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Assessing flood vulnerability on livelihood of the local community: a case from Southern Bagmati corridor of Nepal

Abstract

Flood is one of the prominent hazards in terai region of Nepal. The people living at the bank of the river are more vulnerable to floods. The study was objectively conducted to assess vulnerability from floods on livelihood of riverine households & communities living at up-stream, mid-stream and down-stream at Bagmati river of Sarlahi and Rautahat district of Nepal. About 25% sample size, focus group discussion & key informant's interview were surveyed & carried out through random sampling. A pre-tested semi-questionnaire and check list was prepared & used to collect the socio-demographic profile, livelihood strategies, social networks, financial aspects, physical structure and facilities, health, food, water, forest and natural disasters and climate variability. The duration of study was from July 2019 to December 2020. Collected data were analyzed to calculate the indexed value and vulnerability index using Haln et al.,[1] and IPCC[2] for comparing the components of flood vulnerability from livelihood aspects. A multi-dimensional integrated flood risk assessment framework, Livelihood Vulnerability Index (LVI) developed by Haln et al.[1] and LVI-IPCC, was adopted to quantify household-level flood vulnerability. Results showed that flood vulnerability was higher in downstream/lower belt (with highest LVI value 0.528), followed by Middle belt with medium LVI value 0.506. The least vulnerable is upper belt which has low LVI value 0.323. A significant correlation was observed between contributing factors: vulnerability, contributing factors-exposure, sensitivity and adaptive capacity. Gradation of flood vulnerability found as significantly different. The multivariate analysis recommended that households' having better preparedness and mitigation measures was influenced by their ability to responds to floods vulnerability. The empirical approach and analysis of this study could be used to reduce vulnerability, enhance adaptive capacity and lower the risk of sensitivity in another region.

Keywords: flood vulnerability, livelihood vulnerability index, adaptive capacity, up-stream, mid-stream and down-stream

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Introduction

Flood has been categorically mentioned as one of the most destructive natural hazards worldwide causing extensive damage to the built and natural environment, and devastation to human settlements.[3] The frequent occurrence of flash floods within the Hindu Kush-Himalayan region poses a severe threat to lives, livelihoods and infrastructures, both within the mountains (upstream) and terai/plain (downstream). As a result, flood has been one of the most devastating disasters, especially in Asia.[4]

Nepal is exposed to a variety of natural hazards and human induced disasters. More than 80 percent of the total population of Nepal is at risk from natural hazards, such as floods, landslides, windstorms, hailstorms, fires, earthquakes and Glacial Lake Outburst Floods (GLOFs). Globally, Nepal ranks 4th and 11th in terms of its relative vulnerability to climate change and earthquakes, respectively (Maplecroft 2011, BCPR 2004 cited in MoHA 2015, GoN/MoHA 2017). The flood has most devastating effect in the Terai Section (southern part) of Nepal. Inundation of huge area of urban land indicates that in future human lives are more prone to flood disaster (Shakya, et. al., 2006/Geoinformatics, Survey Department, Nepal). During the monsoon months from June to September, all these rivers are in spate with bank-full discharges and cause flooding and inundation in several parts of the Terai. The problems of flooding and inundation in the terai are more critical due to change in climate in general and change in the rainfall pattern/intensity in particular.[5] On analyzing the monthly rainfall data for the period of 30 years from 1976-2005 (166 meteorological stations) throughout Nepal, it is found that most part of the country, including the Terai and Siwalik, experienced increasing annual trend of pre monsoon, monsoon, post monsoon and winter precipitation (Practical Action, 2009). The floods of 1985, 1993 and 2004 destroyed large tracks of land terraces, farmlands, pastures and orchards in Bhasedwa leaving the country food insecure (Dixit et al., 2007). Consequently, the poor, uneducated and unemployed people are compelled to make a living by settling in flood and land slide prone areas in the hills, Chure, Terai plains. This research paper analyzed the impacts of flooding and inundation on livelihood of Terai along with assessing Livelihood Vulnerability Index.

Materials and methods

The research study focused and concentrated on vulnerable communities and settlements of Bagmati River corridor of Terai region, covering Rautahat and Sarlahi districts, Nepal starting from foothill of Chure range to southern part of Nepal-India boarder. While conducting the study and field survey in southern part of Bagmati corridor of Terai (covering both Rautahat and Sarlahi districts), the research area was divided into 3 belts as it were the most susceptible zone to flood in rainy season. The upper belt/Up-Stream is the foothill of Chure range (Karmaiya area) where the Bagmati Irrigation Dam is constructed. This Bagmati River divides the two district in this zone consisting of Ward no 1 of Chandrapur Municipality of Rautahat district in west while ward no 11 of Bagmati Municipality of Sarlahi District in East. Similarly, Middle zone /Mid-stream also consist of two districts, ward no 3 of Gadhimai Municipality of Rautahat district and ward no 2 of Basbariya Rural Municipality of Sarlahi district. The Third zone/Down-stream consists the ward no 2 and 5 of Durga Bhagwati Rural Municipality of Rautahat district; which is the southern part as well as nearer to the Indian border. Most of the people are having subsistence livelihoods based on agriculture and small business along with private and government jobs. The absence of irrigation facilities, underdeveloped infrastructure, non-availability of agricultural inputs, and small and fragmented land holdings cause agriculture dependent households to suffer even more poverty in this zone.

The duration of the study including since the issue identification of the research site and conduction of preliminary field visit and formulating the questionnaires and final visit of data collection includes the overall period between July 2019 to December, 2020 (Figure 1).

