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# Indigenous Knowledge for Climate Change Induced Flood Adaptation in Nepal

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*Abstract: Floods are becoming increasingly common in Nepal resulting in a huge loss of life and damage to settlements, agriculture lands and infrastructures in various parts of the country. Most recent research findings suggest that climate change has accelerated the intensity and frequency of flood hazards in most parts of the country. Communities are however, making use of options that increase their preparedness for these flood hazards. This paper intends to assess the indigenous knowledge on flood forecasting and flood adaptation strategies at the community level in two districts of Western Terai of Nepal. Two focus group discussion and a total number of 240 households were interviewed during field visit. The collected information was scaled from least preferred- 1 to most preferred-5 based on their preferences. The research findings indicate that there are some very effective local flood forecasting practices such as identifying the position of clouds; monitoring the extent of rainfall in upper catchments; analyzing the mobility of ants; analyzing the magnitude of thunderstorms and wind blows; analyzing the magnitude of hotness; and hearing strange sounds from river/torrents. Synthesis and analysis of these indicators help communities prepare for potential flood events, through (1) preparation of search and rescue related materials; (2) creation of small drainage structures in each plot of land and storage of the valuable material; and (3) the psychologically preparation for floods. This paper argues that these indigenous flood forecasting and adaptation strategies could be particularly useful for migrants, who are in flood prone areas but are not familiar with those practices, in other parts of the country.*

*Keywords: Human Impacts and Impacts on Humans, Climate Change, Flood, Adaptation Strategies, Community Practices*

## Introduction

Climate change and its effects show considerable variability across the world. However, most of the poorest countries and their people are likely to suffer the earliest and the most because of their low adaptive capacity and dependence on agriculture, which is highly reliant on climatic factors (Manandhar *et al.*, 2011). The South Asian region is, thus, the most sensitive to climate change as most of the countries in the region have agriculture based poor economies, and less resilience and adaptive capacity (Stern & Britain, 2006). In this region the average surface temperature in the last 100 years, i.e. from 1906 to 2005, increased by 0.74°C which is higher than the corresponding global value of 0.6°C for the years 1901 to 2000 (IPCC, 2007a ; Maharahatta, *et al.*, 2009), a clear indication of climate change in the region.
Multiple general circulation models show convergence on continued warming, with averaged mean temperature increases of 1.2°C and 3°C by 2050 and 2100 respectively (World Bank, 2009). These models, however, predict different scenarios for the Terai (lowlands lying in the southern part) than for the mountainous regions (northern part) of Nepal. As more than 80% of the people of the country rely on agriculture and fishing for their subsistence (Karki and Gurung, 2012) and almost 90% of the poor people of Nepal lives in rural areas (Sapkota *et al.*, 2011; Nepal, 2002), Nepalese economy and livelihood will be hugely affected by changing climate.

The average annual rainfall of the country is about 1,750 mm, ranging from more than 5,000 mm in the central part of the country to less than 250 mm in the higher north part (Devkota, 2010; GoN, 2010). The recorded rainfall data of Mid-Western Terai from 1970 shows the higher intensity of rains with fewer rainy days and unusual rain with no decrease in total amount of annual rainfall. Such events increase the possibility of hydro-climatic extremes such as irregular

monsoon pattern, droughts and floods (Gautam, 2008). Climate variability coupled with such climate change, might have resulted in various kinds of natural disasters and extreme events which are becoming frequent and escalating in recent years in Nepal, among them floods are the most devastating natural disasters (Regmi, 2007; Lohani, 2007).

Climate change increases flood intensity and thus exacerbate public and private property damages (Malla, 2009; Aggarwal *et al.*, 2004). In Nepal, flood disasters are becoming more frequent, pronounced and devastating in the recent decades (Regmi and Adhikari, 2007). The Mid-Western region of Nepal is experiencing greater than expected floods, which have resulted in immense damage to lives, properties and serious losses in production every year (Maharahatta, *et al.*, 2009). Indigenous people of this region have already experienced frequent drought and severe floods effects due to climate change resulting in huge loss of agriculture lands and products (Osti, *et al.*, 2008; Berkes, 1998).

