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CLIMATE CHANGE AND ADAPTATIVE STRATEGIES OF THE COMMUNITIES OF PANCHKHAAL MUNICIPALITY

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Abstract

Climate change has now become an unquestionable fact that affects the complex relationships between physical landscapes, natural resources, and their modification by local communities to adapt the impact of climate change. In this context, the purpose of this paper is to analyze the climate change and adaptive strategies of the community of Panchkhaal Municipality Ward No.13. The data were collected from both primary and secondary sources using mixed-method research design. Primary data were collected from field observation, questionnaires, interviews, focus group discussions and key informant survey. Secondary data were collected from reviews of published and unpublished documents. The finding shows that traditional adaptive strategies have been changing due to decline in food crop production since the last two decades. As a result, 52.5 percent households seem to be adapting new opportunities for diversifications-altering cropping times, application of agricultural inputs, tunneling and organic farming to adjust to the consequences of climate change. However, the adaption rates are varying depending on time and space and also it is varying on the basis of adaptive capacity of local community. Thus, strong policy efforts should be prepared to mitigate adverse impact of climate change on traditional farming methods.

Keywords: Climate change, adaptive strategies, new opportunities, indigenous, livelihood strategy, and mitigation

Introduction

Climate change has now become an unquestionable issue in both developed and developing countries, like Nepal. The World Bank (2008) estimated that three out of every four poor people in developing countries live in rural areas, and most of them depend directly or indirectly on agriculture for their livelihoods. However, the unusual

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changes in climatic phenomena are unfavorably conditions for agriculture and forestry sectors in developing countries (Maharjan & Joshi, 2013). Climate, often defined as average weather, is described in terms of the mean and variability of temperature, precipitation, and wind over a period of time, more specifically the classical period of 30 years (Le Treut et al. 2007 cited in Maharjan & Joshi, 2013, p. 1). Climate change is an issue of long-term shifts in temperatures and weather patterns. These shifts may be natural, such as through variations in the solar cycle' (United Nations, 2022). The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as:

> '*a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'(United Nations, 2018).*

The Framework Convention on Climate Change establishes principles that climate change is a serious problem for environmental pollution. It is an adverse effect of climate change, due to:

> *'changes in the physical environment or biota resulting from climate change which has significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare' (United Nations, 2018).*

Human activities have been considered the main driver of climate change. It is primarily due to burning fossil fuels generating greenhouse gas emissions around the Earth, trapping the sun's heat and raising temperatures. The United Nations has estimated that the Earth is now about 1.1°C warmer than it was in the late 1800s. The emissions have been continuously rising and 2011-2020 and it was recorded as the warmest decade. The warming is projected to reach around 3.2°C by the end of the century. In this context, the IPCC report (2018) suggests limiting global warming to 1.5°C compared to 2°C for ensuring a more sustainable and equitable society. Natural variability and human activities, such as burning fossil fuels, manufacturing, mining, deforestation, land use changes, etc. are considered causes of climate change. Thus, Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (Maharjan & Joshi, 2013; Appannagari, 2017; Smith; 2021).

Agriculture is a vital development tool for spurring growth, overcoming poverty, and enhancing food security. Agricultural productivity growth is vital for stimulating growth in other parts of the economy. Indeed, climate is one of the most important factors

influencing agriculture. The production of crops and livestock are highly sensitive due to fluctuations in temperature and precipitation lead to large annual losses for farmers across the world (Mendelsohn, 2000). Agriculture sector has also produced around 15 % anthropogenic emission, which exceed 32 % if we consider land use change (Maharjan & Joshi, 2013). As a result, rainfall patterns shift and extreme events such as droughts and floods, the poor people in Africa, Asia, and elsewhere face prospects of tragic crop failures, reduced agricultural productivity, and increased hunger, malnutrition, and disease (The World Bank, 2010). The World Bank (2008) considered that agriculture as the basis for economic growth and to eke out from these adverse conditions. However, it requires a strong policy to increase productivity in smallholder farming. With rising resource scarcity and mounting externalities, agricultural development and environmental protection have become closely intertwined (p. 2).

