

## **The effect of Climate change in the rural livelihood in Nepal (Case of Badarjhula of Chitwan district, Bagmati Province, Nepal)**

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### **Abstract**

The two-third populations of Nepal reside in rural areas. Most of them depend on rain-fed agriculture for their livelihoods. Nepal is severely suffering from the effects of climate change, and hence, the effect of climate change in rural Nepal is more concerned. This paper aims to explore the adverse effects of climate change in terms of natural disaster, loss of agriculture land, loss of people and domestic animal's lives, and livelihood in relation to the Badarjhula village and discusses some measures for minimizing climate change's effect adopting both qualitative and quantitative approaches, though qualitative is dominant. The empirical study of Badarjhula village reveals that the huge amounts of agricultural lands have been destroyed by unexpected-flooding and drought due to climate changes for decades. According to the National Adaptation Plan of Action (NAPA) of Nepal Government, this village lies in the highest "Flood Vulnerability Index" in Nepal. Badarjhula lies in a tropical climate zone and climate prone area. The rural populations belonging to the indigenous and vulnerable community, and poor people of the area mainly depend on subsistence form of agriculture are more vulnerable to climate change. It was found that huge and unexpected induced-disasters such as extreme rains, floods, drought, and fire (both settlements and forests) are making hard rural livelihoods. The frequent conflict between human and wild animals causes both agriculture and property losses. The results also expose that the water sector was also badly hit. Agriculture is the most vulnerable sector in this village and their direct effects are seen in the household livelihood. The effects of climate change need to be addressed in order to secure the livelihood in terms of food security of poor rural people in a sustainable way.

**Keywords:** Adaptation, livelihood, climate change, agriculture

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### **I. INTRODUCTION**

Climate has become a threat to agriculture and livelihoods globally. The entire world has been suffering from it. Especially developing countries are marked more than developed countries. The climate patterns have been changed due to high increase levels of atmospheric carbon dioxide, produced by the use of fossil fuels over the decades. The evidence of warming is that the average temperature of the Earth's surface has increased by 1.4F in the last 100 years and about 1.0F of the warming happened in the last three decades [1]. According to Baste [2], human emissions of greenhouse gases, clearing forests, global temperature variations, etc. have largely been contributed to climate change.

Svante Arrhenius, Swedish scientist in 1896 first speculated the warming from coal-burning, mainly foresaw this as a boon in the colder regions of the Earth [3]. Around 1960 greenhouse gas emissions from energy production were envisaged and predicted for long-lasting environmental changes. There was noticed to have a severe drought, heat, and vast fires in the Amazon rain forest. In these contexts, the first world climate conference was taken in 1979 in Geneva. Then, the issues of greenhouse emissions were more pronounced. As a result, the Intergovernmental Panel on Climate change was established in late 1988. Climate change is primarily caused by global warming of the past 30 years due to human activities, particularly development activities. According to the UN [4] Environment program, climate change is one of the most pervasive and threatening issues in the twenty-first century; temperature changes and the rising of sea-level are putting ecosystems under stress and affecting human well-being. Climate change has now become a global phenomenon.

Nepal cannot be an exception from it because of its location and climate diversity. As it lies between two economic giants China and India; these both have been producing emission high greenhouse gases and

creating a high risk of climate change. China's carbon dioxide (CO<sub>2</sub>) emissions are estimated to have increased – from around 3300 MtCO<sub>2</sub> in 2000 to 8500 MtCO<sub>2</sub> in 2013/14- 25% of the global total [5]. Similarly, India emitted 2,299 million tons of carbon dioxide in 2018. Likewise, Nepal represents a climate diverse country ranging from tropical to alpine/arctic climate. The impact of climate change has been experienced in different sectors in Nepal including agriculture, forests and biodiversity, water resources, and energy [6]. The rapidly retreating glaciers (average retreat of more than 30 m/year), a rapid rise in temperature (>0.06°C), erratic rainfalls and increase in the frequency of extreme events such as floods and drought-like situation are some of the effects in Nepal [7]. Furthermore, Maharjan & Joshi [8] argue that the impact of climate change in agriculture is obvious and ultimately it hits rural livelihoods. The adaptation of climate change is essential for Nepal as it can be understood through political-ecology theory that encompasses the socio-political aspects of food sufficiency and climate change adaptation. The climate change adaptation processes are a socio-political process. It includes the concepts of subjectivity, knowledge, and authority to the analysis of adaptation focuses attention on this socio-political process. The two-thirds of the population in Nepal depends on agriculture for livelihoods; therefore, a study on the effects of climate change on agriculture and livelihoods, and adaptations are crucial. The main objective of the study is to explore the effects of climate change in the rural area which is directly related to livelihoods/food security; and discusses adaptations.