Indigenous people, Tharus, are living in Banke and Dang districts of Nepal. These districts lie in the West Rapti River Basin, one of the river basins of Nepal of Nepal. Flood events have become recurring phenomena in this river basin. In 2010, the flood situation in Banke district remained grim. Many villages remained inundated due to flash floods. Moreover 16,000 people of the 2,600 households in 33 villages were forced to leave their houses and farmlands and are to living as refugees (TKP, 2010). More than 600 hectares of the most fertile land that was yielding three crops a year in Banke and Dang districts in the past was under floods (Kantipur, 2010).

The indigenous people residing in the bank of Rapti River are continuously experiencing flood events from generations (Khatiwoda, 2011; Devkota *et al.*, 2011). Acknowledging that these people have developed systems of flood forecasting and preparedness (Maharjan, 2011; Thapa, 2009; Rajasekaran, 1991), this study aims to assess the indigenous knowledge on flood management and adaptation strategies of these people of West Rapti River Basin in Nepal.

## Study Area

The study was carried out in the West Rapti River Basin, covering both Banke and Dang districts of Nepal (**Fig. 1**). The basin is located between 27° 40’ to 28° 36’ north and 82° 20’ to 83° 10’ east. The West Rapti River (WRR) originates in the Lesser Himalaya, flows through the Siwalik hills and Terai plain of Nepal before joining the Ganga River in India. The total catchment area of the river within the Nepalese territory is 6500 $km^2$ with the elevation which varies from about 317 m (at the outlet point to India) to 3,662 m amsl (at the origin). The main tributaries of the river are Madi Khola and Jhimruk Khola.

