**Exploring the Factors Influencing Climate Change in Agriculture: A Study of Kerabari Municipality, Morang District**

**Abstract**

Agriculture has become more vulnerable to a changing climate characterized by a shift in rainfall, rising temperatures, and increased extreme weather conditions. Such climatic variations have had adverse effects on crop yields and agricultural practices, general productivity being impacted most, since farmers, especially in areas like Kerabari Municipality, are experiencing erratic rainfall, outbreaks of pests, and deforestation. The present study investigates some specific climatic and socio-economic challenges faced by the farmers and identifies how far these challenges hamper their adaptation capacity and agricultural productivity. The in-depth interview, focus group discussions, and field observations are included in the qualitative approach to this research. In this respect, the study examines the various socio-economic determinants that affect their adaptation strategies, as well as how far the current farming practices are appropriate. The results high lighten the need for sustainable agricultural methods, resilient infrastructure, and access to climate information. It is also stated that government support is highly required to help build long-term agricultural resilience and reduce the impact of climate change.

**Key words:** Agriculture, Climate Change, Factors, Influence and Small holder farmers.

**Introduction**

Climate change poses a significant threat to Nepal's agriculture, as weather patterns can significantly impact crop productivity and overall agricultural practices (Bhandari et al., 2017).

The country's diverse topography and monsoon-based agriculture make it vulnerable to unpredictable climatic changes like altered rainfall, rising temperatures, and increased extreme weather events (IPCC, 2014).The erratic monsoon, crucial for Nepal's agriculture, is making it challenging to predict optimal planting and harvesting times.

This unpredictability leads to crop failures, food shortages, and financial stress for farming households dependent on consistent agricultural outputs. Moreover, increased temperature and alteration in precipitation are causing outbreaks of pests and diseases that affect crop health; thus, food security is at higher risk. In the case of Kerabari Municipality within Morang District of eastern Nepal, the agriculture sector is highly vulnerable due to changing climatic conditions. This region is known for its cash crop production, including crops like maize, sugarcane, and vegetables, all of which are sensitive to climate variability (Gautam & Koirala, 2020). It shows extreme sensitivity to deviations of temperature and rain patterns, considering the planting calendar cycle and water availability or outbreaks of disease. For example, maize-which is considered one of the staple crops-has yielded catastrophically minimal tonnages in the case of inconsistent rain patterns, associated with increased ambient temperatures.

Agriculture production within the municipality even increases its vulnerability to climate impacts, where changes in climate directly affect the income generation of farmers. Furthermore, unpredictable weather conditions coupled with the lack of proper irrigation systems make farming even more difficult for smallholder farmers. On the other hand, this research paper will try to show different influencing factors of climate change in the agriculture sector, ranging from temperature and rainfall changes to human activities in the form of deforestation and unsustainable farming in Kerabari Municipality. Widespread deforestation in the region has reduced the natural landscape carbon sinks, further reducing its capability for carbon absorption and regulation of local microclimates, thereby fueling the heating of the region. Unsustainable farming practices, such as over-involvement with chemical fertilizers and inappropriate irrigation techniques, also contribute to exacerbating the climate-related challenges faced at the local level by farmers ( Adhikari et al., 2021). It becomes more relevant to understand these factors as the region becomes more vulnerable to climate impacts in devising adaptive strategies that could somehow mitigate the adverse effects. Precisely, this study shall attempt to identify specific climatic challenges faced by local farmers and ascertain how these have been impacting crop yields and agricultural sustainability. The data collected from farmers, local-level agricultural experts, and a stakeholder on the level at which climate change is affecting agricultural productivity and food security. Besides climatic factors, socioeconomic factors such as access to resources, government policies, and community adaptation strategies also considered during the research study (Famiglietti, 2014). The farmers are generally supposed to have this adapting capability to change, based on access to finances, technologies, and timely information about climatic changes. Moreover, good governmental policies addressing the support to climate-resilient agriculture would, apart from supporting farming subsidies to develop sustainable ways of farming practices, go the length to water management infrastructures-reducing vulnerability to the impact of climate changes. These influences, when understood, add to the valuable information on the climate change-agriculture relationship in the region, besides giving out recommendations on mitigates and adaptation strategies contextualized to the local settings. For instance, the adoption of agroforestry practices, improving irrigation practices, and enhancing farmers' access to information on climate would be potential solutions that would help build the resilience of farming. This strategy would not only help reduce the adverse impacts of climate change on agriculture in Kerabari Municipality but also ensure its long-term sustainability. The study contributes to the broader discourse on climate change impacts within the agricultural sector of Nepal, alongside adaptation strategies to be employed toward the development of resilience at the local levels, by Leiter (2022). According to Shrestha & Khatiwada (2020), information on climate change has grown from traditional channels of radio, television, and newspapers to the digital platform comprising the internet and social media. Information on the impacts of climate change is gaining awareness among the rural households, which in turn affects farming practice and schedules. This research, therefore, focusing on the case study of Kerabari Municipality, provides a deep understanding of the impact of climate change on agriculture at the local level and gives actionable insights for policy-makers and farmers. Understanding local dynamics in Nepal's Kerabari Municipality is crucial for developing effective strategies for food security and sustainable agriculture amidst climate pressures. Addressing climate change challenges is crucial for long-term economic stability and food sovereignty in agriculture, which is the backbone of Nepal's economy and livelihood for rural populations.