The Intergovernmental Panel on Climate Change (2007) defines adaptation as adjustments in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities. It also refers to actions that people, countries, and societies take to adjust to climate change that has occurred. Adaptation has three possible objectives: to reduce exposure to the risk of damage; to develop the capacity to cope with unavoidable damages; and to take advantage of new opportunities (cited in Akinnagbe & Irohibe, 2014, p. 408).

Local communities have developed adaptive strategies based on their ecological, social-cultural and economicsettings. Khatiwada (2014; 2019) argued that continuity and changes of shifting cultivation, agroforestry, conversion sloping terraced into irrigated level-terraced (Bari into Khet), changing in cropping calendar, selecting of drought resisting seeds, and multiple cropping were practicing in eastern hills of Nepal. The preliminary field observation information shows that local communities of Panchkhaal Municipality have also given pace to continuity and change in their adaptive strategies (Shrestha,2020). In this context, an in-depth study is required to clarify unrevealed question how local communities are making their adaptive strategies due to sever impact of climate and climate change in Panchkhaal Municipality of Kavrepalanchock district

Methods and Materials

Data Collection Methods and Tools

The study used a mixed method research design with the mixing of qualitative and quantitative approaches. It is very useful to collect data especially respondents' experience, perceptions and views. This paper based on both primary and secondary data sources. In this study, 124 households in Ward No. 13 who engaged in agriculture

for more than five years were selected based on multi-stage sampling methods. However, Ward No. 13 was purposively sampled for case study. Primary data were collected from the field observation, household surveys, key informant survey, focus group discussions (FGD), and questionnaire surveys. The data were analyzed through triangulation for quality control. Questionnaires, checklists and observation protocol sheets were prepared for data collection tools. Secondary data were collected through different sources, like an official document, library documents, CBS reports, e-resources, national, and international publications. Tables, maps, descriptive statistics tables, and diagrams are used to test the significance of this paper.

Study Area

The study area lies in Panchkhal Municipality Ward No. 13 of Kavrepalanchok district. The area was declared as a Municipality in 2014 by incorporating five Village Development Committees- Panchkhal, Hoksebazaar, Devbhumi Baluwa, Anaikot, and Sathighar Bhagawati and it was extended by adding Kharelthok and Koshidekha Village Development Committees in 2017. It has covered an area of 103 square kilometers (IEE, 2018). It is situated in between 27°39' N 85°37' E. Panchkhaal Municipality seems to be inhabited by different caste and ethnic communities since historical times.