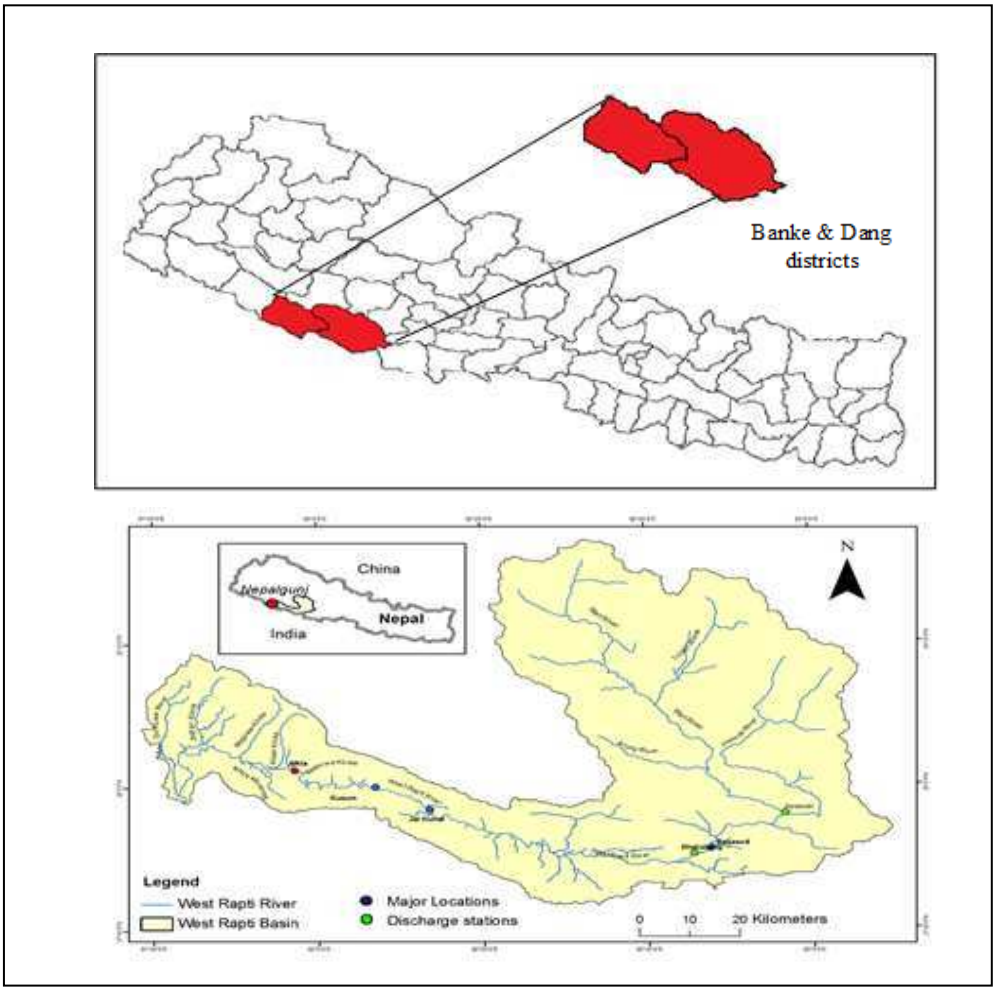


Fig. 1: Location map of West Rapti River Basin of Nepal (Source: Devkota *et al.*, 2013)

The annual average temperature of the study area is 25°C ranging from 15°C in the winter period to 32°C in the summer. The coldest month is January while the hottest month is May (DMSP, 2006). The average annual rainfall varies from 1,151 mm to 2489 mm (DHM, 2010). More than 80% of the rainfall occurs during the four months of monsoon season i.e.: from June to September.

Most of the people living in Banke and Dang districts are indigenous Tharu communities (District profile, 2007). More than 80% people are farmers. They are using indigenous methods in agricultural practices. Since the basin has long history of devastating flood, these people have been using their own flood adaptation strategies for their survival for several years (Devkota, *et al.*, 2013). However, such knowledge has been transferred to the new generation verbally and through demonstration. This basin can, therefore, be considered as one of the ideal basins which are suitable for doing research on the assessment of indigenous knowledge on flood management practices.

## Methodology

Focus group discussions followed by household survey were used to assess the indigenous flood adaptation strategies. Two focus group discussions (FGDs) were conducted in the flood prone areas; one at Holiya Village Development Committee[1] (VDC) of Banke district and another at Lalmatiya VDC of Dang district. People who have firsthand experience in flood adaptation strategies, such as farmers, foresters, VDC secretary, school teachers and local NGOs, were invited in the FGDs. In total, 25 people participated in the FGDs. In the beginning, they were asked to prepare a list of flood adaptation strategies during three periods (pre-flooding, during flood and after flooding) that have been adopted over the past 10 years. Then, they were further requested to select only those adaptation strategies that are most preferred. These most preferred strategies were administered through household survey. According to focus group, there were about 950 households in the basin which are prone to flood every year. Out of them about 240 households (over 25% of the total population) were randomly selected for the interview. During the field visit (Feb-May 2012), the key person of the household was requested to rank selected flood adaptation strategies against a 1-5 scale, where 1 is a least preferred option and 5 is most preferred option. The adaptation strategies for each period were ranked based on the total scores from most preferred, very preferred and moderately preferred strategies.

## Results and Discussion

### *Effect of Floods in the Eyes of Focus Groups*

In the study area, recurrence of flood was common every year during the monsoon season, however the latter the monsoon season was identified to have been delayed and duration its was found to have shortened in recent years. The changing pattern of monsoon with extreme conditions was responsible for the floods which damaged the physical infrastructures like houses, schools, sub-health post, road, culverts, marketing centres, gabion embankments, spurs, hand pumps as well as productive agriculture land, and loss of livestock. The increasing frequency of flood also eroded the social assets such as neighbourhood, brotherhood, labour exchange system, and strong bondage of kinship.

The major impact of floods was loss of livelihood. Many people who live along the flood plains are poor and indigenous people. They have little resources to manage floods. As a result, they lose their homes, crops, animals, livelihoods, and even their lives in floods. There was a huge flood in Rapti River Basin in 2008. About 142 households were forced to leave their houses permanently.