**Methods and Materials**

 This research attempts to focus on how changes in temperature and rainfall are affecting agricultural productivity, crop yield, and long-term sustainability in the region. The results will also be enriched with in-depth interviews, focus group discussions, and field observations depicting the experiences of the local farmers and other stakeholders. As noted by Creswell (2014), such methods are increasingly applied to reach an in-depth understanding of community-level perception and management of climate change.

Moreover, the engagement of different sources of information, such as farmers, agricultural experts, and local authorities, stands to provide a vast variety of perspectives and information to be used in identifying these multivariate challenges and adaptive strategies within the agricultural context, Patton (2015)

**Research design**

The researcher utilized a case study research design that is well-suited for this qualitative methodology. . The design aims to thoroughly examine the unique circumstances of Kerabari Municipality, thereby providing a comprehensive understanding of the localized effects of climate change on agriculture. The case study approach enables researchers to explore intricate connections between climatic changes and agricultural practices through various data sources like in-depth interviews, focus group discussions, and field observations. . This method offers a comprehensive evaluation of the unique challenges faced by the community and the adaptive strategies employed by local farmers and stakeholders (Yin, 2014).

**Sources of Data Collection**

 This research employs two types of data resources. Primary and secondary data collection is two types of data collection methods. Primary data was gathered from farmers, agriculture experts, and local representatives, while secondary data was gathered from CBS reports, newspapers, temperature and rainfall records, articles, books, and UNFCCC records.

.**Data Collection**

**Interviews**: The study involved in-depth semi-structured interviews with local farmers, agricultural experts, and local representatives. The interviews offer valuable insights into farmers' experiences with climate change, their perception of its impact on their crops. interviews delves into the escalating effects of deforestation, unsustainable farming practices, and other human activities on climate change.

**Focus Group Discussions (FGD)**: FGDs were conducted for local farmer groups to discuss common issues related to climate change. The discussions provide a complete understanding of the effects at the community level and modes of coping. In this study, group discussions covered effects of the socio-economic factors involving resource access, government policies, and community adaptation strategies.

**Field Observations** This research focuses on observing agricultural practices, environmental conditions, and climate-induced changes in crop yields, pest outbreaks, and soil health in the field. The observations supplemented the data collected through interviews and focus groups.

