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Participatory vulnerability assessment of climate vulnerabilities and impacts in Madi Valley of Chitwan district, Nepal

S.K. Maharjan^{1*}, K.L. Maharjan¹, U. Tiwari² and N.P. Sen²

Abstract: The severity of climate change impacts is observable and devastating at the local level, especially among the poor and ethnic people settled in the marginal and ecologically fragile areas, because of their least adaptive capacities and resilience. Thus, it is crucial to understand the local climatic risks, vulnerabilities and adaptive capacities to develop appropriate coping and adaptation strategies. However, the reliable climate data and information are not available at local level because of few meteorological stations. Therefore, this study has concentrated on participatory approaches to assess and analyze the climate vulnerabilities and impacts, needs and priorities of the community in Madi valley of Chitwan district. The study has applied participatory tools in the focus group discussions in the valley with a total of 112 participants. The communities in the study site observed flood, drought and riverbank erosion are the most severe climatic threats to them with different intensities based on age, caste, class, gender and sectors. They, further, perceived that wildlife attacks from Chitwan National Park are more dangerous as they affect their livelihoods throughout the year, though more severe in crop harvesting time. The farmers perceived natural and policy factors are highly influential in causing climate change. The major adaptation interventions found in the valley

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PUBLIC INTEREST STATEMENT

Climate change is the hot issue for research at the present age. Many research has concentrated on climate change focusing on diverse sectors such as agriculture, forestry and biodiversity, health and others. Most of these researches emphasized on the climatic trends and forecasting using different models and quantitative data. Very few researches have focused the qualitative data and farmers' perceptions, skills, knowledge and experiences though they are the actual victims of the climate change impacts. This study has concentrated on participatory approaches to gather the impacts to the farmers and their initiatives to deal with it. It was carried out in the group discussions with the farmers. The farmers in the group informed that flood, drought, riverbank erosion are affecting them over the years. Additionally, wildlife attacks and diseases and pests are stressful to the poor farmers. Policy and natural factors are highly influencing to the farmers.

are afforestation and early warning siren and evacuation tower that the communities believe comparatively effective than others.

Subjects: Development Studies, Environment, Social Work, Urban Studies; Development Studies; Rural Development; Environment & the Developing World

Keywords: climate change; participatory approaches; vulnerability; Madi valley; Nepal

1. Introduction

Climate change is a global issue of the present time with the severe impacts at national and local levels. Local communities are also aware of the fluctuations in weather patterns, changes in the climate, its variabilities and implications in their lives and societies. The poorest and marginal people depending on climate sensitive sectors such as agriculture, forestry and natural resources are the most vulnerable and in the frontline to face the climate change impacts such as loss of the lands, lives and livelihoods (Girod, Ehrhart, & Oglethorpe, 2012; Tiani et al., 2015). Climate vulnerability is “the extent of a system or a community being susceptible to or unable to cope with the adverse effects of climate change including climate variability and extremes. Vulnerability is a function of the nature, extent and pace of climate variation to which a system or a community is exposed, the sensitivity of the system and its ability to adapt” (Boureima et al., 2013, p. 2).

The intergovernmental Panel on Climate Change (IPCC) has defined climate change, impacts, vulnerability and adaptation assessment (UNFCCC, 2004). Vulnerability is associated with natural hazards such as floods, droughts and social hazards like poverty and discrimination. Vulnerability of any system depends on the Exposure, Sensitivity and Adaptive Capacity. Exposure is the nature and degree of a system or a community being exposed to the natural hazards as a function of geography (CARE, 2009), whereas sensitivity is the degree of system or community being affected either directly or indirectly and adversely or beneficially by the climate. On the other hand, adaptive capacity is the ability or strength of a system or a community to moderate and to deal with the potential climate change impacts based on wise and effective use of available livelihood resources (CARE, 2009; Locatelli, Herawati, Brockhaus, Idinoba, & Kanninen, 2008; Schipper, Lui, Krawanchid, & Chanthy, 2010).

Vulnerability is generally explained by the characteristics and contexts of the system or community that are susceptible to the risks and hazards based on the socio-economic, physical and environmental conditions (Weston, n.d.). It has been widely discussed, debated and negotiated in the national, regional and international levels, but few concrete and realistic actions are taking place at the ground to respond to the negative consequences faced by the communities (Regmi, Morcrette, Paudyal, Bastakoti, & Pradhan, 2010). These actions are mostly top-down in nature without considering the local climatic issues, contexts, needs and priorities. It is important to consider these local contexts and climate vulnerabilities to develop and implement quick and urgent adaptation actions to deal with the emerging climatic vulnerabilities through building adaptive capacities and resiliency (Maarten, Cannon, & Burton, 2008).

Climate vulnerability is a complex phenomenon influenced by multiple factors, more precisely the livelihood resources, such as economic, social, demographic, political factors and their cause-effect relationships. The exposure, sensitivity and adaptive capacity of individuals, households and communities are depended on the access and control over these factors and resources (CARE, 2009). For instance, the livelihoods of the communities are greatly depended on the environmental resources such as water, forests and lands. The livelihoods of economically poor people are highly vulnerable to weather and climatic variability as they have least resources and alternatives to address the issues (Kaushik & Sharma, 2015). Social and demographic relationship and cohesion have also supported the people to deal with the impacts. Likewise, infrastructures, laws, policies and institutions also influence the communities and their livelihoods to deal with. Thus, it is important to learn and understand the diverse set of influences such as social, cultural, economic, institutional, political and psychological factors that support and enhance people's livelihoods (Tiani et al., 2015).

Figure 1. Map of Madi valley, Chitwan.



Table 1. Practical guidance on tools for assessing community vulnerability

| Vulnerability components | Practical guidance on tools for assessing community vulnerability |
|--------------------------|---|
| Exposure | Seasonal calendar, historical timeline, rain calendars, climate diaries |
| Sensitivity | Hazard mapping, hazard trend analysis, hazard ranking, hazard impact ranking, mental models, transect walk for risk identification, climate hazard impacts on livelihood matrix, participatory scenario development for potential risks |
| Adaptive capacity | Community resource mapping, livelihood resource vulnerability assessment, livelihood asset assessment, vulnerability and capacity matrix, venn diagram, stakeholder identification, coping and adaptation strategies assessment matrix, effectiveness of coping adaptation strategies assessment, communication maps, preference ranking, wealth ranking, benefit cost ratio, multi-criteria assessment |

Source: Practical Action, WWF, IUCN Nepal, CECI Nepal & NAVIN (2010).