## **II. LITERATURE REVIEW: CLIMATE CHANGE, AGRICULTURE, AND LIVELIHOOD**

FAO [9] mentions that Climate change and agriculture are deeply interconnected; the agriculture sector is responsible for approximately 21 percent of greenhouse gas emissions such as carbon dioxide, methane, and nitrous oxide. Carbon dioxide emissions, mostly produce from land-use changes i.e. deforestation and cutting down trees. Furthermore, 50 percent of food production depends on nitrogen which comes from fertilizer. Globally, climate change has a relationship with agriculture in developing countries because their livelihood depends on agricultural activities [10]. According to FAO, climate change has both direct and indirect effects on agricultural productivity including changing rainfall patterns, drought, flooding, and the geographical redistribution of pests and diseases. Food security is becoming a high priority worldwide as the population is rapidly growing.

Selvaraju [11] studied livelihood adaptation to climate variability and change in drought-prone areas of Bangladesh. He found that 93 major disasters were recorded that caused nearly 200,000 deaths and worth US\$5.9 billion losses in agriculture due to climate change between 1991 and 2000. A large population of these prone areas was chronically exposed and vulnerable to a range of natural hazards. A few Indian studies confirm an agricultural decline with climate change [12]. Likewise, Kamble [13] studied the impacts of climate change on rural development in India. He argues that the adverse impacts of climate change are seen in the productivity of agriculture, rural employment, in particular, access to improved water and water stress. Similarly, Lewis [14] studied the climate changes in the Near East and North Africa and found that the major trends affecting agriculture in the region, and the victims were small-scale farmers.

The impact of climate change in agriculture has directly affected the economy and lives of people, particularly in rural areas. In Nepal, 83 percent of the population resides in a rural area and this population depends on agriculture [15]. Therefore, the development of agriculture and livestock is key to the national economy. The agriculture sector represents the main source of food, employment, and income for the majority and it is still a dominant sector in Nepal. However, the subsistence form of agriculture is common, and poverty is exceedingly marked in rural Nepal [16]. The two-third population in Nepal adopt agriculture as the main occupation for a livelihood [17]. Bartlett [18] studied climate change impacts in Nepal based on secondary data and found that the impact of climate change on water resources is likely to affect agricultural systems and this is especially critical in the least developed country (LDC) like Nepal where a high percentage of the population is dependent on agriculture for its livelihoods. Rai & Rijal [19] assessed the impacts of climate change in agriculture and livelihood at the Gorkha district of Bagmati province and resulted in a decreasing pattern of productivity of maize, wheat, and millet in recent years, due to intense off-season rainfall followed by waterlogging. Ministry of Agriculture Development also points out that agriculture is one of the most vulnerable economic sectors to the impacts of climate change [20]. The activities of livelihood mostly depend on climatic conditions that are related to agriculture production. Climate change has adverse impacts on agricultural sectors as it contributing to low production. Malla [21] predicts that the impact of climate change in agricultural sectors will have negative impacts in the long. The adverse impact of climate change is making it hard for poor people in rural Nepal. The study area represents poor and marginalized communities as they overwhelmingly depend on agriculture. Therefore, the effect of climate change through a case study in this village is new and fresh. This research fills the gaps and making this study more constructive because this village is the highest climate change prone area, and comprises poor peoples.