**Sampling Strategy**

The study utilized purposive sampling and focused on farmers who produce crops like rice, maize, vegetables, and livestock. Researchers consulted local agricultural experts, government officials, and other key informants to understand the agricultural sector's impact on climate change. The interviews were conducted using the saturation principle, halting data collection once no new information was uncovered

**Result and Discussion**

**Rising Temperature**

Climate change is affecting the growth cycle of crops negatively due to the rise in temperatures, which may shorten the growth period of crops. In the case of Kerabari Municipality, the highly heat-sensitive crops, like maize and sugarcane, will have a lower productivity rate. Higher temperatures can also accelerate evapotranspiration, which depletes the soil moisture needed by crops, further worsening the farmers' problems. It is very well documented that temperature variability has a direct consequence on agriculture; there are studies showing that higher temperatures can negatively impact crop yields by shortening the growing season and intensifying water stress (Lobell et al., 2011). One of the farmers shared, , I always feel that the heat during the growing season is unbearable. The temperature is rising unpredictably, which changed the timing of planting and harvesting of crops. Even then, it was difficult to predict when to plant and harvest. Crop production was affected because of this. The rise in temperature is not only changing crop production but is also changing the soil moisture level, as another farmer mentioned. This is because of climate change. So, because of it, soil moisture is gradually getting drier and cannot sustain the crop and thus production. These qualitative statements show that farmers are aware of the direct impact of temperature variability on the cycle of growth, soil moisture retention, and general agricultural productivity.

**Rainfall Pattern Changes**

Changes in rainfall patterns, driven by climate change, significantly affect agriculture in Kerabari Municipality. The region's reliance on monsoon rains makes it particularly vulnerable to shifts in the timing and intensity of rainfall. Unpredictable rainfall, such as excessive rainfall or droughts, disrupts the regular planting and harvesting cycles, leading to waterlogged fields or water scarcity. These disruptions can severely impact crop growth, reducing yields and overall agricultural productivity. Studies have shown that climate change-induced shifts in rainfall patterns contribute to agricultural vulnerability by making it harder for farmers to predict when and how much rain will fall, complicating the scheduling of key farming activities (Kundzewicz et al., 2019). In this context, one of the farmers said,

The timing of rainfall has significantly altered between approximately 20 years ago and the present day. Sometimes, there is no rain for a long period of time; sometimes, heavy rainfall and the crops get destroyed due to flooding in the fields; and sometimes, crops cannot be planted due to drought. Due to heavy rainfall last year, the Bhaluwa River is causing a major impact on production both by harvesting and flooding the rice crop during the summer season.

. In this situation one of the agriculture experts supported that

The unpredictable nature of rain is significantly impacting crop planning. Farmers are facing financial challenges due to the inability to rely on traditional planting schedules. The paddy harvest, originally scheduled for Ashar 22 20 years ago, now takes place on Ashar 7, with the timing being influenced by the weather. In this context, local representative shared,

Our community is dependent on monsoon rains because during the monsoon season, there is heavy rainfall. When the rains are late or there is too much rain, it does not balance everything. To cope with these changes, we need to manage the canals and canals under a good water management system. For this, irrigation has not been possible due to the lack of a permanent water source, and on the other hand, managing water from groundwater requires a lot of money. Now, drilling is being done in places. This is gradually increasing the irrigation facilities.

This qualitative information highlight the significant challenges posed by irregular rainfall patterns, but at present, despite bearing a large financial burden, there is little support for the impact of the banana farming sector with the support of the village council.

**Extreme Weather Events**

 Extreme weather events, including floods, landslides, and storms because of climatic changes cause a major setback to agriculture in all parts of the world. This places a heavy burden on places like Kerabari Municipality. Major crops go to ruin in bulk while minor infrastructure like irrigation also gets massively damaged; however, fewer hectares of cultivable land would be there. These farmers lose crops in hand and also get a long term balance of bank books. Extreme weather events destroyed crops, not only reducing food availability but also further lowering farmers' income and their capabilities to reinvest in their farm, thus the difficulty in regaining. These studies have showed that extreme events brought about by climate change affect crop production in large quantities with huge losses, further increasing problems of food security and economic troubles in rural society (Field et al., 2012; Dhungana et al., 2020). In this context, one of the farmers said that, "In 2061 BS, violent storms have destroyed the total maize crop field. The crops lost are more destructive because the family needs that for feeding as well as in market sales." In the same way information, this agriculture expert supported that,

Climate change-induced floods and landslides are causing the loss of topsoil, making it challenging to sustain crop production. The damage to infrastructure, including irrigation systems and storage facilities, is significantly disrupting agricultural activities, thereby significantly affecting agricultural production.