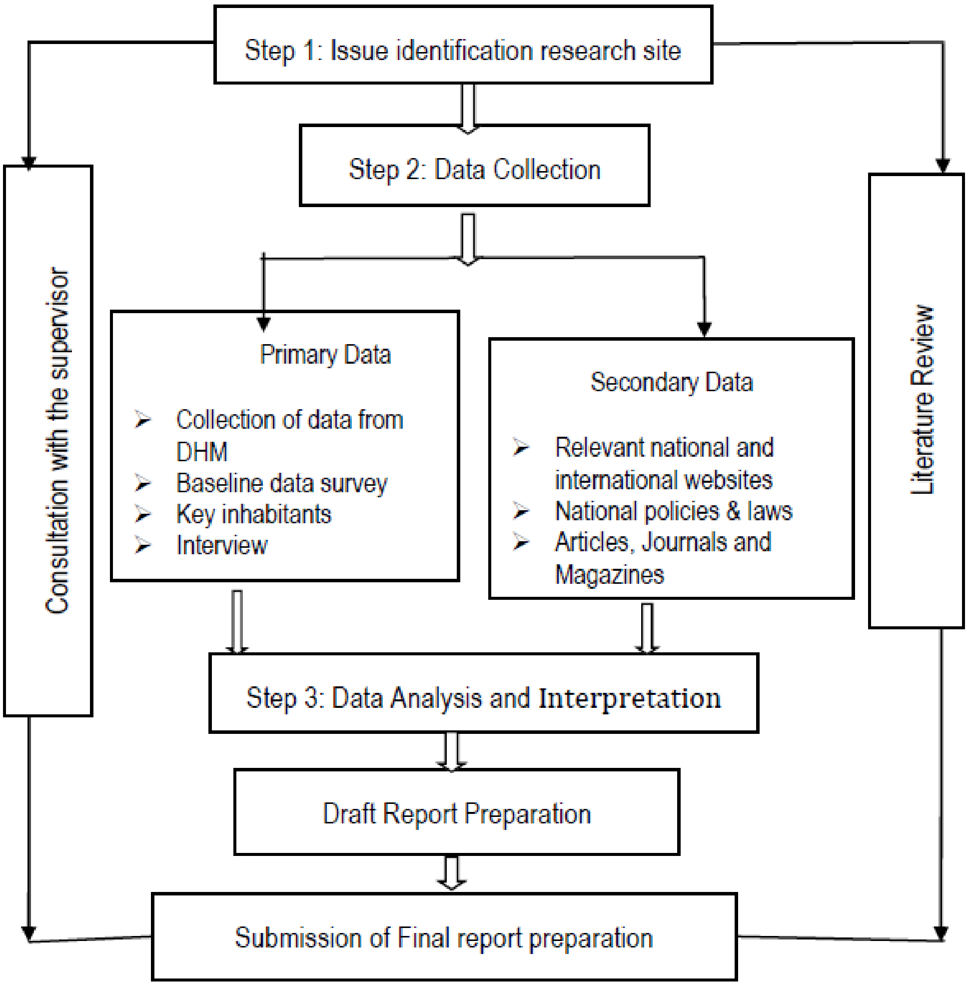

Figure 1 The overall procedure is expressed in flow chart.

Methodology

The field study was conducted in two stages: the preliminary visit was conducted in early October 2019 to find out the indexes and subcomponents to compute the Livelihood Vulnerability Index (LVI) and final field visit and interaction with community and relevant stakeholders was done in December 2019 to collect the required primary data and secondary data. The primary data was collected through Household survey, conducted on the base of random stratified sampling, by using 20% sample size (i.e. 182 sampled HHs out of total 922 HHs), for the comparative analysis of livelihood vulnerability Index (LVI) of flood prone zone within the Bagmati Corridor of Rautahat and Sarlahi district of Nepal. The data was collected from the households in all three belts using sample size formula with relevant to 2011 national census survey for all major components like Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Networks (SN), Financial Aspects (FA), Physical structure and Facilities (PSF) Health (H), Food (F), Water (W), Forest (F) and Natural Disasters and Climate Variability (NDCV) and completed with secondary data on rainfall and temperature (Figure 2). The sample size for household survey was calculated and completed by using the formula of sample size (n), (Arkin & Colton, 1963). At 5 percent significance level, estimation of standard error to be ± 0.05 and assuming the expected rate of occurrence of the attribute not less than 95 percent, the sample size for the semi-structured interview survey was estimated,

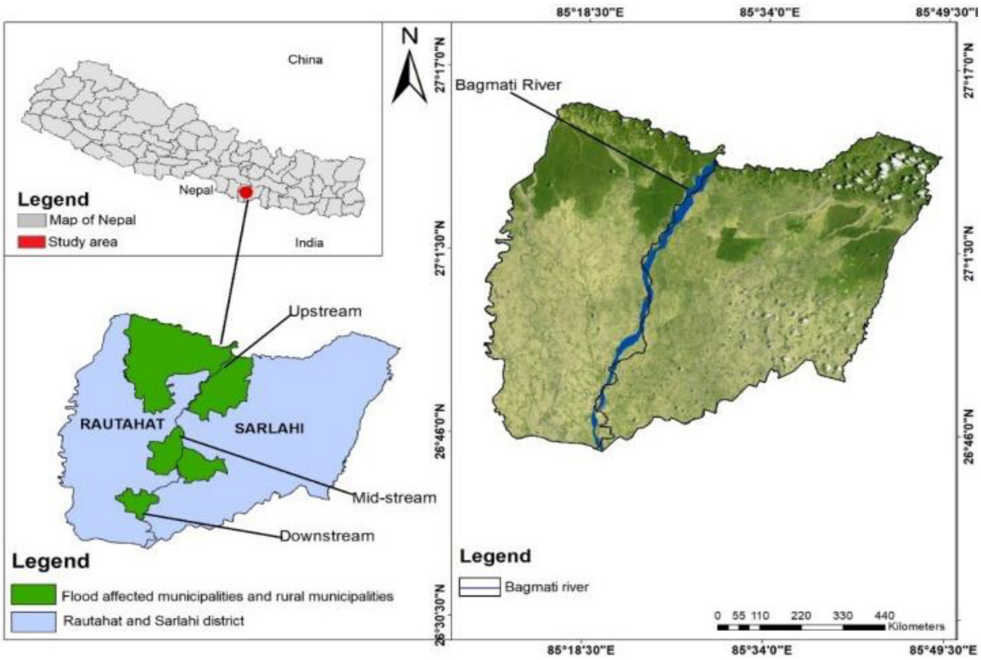

Figure 2 Study area.

$n = \left(NZ^2PQ\right) / \left(Ne^2 + Z^2PQ\right)$, Where, N= total no. of households (547)

Z= the value of standard variant at 95% confidence level (1.96)

e=Acceptable error (± 0.05)

P=the expected rate of occurrence of the attributes (95%, that is 0.95)

Q=the expected rate of non-occurrence of the attributes (100-95%=5%, that is 0.05)

Substituting the values in the above formula, we get desired values.

Two FGD (Focused Group Discussion) were conducted in each study division while overall 15 KII (Key Informants Interview) and personal interview was conducted with key stakeholders, representatives of Governmental and Non-governmental organization working in flood risk and disaster management sector. While conducting KII and FGD, both male and female were chosen who represented farmers, teachers, Government officer and representative, health worker, housewife, students etc. The data published by Central bureau of Statistics, relevant researches, papers journals, relevant national policies, available data from Municipality and Rural Municipality, ancillary data sources including available resource maps, GIS maps were studied and used as secondary information. During field study and survey, the focus was made to ensure gender perspectives and equal participation (Table 1).