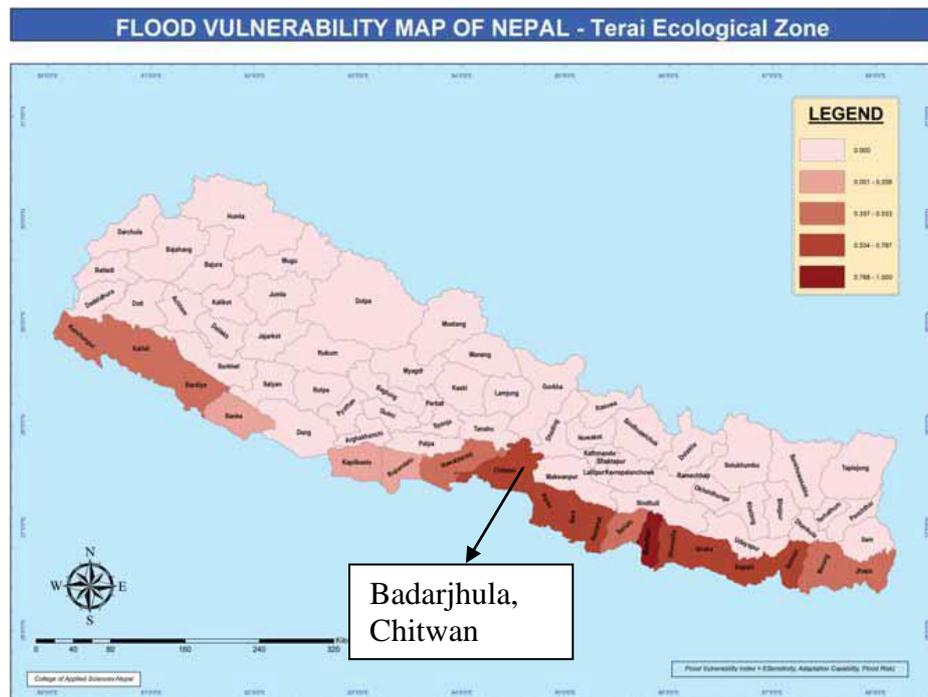
### III. STUDY AREA AND METHODS

This study explores the effects that occurred due to climate change over a decade. The study is mainly based on an empirical approach as a case study through primary data supporting by secondary sources of data and information. There were eight numbers of settlements blocks and each block ranged around from 10-30 households. Block 6 and 3 were chosen for focus group discussions; these blocks were larger in terms of population and area. The discussion covered all age groups (16-75) and males and females both. The size of the group ranges from 20-26 people. Altogether, there were around fifty numbers of respondents. The effects of climate change were notified through the observation considering ten years before (2003 before). The seasonal calendar, preference ranking, well-being ranking, and timeline regarding the effects of climate change were discussed. Secondary data include the Nepal government’s policies and plans such as NAPA and LAPA and reports and documents were intensify reviewed. The present study uses both qualitative (it is dominant) and quantitative approaches were adopted to explore and analyze the study. Almost all households were farmers; they possessed about 0.5 ha of land on average. However, they did not have the land registered certificate.

**Table 1:** Respondents by age and gender

Age	Male	Female	Total
16-40	20	17	37
> 40	8	5	13
Grand Total	28	22	50

Badarjhula is located at Badarjhula-6, Ayodhyapuri Village Development Committee (now Madi Municipality as per new federal structure), Chitwan district of Bagmati Province, Nepal. The area is lying in the Siwalik belt and surrounded by forest. Badarjhula is inhabited after 1960 when people from different districts of mid-Nepal had migrated. Nepal Government forced to remove these populations from this place to protect the forest, but they did not abandon this place and developed as a settlement (see Figure 3). This place is located in the Terai, the subtropical southern part of Nepal. Badarjhula is situated within the buffer zone of Chitwan National Park (CNP), which is famous for a world heritage property, and it contains a Ramsar Site. The CNP has a history of over 3 decades. The park is especially renowned for its protection of One Horned Rhinoceros, Royal Bengal Tiger, and Gharial Crocodile [22]. Forest encroachment has largely been found in the area. This is leading to forest degradation and deforestation and it is causing flooding and loss of wildlife habitat to some extent. NAPA [23] identified the Climate Change Vulnerability Indexes and the whole Chitwan district is listed in the high district level climate change vulnerability index(referring to Figure 1).