2. Methodology

Wide range of methodological frameworks and approaches have been developed and executed to assess and analyze the climate vulnerabilities based on the resources and production systems, time-frame and geographic coverage and purposes of assessments (Practical Action, WWF, IUCN Nepal, CECI Nepal and NAVIN, 2010; UNFCCC, 2011). Among these approaches, this study has applied the participatory research approaches to understand local vulnerabilities and climatic contexts by involving the local communities and stakeholders in the process since they are the real victims of the climate change impacts in their daily lives. These communities have their own ways of managing the available resources and dealing with the impacts based on their knowledge and experiences, despite their differential levels of literacies. It is a bottom up approach to explore vulnerabilities and responses of local communities to climate change (Tiani et al., 2015).

Not a single approach fits to all climate vulnerabilities and adaptation measures and processes (Girod et al., 2012; Moret, 2014; Tiani et al., 2015). Some of the researchers such as Sour, Phalla, Sovannarith, Somatra, and Sokhem (2014) emphasized on the combination of comprehensive assessment frameworks for assessing vulnerability and adaptation. The study focuses on the qualitative data and information relating to underlying causes of vulnerability at the community level based on their local knowledge, skills and capabilities. Furthermore, the study focuses on the local vulnerabilities and local experiences on climate and livelihoods. Very few methodological frameworks and tools have considered vulnerability as the function of exposure, sensitivity and adaptive capacity as defined by IPCC. Practical Action, WWF, IUCN Nepal, CECI Nepal and NAVIN (2010) collectively recommended following practical tools for participatory research process to assess vulnerability (Table 1).

The study applied the combination of the participatory tools in the focus group discussions (FGDs) with the total participants of 112 (46% female and 54% male) to gather the information on local climate vulnerabilities and contexts. Most of the participants are farmers and some agricultural laborers as they become landless because of the floods and riverbank erosion, especially those living at the riverbanks. However, they have leased the piece of land from others for cultivation. Altogether 5 FGDs were organized in the selected sites of the valley based on the interactions with the community leaders in terms of climate change impacts faced by the communities in the past. In terms of ethnicity, the participants were in the ratio of 40–60 between indigenous (Tharu, Bote, Gurung) and mainstreamed groups (Brahmin, Chhetri). There were more women participants in the FGDs conducted in the indigenous groups. The approach was highly inclusive and participatory with the active participation of youth, elderly, women and ethnic people in the process.

The participatory tools used were hazard mapping, historical timeline, climate hazard ranking, seasonal calendar, vulnerability assessment, vulnerability matrix, forced field analysis. Each specific tool used in the discussion has its specific objectives and methodology (Table 2). Since the communities have faced climate vulnerabilities every year, they have lots of experiences and knowledge to

Table 2. Main focus, purpose and methodology of participatory tools used in the study

| Tools | Main focus and purpose | Methodology |
|-----------------------------|---|---|
| Historical timeline | Analysis of the historical hazardous events in the locality and its severity/intensity from community point of view | The community listed out the extreme events such as flood, drought in the period of 30–40 years including the impacts and also noted down the major political, socio-economic and environmental/climatic changes and development interventions in the specific date over the years |
| Hazard Mapping | Community's perceptions on vulnerabilities and impacts in the given area including the areas rich in livelihood resources, its accessibility and control over | The facilitator explained the purpose and methods, then, the community drew the map of the area by themselves in a brown paper indicating the climate vulnerability prone areas and the areas rich in resources |
| Climate hazard ranking | Identification of the most prominent climate vulnerabilities in the area based on pairwise ranking basis | The community listed out the climate hazards and vulnerabilities, then ranked based on pairwise ranking. The hazards with the highest score is the most disastrous hazards in the area |
| Seasonal Calendar | Identification of the periods of stress, hazards, vulnerability and other issues in the community including livelihoods and coping strategies. Also to analyze the changes in the seasonality as well | The community listed out the months in the first column and major hazards, affected crops and adaptations in the first row. The community were asked to discuss and provide the hazards, its impacts on agriculture and adaptation practices in each month, which help to identify the most severe months and busiest month for the communities |
| Vulnerability Assessment | Analysis of vulnerabilities across different social groups and sectors including identification of the most vulnerable people and sector | For this exercise, the community ranked 0–4 (from least to highest) for the impacts of climate change to different social groups and sectors accordingly |
| Forced Field | Community's views on the factors causing problem and those that counteract it and stop it from getting worst | First, the community listed out the causal and counteracting factors based on community's perceptions, then rank each factor from 0 to 4 (least to highest) |
| Vulnerability Matrix | Hazards with the most severe impacts on the livelihood resources and to identify the coping strategies to address the hazards | First of all, the community listed the livelihood resources and major climate change impacts. Then, they ranked the impacts from 0 to 4 (from least to highest) on livelihood resources and also ranking of contributions of the resources in coping strategies (0–4; least to highest as well) |
| Stakeholders identification | Analysis and understanding the institutions that are crucial for adaptation including the roles of CBOs in local adaptation planning process | The community representatives listed out the stakeholders/institutions in the area. Based on their roles and contributions, the community identified the local trustworthy stakeholders in the climate change adaptation either highly or medium or least influential in the area |

share widely, however expect the successful adaptation interventions from the government and other responsible agencies, thus, their livelihoods would be improved with the least climate vulnerabilities and impacts. The communities have their own way of understanding climate change, its vulnerabilities, coping and adaptation strategies in addition to the supports from the external agencies including the government and other civil society groups. The list, purposes and methodology of participatory tools used are presented hereunder.

2.1. Study site

The study site is the Madi valley, which is recently declared as eco-municipality in Nepal in 2015 by combining four Village Development Committees (VDCs) namely Gardi VDC, Baghauda VDC, Kalyanpur VDC and Ayodhyapuri VDC with the total area of 21,789.9 ha. The study was mainly focused on the 4, 5 and 6 wards of the municipality that used to be Baghauda VDC earlier. It is surrounded by Chitwan National Park (CNP) in the North, East and West and Someshwor hill in the South which connects to Valmiki Tiger Reserve of India. The valley is identified as the heart of TAL (WWF, 2015). The Reu river separate the valley with the CNP. It has the total population of 37,683 in 8,960 households. Most of the households in the valley depended on agriculture as the main source of livelihoods that includes cereals and vegetables production, livestock farming and fisheries for household consumption, nutrition and also source of income, employment (DADO Chitwan, 2071/72 BS²). The local communities are forced to live the miserable life mainly because of climate induced disasters and wildlife from the park. The climate change vulnerabilities are increasing over the years to

the ecosystem and livelihoods in the landscapes (Wagley et al., [n.d.](#)). It is isolated from the mainland Chitwan because of the CNP. However, construction of bridges at Rapti and Reu Rivers and road to Narayangarh, the district headquarter, have improved the connectivity of the people to the city and the rest.