Table 1 Study area and number of households according to CBS, 2011 and sample size

S.N.	Study section	Study area			Households (HHs) number	Total households number	Total samples size
		Settlement	Existing administrative division	Previous administrative division			
1	Up-stream	Gopalkuti	Chandrapur Municipality, Ward No.1, Rautahat	Paurai VDC, Ward No.1	255	498	67
		South Bagmati	Bagmati Municipality, Ward No. 12, Sarlahi	Karmaiya VDC, Ward No.4	243		
2	Mid-stream	Laxmipur	Gadhimai Municiaplity, Ward No. 3, Rautahat	Gamhariya VDC, Ward No. 8	85	208	57
		Manpur	Basbariya Rural Municiaplity, Ward No.2, Sarlahi	Manpur VDC, Ward No. 9	123		
3	Down-stream	Badarwa	Durgabhagwati Rural Municipality, Ward No. 2, Rautahat	Badharwa VDC, Ward No. 3	82	216	58
		Badarwa	Durgabhagwati Rural Municipality, Ward No. 5, Rautahat	Badharwa VDC, Ward No. 5	134		

Source: CBS (Central Bureau of Statistics), Nepal, 2011

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Livelihood vulnerability index (LVI) using hahn et al. 2009 with added components and subcomponents

This LVI assessment includes ten major components: Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Networks (SN), Financial Aspects (FA), Physical structure and Facilities (PSF) Health (H), Food (F), Water (W), Forest (F) and Natural Disasters and Climate Variability (NDCV). Each component comprises several indicators or sub-components. The indicators were developed based on a review of the literature, field analysis and expert consultation. The LVI uses a simple approach of applying equal weights to all major components. Each of the sub-components was measured on a different scale; therefore, it is first necessary to standardize them for comparability. The equation for standardizing numerical values is the same as that used in constructing the Human Development Index— HDI:

$$\text{IndexS}=\frac{S-S_{\min}}{S_{\max}-S_{\min}} \quad \text{(I)}$$

Here,

S= Original sub-component

S_{max}-S_{min}= maximum and minimum values reflecting low and high vulnerability

An index for each major component of vulnerability was created by averaging the standardized sub-components i.e.

$$M_i=\frac{\sum_{i=1}^{n} indexS_i}{n} \quad \text{(II)}$$

Here,

M_i= 0ne of the seven major components

S_i= sub components, indexed by i

n= number of subcomponents in each major components

Once values for each of the seven major vulnerability components for a site are calculated, they were averaged using equation:

$$LVI=\frac{\sum_{I=1}^{n} W_{m_i} M_i}{\sum_{i=1}^{8} W_{m_i}} \text{ which can be expressed as}$$

$$LVI=\frac{W_{SDP}SDP+W_{LS}LS+W_{SN}SN+W_{FA}FA+W_{PSF}PSF+W_{H}H+W_{F}F+W_{W}W+W_{FR}FR+W_{NDCV}NDCV}{W_{SDP}+W_{LS}+W_{H}+W_{SN}+W_{FA}+W_{PSF}+W_{F}+W_{W}+W_{FR}+W_{NDCV}} \quad \text{((III)}$$

Where,

LVI = Livelihood Vulnerability Index

W_{m_i} = Weights of each major components

M_i =Each major component

The weights of each major component, Wmi, are determined by the number of sub-components that make up each major component and were included to ensure that all sub-components contribute equally to the overall LVI (Hahn et al., 2009). In this study, the LVI was scaled from 0 (least vulnerable) to 1 (most vulnerable). This index is easier to compute because with the exception of precipitation and temperature data, it uses primary data from households. The precipitation and rainfall data, used in this study, was obtained from Department of Hydrology and Meteorology (DHM).

Calculation of LVI–IPCC: IPCC framework approach: After the calculation of LVI using Hahn et al.[1] method, an alternative method was used for calculating the LVI with incorporated as IPCC vulnerability definition. Ten components in the LVI-IPCC framework and sub-components outlined below as well as equations were used to calculate the LVI-IPCC.

Category of major components into IPCC contributing factors to vulnerability:

a. **Exposure:** Natural disasters and climate variability
b. **Adaptive capacity:** Socio-demographic Profile; Livelihood Strategies; Social Networks; Financial Aspects; Physical Structure and Facilities
c. **Sensitivity:** Health; Food; Water; Forest

The LVI–IPCC diverges from the LVI when the major components are combined. Rather than merge the major components into the LVI in one step, they are first combined according to the categorization scheme in below table using the following equation:

$$CF=\frac{\sum_{i=1}^{n} W_{M} M_i}{\sum_{i=1}^{8} W_{M}}$$

Where

CF = Contributing Factor

W_M = Weight of each major component

M_i = Major component indexed by i

n= number of major components in each contributing factor

Once exposure, sensitivity and adaptive capacity were calculated, the three contributing factors were combined using the following equation:

$$\mathbf{LVI-IPCC}=(e-a)*S$$

Where

LVI-IPCC = LVI expressed using the IPCC vulnerability framework

e = exposure a = adaptive capacity s = sensitivity

The scale of the LVI-IPCC ranges from: -1 (least vulnerable) to 1 (most vulnerable).

Risk calculation has been done in this research as follows

Risk = Hazard X Vulnerability or R = H X V

Weighing and aggregating Hazards is done identically as with of indicators of vulnerability

$$H=\frac{\sum_{i=1}^{8} S_i}{n}$$

Indicating S = all the sub component of major components So,

	Up stream	Mid stream	Down stream
Sum of Indicators Values	15.473	27.192	28.817
Sum of all sub components	55	55	55
Hazards	0.281	0.494	0.524
Vulnerability	0.323	0.506	0.528
Risk	0.09	0.25	0.277

The risk value 0 indicates the lowest risk while 1 indicates the highest risk of flood.

Statistical analysis of data

Statistical analysis of data was carried out after coding questionnaires in excel sheet. Statistical analysis was undertaken. The comprehensive analysis result with all findings has been presented in Annex 1 section of this paper. It can be referred for integrated data purpose.

In this study, to assess the LVI of households, data were collected from 3 belts (Up-stream, Mid-stream and Down-Stream) on the basis of 10 components (namely: Socio-demographic Profile, Livelihood, Social Networks, Financial Aspects, Physical Structure, Health, Food, Water, Forest and Natural Disasters & Climate Variability) with 55 sub-components which are presented in Annex I. The vulnerability indices of the major components ranged from 0 to 1 as shown in Annex. The 0 indicates the least vulnerable while the 1 indicates the most vulnerable. In the following section, vulnerability assessments are analyzed and described in details of major components with all three belts.