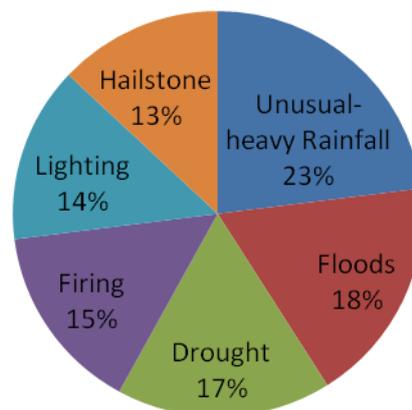
**Figure 1:** Map of Nepal showing 'Districts Ranking Flood Vulnerability' (Source: NAPA, 2010)

#### **IV. OBSERVED EFFECTS OF CLIMATE CHANGE IN BADARJHULA/FINDINGS**

This section includes the findings based on Group Discussion and observation. During the observation and interaction with local people (group discussion), it was noticed that this place has been severely affected by climate change over the last decade. There was a regular cycle of monsoon on a regular basis before 10 years. Floods during the monsoon (mainly June and July) are a natural phenomenon in Nepal. But, the raining before and after the monsoon has been altered the previous monsoon patterns and resulted in extreme cases like unusual-heavy rainfall and flooding and drought after, and before the rainy season. The occurrence of a firing (both forest and settlements), hailstone, and lighting was also noticed that did not occur frequently in the past. Such alterations have severely been hit to poor and marginal populations in terms of livelihood. The National Adaptation Plan of Action (NAPA) has also rated this place as the highest in the “Flood Vulnerability Index” (Figure 1). The study area is located in the buffer zone surrounded by the Government forest and the National Chitwan Park zone, which is considered the sensitive area in terms of biodiversity. According to the Group Discussion, these isolated-settlements (surrounded by forests) mainly comprise poor people- Dalits (untouchably) and indigenous/Janajati (Tharu and Tamang community) and vulnerable group (Chepang community). They all depend on agriculture for livelihood. Mainly they were more vulnerable to climate change because they entirely depend on nature and agriculture.

As of the group discussion, the major livelihood sectors in this village are identified as agriculture (80 %), fishing (5 %), and others (15%). However, the majority of the farmers have a small size of land (below one hectare) for agriculture. Figure 2 reveals the extent of the impact of climate change-induced disasters over the last 10 years in the study area; unusual rain and floods represent the higher extent of the impact.

#### **Extent of Impact of Climate Induced Disaster in last 10 Years**



**Figure 2:** Extent of Impact of Climate-Induced Disaster in the last 10 Years as per Group Discussion



**Figure-3:** Forest Encroachment

***Rains, River floods disasters***



**Figure 4 :** Nine rain-fed rivers passing through the settlements in Google Earth Image

In Google Image (Figure 4), Badarjhula settlements are located in between nine numbers of small rivers which flows from north to south, and the flood is threatening to the local settlements. Only half of the small rivers have been water in the whole year, while others do not have water in the dry season. The course of the rivers has been changing every year and bringing more threats to the settlements. Every year, the water of the rivers has been entered into settlements and swept some cultivated land that reduced agricultural productions. It has resulted in fluctuations in production and prices. The majority of the respondents accepted that they have been lost agriculture production and faced the insufficiency of food. However, agriculture in Nepal represents subsistence in nature; most people have been engaged in agriculture for their livelihood mainly. The variations in altitude over a short distance in Nepal have resulted in adverse impacts on the physical and social environment causing flood and drought. Nepal faces high altitude topography in the north and low in the south of Nepal and thus variations in temperature; this unique ecosystem has contributed to extreme flood in Nepal.