### *Flood Forecasting Techniques*

Flood forecasting and early warning systems can save many lives and properties. Communities are enriched with indigenous knowledge of flood forecasting and early warning practices. Five main flood forecasting techniques used over the past decades as listed out from the focus group discussion are given in **Table 1**. The respondents' perception to these techniques in terms of frequency (F), relative frequency (RF) and cumulative relative frequency (CRF) are given in **Table 1**.

[1] VDC is the lowest administrative unit of the government of Nepal

Table 1: Respondents' perception on different flood forecasting techniques

| Responses | Observing position and movement of clouds in the sky | | | Observing the rain in the upper catchment area | | | Watching ants' movement | | | Feeling the magnitude of hotness | | | Analyzing the magnitude of thunderstorms | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** |
| MoP | 103 | 42.9 | 42.9 | 46 | 19.2 | 19.2 | 17 | 7.1 | 7.1 | 35 | 14.6 | 14.6 | 60 | 25.0 | 25.0 |
| VeP | 49 | 20.4 | 63.3 | 108 | 45.0 | 64.2 | 61 | 25.4 | 32.5 | 126 | 52.5 | 67.1 | 103 | 42.9 | 67.9 |
| MdP | 43 | 17.9 | 81.3 | 76 | 31.7 | 95.8 | 95 | 39.6 | 72.1 | 53 | 22.1 | 89.2 | 45 | 18.8 | 86.7 |
| LsP | 40 | 16.7 | 97.9 | 8 | 3.3 | 99.2 | 52 | 21.7 | 93.8 | 17 | 7.1 | 96.3 | 29 | 12.1 | 98.8 |
| LeP | 5 | 2.1 | 100 | 2 | .8 | **100** | 15 | 6.3 | 100 | 9 | 3.8 | 100 | 3 | 1.3 | 100 |
| Total | 240 | 100 | | 240 | 100 | | 240 | | | 240 | 100 | | 240 | 100 | |
| **Rank** | **IV** | | | **I** | | | **V** | | | **II** | | | **III** | | |

Note: MoP = Most preferred; VeP=Very preferred; MdP= Moderately preferred; LsP= Less preferred LeP= Least preferred & 'F' is frequency, 'RF' is relative frequency (%) and 'CRF' is cumulative relative frequency (%)

Each of forecasting method was ranked based on the CRF of most preferred, very preferred and moderately preferred responses. All the five techniques have good use as all of them have over 70% CRF. Therefore, each one of them could be used in the absence of others. However, where information is available some of these techniques are more preferred than others. Among them, "observing the rain in the upper catchment area" is ranked first (CRF=95.8%) followed by "feeling the magnitude of the hotness" (CRF= 89.2% CRF), "observing the position and movement of cloud" (CRF =86.7%), and "analysing the magnitude of thunderstorms in the sky" (CRF= 81.7%).

People strongly believe that if there is rainfall in the upper catchment area, there is a possibility of floods, especially, high intensity rainfall in a monsoon season for a long period of time is devastating. Communities expressed that the rainfall in the Terai region (where they live) alone would not induce high flood level. Likewise, if the magnitude of hotness is high in the monsoon season, there is a very good chance of rainfall and floods. Similarly, the magnitude of the thunderstone is considered as another indicator of possible rain and consequent flood by these indigenous people. People also guess the chance of heavy rainfall by assessing the position of the cloud in the sky. Communities believe in a saying that if the black cloud is located in the eastern side of the sky, and if there is no mobility of this cloud at all, then there will be heavy rain within an hour. Therefore, the colour and direction of clouds are very important for them. Similarly, if they see thousands of ants moving in a row then they believe there is a possibility of heavy rainfall on a day or so. However, this indicator is considered the least reliable one among the five main techniques.