Results and discussions

Socio-demographic considerations

The indexed values of socio-demography were of up-stream, mid-stream and down-stream were assessed considering 7 sub-components. The estimated highest average value of the community of down-stream with 0.406 which was followed by mid-stream with 0.354. However, the highest indexed value was 0.965 of community living to midstream but the least indexed value was 0.015 at upstream. The performance of Kruskal Wallis test showed that there was no significance difference in indexed value of socio-demography of local community living at up-stream, mid-stream and down- stream. The overall result has been presented in Table 2 below. The estimated rank showed very close indexed value of community living at down- stream and mid- stream with 12.64 and 12.79 respectively but it was around 41% less (7.57). In comparison to three belts, the socio-demographic profile of Upper belt (0.157) was found to be less vulnerable than compared to the Middle belt (0.354) and lower belt (0.359). The one major variance is due to the dependency ratio, which is directly proportional to family size, leading smaller the family size, less the dependency ratio in this case. The upper belt (0.115) has a lesser dependent population than other counterparts (Middle belt: 0.265 and lower belt: 0.359). So, in terms of dependency ratio lower belt is most vulnerable compared to the middle belt and upper belt. The upper belt (0.328) respondents reported a lesser proportion of head of the family did not attend the school comparing to very high of the middle belt (0.965) and lower belt (0.877). Similarly, female-headed household of the upper belt (0.104) is also low comparing to the middle belt (0.211) and lower belt (0.193). The infant Mortality rate is the same between the middle belt and lower belt of having values of 0.123 each and is highly vulnerable to the upper belt (0.015). The 7% of Middle belt households reported raising orphans followed by a lower belt (0.035) and upper belt (0.03).

Table 2 Socio-demographic considerations

Sub-Components	Up-Stream		Mid-Stream		Down-Stream	
	Value	Indexed	Value	Indexed	Value	Indexed
Dependency Ratio(<15 years and >65 years)	1.836	0.115	4.246	0.265	4.596	0.287
Percent of female-headed households	10.4	0.104	21.1	0.211	19.3	0.193
Percent of households where head of household has not attended school	32.8	0.328	96.5	0.965	87.7	0.877
Percent of households with orphans	3	0.03	7	0.07	3.5	0.035
Percentage of HHs where member had no formal or informal skills	26.9	0.269	45.6	0.456	59.6	0.596
Average Family size	7.014	0.24	9.67	0.386	10.14	0.406
Infant Mortality Rate	1.5	0.015	12.3	0.123	12.3	0.123
Average value	11.921	0.157	28.059	0.354	28.162	0.36
Mean rank difference						
Kruskal Wallis test	No significant difference at 95% confidence level (P=0.201)					

The education level of household head was found to be important determinant of resilience. Household heads with higher levels of education have a better level of planning, access and effectiveness of early warning information from different sources, better reactions and rehabilitation skills during and after natural shocks, alter agricultural operation and adopt extension strategies. Hence, education is one of the key factors in building the resilience level of households to induced shocks (flood). The findings show that percentage value and indexed figure on families not attended school was higher (87.7 and 0.877) in downstream and lower in upstream (32.8 and 0.328). Similarly, findings show that the percentage of family's members had no formal or informal skills were higher (59.6) in down steam and lower (26.9) in upstream. The households with educated house head had small size of population as well as shows lower level of dependency. This shows that education level is inversely proportional to dependency level of households in the belt. Thus, decrease in dependency level of households helps to increase the education level of households. Furthermore, in belts where level of education was low, formal and informal skill levels were also low. As per the study conducted by Morgan et al. (2009), the children with low socio-economic stats develop academic skills slower than children from higher socio-economic status groups. For instance, low socio-economic status in childhood is related to poor cognitive development, language, memory, socio-emotional processing and poor income and health in adulthood. This may increase the future vulnerability too. It was explored from the study that community people living in down-stream were more vulnerable and facing high risk to floods in compare to up-stream.

Livelihood aspect

The estimation of indexed values for livelihood component considers 7 sub-components. The estimated average indexed values of this component of the community living up-stream, mid-stream and down-stream were 0.358, 0.493 and 0.483 respectively. The Kruskal Wallis test showed that there was no significance difference in these average value at 955 confidence level since P-value was 0.445 (greater than 0.05). However, the mean rank value showed similar values 12.07 and 12.36 of community living at mid-stream and down-stream respectively but it was around 31% (8.57) less of up-stream. In the context of livelihood, the Middle belt is found to be more vulnerable than the other two belts. The overall result of livelihoods aspect has been presented in Table 3 below. The average within the sub-components of Middle belt is 0.493, followed by a lower belt (0.483) and Upper belt (0.358). In the context of Nepal, the percentage of household working in a different community reflects the community is more sustainable and resilience than depending on their locality. The percentage of household not working in the different community is low in the upper belt (0. 687) followed by a middle belt (0.702) and lower belt (0.789). Similarly, unemployment was highest in the Middle belt (0.825) than in lower (0.544) and Upper belt (0.239). This is because of Upper belt is more developed and connected with national highway making them more dependent on their own small business or job opportunity to nearby governmental organizations or other organization. Along with it, the lower belt is nearby Gaur, headquarter of Rautahat district may have led to some opportunity of earning. With most people were unemployed in the middle belt had led them to agriculture dependent. The Middle belt (0.298) has the population highly dependent on agriculture than upper (0.170) and lower belt (0.211). The population dependent solely in agriculture is more vulnerable. Similar findings reported that farmers were more vulnerable than others occupation (like jobs and other business) as the findings reflect that the average agriculture livelihood diversification index was low (0.274) in down-steam and high (0.343) in up-stream. The percentage farmers of changing the sowing and cropping schedule found to be similar though middle (0.246) had slightly lower values than the upper (0.299) and lower belts (0.298). This also means middle settlements are more vulnerable. Being the middle belt agriculture-dependent (farmers) had made them less vulnerable in terms of agricultural livelihood diversity index as they had been sowing more variety of crops to sustain their life. The value of household reporting loss of livestock of the upper belt is very low i.e. 0.06 comparing to the other counterparts (0.333 and 0.439).

Table 3 Livelihoods aspect

Sub-Components	Up-Stream		Mid-Stream		Down-Stream	
	Value	Indexed	Value	Indexed	Value	Indexed
Percent of households with family member not working in a different community	68.7	0.687	70.2	0.702	78.9	0.789
Percent of households dependent solely on agriculture as a source of income	17.9	0.179	29.8	0.298	21.1	0.211
Percentage of households without jobs	23.9	0.239	82.5	0.825	54.4	0.544
Percentage of households with no training to enhance livelihood	70.1	0.701	78.9	0.789	82.5	0.825
Percentage of households changed their sowing and cropping schedule	29.9	0.299	24.6	0.246	29.8	0.298
Percentage of households reported loss of livestock	6	0.06	33.3	0.333	43.9	0.439
Average Agricultural Livelihood Diversification Index	34.4	0.343	25.8	0.258	27.4	0.274
Average value	36.083	0.358	53.217	0.493	51.767	0.483
Mean rank values						
Kruskal Wallis test	Significance value (P-value) 0.445					