Badarjhula is situated at Siwalik geological ranges which are considered as fragile; it consists basically of fluvial deposits. Human settlements along and between small rivers are at risk and vulnerable. The river floods are harming settlements and farmlands. The sediment of rivers is depleting soil quality and loss of agriculture productivity. The analyses of monthly flow trends of some of the rivers indicate the increasing trend of snowmelt in the runoff in the case of snow-fed rivers, while, in non-snow-fed rivers (rain-fed rivers), wet season flows are increasing and dry season flows decreasing [24].

#### ***Drought and Fire hazards***

Fire (hay and wood fires) is another disaster that has been taking place in the village during the dry season particularly. As per Group Discussion, the village was caught by fire four times and it had destroyed dozens of houses, property, and animals. People seldom noticed such incidents before 10 years. Following the rise in temperature, the role of climate change seems to be explicit. The frequent occurring of the fire was due to climate change because such type of incident did occur in the past (before 10 years). The firing has not been limited at the settlements, but also in the forest. The drought and firing have been hampered agriculture production and livelihood. Many regions in the Middle East, Asia, and Africa are experiencing higher air temperatures, drier air, and more severe or frequent droughts. The warming aggravates the dry land expansion by causing a higher vapor pressure deficit and evaporative demand, and the decreased soil moisture may lead to an increase in the sensible heat flux (Hs) and a decrease in the latent heat flux and have an even stronger impact on temperature extremes [25].

#### ***Human-wild animal conflict***

Since the Badarjhula lies in the buffer zone of the Chitwan National Park, there is a high possibility of wildlife conflict. Wild elephants have already destroyed houses of the settlement. Further, wild bears are damaging crops. The tiger is also another threat to the community people. People used to patrol the settlements with fire and light at night to prevent wild animals entering from the nearby forest in the settlements. Human-wild animal conflict can be explicitly seen in Bardarjhula over a decade. As of group discussion, dozens of people were killed on the animal attack. However, such events were less experienced before 10 years. Tharus (local indigenous people of the area) are famous for tackling wild animals, but now they also felt threatened by it. The nexus between human-animal conflict and climate change in East African countries and argued that how climate change alters the functions and structure of terrestrial ecosystems thus making human-wildlife conflicts inevitable [26].

#### ***Water sources***

Small rivulet namely 'Bhalu' rivulet is the major source of drinking water in the study area. Water is distributed through the pipe. Likewise, there is another 'Bimire' rivulet near the settlement. One water-mill is operated through this rivulet; about 25 liters per second of water is being used for grinding of cereals like rice, wheat, maize, millet, etc. Since there is no electricity facility in this village. The water quantity in terms of flow-water in river and groundwater is being dried up compared to the then past. Two numbers of small water resources (for drinking water) have already been dried up in this area over a decade. Similarly, two water reservoirs of drinking water were found in pollution due to floods and sediments. As the respondents, such problems have been faced for 10 years. The drying up of water directly hits people's livelihood activities such as irrigation and drinking water. It could pose a threat to human health as well. The impacts of climate change have direct consequences in livelihood activities and it urges attention to water security.

#### ***Hailstone***

The frequent occurrences of hailstone have largely been destroyed agriculture productions and damage houses and other properties like animals. Since the majority of people reside here in small houses. Similarly, lightning has adverse impacts; seven people have lost life over 5 years and a dozen found injuries.

#### ***Other hazards and climate change impacts***

Presently, Climate change has become a part of human life and nobody can escape from it because all sectors relating to human life and livelihood have been connected with climate change. The occurrence of climate change cannot be perfectly predicted. The flooding, aridity, drought, extreme cold, and forest fires are some indicators of climate changes faced by developing countries including Nepal and its impact can be overtly seen in agriculture and livelihood. As MoHA [27] dataset, 13 types of disasters were recorded during the last two years with a total number of 2,940 disaster events-these are fire are the highest in number (N=1,856), followed by lightning (N=299), landslide (N=290), flood (N=244) and heavy rainfall (N=118). Nepal's Tarai/Madhesh (low land in the southern belt) has been facing extreme cold and fogs in the winter season. Cold waves have negative impacts on agricultural productivity and showed a reduction in the production of crops by 27.8 in potato [28]. The adverse impact of cold waves on human health was largely noticed. The cold wave's cases have been triggered after the 1990s. As of Nepal Health Research Council, between 2001 and 2010, 376

people died, and 1,793 people were affected due to the cold; the highest deaths were noticed in 2004, with 108 deaths [29].