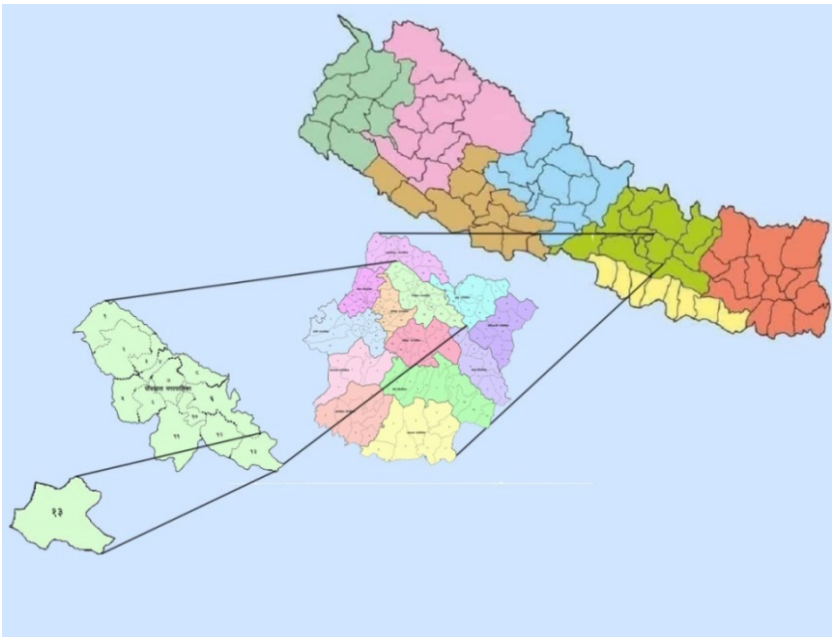

Figure 1: Location map of study area

Results and Discussions

Status of Agriculture and Climate Change

Agriculture is a production sector and major sources of livelihood in Panchkhaal Municipality. It provides both employment and income sources to fulfill the basic needs of people. However, agriculture is highly place specific activity. It is largely affected by geo-spatial, socio-cultural and technological factors. Indeed, climate change is a single detrimental factor that reversely affectsthe agriculture sector. Climate change will bring complex links between the issues of agricultural production, distribution and supply of food. Agriculture is also considered as a driver of emission reduction from deforestation. The population of the study area is increasing at a rapid rate, which will increase demands on land for food and fuels. There is, therefore, an emergence of increasing agricultural production but with climate change there will be added pressure on agriculture. Agriculture will be affected by both long-term mean temperature, precipitation and wind trend as well as by climate variability. In addition, agriculture will also be affected by the elevated carbon dioxide concentration, increase in weeds, pest and disease pressure (FAO, 2009). As agriculture sector is one of the contributors of the greenhouse gases, it also has mitigation opportunities for reduction of greenhouse gases by reducing its emission as well as acting as a sink for carbon sequestration.

Temperature and Rainfall Conditions

Nepal is highlysusceptibletoclimatechangeandhasnowpracticedchangesin terms of temperature and precipitation. An average temperature of Panchkhaal Municipality is 24.9°C. throughout the year. Temperaturerises up to 38°C in the summer andwinter isgenerally drywith a record oflow temperature as -10°C in 2008 (Upadhyaya,2012).

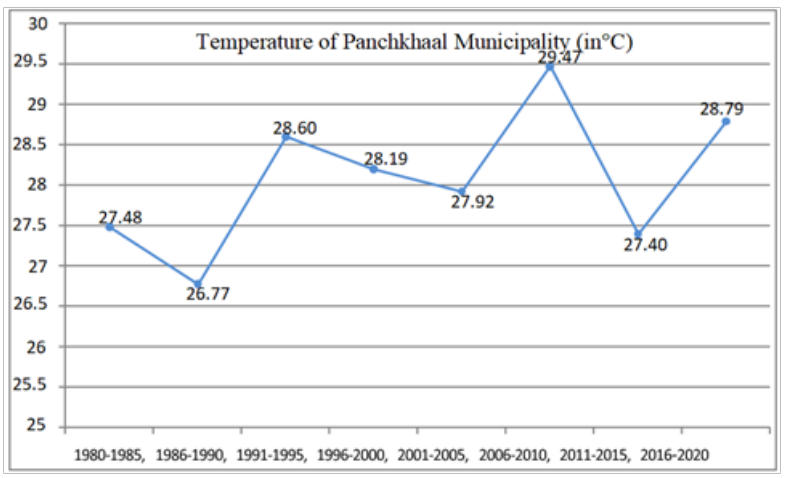

Figure 2: Raifall in Panchkhaal Municipality

Figure 2 Shows that the trend of temperature in Panchkhaal Municipality. The figure revealed 40 years climatic data which represents to the highest temperature was recorded (29.47°C) in 2006-2010, and lowest (26.77°C) in 1986-1990. The temperature since 1980 to 2020 seems to be fluctuated at 3°C. Figure 3represents to the trends of the rainfall in Panchkhaal Municipalitysince 1980 to 2020. The figure reveals that the highest rainfall recorded (110.12 cm) in 1996-2000and lowest (66.86cm) in 2006-2010. During this period rainfall seems to be fluctuated around 44 mm in this municipality.