The percentage of households with no training to enhance livelihood is highest in the lower belt (0.825) than in the middle (0.789) and upper belt (0.701) because trainings and capacity building efforts and enterprise development activities on livelihood enhancement were less in lower belt than upper and middle belt. Similarly, people in lower belt had limited awareness and livelihood opportunities than upper belt. Most of these family members were expatriate in developed places like cities, India or in other foreign countries for employment and this is supported by various findings where such migration for income has been studied (Gautam 2017). This may lead to higher income sources which can be implemented in livelihood development or maintaining health and other facilities. There might be the probability of increase in vulnerability of these households to external stress since household members may return with certain social vices or health challenges. Some family members do however remit to their households. The long-standing survival practices like growing crops, raising animals, collecting natural resources etc. had been decreasing as most of the peoples are practicing other livelihoods practices rather than depending on the agriculture and shifted or interested towards the new survival strategies (Tamang et a. 2014). Along with the wiping of the fertile lands by flood had decreased the fertility of the soil and dependency on new version of seeds in every session had made the farmers life miserable. Along with dependency in costly marketed artificial fertilizers rather than natural fertilizers were major reasons on decreasing fertility of soil as well as separating from the agriculture practices in these areas. Infertility and dispossession of land as well as dependency on primary irrigation facilities have made the situation even worse. Unskilled labors are left with no opportunities to earn, and hence, migrate to other areas. The outmigration of people in order to earn a wage helps them to sustain their livelihood (Gautam 2017, Tamang et a. 2014). The effective training with use of local resources to enhance agriculture which may lead to uplifting of livelihood is the most required strategies in this area where the abundance of agricultural land is available.

Social network component

The social network component considers five sub-components to estimate the indexed values of livelihood vulnerability index. The average indexed values were 0.298, 0.590 and 0.547 of local community living at u-stream, mid-stream and down-stream respectively. Statistically, Kruskal Wallis test showed that, there was no significant difference in indexed values of social network component at 95% confidence level (P-value=0.523) however, the rank value of mid-stream and down-stream were very similar with 9.30 and 8.50 respectively while it was about 33 percent less of the community living at upstream with 6.30. Thus, here also the community living at up-stream is more vulnerable. The overall result of social network component has been presented in Table 4 below. While, average receive and give ratio is found to be a similar, the upper belt (0.92) found slightly to be more vulnerable comparing to lower belt (0.839) and least of the middle belt (0.811). The percentage of households that had not gone to their local government for assistance in the past 12 months is very low in upper belt i.e. 0.328 followed by the middle belt (0.590) and lower belt (0.702). The households that had not received any helps due to flood are minimum in the Upper section (0.179) while the middle (0.86) and the lower section (0.404). There were very few people who were not involved in any organization in the upper belt (0.06) while in middle belt had 0.737 and lower had 0.754. Similarly, there is no house which has no communicable devices at home in the upper belt while middle and lower belt had the same value of 0.035 which is very negligible.

It can be argued that social systems play a prominent role in human vulnerability to hazards is central to the idea of social vulnerability. A good social networking mostly lessens the impact of stresses on individual households. The average receives give ratio was negligible in upper belt means there is proper harmony between the neighbors while the ratio has been slightly higher in middle and lower belt means the social harmony is unconventional. This might be due to high illiteracy, poverty creating maintaining of their daily life is difficult for their own. The help seeking from the government was relatively high in all belts reflects that either the government were not able to fulfill the needs of the people or there is more dependency among the people towards the government. Most households are more comfortable soliciting assistance from friends and relatives than from local authorities. This may lead to unsustainability in society creating more chaos. The unbalance between the government and people can be easily separated from the assistance received from the government by households. These results indicate a need for strengthening community networks and local organizations such as Woman Union, Farmer Associations etc. at the village level to reduce social network vulnerability. With the advancement of technology, at least the peoples can be aware of the ongoing circumstances through dependence on communicative devices.

Table 4 Social network component

Sub-Components	Up-Stream		Mid-Stream		Down-Stream	
	Value	Indexed	Value	Indexed	Value	Indexed
Average Receive: Give ratio	92	0.92	81.1	0.811	83.9	0.839
Percent of households that have not gone to their local government for assistance in the past 12 months	32.8	0.328	50.9	0.509	70.2	0.702
Percentage of HHs not receiving helps due to flood	17.9	0.179	86	0.86	40.4	0.404
Percentage of HHs that have not been member of any organization	6	0.06	73.7	0.737	75.4	0.754
Percent of HHs have no communicative devices (TV, radio, mobile etc.) at home	0	0	3.5	0.035	3.5	0.035
Average value	29.74	0.298	53.525	0.59	47.375	0.547
Mean rank values	were 6.30, 9.30 and 8.50 of up-stream, mid-stream and down-stream respectively					
Kruskal Wallis test	Significance value (P-value) 0.523					

Financial component

Financial component considers five major sub-components to estimate the vulnerability index. The average values of financial component were 0.495, 0.612 and 0.686 of the community living at up-stream, mid-stream and down-stream respectively. Kruskal Wallis test showed that, there was no significance difference in indexed value of financial component. In terms of financial aspects, Upper belt (0.495) is found to be less vulnerable than lower (0.671) and middle belt (0.612). The overall result of financial component has been presented in Table 5 below. The average borrows lend ratio was found to be higher in Upper belt i.e. 0.724 followed by a lower belt (0.671) and middle belt (0.591). The households who do not have access to financial services to any financial institution is less in the upper belt while there is drastic high in the middle belt (0.544) and lower belt (0.614). The percentage of household not working in the different community is low in the upper belt (0. 687) followed by the middle belt (0.702) and lower belt (0.789).

Table 5 Financial component

Sub-Components	Up-Stream		Mid-Stream		Down-Stream	
	Value	Indexed	Value	Indexed	Value	Indexed
Average Borrow: Lend Money ratio	72.4	0.724	0.591	0.671		
% of households do not have access to financial services to any financial institution	7.5	0.075	54.4	0.544	61.4	0.614
% of households do not have any family members working outside the village at relatively developed place	68.7	0.687	70.2	0.702	77.2	0.772
Average value	49.533	0.495	62.3	0.612	69.3	0.686
Mean rank values						
Kruskal Wallis test	No significance difference since P value was 0.670 (less than 0.05)					

This result has been supported substantiating income generation activity constituting livelihoods triggers the safety (Khatwada et al. 2017, Gentle and Maraseni 2012) and households borrowing more money than they lend are more vulnerable.[1] The society with certain prosperous households and many dependent in these households enhance the financial vulnerability. This is the exact situations of the middle belt and lower belt enhancing poverty and expatriate. Most of them even do not have access to financial services and institutions which might reduce the vulnerability of society.