Likewise, agriculture in Nepal depends on monsoon mainly, but changing patterns of climate/weather are significantly contributing to both extreme rain and drought (dryness); both are harmful to agriculture production. The decreases in water resources in the non-monsoon seasons would adversely affect agricultural production. Nepal has been facing a shortage of rice production since 1980, though it had been exported to surplus production before it. This prompted rural people to go outside for livelihood. The increment of temperature and CO<sub>2</sub> may increase in the population of pests and diseases that harms crop production. These factors are harming agricultural production and livelihood is becoming a difficulty.

### **Food Sufficiency/security**

UN defined Food security means that all people have access to sufficient and safe food based on their food preferences at all time. According to Census data of 2011, around 30,845 hectares of land owned by 5 % of households became uncultivable due to climate-related hazards. Nepal ranked 57 th in the Global Hunger Index (GHI) with a GHI value of 19.8 out of 88 countries, which indicates an alarming situation [30]. Table-2 shows that the majority of people have food sufficiency only between 3 and 8 months while only 10 % of people produce food sufficient throughout the year. There is not found people who produce surplus production. The adverse impacts of climate change have been destroying cultivated land and resulted in low production and impacting livelihood. To cope with insufficiency, most of them used to go to Chitwan, Kathmandu, and India for labor works.

**Table-2:** Food sufficiency condition among the respondents

<b>Duration of food sufficiency (in months)</b>	<b>Percent of Respondents, food sufficiency</b>
Less than 3 month	28.00
3-8 months	62.00
9-12 months	10.00
Surplus	0.00
	100.00

## **V. NEPAL GOVERNMENT PLAN, POLICY, AND STRATEGIES ON CLIMATE CHANGE ADAPTATION**

To deal with problems of climate change and for adaptation, Nepal government has formulated climate change policy, strategies, action plans, Local Adaptation Plan for Action (LAPA), National Adaptation Plan of Actions (NAPA), Reducing Emissions from Deforestation and Forest Degradation (REDD) Strategy, Climate Finance Framework, and Budget Code, Green Growth Strategy, Gender Mainstreaming in Climate Change Action Plan, and other climate change documents. National Adaptation Programme (NAPAs) has been prepared by the least developed countries. It was implemented by the UN for the Least Developed Countries (LDCs) to identify priority activities that respond to their immediate needs to adapt to climate change. Likewise, NAPA identified climate change prone areas in Nepal which helped to predict or use adaptation programs. Furthermore, NAPA endorsed in September 2010 has outlined how climate change implications in all six thematic areas will impact women’s livelihoods. Water scarcity, food insecurity, depleting natural resources, and increased spread of human diseases all have a significant impact on women. Nepal has prepared this National Framework on Local Adaptation Plans for Action [31] to implement NAPA priorities. The National Framework for LAPA aims to integrate climate change resilience into local-to-national development planning processes and outcomes. Similarly, the REDD Strategy aims to address deforestation and forest degradation issues in terms of policies. The concept of the Green growth economy has emerged for community-based forest management.

Since the implementation of climate change policy in 2011, Nepal has implemented several adaptation plans and carried out economic assessments on the impacts of climate change in key economic sectors. These were water resources and agriculture and generated and shared knowledge, lessons, and learning. The climate change policy 2011 emphasized on adaptation strategies mainly. The Policy recommits to frame national strategy on low carbon economic development, and carbon trade as per the Climate Change Policy 2011 [32], and prepare a roadmap to the Paris Agreement, Nationally Determined Contribution (NDC) for clean energy, National Adaptation Plan of Action (NAPA), and Transparency Framework. The Ministry of Finance endorsed the country’s first Climate Change Financing Framework (CCFF) in Dec 2017 to strengthen the public financing system and coordination in planning and budgeting climate responses. Furthermore, Climate policy 2011 is updated in 2019. The Climate Change Policy 2019 redefines climate policy ensuring food security, and livelihood improvement. It also emphasizes climate-friendly rural construction activities, conducive environment for health, and climate-resilient economic development. It emphasizes empowering the Local Governments to implement activities of mitigation and adaptation, and carry out monitoring and evaluation. The