### *Flood Adaptation Strategies*

Field study found that managing flood by people's own knowledge and skills is an interesting feature in the study area. People are trying to mitigate the possible effects of flood by their own efforts and knowledge. It was observed and reflected during the interaction that people have close affiliation with the flood and its nature. However, due to uncertain and erratic rainfall, people were found afraid from likely risks generated by flood. The people of the Rapti basin, who experience frequent flood events, have developed different flood management

schemes/techniques for pre-flood, during flood and post flood period. Some of these techniques or schemes are given below.

### *Pre-Flood Adaptation Strategies*

Most people consider flood as a part of their lives. The respondents are found mentally ready to face and struggle with the possible flood disaster and prepared accordingly at individual and household levels. Raising the bottom of the floor of the house, constructing drain around the properties, moving properties to safe locations and keeping emergency materials are the major four activities identified as pre-flood adaptation strategies during the focus group discussion. The respondents had ranked their perception on these different preparation activities before flooding according to their preferences as given in **Table 2.** For each of selected pre-flooding preparation, based on CRF, constructing drain to dispose the flood water around the house and other properties like tube wells, cow sheds or even agricultural plots etc. was ranked 1$^{st}$ (CRF=93.8%). Keeping of properties in safe places was ranked 2$^{nd}$ (CRF=90.8%) while raising the bottom floor of the house was ranked 3$^{rd}$ (CRF=89.2%). Making arrangements of emergency materials (e.g. keeping plastic sheets, tents, rope, rubber tubes, empty drums, torchlight, etc. especially during monsoon as part of emergency stock) was ranked 4$^{th}$ (CRF = 82.5%).

People create small drainage in each plot of land, as poor drainage system is the foremost reason of flooding. In order to save the paddy land from the possible flood, people make drainage outlet in each plot of land allowing the water to pass from the given plot. Similarly, the study found that storage of the valuable materials like ornaments, cash, cloths, stove, jute sacks and utensils is almost important as to save the lives and livestock. People usually collect and keep the important documents and utensils in the safer place wherever possible either within the house or in the house of close neighbour/kin for more safety. Likewise, raising the bottom floor of the house is important to save the lives and properties. Of course, people try to manage the basic materials (food, cloths etc.) that are needed during the flood. However, this depends on the economic condition of the family. Rich families are able to afford such materials while the poor ones are less likely to afford such emergency material as a pre-disaster adaptation activity.

Table 2: Preference of pre-flood adaptation strategies

| Responses | Raise the bottom of the floor of the house | | | Construct drain around the properties | | | Move properties | | | Keep emergency materials | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** |
| MoP | 98 | 40.8 | 40.8 | 44 | 18.3 | 18.3 | 74 | 30.8 | 30.8 | 56 | 23.3 | 23.3 |
| VeP | 46 | 19.2 | 60.0 | 111 | 46.3 | 64.6 | 87 | 36.3 | 67.1 | 95 | 39.6 | 62.9 |
| MdP | 70 | 29.2 | 89.2 | 70 | 29.2 | 93.8 | 57 | 23.8 | 90.8 | 47 | 19.6 | 82.5 |
| LsP | 25 | 10.4 | 99.6 | 9 | 3.8 | 97.5 | 20 | 8.3 | 99.2 | 37 | 15.4 | 97.9 |
| LeP | 1 | 0.4 | 100 | 6 | 2.5 | 100 | 2 | 0.8 | 100 | 5 | 2.1 | 100 |
| **Rank** | **III** | | | **I** | | | **II** | | | **IV** | | |

Note: MoP = Most preferred; VeP=Very preferred; MdP= Moderately preferred; LsP= Less preferred LeP= Least preferred & 'F' is frequency, 'RF' is relative frequency (%) and 'CRF' is cumulative relative frequency (%)

During the household survey, three respondents added some other additional adaptation strategies. Preparing the bed at higher level before the flood is one of them. Beds are especially useful to keep children safe during the flood. Similarly, selling chickens and cattle, and preparing the bamboo basket for storing sufficient food materials (beaten rice, salt, sugar, noodles, etc and dried vegetables, potato chips, pulses) in advance of the monsoon season are some of the other pre-flood adaptation strategies.