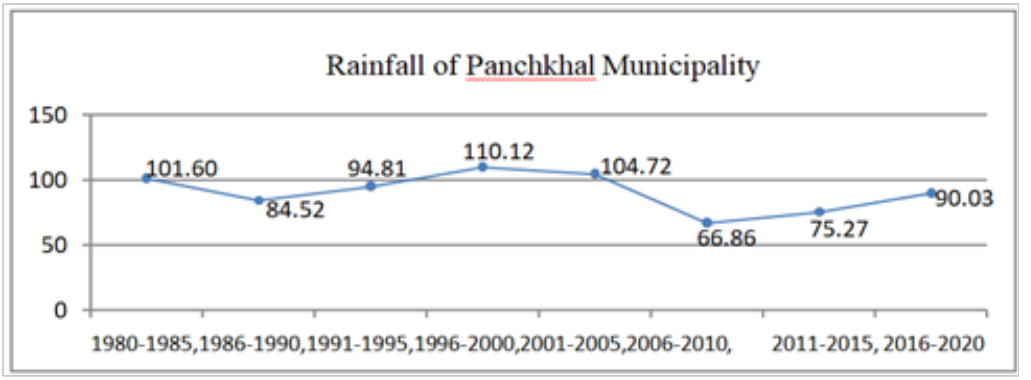

Figure 3: Temperatures of Panchkhaal Municipality

Local Knowledge and Perception of Climate Change

In this paper, the knowledge generated and continued by the community of the Panchkhaal Municipality is known as local knowledge. This knowledge has been generated by own experience, tested, and adapted in their socio-cultural environments over centuries. This study revealed that local communities of this municipality have used fossil fuels, chemical fertilizers, and pesticides to increase agricultural production. It has also played a considerable role in the growing concentration of greenhouse gases (GHG) in the atmosphere. The concentration of GHG has been increasing temperature, changing precipitation patterns, decreasing agricultural production, sources of water becoming withdrawal, and increasing diseases. However, local communities have used low-carbon emitted ways of living to contribute miniature effect of climate in their local livelihoods. They are largely dependence on local biological diversity, ecosystem services and cultural landscapes for making their sustenance living. They have linked with their lands, water and forest resources located at their social-ecological margins for habitation in a small undulating hill-slopes and narrow river valley. They have collected climatic information from their knowledge of the land, sky and weather phenomena. They are excellent observers, interpreters and offer valuable insights of environmental change. Their knowledge provides a crucial foundation for local adaptive strategies to sustain resilience of their social-ecological systems. They are involving in diversified

livelihood activities to mitigate crop failure in adverse climatic conditions, such as vegetables, floriculture, mushroom, poultry farming, fishing, and dairy. They have also used their knowledge to increase soil fertility, weeding, mulching and managing wild species.However,local communities have considered thattheir knowledge is still traditional, regressive, weak and inferior to meet their growing needs as compared to modern knowledge (Moseley, Perramond, Hapke, & Laris, 2014).

Figure 4: Cropping pattern of Panchkhaal Municipality

Nowadays, local communities have been aware to collect climatic information from radio, Television, and News Papers (Table 1).

Table 1: Sources of information about climate change

Sources	Gender				
	Male	Percent	Female	Percent	Total percent
Internet and Facebook	28	22.6	16	12.9	35.5
Newspaper	18	14.5	12	9.7	23.2
Radio, Television	13	10.5	11	8.9	19.4
Neighbor	8	6.4	7	5.6	12.0
Others	6	4.8	5	4.0	8.8
Total	**73**	**58.9**	**51**	**41.1**	**100.0**

Source: Field survey, 2020.

Table 1 shows the source of the information about climate change in the study area. The result indicates that the internet and Facebook as the prime source of knowledge about climate change which covers the largest percentage of households (35.5%). It is followed by the Newspaper in the second (23.2%) and the neighbor in the least (12.0%). Gender-based responses are similar to these findings, such as males (58.9%) and females (41.1%) for Internet and Facebook in the first and newspaper in the second males (14.5%) and females (9.7%).

One of the key informants reported about the source of information as follows:

> *I always listen to radio and watch television also frequently read daily newspapers. I have used these sources to collect climatic information. In addition, I have also used Internet, Facebook, and social media to get information. Social media and mausamchautari provide information about temperature, rainfall, sunrise, sunset, clouds, humidity, etc. These sources provide knowledge for cropping calendar and harvesting to mitigate climate change.*

Climate Change and Local Livelihood Activities

The communities of Panchkhaal Municipality have been involved in agricultural activities. They have developed their own adaptive strategies based on seasons, onset of monsoon, and harvesting time. It shows that subsistence agriculture was a mainstay of livelihood in the study area before the road construction. Indeed, traditional method of cultivation was unable to meet households' needs. After the construction of Araniko-highway local communities have been involving in diversified livelihood strategies. One of the informant reported that 'nowadays, majority of the households are altering their traditional farming practice into market-oriented cash crops- vegetable, mushroom, poultry, livestock, and fishing. A small proportion of households are also involving in dairy, cottage industry, and petty trading. As a result, the consumption of chemical fertilizers, pesticides, and insecticides is increasing'. Table 2 shows the households involved in diversified livelihood activities.