3. Results

3.1. Historical timeline

The exercise on historical timeline was carried out in two different sites focusing on climate vulnerabilities, adaptation and development related interventions. The local communities have knowledge and experiences about their locations, past history of major events, threats and how vulnerabilities that have changed their lives over the years. With this participatory approach, the communities have identified flood, river bank erosion and drought as the severe threats and climate vulnerabilities in the valley since that have been continuously affecting their livelihoods over the years. A farmer in the discussion disclosed that a total of 2/3rd of the land in Madi has become barren and unproductive because of flood, riverbank erosion and drought. Maharjan, Sigdel, Sthapit, and Regmi (2011) also found the similar situation in the study carried out in far-western Nepal. Different coping and adaptation interventions were found out in the valley to deal with climate impacts such as plantation of trees, construction of check dams, installation of early warning system and evacuation centers among others with the support of non-government organizations. But the success of those interventions are not satisfactory. Some Tharu farmers in Ratani tole became homeless and landless, thus, forced to live in a small hut at the bank of the Reu River because their land is under the river now. The women farmers informed that they don't have money to buy land in the uplands and close to the roadside, thus, they are forced to leave in the public land close to river. Every night in the rainy season, they have to be alert from the flood and riverbank erosion. However, they felt that the check dam constructed last year (in 2015) has saved huge amount the land from riverbank erosion in 2016.

Furthermore, it is also found that the non-climatic factors such as wildlife attacks from the CNP destroy the agricultural production and even stored seeds and grains. The farmers perceived it is worse than any climate change hazards because wildlife attacks occur throughout the year impacting human casualties, households and livelihoods whereas climatic hazards are seasonal in nature. A seventy years old male farmer asked for possibility of early warning system from the wildlife similar to the climate threats. Only the farmers closest to the early warning system were aware of the system. Despite the demarcation and fencing of the park perimeter to protect from the wildlife, it is not successful to protect human settlements and agriculture fields from wildlife.

It is found that especially women, elderly and children are highly affected by the climate change impacts and wildlife attacks. In addition, ethnic people, poor and Dalits are severely affected because most of them lived close to rivers, streams and national park and forest. Additionally, they have less awareness and education as compared to the mainstream society (Brahmins and Chhetris) as most of them cannot read and write during the participatory exercise and most of them do not watch television and listen to radio. Upadhyay (2013) also found that the poor and people living in the marginalized areas suffer the most of economic losses and food insecurity because of wildlife because of less access to resources, lack of alternative sources of income and least voices in decision-making. One of the respondents disclosed that the some of the local residents destroyed the fences for their benefits either to collect fuelwoods or illegal activities in the park that also eased the wildlife to destroy human settlements and agriculture. Lamsal (2012) supported it with more than 60% of the people involving in illegal activities in the park lived in the buffer zone and local areas.

The historical timeline is efficient to assess the vulnerability at household, community and national level (Practical Action, WWF, IUCN Nepal, CECI Nepal & NAVIN, 2010). With the use of this tool, the information on the trends, frequency and severity of climate hazards, vulnerabilities and impacts are gathered in Madi valley including socio-economic and political changes. Regmi et al. (2010)

Table 3. Historical timeline of climate vulnerabilities and adaptation/development interventions in Madi valley

| Year (BS) | Climate and related events | Adaptation/development interventions |
|----------------------------|---|--|
| 2019 BS (1962/63) | The settlers from hills migrated to Madi area | |
| 2026 BS (1959/60) | Occurrence of huge flood and whole Kharkatta was destroyed | Establishment of Jagannath Primary school (2023) |
| 2050 BS (1993/94) | Occurrence of flood in Ratani, Dhobaha, Seruwa, Chanarpuri. Most of the lands were under water | Plantation of trees, bamboos in the affected areas and riverbanks, check dams constructed using bamboos |
| 2052 BS (1995/96) | Drought occurred, Maoist conflict started | Establishment of Dakshinkali Primary school (2042) |
| 2054 BS (1997/98) | Maoist conflict became severe and severe drought affected the production almost Zero | Bought food from the market to fulfill the loss of agricultural production |
| 2056 BS (1999/2000) | Flood occurred, 15–16 people died, 5–6 were not recognized, some houses and agricultural lands destroyed by the riverbank erosion, almost 2.5 Biggh ^a of land converted into barren land caused by the flood, additional 2–3 biggha lands swept away at Dangre Stream and 2 persons died | Concept of buffer zone started (compensation for wildlife destroying the crops and human casualties, goat and green technologies) and 8 households were shifted to buffer zone area and concept of community forestry also began, Check dam constructed using wire, bamboos and stones to protect the land |
| 2059 BS (2002/03) | Every year wild animals affect the crop fields | Initiatives to protect the crops from animals started |
| 2060 BS (2003/04) | | Concept of Farmer's group was introduced |
| 2061 BS (2004/05) | Drought—least production of maize and mustard | Change is food habits |
| 2062 BS (2005/06) | Maoist conflict in <i>Bandarmude</i> area—a total of 39 people died in that conflict | Ban Landmines Campaign Nepal (NCBL) provided the supported both financial and technical support to the affected 18 people and households through bottom up approach, Jagannath upgraded to Lower secondary school |
| 2063 BS (2006/07) | No rain, Democracy after the peace agreement between Maoist and the government | |
| 2066 BS (2009/10) | Cold wave affected the agriculture completely | The community based disaster risk reduction project (UNDP) was started, but not effective in implementation |
| 2067–68 BS (2010/11–12/13) | Flood displaced 20 households, river bank erosion destroyed agricultural lands, increased the hot wave and forest fire | Resettled in the buffer zone areas, Construction of bridge at Riu river Bankatta. Clothes, tarpaulin sheets, biscuits and other foods were distributed to the victims by both government and NGOs |
| 2070/71 BS (2013/14–14/15) | Cold wave | Homestay concept was introduced, the road blacktopped |
| 2072 BS (2016/17) | Severe drought, Even winter crops were not planted due to severe drought. Decreased production of maize, wheat, mustard, water sources were dried, thus, had to travel more than 1 km to fetch drinking water | Eco municipality announced, Early Warning System introduced by installation of rain gauge and climate centers, however, local people are still unaware |
| 2073 BS (2018/17) | Flood occurred, 2 people died in flood | Gavin wire dam constructed with the support of CBDRR, Department of water borne disaster reduction established |

^a1 biggha is 0.2529 hectares, equivalent to 1618.9 square meters.

supported the efficiency of the tool in assessing and analyzing the climate hazards. Based on the discussion with the community while drawing timeline, it is realized that the settlements in Madi started in around 2019 B. S. (1962/63 AD) after eradication of Malaria outbreaks in the Tarai region of Nepal (Table 3). The historical evidences in Tarai also showed that the migration from hills begun after eradication of malaria in the late 1950s (Gartaula & Niehof, 2013). Since Madi is isolated because of the national park and close to the Indian border, it can be anticipated that the migration occurred comparatively late than other parts of the region.