### *During the Flood Adaptation Strategies*

In the majority of the communities, rotation-wise flood monitoring strategy has been implanted. Youths are usually given the task of monitoring the flood at night. During the evacuation of the people towards comparatively safer place, the roles of youths are crucial. Schools are closed for some days and youths are involved in rescuing the people who are especially affected by the flood. The families whose houses are completely damaged or destroyed take shelter at school, health posts and neighbour's houses. Those households who have multi-storey cemented buildings stay in the upper floors. During focus group discussion, it was found that generally, people took the decision to leave the house or go to appropriate place when the flood level is more than 60 cm from the ground level. Five major activities were identified as the adaptation strategies as shown in **Table 3**. are follows: releasing domesticed animals, taking valuable properties, using sand bag to divert flood water, standing/sitting on the roof of houses or climbing tree, and shouting and escaping. Among these major practices, releasing of domesticated animals was ranked 1$^{st}$ (CRF = 95.0%), taking valuable properties was ranked 2$^{nd}$ (CRF= 91.7 %), using of sand bag to divert water was ranked 3$^{rd}$ (CRF= 81.3 %), and climbing in the roof of houses or tree was ranked 4$^{th}$ (CRF = 75.0 %). In the study area, flood diversion usually is done by making a canal and a wall of sand bag around the important properties.

Table 3: During flooding adaptation strategies

| Responses | Climb tree and roof of the houses | | | Release domestic animals from the shed | | | Take valuable properties | | | Shout and escape | | | Use sand bag to divert flood | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** |
| MoP | 56 | 23.3 | 23.3 | 57 | 23.8 | 23.8 | 73 | 30.4 | 30.4 | 25 | 10.4 | 10.4 | 44 | 18.3 | 18.3 |
| VeP | 59 | 24.6 | 47.9 | 91 | 37.9 | 61.7 | 79 | 32.9 | 63.3 | 74 | 30.8 | 41.3 | 84 | 35.0 | 53.3 |
| MdP | 65 | 27.1 | 75.0 | 80 | 33.3 | 95.0 | 68 | 28.3 | 91.7 | 67 | 27.9 | 69.2 | 67 | 27.9 | 81.3 |
| LsP | 38 | 15.8 | 90.8 | 9 | 3.8 | 98.8 | 9 | 3.8 | 95.4 | 46 | 19.2 | 88.3 | 26 | 10.8 | 92.1 |
| LeP | 22 | 9.2 | 100 | 3 | 1.3 | 100 | 11 | 4.6 | 100 | 28 | 11.7 | 100 | 19 | 7.9 | 100 |
| **Rank** | **IV** | | | **I** | | | **II** | | | **V** | | | **III** | | |

Note: MoP = Most preferred; VeP=Very preferred; MdP= Moderately preferred; LsP= Less preferred LeP= Least preferred & 'F' is frequency, 'RF' is relative frequency (%) and 'CRF' is cumulative relative frequency (%)

During the flood, people take care of children and elderly as they can be the first victims of the flood. They are vulnerable because of their innocence, inability to run fast and due to health and physical vulnerabilities. Similarly, the kids are usually rescued by being kept them in the second storey of the bunked bed. For this very purpose, double storey beds are made. If the rescue and relief materials (e.g. rubber tubes and family fishing boats) are available within the house, they use and share them use to save others from the raising flood.