Table 2: Medium of Livelihoods

Medium	Respondents	Percentage
Mixed agriculture	65	52.5
Vegetables farming	32	25.8
Food crops	12	9.7
Livestock farming	9	7.2
Others	6	4.8
Total	**124**	**100**

Source: Field Survey, 2020

Table 2 shows that 52.5 percent households occupy mixed agriculture as a major livelihood. It is followed by vegetable farming in the second (25.8 percent) and others in the least (4.8 percent). Others indicate that the farmer involves in Bee farming, Livestock farming, an Mushroomfarming. Mixed farming means the farmers are involved in cash crops and food crops.

The chief of the Agriculture Knowledge Centre told that:

> *'communities are gradually changing their traditional method of cultivation into cash crops i.e. vegetables, poultry and dairy. This municipality is selected for potatoes production zone in the Prime Minister Agriculture Modernization Project (PMAMP). Potato is a major source of income in Panchkhaal Municipality. Majority of households have been producing potato for commercial purposes due to the efforts of governmental, non-governmental organizations and communities self-motivations'.*

The result also revealed that local communities have also practicing commercial vegetable farming to generate better income as compared to cereal crops. They have given pace to alternative crops with the application of farm inputs, improved seeds and low amount of investment. The finding shows that continuity and change of subsistence farming is an adaptive strategy, where livelihood diversification is playing a significant role to sustain local way of living.

Climate Change and Agricultural Adaptive Strategies

Adaptation to climate change involves changes in agricultural management practices in response to changes in climate conditions. The common agricultural adaptation strategies used by farmers were drought resistant varieties of crops, crop diversification, changes in cropping pattern and calendar of planting, conserving soil moisture through appropriate tillage methods, improving irrigation efficiency, and afforestation and agro-forestry (Akinnagbe & Irohibe, 2014). This paper also revealed agricultural adaptive strategies to the impact of climate change in Panchkhaal Municipality. They have developed three possible strategies: to reduce exposure to the risk of damage, to develop the capacity to cope with unavoidable damages, and to take advantage of new opportunities. The households' responses towards their adaptation strategies are summarized in Table 3.

Table 3: Agricultural adaptive strategies of the study area

Statements	Frequency		Percentage	
	Yes	No	Yes	No
Traditional knowledge	25	99	20.1	79.9
Modern knowledge	49	75	39.5	60.5
Changing planting date	78	46	62.9	37.1
Changing plant species	77	47	62.1	37.9
Additional irrigation	95	29	76.6	23.4
Changing the use of chemical fertilizer, pesticides and insecticides	101	23	81.4	18.6
Tunnel farming	25	99	20.1	79.9
Organic farming	5	119	4.0	96.0

Source: Field survey, 2020

Table 3 shows the adaptation strategies of the farmer in the study area. The figure indicates that the majority of the households (81.4%) have been altering their cropping patterns with the application of chemical fertilizer, and pesticides. It is followed by thechanging planting calendar in the second (62.9%) and the use of organic farming the least (4.0%) for making their adaptive strategies.

One of the key informants reported that:

> *I have used land to produce paddy for household consumption for the last 20 years ago. Nowadays, I have changed my traditional farm-practice into commercial crops. I have started producing vegetables in tunnel for markets. I think, alternative farming can yield more income and employment as compared to paddy cultivation. Before tunnel farming I have only used local seeds and compost manure. Nowadays, I have been using high yielding varieties seeds, chemical fertilizers and pesticides for increasing production.*

In addition, the local communities have been practicing the following adaptive strategies in the study area:

Selection of drought resistant varieties of crops: Local communities select to more drought resistant crops in drought-prone areas for reducing vulnerability to climate change. For example, maize, root crops and tunnel requires significantly less irrigation water compared to paddy cultivation.