In relation to other development interventions reflected in the timeline, declaration of Madi as an eco-municipality in Nepal and identification of ecotourism hotspot are important for the community since it is adjacent to the CNP with many potential tourism hotspots such as *Baikuntha* Lake, *Goddak*, *Chharchhare*, *Balmiki Ashram*, *Someshwor Kalika* temple, *Pach Pandav* Area for religious tourism and pilgrimages. Likewise, the valley is known for agricultural productivity and fisheries despite yearly impacts of climate and wildlife. Additionally, the trekking route from *Sauraha*³ in the east to *Madi* has been already explored for tourism (Trip & Trek, 2016). The concept of homestays, eco-tourism has

Figure 2. Hazard mapping of Seruwa, Gardi in Madi Valley.



been already introduced in the valley that could be combined with agritourism and religious tourism. The Himalayan Times, (2015) revealed the tourism potentiality in the *Madi* area of *Chitwan* because of historical, natural, religious and cultural significance, but still lack is publicity. One of the major events in the valley that farmers never forget was the Maoist conflict in *Bandarmude* area where 39 people were killed and 78 people injured in the bomb blast in a public bus. After a year of incidence in the valley, there was a peace agreements between the government and Maoist communist party of Nepal.

3.2. Hazard mapping

With the hazard mapping the communities realized the hazard prone areas such as flood prone areas, droughts, riverbank erosions and other socio-economic and environmental resources including access and control of the communities over the resources in their areas. The map below was drawn by the community representatives by explaining the resources important for them and the areas prone to the climate hazards. In the Figure 2, the red marks indicate the climate vulnerabilities due to flood and riverbank erosions. Mostly the ethnic communities such as Tharu, Bote and Dalits are living adjacent to the rivers, streams and national parks and are the most vulnerable to the hazards due to riverbank erosion and wildlife attacks. The communities in the roadside are mainly the mainstream groups such as Brahmin and Chhetris, thus less vulnerable to the climate vulnerabilities. The study done by Wagley et al. (n.d.) also found the areas close to the river especially Reu river, Rautani river are highly affected from the flood.

CARE (2009) and Regmi et al. (2010) also used it for understanding and analyzing exposure and sensitivity of the given area. It is found that floods, droughts and riverbank erosion is prominent and severe in the valley similar to the timeline. Wagley et al. (n.d.) also found flood as the major vulnerability in the landscape, but they additionally found landslide, forest fire, are more prominent than the drought and riverbank erosion in their study. The community also informed that flood is very eminent especially in the low lying areas, whereas drought is prominent in the uplands. ADB (2011) also identified the areas prone to flooding, droughts, cyclones and sea level rises, storms by use of maps to assess the community vulnerabilities and risks. They also used the GPS data and some photographs for a visual baseline.

Udono and Sah (2002) and Boureima et al. (2013) emphasized on the importance of understanding the nature and behavior of impacts and how to reduce the impacts and also strengthen capacity to deal with the effects. Hazard mapping provides the information on what kind of vulnerabilities, in which places, who are sensitive to such vulnerabilities. It also provides information on how and when such vulnerabilities occur. They again revealed that hazard maps are very compatible with Geographical Information System (GIS), which can be useful in arranging a high volume of data necessary to provide a hazard map. Madi is surrounded by forests and dozens of the rivers and streams including Rapti and Reu rivers flowing from South to North (The Himalayan Times, 2015). GoN (2016) reported the vulnerability map of about 68,600 households of 2,529 vulnerable communities.

3.3. Climatic hazard ranking

The climate hazard ranking exercise was carried out in two focus groups mainly to rank the most severe climate risk and vulnerability in the region. Through this exercise, drought, flood and river bank erosion were recognized as the most severe hazards due to climate change. In the first FGD ranking, drought, flood, forest fire and riverbank erosion are identified as the severe hazards whereas in the second one, drought, insects and diseases, riverbank erosion and storm received the highest ranking (Figure 3). This indicates that the local climatic issues are different within the valley as the exercises were carried out in two different locations. The first FGD was conducted in the area dominated by mainstream society whereas second was in the Tharu dominated area. Regmi et al. (2010) also highlighted on different hazard rankings in different places and groups. Additionally, the community disclosed that drought and insects/diseases affect the crops throughout the year whereas flood and riverbank erosion affect mainly in the rainy season. Wagley et al. (n.d.) also supported this finding indicating the seasonality of the flood and river bank erosion. However, the severity of impacts of the flood and riverbank erosion is devastating which even lead to the loss of lands and livelihoods as reported by the communities.

Riverbank erosion is induced by the flood, thus, it appeared in the 3rd and 5th ranking in the first and second FGDs. Interestingly, insects and diseases emerged in the 2nd rank in the second FGD. The study conducted by Wagley et al. (n.d.) also reported the severe impact of climate change on the insurgence of pests and diseases. They further reported that decrease in the rainfall and increase temperature and humidity have led to increase incidence of disease. Likewise, Malla (2008) also emphasized on high influence of temperature, rainfall pattern and humidity on the development and distribution of pests and diseases. The first exercise was carried out in the area close to the Reu river which is flood prone area whereas 2nd exercise close to Magai stream. The UNDP Adaptation Policy Framework (APF) has also emphasized on the pairwise comparison of hazards to prioritize the eminent hazards (Practical Action, WWF, IUCN Nepal, CECI Nepal & NAVIN, 2010).

3.4. Seasonal calendar

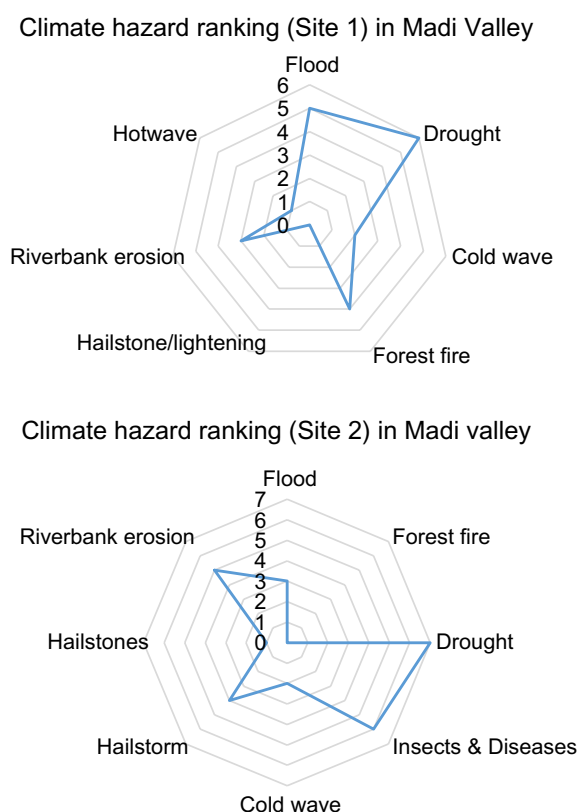
The calendar has disclosed that months of June/July–September/October are severe to flood and riverbank erosion whereas rest of the months are prone to drought. Other climatic hazards such as hot wave, hailstone, windstorm are eminent from February/March when the days becoming warmer. Forest fire also occurs mostly during dry season (Table 4). Rohwerder (2016) also highlighted the seasonal disasters in Nepal such as floods, landslides, fires, droughts and diseases. She further added most of people get affected during monsoon (July–September) due to landslides, floods, thunderstorms, diseases and drought. The communities also reported the non-climatic hazard i.e. wildlife attack which is severe mostly during the harvesting time of both winter and summer crops. Most of them are affected by wildlife attacks throughout the year. The wildlife even destroy the grain stored inside the house. Thus, farmers close to the national park are prone to wildlife even more than any climatic hazards.