In this condition the local representative said that,

In this context, when these extreme events strike, it's not just the crops that are hit. Roads get washed out, and entire villages get cut off from essential services. The economic and social cost our community bears is humongous, and recovery takes years.

 This qualitative information brings forth daunting challenges brought by extreme weather events, which indicate that the agricultural sector needs resilient infrastructure and emergency preparedness to support livelihoods dependent on it.

 **Pest and Disease Outbreaks**

Climate change has accelerated the growth of pests and diseases due to increased temperatures and humidity, allowing them to thrive and spread.

Pests and diseases pose significant threats to crop health, resulting in reduced yields and a growing need for effective pest control measures. Farmers are experiencing increased operational costs due to the application of pesticides and other measures to reduce losses. Climate change-induced weather changes increase pest and disease outbreak severity and frequency, compromising agricultural productivity and sustainability, as evidenced by various studies (Chazdon, 2008; Gopal, 2017). One of the farmers stated in this context,

Previously, weather could be forecasted to an extent and the outbreak of pests could be controlled to an extent. But nowadays, because of the changing climate, new diseases are coming out in crops and livestock. Due to which some of the pests can be identified and treated on time, leading to lesser losses in crop production while some of the diseases can't be identified and the farmers have to suffer huge losses. For instance, potato leaves used to dry up about 10 years ago but the disease could not be ascertained and caused massive losses. An agricultural expert supported the of this issues, " With the increased burden of the pest and diseases among farmers, we are increasing our investment in pesticides and other control measures while offering agricultural training and education to farmers. The program, though not wholly effective, is trying to reduce the disease somewhat" To this regard, a local representative said,

The increased cost of management of pests and diseases is increasing the cost of agriculture in general. Poor and small-scale farmers have, therefore, suffered more, having little to counter the challenges that confront them. The productivity and economic stability of the farmers are also being addressed through training and agricultural education. We offer the program that is far from being adequate, and which we intend to gradually expand. This is because of the fact that climatic change has made weather patterns and outbreaks of some pests' unpredictable hence introducing new diseases in crops and livestock complicating management and resulting in massive losses. For instance, the potato disease which attacked a decade ago caused devastating damage due to late identification and treatment.

In this context, as a response, agricultural experts said,

The rising cost of pest and disease management is increasing the overall cost of agriculture. Small farmers are particularly vulnerable, as they have limited resources to deal with these challenges. We are addressing the issues affecting farmers' productivity and economic stability by offering training and agricultural education. The program is not sufficient and we plan to gradually increase it.

In conclusion, climate change has made weather patterns and pest outbreaks more unpredictable, introducing new diseases in crops and livestock that complicate management and lead to significant losses. For example, a potato disease from a decade ago caused severe damage due to delayed identification and treatment. In response, agricultural experts are increasing investments in pesticides and offering training to farmers, though these measures are not fully effective. The rising costs of pest and disease management are particularly burdensome for small farmers with limited resources. Local representatives are supporting farmers through training and education programs and plan to expand these efforts to improve agricultural productivity and economic stability. These challenges underscore the need for ongoing adaptation, increased support, and resource investment to help farmers cope with the evolving threats of climate change.

**Soil Degradation**

Climate Change is causes of deforestation are farming or firewood production; it could directly be equated to how much forests will be able to store carbon in order to lower the levels of CO2 and consequently stop climate change. Forests become carbon sinks. They absorb and reduce the effect of CO2 in the air, which mitigates climate change. The clearing of forests by humans releases the carbon inside them into the atmosphere. In addition, the removal of forest cover upsets local microclimates, leading to increased temperatures and altered rainfall patterns. These changes create an unstable environment that is increasingly unsuitable for traditional farming, thereby worsening the impacts of climate change on agricultural productivity. Studies have shown that deforestation leads to increased temperatures and altered precipitation patterns, which are detrimental to crop growth and farming practices (Lambin et al., 2001; Rudel, 2009). One of the farmers said, "Deforestation is causing gradual increase in temperature. Climate change has brought erratic rainfall, so it is unpredictable to farm due to its unpredictability."