Physical structure

Average indexed value of physical structure was recorded as the highest of community living at down-stream with 0.764 but it was the lowest of the community living at up-stream with 0.245. Statistically, Kruskal Wallis test showed that, there was no significant difference in mean value of indexed value of the community living at up-stream, mid-stream and down-stream since P value was slightly greater than 0.05 (i.e. 0.06). However, the mean rank values were 6.50, 13.57 and 12.93 of the community living at upstream, mid-stream and down-stream respectively. The overall result of physical structure has been presented in Table 6 below. The percentage of households without solid houses were less in the upper belt (0.433) followed by a lower belt (0.914) and middle belt (0.982). The percentage of households affected by floods are highest in the lower belt (0.897) followed by the middle belt (0.860) and very low of the upper belt (0.045). Similarly, the households whose land is damaged by flood is 100% in the lower belt followed by a middle belt by 96.5% and just 26.95% was damaged of the upper belt. The percentage of households without access to critical facilities was highest in the middle belt (1) followed by a lower belt (0.862) and the lowest of the upper belt (0). There is every emergency response facilities in upper belt meaning less vulnerable while the middle belt (0.404) were more vulnerable than the upper belt and most vulnerable is a lower belt (0.655). There was access to the road for all responses of the upper and middle belt but slightly 0.052 of the lower belt doesn't consist of road. Overall insurance of property is very low in all the belts as all of the responses of the middle belt had not done insurance while 97% of upper belt and 96.5% of the lower belt had not done insurance of the property. With an overall average of these subcomponents of physical structure major component, Lower belt (0.764) is most vulnerable, following the similar value middle belt (0.744) was vulnerable than upper belt (0.245).

Table 6 Livelihoods aspect

Sub-Components	Up-Stream		Mid-Stream		Down-Stream	
	Value	Indexed	Value	Indexed	Value	Indexed
Percentage of households without solid house	43.3	0.433	98.2	0.982	91.4	0.914
Percentage of households with house affected by Floods	4.5	0.045	86	0.86	89.7	0.897
Percentage of households whose Land is damaged by flood	26.9	0.269	96.5	0.965	100	1
Percentage of households without access to critical facilities (Health post and water treatment plant.)	0	0	100	1	86.2	0.862
Percentage of households with access to emergency response (police, social community clubs, flood rescue center etc.)	0	0	40.4	0.404	65.5	0.655
Percentage of households with no access to road	0	0	0	0	5.2	0.052
Percentage of households without property Insurance	97	0.97	100	1	96.5	0.965

Table Continued...

Sub-Components	Up-Stream		Mid-Stream		Down-Stream	
	Value	Indexed	Value	Indexed	Value	Indexed
Average value	24.529	0.245	74.443	0.744	76.357	0.764
Mean rank values	6.50, 13.57 and 12.93 of up-stream, mid-stream and down-stream respectively					
Kruskal Wallis test	P-value=0.06					

Most of the housing structure of the belts is made of the mud, wood or bamboo. These houses are not resistant to flood hazards. The dwellers were unable to build the hazard resistant houses due to the severe poverty. Every year the flood destruction occurs, their property damages and rebuilds the structure aftermath. This scenario had increased the vulnerability in this region. Similar is the case in terms of land, flooding had degraded the fertility of the soil. They had diverse the regular crops with new varieties. Though they had diverse the crops, the productivity is less leading to panic situations. The lack of critical facilities like health post, water treatment plant along with emergency responses like police, social community clubs, and rescue center had added the vulnerability. The insurance of the property can reduce the vulnerability of the society as local authorities and other concerned authorities can implement the right insurance policy to enhance the livelihood of the society.

Access to health facility

The indexed value of the access to the health in up-stream, mid-stream and down-stream was varying. It was the highest to the community living at down-stream with 0.464 while it was the lowest for up-stream with 0.196. Statistically, Kruskal Wallis test showed that, there was significance difference in mean value of health component of the community living at up-stream, mid-stream and down-stream at 95% confidence level since P-value was 0.033. The overall result related to access to health facility has been presented in Table 7 below. Moreover, the lowest rank was recorded around 6.71 at upstream and it was the highest 15.36 at down-stream and followed by 10.93 at mid-stream. Looking analytically, the major components of Health are made up of 7 components. When all the sub-components value was aggregated, the lower belt was found to be most vulnerable (0.464) following the middle belt (0.325) and as well the upper belt is least vulnerable (0.196). The average time taken to reach health facility is highest for the lower belt (0.404) trailed by the middle belt (0.155) and with least distance is of the upper belt (0.045). In the lower belt, households with chronic disease are highest (0.379) compared to the middle belt (0.325) and upper belt (0.284). More the households in the lower belt (0.345) reported that the family member had to miss the work or school due to illness in one month compared to negligible of the upper belt (0.075) and middle belt (0.053). The average disease exposure prevention index is highest of the lower belt (0.53) followed by the middle belt (0.228) and the upper belt is only 0.054. All the respondents of the upper belt had a toilet in their houses while 41.4% of lower belt and 22.8% of middle belt respondents had no toilets in their houses. In terms of child delivery and immunization, very less percentage of households was not having proper facilities for child delivery and immunization in the upper belt (0.03) but in the lower belt (0.155) and of the middle belt (0.298) had bizarre status. The percentage of households with no health insurance is 100% in the middle belt followed by a lower belt (0.966) and of the upper belt (0.881).

Table 7 Access to health facility

Sub-Components	Up-Stream		Mid-Stream		Down-Stream	
	Value	Indexed	Value	Indexed	Value	Indexed
Average time to health facility (in minute)	10.22	0.045	22.81	0.155	57.707	0.458
Percent of households with family member with chronic illness	28.4	0.284	31.6	0.316	37.9	0.379
Percent of households where a family member had to miss work or school in the last 2 weeks due to illness	7.5	0.075	5.3	0.053	34.5	0.345
Average Disease Exposure*Prevention Index (Modified)	0.054	0.228	0.53			
Percent of households without Toilet	0	0	22.8	0.228	41.4	0.414
Percentage of households not receiving proper facilities for child delivery and immunization	3	0.03	29.8	0.298	15.5	0.155
Percent of households without Health Insurance	88.1	0.881	100	1	96.6	0.966
Average value	22.87	0.196	35.385	0.325	47.268	0.464
Mean rank values						
Kruskal Wallis test	P-value=0.033					

Inadequate access to health services tends to decrease the health status of community resulting increase in sickness, thereby increasing their vulnerability to extreme events in middle and lower belt. However, the upper belt reported the least households with ill health as a result of better livelihood options and private health facilities. The family members with chronic disease is high due to unhygienic and carelessness in living style. The greater health index is caused by higher proportion of households with family member getting illness due to flood reflecting to disease like dysentery, diarrhea, dermatic disease etc. these finding suggests that these diseases may have negative impact on household income limiting of number of healthy workdays. A large number of households do not treatment in government and private hospitals and did not have access to proper facilities for child delivery and immunization.