The calendar also highlighted the adaptation interventions, but most of the interventions are spontaneous adaptation, not planned. Since huge land mass has been swept away, the government and civil society organizations jointly with communities should have planned well to construct the check dam and plantation of trees well in advance to address the flood and riverbank erosion. Some initiatives are taken in some parts of the valley, but not succeeded. In terms of drought, the water conservation ponds, cemented canals, tube well are constructed with the support of TAL, Nepal Water for Health (NEWAH) and Buffer zones. Seasonal Calendar is the widely used participatory tool in development and academic fields. It is a visual tool of distribution of seasonality over the time, also applied in climate change discourse (Flora & Fauna International, 2013; Hinds, 2013), especially for identifying stresses, vulnerabilities, livelihood and coping strategies (CARE, 2009).

3.5. Vulnerability assessment

The vulnerability assessment tool is effective to analyze the differentiated impacts of vulnerabilities across different social groups and sectors. Additionally, it systematically identifies and understands

Figure 3. Climate hazard ranking of climate vulnerabilities in two different sites of Madi valley.



the most vulnerable people and sector from climate vulnerabilities based on ranking (Tiani et al., 2015). It also measures the stability and vulnerability of any system and community (IUCN, 2015). GoN (2016) highlighted that the vulnerability assessment serve as the basis for preparation, prioritization and implementation of adaptation plan. The vulnerability and impacts of climate change vary across the regions and sectors (Tiani et al., 2015). In this exercise, the participants have given the score of zero for the least or no vulnerable to the hazard and four to the very high vulnerability to the hazard. In terms of age, young people are most vulnerable from the major climate and non-climatic vulnerabilities such as flood, drought and wildlife in the valley. Whereas, women are highly sensitive in terms of gender and poor, disable people, Dalits and ethnic people are the most vulnerable in relation to class and caste (Table 5).

The study done by UNICEF (2007) reported that climate change is contributing to the burden of diseases to the children and young people in addition to the direct impact. According to WHO (2002), 2.4% of diarrhea and 6% of malaria in the developing countries caused by climate change that disproportionally affect the young people. Mainaly and Tan (2012) also reported that women are more vulnerable to climate change impacts than man since they have comparatively least adaptive capacities, and accessibility to the resources. The situation is worst in Nepalese context because of the discrimination and inequalities against women due to culture and traditions. Pandey (2016) reported the additional burden and stress to women in agriculture due to absence of rainfall as men left the households and farms to find jobs abroad. Likewise, Nonoguchi (2012) also believed that women are more vulnerable because of limited access to resources. However, she also emphasized that it's a stereotype view to women as helpless victims when overemphasized on women's limited access to the resources. She, further, highlighted the problematic view of other socio-economic factors of class, caste/ethnicity and age like gender. GoN (2016) highlighted 1.1 millions of women, poor and marginalized people as the most vulnerable to climate change in Nepal.

Table 4. Seasonal calendar of climatic hazards, agricultural crops and events and adaptation interventions in Madi Valley

| Months | Climate hazards | Agricultural crops and events | Adaptation interventions |
|-------------------|--|--|--|
| Baisakh (Apr/May) | Drought, hot wave, forest fire, hailstone, windstorm | Harvesting of wheat and Mustard, Bottle gourd, Beans and other vegetables (Cucurbits) Celebration of New year (festival) | Construction of Dam and protection of river banks, Water-boring for irrigation, mulching |
| Jestha (May/Jun) | Drought, forest fire, windstorm, Flood and river bank erosion, destruction by wildlife | Drought resistant crops such as Zinger, cucurbits and preparation of rice seed beds, repair and maintenance of earthen canals if necessary | Mulching and irrigation in the vegetables and seedbed as appropriate |
| Asadh (Jun/Jul) | Flood and river bank erosion, destruction by wildlife | Land preparation and Plantation of rice | Construction of dam and plantation of trees such as Bakaino (<i>Melia azedarch</i>), Bans, Sissoo (<i>Dalbergia sissoo</i>), Liplipe, cultivation of resistant rice like Sabitri (flood) & Radha-4 (drought) |
| Shrawan (Jul/Aug) | Flood and river bank erosion, destruction by wildlife | Inter-cultural operation in rice fields | |
| Bhadra (Aug/Sep) | Flood and river bank erosion | Intercultural operation in agriculture fields, Celebration of Rakshabandan (festival) | |
| Asoj (Sept/Oct) | Flood and river bank erosion | Harvesting of early variety rice and seed sowing of mustard, and green vegetables and spices, Celebration of Dasain, Jitiya (festival) | Mulching in vegetables and spices |
| Kartik (Oct/Nov) | Cold wave begins | Harvesting of rice, seed sowing of wheat, mustard, grain legumes (Musuro), Plantation of potato, onion, garlic, pumpkin Celebration of Deepawali (festival) | Mixed farming |
| Mangsir (Nov/Dec) | Cold wave, destruction by wildlife | Seed sowing of wheat, mustard, grain legumes (Musuro-Lentil), Plantation of potato, onion, garlic, pumpkin | Land preparation for Riverbed and Riverbank farming |
| Poush (Dec/Jan) | Cold wave, destruction by wildlife | Harvesting of Potato and other vegetables | |
| Magh (Jan/Feb) | Cold wave, destruction by wildlife | Storage of potato Celebration of Mage Shankranti (Festival) | |
| Falgun (Feb/Mar) | Hailstone, destruction by wildlife | Maize cultivation Celebration of Holi (Festival) | |
| Chaitra (Mar/Apr) | Drought, hot wave, forest fire, Hailstone, Windstorm, destruction by wildlife | Intercultural for maize cultivation, Celebration of Chaite Dasain (festival) | Water-boring for irrigation |

In relation to sectors, differentiated impacts in agriculture, forestry and ecology types. Wetlands and irrigated plots of agriculture lands are more vulnerable to flood and rain-fed land are vulnerable to drought. Tarai (flat land) are sensitive to flood and drought both whereas hilly region is sensitive to landslide and wildlife, though wildlife attack is also severe in the Tarai. Malla (2008) also found the more damage on agriculture in Tarai region due to climate change including the extinction of biodiversity and emergence of new invasive species. Dhakal, Sedhain, and Dhakal (2016) reported that National Adaptation Programs of Actions (NAPA) identifies the agricultural land in southern plains are vulnerable due to floods and inundation.

