As a result, the temperature is changing. Such a change in this municipality's ward no. 1 has also appeared. Similarly, Climate change is a matter of concern to the world. It is a matter of concern to the world. As a result, there is no rain in time, and the cultivation time is changing. Such a change in this municipality's ward no. 1 has also appeared.

The majority (66.2%) of the farmers, followed by 50.6 percent farmers has changed the working time due to the temperature, and rainfall. Similarly, 8.9 percent and 6.7 percent of the farmers are undecided about them. It indicates that due to the effect of temperature and rainfall the farmers have changed their cropping times. Farmers support one of the following:

> *Earlier, I used to plant potatoes at the end of Kartik month, but now, due to climate change, the temperature has increased, and it has started to be planted at the end of Kartik and the beginning of Kartik month. Another farmer is also supported, due to climate change; water is not falling on time. Environmental phenomena such as irregular rains and droughts have*

> *appeared. Due to climate change, water is not falling on time. Environmental phenomena such as irregular rains and droughts have appeared. As a result, I have also changed the time of cultivation. For example, about 20 years ago, paddy was planted in rice in Jeshtha month, but now paddy is planted in Asar month.*

It is clear that climate change has become a matter of concern around the world. Due to this, the temperature and rainfall has been affected, and the farmers have changed the cultivation time.

Exposer visit

A series of training sessions and exposure visits are organized for local residents in identified livelihood areas, particularly home gardening, intensive farming, marine and pond fisheries, animal husbandry, cattle rearing, herbal crops and non-timber forest production, commercial vegetable production, fruits, and vegetables. Processing, carpet manufacturing, home textiles, and organic horticulture sectors are included. The majority (75.1%) of the farmers didn't exposer visit, and few of the farmers (24.9%) exposed visit. This means that only a few farmers have studied the impact of climate change on agriculture in other areas. Because the agricultural group here does not seem to be particularly interested, only a few farmers have switched to agricultural crops after visiting the exposer. One of the farmers supported the following paragraph:

> *I have visited Ward No. 2 from the agriculture group of Ward No. 10 to study organic farming techniques. I started organic farming because it is healthy from the point of view of health. But I have done it in a small area. I have used it myself without selling it on the mark*et.

It is clear that farmers use more chemical fertilizers and pesticides for farming. Due to a lack of market and agricultural training and education, they do organic farming in fewer amounts. Chemical farming helps to change the climate.

Information on urbanization *and industry*

In my study, urbanization is the process of increasing the concentration of population in cities and urban areas, which leads to the growth and development of urban infrastructure. It is the movement of people from rural to urban areas in search of better opportunities, comfort, and an improved quality of life. Urbanization shapes profound economic, cultural, and social dynamics and affects many aspects of modern life. It is changing the agricultural landscape, resulting in less arable land due to urban sprawl and increasing pressure on existing arable land to meet growing food demands in the study area. Climate change is affecting crop production, water availability, and the spread of pests and diseases, posing

challenges to agriculture and adapting to urban and rural areas to ensure food security and sustainability. Similarly, industrialization of agriculture has greatly increased productivity through mechanization and technological development, but industrialization in this municipality has also caused environmental problems such as soil erosion, water pollution, and loss of biodiversity, harming agricultural production, especially vegetable farming. Promoting resilient and sustainable food systems requires a delicate balance between urban development and agricultural needs, while also adapting to climate change (table- 7).

***Table 7*: Information on urbanization and industry**

	Statement	No. of responses	Percent
Urbanization	Yes	118	43.9
	No	151	56.1
Industry	Yes	172	63.9
	No	97	36.1
Total		269	100.0

Source: Field study, 2020

Table 7 shows information on urbanization and industry in the study area. Majorities (63.9%) of farmers have been informed about industry, followed by 56.1 percent didn't inform about the urbanization. Similarly, a few farmers (36.1%) didn't inform about the industry. It reveals that, many farmers are informed about urbanization and industry in the Panchkhal Municipality.

Conclusion

This paper analyzes the adaptation strategies adopted by local farmers of Panchkhal Municipality, particularly ward no. 1, to mitigate and cope with the effects of climate change on agriculture in this particular geographical region. In this geographical environment, local farmers have developed and used differentiated adaptive strategies based on agriculture, animal husbandry, petty trading, and migration to sustain households' income and wellbeing according to climate change. However, informed consent from the farmers shows that it is a useful asset for making alternative adaptive strategies such as organic farming, tunnel farming, unseasonal farming, as well as commercial vegetable farming, poultry farming, mushroom farming, and livestock rearing. Similarly, the majority of farmers have changed their planting dates and crop species. A few of the farmers have used indigenous agriculture adaptation strategies. The result indicates that local farmers are getting climate information from radio, TV, modern technology experience, and newspapers. This paper has also revealed that when weather conditions are favorable, market-oriented high-value cash crops yield better profit. It is concluded that local knowledge is a valuable asset for adaptive strategies to mitigate the adverse effects of climate change.

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