Food component

The food is another key component which considers five sub-components to estimate the livelihood index. The average indexed values were 0.339, 0.458 and 0.498 of the community living at up-stream, mid-stream and down-stream respectively. Statistically, Kruskal Wallis test showed that there was no significance difference in indexed values of food component of community living at upstream, mid-stream and down-stream since P-value was 0.471. The overall result of food component has been presented in Table 8 below. The mean rank values were 6.0, 8.90 and 9.10 at upstream, mid-stream and down-stream respectively. Comparatively, the population dependent on agriculture is decreasing where plenty of lands (fallow land) is available. In the upper belt, only 13.4% are dependent in agriculture, followed by 29.8% in the middle belt, and 19% in the left belt. The average number of months struggle for food was very similar in the middle belt (4.05 months) and the lower belt (4.04 months) and very low of the upper belt (1.45 months). All of the households in lower belt reported of not saving foods while in the middle belt, 86% do not save foods for future and in the upper belt, 77.6% do not save foods for future. Similarly, the households not saving seeds are highest in the lower belt (0.638), followed by the upper belt (0.488). This means middle belt (0.456) is the least vulnerable in this sub-components but in terms of Crop diversity index, the middle belt is most vulnerable (0.270), followed by the lower belt (0.259) and upper belt (0.145).

Table 8 Food component

Sub-Components	Up-Stream		Mid-Stream		Down-Stream	
	Value	**Indexed**	**Value**	**Indexed**	**Value**	**Indexed**
Percent of households dependent on family farm for food	13.4	0.134	29.8	0.298	19	0.19
Average number of months households struggle to find food	1.806	0.15	4.859	0.405	4.844	0.404
Average Crop Diversity Index	1.58	0.145	1.351	0.27	1.034	0.259
Percent of households that do not save crops	77.6	0.776	86	0.86	1	1
Percent of households that do not save seeds	48.8	0.488	45.6	0.456	63.8	0.638
Average value	28.637	0.339	33.522	0.458	17.936	0.498
Mean rank value	6.0, 8.90 and 9.10 at upstream, mid-stream and down-stream respectively					
Kruskal Wallis test	P-value= 0.471					

They percentage of family totally dependent in agriculture farm is decreasing, leading to the more barren land, and increasing the infertility of the soil. It is due to the migration and preference for non-agricultural works and similar findings have been also observed by another empirical research (Chapagain and Gentle 2015). This decreases the productivity of the community leading to vulnerable society. The trend also shows of not saving crops and seeds for future. The lack of irrigation facilities in farmland and the more impact in rainy season had been another major concerns. Simultaneously, crop diversity also decreases. Not only this, leaving the agricultural land barren and engaging in other temporary incoming sources lead to the struggling to find food for months. Along with, poor households are usually landless or small farm people facing financial deficit leading to increase in vulnerability.

Water resource component

The availability (access & utilization) of water resource component considers six sub-components to estimate the livelihood vulnerability index. The estimated average indexed values were 0.167, 0.362 and 0.366 of the community living at up-stream, mid-stream and down-stream respectively. Statistically, Kruskal Wallis test showed that, there was no significance different in indexed values of this component of community living at upstream, mid-stream and down-stream since P-value was 0.335. The overall result of water resource management has been presented in Table 9 below. The mean rank values were 6.92, 10.75 and 10.83 at upstream, mid-stream and down-stream respectively. In terms of access & utilization of water, the lower belt recorded the highest percentage of water conflict (0.931) in compare to the middle belt (0.772) and upper belt (0.701). No households' in all belts use natural water sources for drinking purposes. The percentage of households without water filter is very similar in the middle belt and lower belt (0.877 & 0.879) and only 16.42% of households of the upper belt had no filters in their home. Most of the household's water sources were within the minutes. All of the response's houses had consistent water supply in the upper belt while 31.6% of households in the middle belt does not have consistent water supply while 19% does not have in lower belt. The more the water they store less they will be vulnerable. Upper belt stores the highest amount of water i.e. 7.269l, followed by middle belt i.e. 5.719l and lowest at the lower belt by 5.12 l. After aggregating these sub-components of water, we can conclude that the lower belt (0.366) and middle belt (0.362) are more vulnerable to the upper belt (0.167).

These areas always had conflict with government in terms of flood consequences and management. The dwellers react as government had done nothing for them but believe that nongovernmental organization had supported them. The average time taken to reach a water source is found to be negligible as almost all of the households had the hand pumps, wells etc. Most of the households the hand pumps are 25 feet depth resulting them undrinkable but had consistent water. The water is consistent, so they store the water less as used for kitchen proposes. The hand pump water is undrinkable still most of the households in lower and middle belt does not have filter to water or even they do not boil it. With explanation from above, it clears that risk of water borne disease is high which can lead to less productive days risking to economic as well as health vulnerability.

Table 9 Water resources

Sub-Components	Up-Stream		Mid-Stream		Down-Stream	
	Value	Indexed	Value	Indexed	Value	Indexed
Percent of households reporting water conflicts	70.1	0.701	77.2	0.772	93.1	0.931
Percent of households that utilize a natural water source	0	0	0	0	0	0
Average time to water source	30	0	33.68	0.033	30	0
Percent of households without water filter	16.42	0.164	87.71	0.877	87.93	0.879
Percent of households that do not have a consistent water supply	0	0	31.6	0.316	19	0.19
Inverse of the average number of liters of water stored per household	7.269	0.137	5.719	0.174	5.12	0.195
Average value	20.632	0.167	39.318	0.362	39.192	0.366
Mean rank value	6.92, 10.75 and 10.83 at upstream, mid-stream and down-stream respectively					
Kruskal Wallis test	P-value= 0.335					

Forest resource availability

The availability of the forest resource considers three major sub-components to estimate the livelihood vulnerability index. The average indexed values were 0.797, 0.753 and 0.494 of the community living at up-stream, mid-stream and down-stream respectively. Statistically, Kruskal Wallis test showed that, there was no significance difference in mean value of this component of the community at up-stream, mid-stream and down-stream at 95% confidence level since P-value was 0.670. The overall result forest resource availability has been presented in Table 10 below. The mean rank values were 4,5 and 6 of the community living at up-stream, mid-stream and down-stream. The percentage of households using a forest-based product is highest in the upper belt (0.948) followed by a middle belt (0.877) and of the lower belt (0.731). The distance to travel the forest products is highest in the lower belt (0.257) followed by the middle belt (0.1629) and upper belt (0.0647). So, in terms of forest components, lower belt (0.494) is more vulnerable than the upper belt (0.797) and middle belt (0.753) who had similar values.

Table 10 Food resources availability

Sub-Components	Up-Stream		Mid-Stream		Down-Stream	
	Value	Indexed	Value	Indexed	Value	Indexed
Percentage of households using only Forest-based energy for cooking purpose	94.8	0.948	87.7	0.877	73.1	0.731
Average time to fetch firewood	6.47	0.0647	16.29	0.1629	25.68	0.257
Average value	50.635	0.7975	51.995	0.753	49.39	0.494
Mean rank value	4, 5 and 6 at upstream, mid-stream and down-stream respectively					
Kruskal Wallis test	P-value= 0.670					

The main source of energy for cooking is forest based. The distance they had to cover to collect the fire wood is significantly high in lower belt, so they used to buy with wood venders who come to their locality. These wood venders are also not regular and had severe problems in rainy days and flood hazard period. They had severe problems in this period to have cooking food. So, people in lower belts are more vulnerable to middle and upper belt in terms of forest resources component (access and utilization). This issue has been discussed in various forms (Nagendra 2002, Iversen et al. 2006).