3.6. Forced field analysis

The forced field analysis is extensively used tool in participatory research primarily to understand people's view on the factors that cause vulnerabilities mainly due to climate change and the counteracting interventions to deal with the impacts (Chevalier & Buckles, 2008). As per the perception of the farmers in Madi valley, the factors causing vulnerabilities are mainly natural and policy factors since these factors are beyond their access and control.

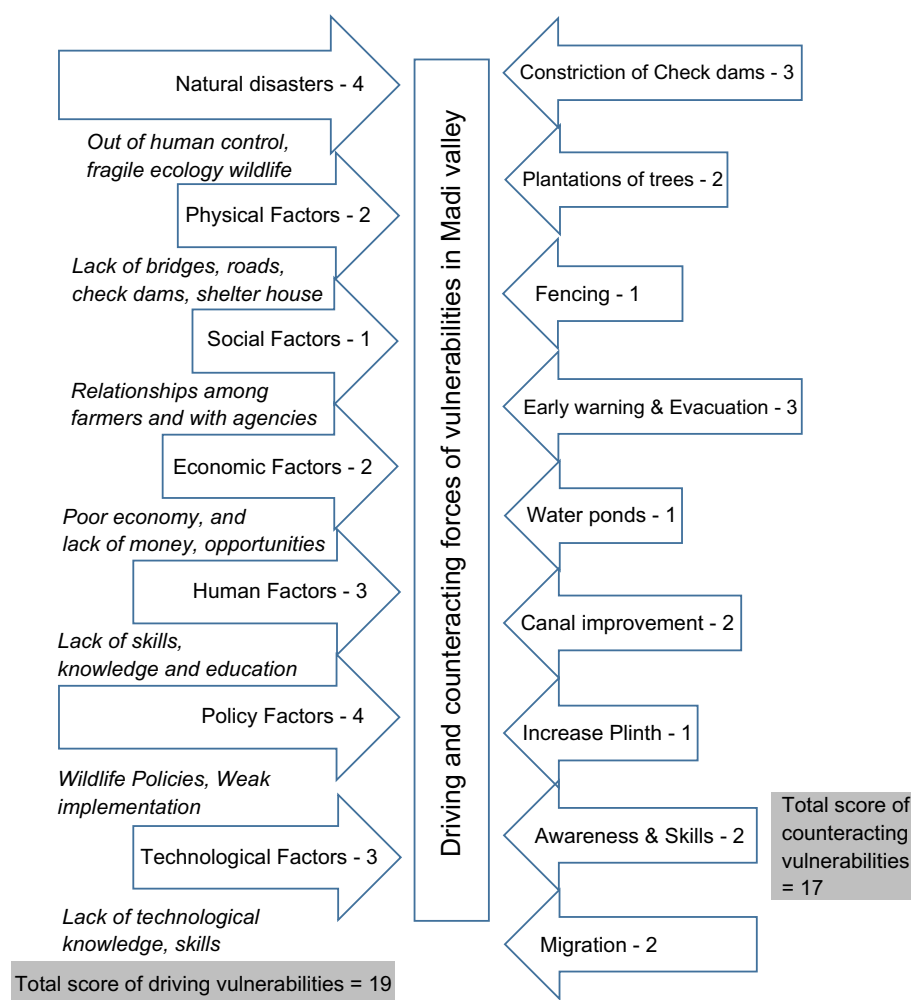
Table 5. Climate hazards and vulnerabilities as per social groups and sectors

| | | Climatic hazards | | |
|----------------------|----------------|------------------|---------|----------|
| | | Flood | Drought | Wildlife |
| <i>Social groups</i> | | | | |
| Age | Young | 4 | 4 | 4 |
| | Adult | 3 | 3 | 3 |
| | Elderly | 4 | 3 | 3 |
| Gender | Male | 4 | 4 | 2 |
| | Female | 3 | 3 | 3 |
| Class | Poor | 4 | 4 | 3 |
| | Middle | 3 | 3 | 2 |
| | Rich | 2 | 3 | 2 |
| Culture/caste | Disable people | 4 | 4 | 4 |
| | Dalit | 4 | 4 | 3 |
| | Janjatis | 4 | 4 | 3 |
| | Chhetri | 3 | 3 | 3 |
| | Brahmin | 3 | 3 | 3 |
| <i>Sectors</i> | | | | |
| Agriculture | Rainfed | 2 | 1 | 2 |
| | Irrigated | 3 | 2 | 1 |
| | Bari land | 2 | 2 | 2 |
| | Wetland | 4 | 3 | 1 |
| Forest type | Community | 1 | 2 | 1 |
| | Government | 1 | 1 | 1 |
| | Other forest | 1 | 1 | 1 |
| Ecology type | Tarai | 4 | 4 | 3 |
| | Hill | 3 | 3 | 4 |

Regmi and Bhandari (2013) found multiple factors such as physical infrastructure, technology, resources, skills cause vulnerabilities and adaptive capacity. The communities are forced to face these impacts as they are living in the fragile and marginalized lands such as riverbanks, close to the forest (national and community forests). They further emphasized on the roles of policies and institutions in enabling the communities towards other factors such as technologies, human skills. In case of Madi valley, the communities believed that the park policies and other wildlife conservation related policies are not favorable for the people's livelihoods. Even the compensations for damaging crops, houses and human casualties by wildlife are not satisfactory to the people because of tedious and lengthy process. However, most of the communities have strong social relationships and nature of supporting and helping each other. The scoring perception score of driving factors is 19.

In relation to the countering interventions to the impacts, the community recognizes construction of check dam in the rivers and streams, and early warning siren and evacuation centers are comparatively better than others, though not succeeded in all places because of lack of proper planning. If it is planned well and executed on time, they believe that huge losses could be prevented. Additionally, the communities and supporting agencies (governmental and non-governmental) have emphasized in awareness raising and skill enhancements, thus, the people are aware and alert of impacts and coping/adaptation options to deal with the impacts. Adaptation interventions are plantation of trees such as bamboos, and *Saccharum* in the river banks and affected areas. Additionally, canal improvements and migration are additional efforts done by communities to counteract the impacts in the flood prone areas. The communities in the flood prone areas have

Figure 4. Driving and counteracting factors of vulnerabilities in Madi Valley.



raised the plinth level using the wooden poles to protect from the flood. However, they experienced big holes and not succeeded whenever, the land is under water for couple of days. The reason is the amount of sands in the soil which makes it inefficient intervention. Likewise, solar and electric fencing is not operated well because of flood and other human and wildlife factors. Water conservation pond is the mechanism only considered by only few people and not succeeded in some places. The total score communities perceived for counteracting vulnerabilities is 17, despite number of counteracting interventions with different levels of successes and scopes (Figure 4).