In the same way, an agricultural expert supported "deforestation reduces carbon sink capacity in this area that increases the intensity of climate change". The other expert also added, "not only is the storage carbon released by deforestation but it enhances the local microclimate, and for that reason, it provides more extremes in the weather pattern, which has further affected crop production."

Both farmers and agricultural experts in Kerabari have highlighted the significant impact of deforestation on the local climate and agriculture. A farmer noted that deforestation contributes to rising temperatures and unpredictable rainfall, complicating farming efforts. Experts have observed that the loss of forest cover reduces the area's ability to function as a carbon sink, exacerbating climate change. Additionally, deforestation alters the microclimate, leading to extreme conditions that further degrade crop yields. These insights emphasize the critical need to maintain forest cover to ensure climate stability and support agricultural productivity.

**Soil Erosion**

 Soil erosion mainly caused due to unproductive agriculture has the significant effect on the agricultural productivity. Imbalanced or excessive uses of chemical fertilizers and pesticides, and lack of irrigation management, disturb the natural balance in the soil. This reduces its potential to retain its vital nutrients and moisture in the soil, highly essential for healthy crop growth. Fertile soil supports agricultural productivity by a great amount; it provides the right environment for plants to flourish. On the other hand, poor soil quality resulting from such practices reduces fertility and makes it harder for the farmer to cultivate crops. Climatic change enhances the problem further because it affects weather patterns, increases the revalence of extreme climatic events like droughts and floods, which deteriorate the soil further (Boserup, 1965; Chazdon, 2008). This creates a vicious cycle that threatens food security and the sustainability of agricultural practices. One farmer said,

"I am a victim of inappropriate agricultural practices when it comes to soil health. The overuses of chemical fertilizers, pesticides, and uncontrolled irrigation have highly resulted in visible soil degradation that is gradually becoming unsuitable for crop growth. He added that the shortcuts which had been previously considered to yield a high volume are unsustainable and are being very costly regarding the land. Soil deterioration is worsened by increased fertilizers and pesticides, reducing soil fertility and worsening the problem.

 In this context an agriculture expert supported,

Over-reliance on chemicals and climate change are significantly affecting soil fertility due to adverse human activities. Torrential rains leading to excessive erosion of the land further deplete its productive capabilities for agriculture." The expert pointed out that using chemicals results in a short-term gain of crops, but eventually the structure of the soil gets degraded due to this and causes bad water retention as well as compaction of soil. Moreover, heavy rain, which is said to be a cause of climate change, often in this area, and thus soil erosion accelerates; completely degrading agricultural occurs more potency.

Both the farmers' view and the expert's explanation have shown the interlinking between farming practices and climate change, with an impact on the soil health. The situation demands urgent intervention through the adoption of more sustainable agricultural practices that give priority to soil conservation, water management, and reduction in chemical inputs. Without these changes, agriculture in the region may be at serious risk for the long term, with implications against food security and farmers' livelihoods.

**Water Resource Availability**

Climate change significantly impacts water resource availability, a crucial factor in the sustainability of agriculture, particularly in water-intensive crops like banana plantations. The increasing temperatures and unpredictable rainfall are posing a threat to the predictability of drinking and irrigation water. During dry seasons, the scarcity of water poses significant challenges for farmers to ensure uninterrupted crop production.

. Water is required to support the growth of banana plants and maintain moisture in the soil to avoid water stress in banana plantations. This disruption not only hampers agricultural productivity but also raises the risk of crop failure and instability in farmers' incomes who depend on constant irrigation for their livelihood. Various studies prove that water scarcity, caused by climate change, is directly related to the reduction in agricultural yields and can have long-term effects on the viability of farming in affected regions (Gautam & Koirala, 2020; Field et al., 2012). In this context, one of the farmer said, "The water level in the river is much lower than before and during the dry season we are not in a position to supply sufficient amount of water for our crops, which gives problems in the production of crops in the dry seasons." In this way, the agriculture expert supported,

Climate change is significantly impacting agricultural productivity due to the decrease in water availability for irrigation. The reduction level of ground water and underground water and changing rainfall patterns are making it difficult for farmers to plan for the coming seasons, leading to inconsistent crop production.