### *After Flood Adaptation Strategies*

People return to their houses when the water level decreases to a safer level. During this stage, they assess the damage caused by flood so that immediate plan could be made for action in the priority basis. **Table 4** shows the ranks of post-flood adaptation activities based on people's perception. Repairing the house, managing food, making temporary shelter and repairing hand pump for drinking water are major practices which are carried out by the flood affected people after the flood. Based on CRF value, these people are giving the first priority for repairing the house (CRF = 94.0 %). Managing food was ranked 2$^{nd}$ (CRF = 92.1 %), making warm clothes was ranked 3$^{rd}$ (CRF =92.1 %), and repairing hand pump for drinking water was ranked 4$^{th}$

(CRF=79.6 %; Table 4). People dry their materials which become wet during the flood under the sunlight. Elderly and women are mostly involved in the separation of good grains from the damaged ones. People often resort to loans to get warm clothes for family members and to procure additional food that is for post-flood period.

Table 4: Post-flood adaptation strategies

| Responses | Managing food | | | Repairing the house | | | Managing warm clothes | | | Repairing hand pump for drinking water | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** | **F** | **RF** | **CRF** |
| MoP | 107 | 44.6 | 44.6 | 43 | 17.0 | 18.0 | 61 | 25.4 | 25.4 | 38 | 15.8 | 15.8 |
| VeP | 45 | 18.8 | 63.3 | 110 | 45.8 | 64.0 | 88 | 36.7 | 62.1 | 109 | 45.4 | 61.3 |
| MdP | 69 | 28.7 | 92.1 | 72 | 30.0 | 94.0 | 72 | 30.0 | 92.1 | 44 | 18.3 | 79.6 |
| LsP | 18 | 7.5 | 99.6 | 13 | 5.4 | 99.2 | 15 | 6.3 | 98.3 | 42 | 17.5 | 97.1 |
| LeP | 1 | 0.4 | 100 | 2 | 0.8 | 100 | 4 | 1.7 | 100 | 7 | 2.9 | 100 |
| **Rank** | **II** | | | **I** | | | **III** | | | **IV** | | |

Note: MoP = Most preferred; VeP=Very preferred; MdP= Moderately preferred; LsP= Less preferred LeP= Least preferred & 'F' is frequency, 'RF' is relative frequency (%) and 'CRF' is cumulative relative frequency (%)

It is noted here that not all houses are damaged by the flood. In fact, it depends on the magnitude of the flood, the condition of house and the physical set up of the village. Those houses that are partially damaged are repaired and made liveable. For the completely collapsed houses, people manage the materials like bamboo, rope, hay and wood from nearby forest. With regards to this, the role of community forest user committee (one one elected body in the village) is crucial. People stay in their neighbour's or family member's or kin's homes for some time until the damaged house are repaired to live. Some of the community leaders provide assistance for the affected families during this period.

## Conclusion

Intensive and erratic rainfall is a major cause of increasing flood hazards in Nepal. Through intensive focus group discussion and household survey, this study assesses the indigenous knowledge on flood forecasting and flood adaptation strategies at the community level in two western districts of Nepal People in the study area strongly believe that climate change is inducing high intensity rainfall in shorter period subsequently creating flood problem.

All the flood forecasting methods, and pre, during and post flood adaptation strategies were documented and ranked through iterative process. These indigenous methods are adaptation strategies are working well and saving lives and properties in the study area. Therefore, these flood forecasting methods and adaptation strategies could be a useful guidance for other parts of the Nepal where people have faced similar problem.

In the study area, many people have become homeless and their productive land has become uncultivable due to sedimentation after the flood events. The affected families in such areas need special attention in terms of provision of shelter, resettlement along with improvement in human lives and livelihood. Therefore, it is a necessary to understand the nature and the extent of the damage for livelihood improvements after such events. The immediate adverse impact of floods manifests in current income losses arising from crop losses and production disruptions in other sectors of the economy. There are even much larger economic losses due to damage to capital assets including infrastructure, houses, and livestock. The diversified technological options including skills development, awareness and capacity building of flood affected communities into the mainstream development practices in an integrated way can reduce disaster risk and vulnerability in a sustainable way. This will help to manage the flood resistance capacities of

people living in the flood prone area. Therefore, all concerned local, regional and national level authorities are strongly recommended to work in this direction. Moreover, a planning for immediate, medium and long term rehabilitation and recovery actions for vulnerable people are strongly recommended.

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