3.7. Vulnerability matrix

The vulnerability matrix supports in understanding the vulnerability contexts and quantifying the climatic hazards and resilience capacity of the local communities. It further assists to identify the roles of different resources in increasing vulnerabilities and enhancing resilience (Regmi et al., 2010). This exercise was carried out in the focus groups by asking the score of 1–4 from least to highest for impacts and availability of resources respectively. Based on impacts and severity on natural, physical and socio-economic resources, the communities have ranked flood/riverbank erosion (with total score of risk = 6) as the highest risk, followed by drought (4) and wildlife attacks (4). Similar exercise carried out by weADAPT (2011) flood, landslide, hailstones and storms with the direct impacts on property and financial resources. The communities have the highest resilience capacity to deal with hailstorm (2.66) while analyzing the available resources to cope with (Table 6).

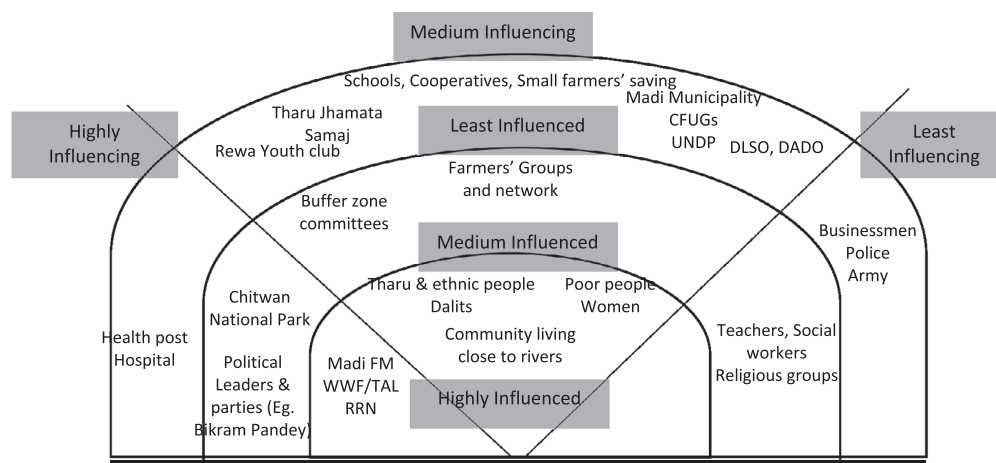
Table 6. Impacts on the livelihood resources and total resilience capacity

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|--------------------------|---|--|--|--|---------------------|--|--|--|---|
| Hazard context | Types of livelihood resource affected | | Severity of economic impacts based on 2 and 3 (rating of severity 1–4) | Frequency of hazard events (rating of frequency 1–3) | Total risks (4 × 5) | Types of livelihood resources available to cope with impacts | | | Total resilience capacity (7 + 8 + 9)/3 Average of 7, 8 and 9 |
| | Extent of Natural resources affected (extent of rating 1–4) | Extent of physical resources affected (extent of rating 1–4) | | | | Availability of economic resources (rating 1–4) | Availability of human capital (rating 1–4) | Availability of social and institutional capacity (rating 1–4) | |
| Flood/River bank erosion | 4 | 2 | 3 | 2 | 6** | 1 | 3 | 3 | 2.33 |
| Drought | 3 | 0.5 | 2 | 2 | 4 | 1 | 2 | 1 | 1.33 |
| Insects and Diseases | 1.5 | 0.5 | 1.5 | 1.5 | 2.25 | 3 | 2.5 | 2 | 2.5 |
| Hailstorm | 1 | 1 | 1 | 0.5 | 0.5 | 3.5 | 3 | 1.5 | 2.67** |
| Cold waves | 0.5 | 0.25 | 0.5 | 1 | 0.5 | 3 | 2 | 1 | 2 |
| Wild animals | 3 | 1 | 2 | 2 | 4 | 1 | 3 | 3 | 2.33 |

** Indicates the highest impact score in terms of risks and resilience capacity.

Figure 5. Rainbow diagram of stakeholders in Madi valley in terms of hazards and adaptation.

Notes: CFUGs—community forest user groups, DLSO—district livestock service office (DLSO), DADO—district agriculture development office, RRN—rural reconstruction Nepal, UNDP—United Nations development programme, WWF/TAL—world wildlife fund/ Tarai arc landscape.



ICEM (2015) highlighted on the rating of exposure, sensitivity and other parameters from scoring low to very high based on the judgements of pas extreme events, which is scientific and factual evidence based on community knowledge and experience. The exposure and sensitivity provide the measure of vulnerability and potential impact of the vulnerability on the system or community. In addition, ICEM highlighted on the impact scoring matrix detailing the potential impacts of the vulnerability matrix.

3.8. Stakeholder identification

Stakeholder identification is a SAS² tool to identify the key stakeholders being affected and influencing the key problem i.e. climate change in this case. The participants in the FGDs self-identified the key stakeholders who are directly affected from the climate change impacts and the stakeholders that are influencing the climate change adaptation interventions in the valley. The communities living in close to the river and national parks including Tharu (dominant ethnic group) and other ethnic groups such as Gurung, Magar, Bote and Dalits, women are the most affected people from climate change impacts. Civil Society Organizations such as Madi FM, WWF/TAL, RRN are highly influencing for adaptation interventions (Figure 5). Madi FM plays roles on awareness raising whereas WWF/TAL, RRN support on adaptation interventions in addition to awareness and skill enhancement. Interestingly, political leaders and parties are also in the list of highly influencing for adaptation options since they decide in multi-party forum for most of such interventions. Additionally, Political leaders such as current Minister, Physical infrastructure, and some political leaders supported the community for development and adaptation interventions. Sova, Helfgott, and Chaudhary (2013) emphasized on the power and influence of actors and stakeholders at multiple levels including the determining the resources, prioritizing actions and maintaining the institutions.