A local representative acknowledged the irritation over water availability; the farmers mentioned the problem of drinking water due to irregular water supply, saying that

Earlier the river water was the only source of drinking water and irrigation, but now it has become a source of groundwater along with groundwater. Despite the reduction in drinking and irrigation water issues, no mention has been made regarding the issue. However, there is a role for us to help find alternative water sources and invest in better water management systems to mitigate the impact of climate change.

In conclusion, climate change is reducing water availability for drinking and irrigation, significantly impacting agricultural sustainability, particularly in banana plantations. Farmers struggle to maintain consistent crop production during dry seasons due to decreased river water levels and declining groundwater. An agriculture expert noted that changing rainfall patterns exacerbate these issues, complicating farmers' planning and leading to inconsistent yields. Farmers also face challenges with drinking water supply, now relying more on groundwater as river levels drop. A local representative acknowledged these concerns and emphasized the need for alternative water sources and improved water management systems to mitigate the effects of climate change

**Socioeconomic Factors**

The impact of climate change on agriculture, particularly in Kerabari Municipality, is exacerbated by socioeconomic factors. Lack of financial capital, non-availability of all sorts of climate-resilient infrastructure, and lack of government support have been identified as major obstacles for farmers to adopt climate-smart practices and technologies. Most farmers in Kerabari do not have access to or the means of acquiring credit or funds for irrigation systems, drought-resistant varieties, or other adaptation measures. This financial constraint leaves them more exposed to climatic shifts since they are unable to develop any remedy for the risk brought about by such unstable weather patterns. In addition, weak implementation of policies and denial of information regarding the exact climate condition is further worsened by the situation because farmers can never make appropriate decisions concerning their crops' management and the water usage in these farms. These socioeconomic challenges not only limit their adaptation to climate change but also reduce agricultural productivity and economic stability in general (Adhikari & Shrestha, 2019; Bhandari et al., 2017). In this regard, one of the farmers said,

"The socio-economic impact of climate change is significant. Given the meager means of generating more finances, I fail to invest in climate-resilient technologies such as drip irrigation or drought-resistant crop varieties. I want requires financial assistance from both government and non-government sectors. The farmers are facing procedural challenges in obtaining financial loans and grants, hindering their ability to secure adequate government support and grants, thereby limiting their investment capacity. The issue has resulted in production challenges and the need for excessive chemical fertilizers and seeds to boost production.

**Conclusion**

The study underlines the fact that the farmers in Kerabari Municipality face unparalleled challenges due to the dual pressures of climate change and socioeconomic constraints. Major issues identified include increased frequency of extreme weather events, such as floods and droughts, which destroy crops and disrupt farming cycles. Pests and deforestation contribute to challenges in agriculture, resulting in low productivity and long-term ecological damage. Unsustainable agriculture and water shortages are leading to soil degradation, reducing fertility and impacting crop yields. The lack of finance and the absence of resilient climate infrastructure are hindering farmers from implementing necessary measures.

 To tackle such pressing concerns, the research favors the development of climate-resilient practices, of which agroforestry will increase biodiversity and stabilize the local climate. Water use must also be optimized to ensure crop survival during dry periods through better irrigation systems. The study suggests that timely climate information should be provided to farmers to aid in informed decision-making regarding crop management and resource allocation. Government support and financial subsidies are crucial for empowering farmers to transition towards sustainable agriculture The study indicates that effective strategies for mitigating climate change require a coordinated effort from farmers, local authorities, and agricultural experts. Such collaborative approaches are the cornerstones for assuring food security and ensuring agricultural sustainability in Nepal, thus paving the way for resilient farming communities who can be strengthened despite the constant challenges that climatic change provides.

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