Crop diversification: Local communities have given importance to crop diversification. They have produced high value cash crops, such as large cardamom, ginger, avocado, kiwi, orange, ginger etc. They have altered food crops into cash crops.

Change in cropping pattern and calendar of planting: Local communities have adapted to the adverse effects of climate change through the alterations in rainfall resulting in changes in cropping pattern and calendar of operations.

Mixed cropping: Mixed cropping involves growing two or more crops in proximity in the same field. One of the key informants reported that:

> *Mixed farming is a main stay of my livelihoods. I have often produced food crops for household consumption, vegetables for markets and animal husbandry for dairy and meat. I think, this adaptive strategy makes us more resilient in adverse conditions of drought, erratic rainfall and flood. In this context, I have given pace continuity and change of my farming practices since the last 20 years.*

Improved irrigation efficiency: Local communities have reported that most adaptation methods provide benefits even with the lower end of climate change scenarios, such as improved irrigation efficiency.

Agroforestry: Local people were motivated towards tree planting for commercial purpose. They have practiced to large cardamom, avocado, orange, kiwi and timber to adapt the impact of climate change.

Livestock adaptation strategies: Livestock rearing is another important traditional adaptive strategy. Local communities are creating on their in-depth knowledge of the environment in which they live. Their livestock practices have been changed through diversification, intensification and/or integration of pasture management, livestock and crop production by employing stall-feeding.

Labour migration: Labour migration is a mode of adaptive strategy to compensate households' income. Most of the youth people are seeking seasonal migration in Dhulikhel, Banepa, and Kathmandu valley as well as foreign employment. They are sending remittances derived from migration to adapt to adverse effects of climate change.

Livelihood diversification: Local communities have involved in livelihood diversification to adapt climate change. Introduction of both farm and non-farm

activities increased diversify livelihood opportunities, such as commercial crops, fruits and vegetables, poultry, fishing, dairy and petty trading.

Climate Change Education in School Curricula

Climate change education is concerned with incorporating knowledge about global warming and climate change with teaching about the environment, development, human beings, and history into everyday life. It is meant to provide educators, politicians, and others with accurate information on how to cope with and adapt to climate change (https://www.greenjournal.co.uk).

The issues of climate change have been frequently stressed to increase vulnerability and reduce adaptive capacity in Nepal. The adverse effects of climate change have a particularly devastating effect on lives and livelihoods of communities. Climate change has also severe impact on resources, food production, widespread poverty and national economies. In this context, local communities have developed their own adaptive strategies. These strategies and experiences are valuable sources of knowledge for future generation. They need to share local knowledge that is generated by communities. Livelihood diversification, forest management practices, soil fertility and moisture management practices, water conservation practices etc. are some of the techniques to face risks associated with climate change. Thus, this type of knowledge is needed to incorporate in school curricula.

The impact of climate change has also associated with migration patterns and school enrolment, infrastructure maintenance and personnel, as well as disaster risk management (UNESCO, 2012).

Thus, climate change education can be used in both formal (School and universities curricula) and non-formal education. Students should also be involved in community-based programs, especially for resource management and conservation connection to climate change. They need knowledge about mitigation to the impact of climate change. In Nepal, Curriculum Development Centre (CDC) has introduced climate change education in school curriculum.

Conclusion

This paper examines impact of climate change and the adaptive strategies of the local communities in Panchkhaal Municipality. In this geographical environment, local communities have developed diversified adaptive strategies

based on agriculture, animal husbandry, petty trading and migration to sustain households' income and wellbeing. However, the majority of the households have been involving in mixed farming. The result indicates that local communities are getting climatic information from radio, TV, internet and Facebook. Their knowledge seems to be a useful asset for making alternative adaptive strategies such as commercial vegetables farming, poultry, fishing, mushroom, and livestock rearing. This paper has also revealed that when weather conditions are favorable, then market-oriented high-value cash crops yield better profit. The paper concludes that local knowledge is a valuable asset foradaptive strategy to mitigate the adverse effect of climate change.

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