4. Discussions

Wide range of participatory tools and approaches are existed at different organizational levels, but very few are concentrated on climate change vulnerability assessment (Tiani et al., 2015). Among the diverse set of choices of tools used, the main purpose was to assess and analyze the big picture on what kinds of vulnerabilities and impacts that communities have faced over the years. It is a systematic way to understand and analyze the vulnerabilities and to identify the most vulnerable groups within a community. In the process, the participatory tools are customized based on local situations and needs. Oxfam Australia (2012) also supported on local adaptation of the tools based on the local contexts. The communities have understood and internalized the local climatic contexts and extreme events during and after the exercises. Hinds (2013) also recognized that these assessments empower the community, the practitioners and the policy makers to understand and advocate the community's perceptions on local climate related issues to address the impacts faced by the communities. Tiani et al. (2015) further added that the local communities are empowered

through their participation and contribution by enhanced awareness, increased the quality of data, ideas and solutions and enhanced the confidences in expressing their views in the whole process of assessments.

IUCN (2015) has emphasized on the combination of qualitative and qualitative methods to understand the socio-economic and environmental systems and to gather reliable information on the systems to respond climate change with the involvement of local experts and communities. However, the study has focused more on qualitative assessment of the vulnerabilities, since very few research is focused on qualitative assessment in the area. Furthermore, the meteorological station in the areas is 35–40 km away from the study site, which may not reflect the exact climatic data and trend of the locality. Boureima et al. (2013) emphasized on the analysis of climate vulnerabilities and risks based on the knowledge and understanding of local situations, needs and priorities.

The successful use of participatory approaches is based on previous experiences on particular methodology, cultural sensitivity and awareness on community, respect, humility and patience, facilitation and communication skills of the practitioners (Chambers, 1994; Turnbull & Turvill, 2012). Participatory vulnerability analysis enhances rural communities to better understand exposure to climate risks. It organizes and builds communities themselves to understand local contexts to deal with complex factors (human, social, economic, political, and natural) affecting the livelihood resources. Regmi et al. (2010) confirmed uncertainty as the key factor of climate change at the local level. Whenever local communities systematically assessed local climatic contexts and their needs and priorities to adapt to climate change, they can effectively contribute to adaptation planning (Boureima et al., 2013). Inclusive participation of the communities, local knowledge and practices, sharing and control are important in the participatory research (Regmi et al., 2010).

Multiple dimensions of vulnerability such as several threats, dynamic processes, differential exposure, sensitivity and collective actions have been studied by many researchers and practitioners. Recent studies carried out by CIFOR has discovered local people sharing their experiences on climate change is one of the ways to understand the extent and scope/depth of vulnerability, which is yet to be measured. It is better to use a combination of participatory and analytical tools to understand the vulnerability dimensions (Tiani et al., 2015). Combination of tools help in analyzing the similar issues in different ways, which allow the cross-checking and triangulation of the information and inconsistencies in the information. For instance, the resource map/hazard map and historical timeline/trend analysis allow to analyze the similar information for more accurate results with minimal discrepancies and irregularities (Oxfam Australia, 2012).

The community members are the main stakeholder for any vulnerability and capacity assessment. It is important to consider that communities are not homogenous since they are significantly different in terms of gender, age, socio-economic status, religious and political affiliations and their individual and collective interests as well (Turnbull & Turvill, 2012). Tiani et al. (2015) also emphasized on complexities of people's lives and factors such as local knowledge, past experiences, skills, household compositions including gender, age and existing coping mechanisms. They further elaborated that the vulnerabilities and local perceptions are context specific and site specific depending on diverse factors such as education, culture, gender, age, resources endowments and institutional factors. In all cases, it is better to ensure balanced representation of men and women, elderly, disabled and ethnic/social minority groups in the processes (Oxfam Australia, 2012).

The flood, droughts, diseases and pests, riverbank erosion and wildlife attacks are found most eminent vulnerabilities in the valley. The study conducted by Wagley et al. (n.d.) also found the flood, drought and riverbank erosion as most significant vulnerabilities in the area. However, they also found landslides as highly vulnerable hazards in the area especially in the Southern parts of the Madi especially adjoining the Chure Belt along the national park. The current study has mainly focused on the ward 4, 5, and 6 of the municipality, which used to be Bagauda VDC. Furthermore, it is found that the poor, marginalized and ethnic people living close to the river and forest are prone to climatic and

non-climatic vulnerabilities including wildlife attacks. Wagley et al. (n.d.) also found similar results in their study. They underlined the wildlife attack of elephant in the study site, thus emphasized on the necessity of construction of huge embankment and dam including solar fence to stop the wildlife intrusions. However, communities have difference views and observations on these interventions. Communities have argued the success of these interventions.

5. Conclusions

In order to minimize the impacts of climate change, it is important to assess and analyze risks and the vulnerabilities. Based on the location and site specific risks and vulnerabilities, the appropriate adaptation and mitigation plans could be developed and implemented. Poor and marginalized people are the most vulnerable who are facing the direct and foremost climate change impacts since they are living in the fragile ecology with least adaptive capacities. Among different methods and approaches of assessing risks and vulnerabilities, participatory approaches are gaining popularity in both development and academic sectors. The participatory approaches engaged multi-stakeholders, mainly communities representing youth, women, elderly, disabled and ethnic peoples/groups in the process through bottom-up manner. Additionally, the participatory approaches allow people to express their views and opinions on climate change issues and vulnerabilities based on their lifelong experiences, observations and knowledge.

This study has applied some participatory tools and methods mainly hazard mapping, historical timeline, pairwise ranking, seasonal calendar, vulnerability assessment, vulnerability matrix, forced field analysis to assess and analyze the risks and vulnerabilities. The combination of these tools and methods also help in triangulation of the information on climate risks and vulnerabilities. Based on the study, it is realized that flood and flood induced riverbank erosion, drought and wildlife attacks are the main and severe hazards in the Madi valley. All of these impacts are site specific with differentiated impacts to the people based on exposure, sensitivity and adaptive capacities. The communities, especially ethnic and Dalits living in the riverbanks and close to the forests (both National Park and community forest) are highly vulnerable to the risks and vulnerabilities. Riverbanks are prone to flood, whereas uplands are prone to drought. Wildlife attacks are very severe in most of the places especially close to the forest and national park throughout the year. Since the valley is surrounded by national parks and forest, farmers have faced the impacts from wildlife all year around. Many factors are associated on the climate and non-climatic vulnerabilities and impacts. Policy and natural factors are in the highest ranks among the communities. Many local coping strategies and adaptation practices supported by government and non-government agencies to minimize the climate change impacts, however, not all such interventions are succeeded. The authors have planned to assess and analyze such coping and adaptation interventions in the valley in future including the participatory benefit cost analysis of the adaptation interventions and factors analysis of the adaptation interventions.

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Notes

1. TAL is a joint program implemented by Government of Nepal and WWF Nepal to empower the local communities towards integrated biodiversity conservation and economic development through sustainable use of the resources.
2. BS is a Bikram Sambat, Nepalese Year, which is 57 years ahead than the AD. 2071/72 connotes 2015.
3. Sauraha is well known tourist destination for diverse wildlife and mesmerizing beauty in Chitwan district of Nepal.

Cover image

Source: Author.

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