main idea of climate change policy [33] is to strengthen climate-resilience making the ability to the communities to prepare for and respond to hazardous events related to climate. Likewise, the Environment Protection Act 2019 and Regulation 2020 have provisions to study climate change's impact on development projects and emphasize the reliance adaptation approach for the mitigation.

## **VI. DISCUSSION**

Based on the above discussion, climate change is one of the threats in the wake of rural livelihood and development depleting agriculture land. Regional and national studies in Asia suggest that rice production will suffer under climate change [34]. The heterogeneity of Nepal's rural development is based on agricultural land and climate change parameters are well demonstrated in the present study. The poor and indigenous people of rural areas are more vulnerable to climate change. To cope with it, Nepal's National Adaptation Plan of Action (NAPA) recognized that climate change's impacts would be uncertain, and vulnerability will be increased in the future. Despite some efforts in tackling climate change by the existing policies and plans, many farmers in rural areas like Badarjhula are still unaware of the impact of climate change, so awareness is crucial. As CBS [35], more than fifty percent of households do not know about climate change (p. 30). Only a few of them know that deforestation is the main reason behind climate change. Nonetheless, it does not mean that there is no indigenous knowledge, though they did not have any idea about its patterns. However, historically, people of the region have been a nature-friendly as they worship various species of trees, and rivers as well. It implies people's intimacy towards nature. There are many sacred places and trees in the village. The agency and structure cannot be forgotten. Therefore, indigenous knowledge and experiences should also be considered while talking about resilience and sustainability. Resilience is not a simple re-branding but is a concept that embraces adaptation, change, and transformation [36]. Furthermore, Tanner [37] argues that a livelihood perspective strengthens resilience thinking by placing greater emphasis on human needs and their agency, and empowerment. The resilience will only be competent if the pragmatic economic system can be generated which is related to transformation balancing between society, economy, and nature.

The present consumable-oriented and economies-centric policy and system largely eroded the old trend of intimacy between humans and nature that needs to be thinkable considering climate change and forthcoming generation's future. The time has now come to consider how the environment could be enriched making fewer harms to nature securing ecology. Ecological security has become a fundamental issue after COVID-19. Ecological security is an expansion in asset effectiveness, managing and measuring calamities, environmental change, and ecosystem management, etc. [38]. Besides, institutional interventions like index-based insurance and social protection in terms of adaptive safety nets empower farmers to manage risk and climate adaptation [39].

## **VII. CONCLUDING REMARKS**

The long-term visionary policies regarding the utilization of natural resources and adaptation are obvious that will ensure food sufficiency and proper utilization of natural resources in necessity based. Nepal takes it as the socio-political aspect of food sufficiency and climate change adaptation policy. Local people must know about the present fluctuate a situation of climate change's incidents and its challenges because it is not only an objective matter but also a subjective matter, that will help for sustainable adaptation and resilience concept. Temporarily, the agro-forest concept may be the one option for agriculture development to cope with the problem arising due to climate change. But the policy towards wood (timber) business is not easy in Nepal; various procedures are required to sell private wood. The role of local government to cope with climate change's effects may be vital because they can have mobile resources efficiently at the local level and rural areas. The pragmatic policy and enough budget only will help to harness climate change's impact on livelihood especially food security ensuring poor people's basic needs. Besides, creating awareness, and the social safety-net (in the case of food insufficiency) for the rural poor farmer and vulnerable people in the region will be needed unless the availability of alternative livelihoods. Along with it, the forecast system of raining and weather must be more effective for its prediction in a national as well as regional level; advanced technology-based research and monitoring system are urgent to minimize the adverse impacts of climate change in Nepal. Thus, interdisciplinary research and approach are apparent in tackling climate change.

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