Natural disasters and climate variability

Risk of natural disaster and climate variability are another important component of vulnerability index. The indexed value was calculated considering six important sub-components. The estimated value of this component was the highest at down-stream with 0.579 while this was the lowest at up-stream with the 0.292. Statistically, Kruskal Wallis test showed that, there was no significance difference in mean value of this component of the community at up-stream, mid-stream and down-stream at 95% confidence level since P-value was 0.140. The overall result of natural disaster and climate variability has been presented in Table 11 below. The mean rank values were 6.17, 10.17 and 12.17 of the community living at up-stream, mid-stream and down-stream. In the sector of natural disasters and climate variability, lower belt (0.579) is most vulnerable. The middle belt had slightly less value indicating is less vulnerable than the lower belt (0.5) but more vulnerable than the upper belt (0.291). The flood event is more frequent in the middle belt (0.987) and lower belt (1) and very less at the upper belt (0.211). The majority of households in the lower belt (0.724) and middle belt (0.684) did not receive a warning about impending natural disaster however this percentage is low in the upper belt (0.179). The highest number of households to report injury or death in the last 6 years are lower belt (0.552) followed by the middle belt (0.228) and upper belt (0.03). The mean standard deviation of the maximum temperature of the upper belt (0.530) shows middle and lower belt having the same value of 0.37 is less vulnerable. Similar is the case of the minimum temperature of the upper belt (0.57) is most vulnerable compare to the middle and lower belt of having the same value of 0.47. The mean standard deviation of average precipitation differs from the above cases, lower belt is most vulnerable (0.36) followed by middle belt (0.28) and least vulnerable is upper belt.

Table 11 Natural disaster and climate variability

Sub-Components	Up-Stream		Mid-Stream		Down-Stream	
	Value	Indexed	Value	Indexed	Value	Indexed
Average number of flood events in the past 6 years	1.268	0.211	5.807	0.968	6	1
Percent of households that did not receive a warning about the pending natural disasters	17.9	0.179	68.4	0.684	72.4	0.724
Percent of households with an injury or death as a result of the most severe natural disaster in the past 6 years	3	0.03	22.8	0.228	55.2	0.552
Mean standard deviation of the average maximum temperature by month	1.19	0.53	5.37	0.37	5.37	0.37
Mean standard deviation of the average minimum temperature by month	5.71	0.57	6.47	0.47	6.47	0.47
Mean standard deviation of average precipitation by month	23.43	0.234	187.35	0.28	145.75	0.36
Average value	8.75	0.292	49.366	0.5	48.532	0.579
Mean rank value	6.17,10.175 and 12.17 at upstream, mid-stream and down-stream respectively					
Kruskal Wallis test	P-value=0.140					

The middle belt and lower belt are one of the major disaster-prone zones in terms of drought in summer, flood in rainy season and cold wave in winter. Though they consider flood as major shocks among all because they were able to resist the other disasters as they can get foods and can simply resist it but in flood, havoc increases with hunger, illness, anxiety etc. The majority of the dwellers in lower and middle belt do not receive the any warning. As mobile SMS system is provided to some households as they were unable to read and sometimes the police inform them, but it would be already late. This had led them to inadequate preparation. The meteorological data also shows that middle and lower belt recorded the more precipitation and also witnessed more variation in both maximum and minimum daily temperature. Due to the relatively similar geological regions, the appears to be little or no differences in both the middle and lower belt had similar ecological variability, however Upper belt is nearby Chure range have different ecological variation so difference can be observed.

After all, aggregating all the major components, Lower belt (0.515) was most vulnerable, followed by Middle belt (0.493). The least vulnerable in these 3 belts is Upper belt with value 0.306. The 7 major components like Socio-demographic Profile, Financial Aspects, Physical Structure, Health, Food, Water and Natural Disasters and Climate Vulnerability makes the Lower belt most vulnerable. Similarly, Middle belt had highest value in remaining 3 major components. These major components are livelihood, Social Networks and Forest. The upper belt had no major components with highest value leading them to least vulnerable (Figure 3).

Livelihood vulnerability index: Vulnerability assessment shows that livelihood vulnerability index was the highest 0.528 of the community living at down-stream and it was the lowest 0.323 of the community at up-stream. The value of this was 0.506 of the community living at mid-stream.

Livelihood vulnerability index using IPCC analysis (LVI-IPCC analysis)

The results of LVI-IPCC were similar to LVI, the most vulnerable belt is lower belt (0.038) followed by Middle belt (0.031). Vulnerability triangle plots the contributing factor results in livelihood vulnerability index IPCC approach. All of the three major contributing factors (i.e. adaptive capacity, exposure and sensitivity) of the IPCC vulnerability approach value were found to be higher in lower belt. The least vulnerable was Upper belt (0.009).

All the belts had highest exposure value means the households are controlled and regulated by the whims of nature. This had created the economically capable and better developed upper belt more adaptive to the stress of climate and flood forming to needs to cope with sensitivity's major components. The middle belt and lower belt are under poverty line had through the less adaptive to the stress from climatic exposure leading to weakening the sensitivity too.

The adaptive capacity of upper belt is lesser than its sensitivity. It reflects households of upper belt had better socio-economic status, livelihood with better housing structure. They had sufficient lands with better facilities to grow crops and can grow diverse crops within their land and even had better opportunities to job to uplift the livelihood. Then again lacks the proper health, water and food facilities. This means upper belt still has chances of increment in LVI if the health, water, food facilities are not improved, and alternative of forest products is implemented (Figure 4) (Table 12).

In the middle and lower belt, the utilization of agriculture land, increasing the productivity, better physical structure like housing is made than vulnerability can decreased as the values of sensitivity is lower than adaptive capacity. Although sensitivity value is lower than adaptive capacity, there is immense requirement of health, water and food facilities. The food required can be fulfilled if the flood interruption can be managed. The lack of nutrition and undrinkable water had caused more illness where proper health facilities are lacking creating the more vulnerable belts. The uses of multiple indicators that relating to exposure and adaptive capacity that determines the sensitivity of the future impacts. This understanding with different indicators and their correlation with other indicator can contribute in national policy advisors and concerned required practitioners. The LVI provides a method for identifying points of intervention for tracking the potential impacts of climate change by presenting sectorial vulnerability scores in addition to the overall composite index. And finally, by visually presenting the index, we will be able to rapidly assess the contributing components of vulnerability in way that otherwise would not be apparent if utilizing solely tabular data (Hahn 2008).

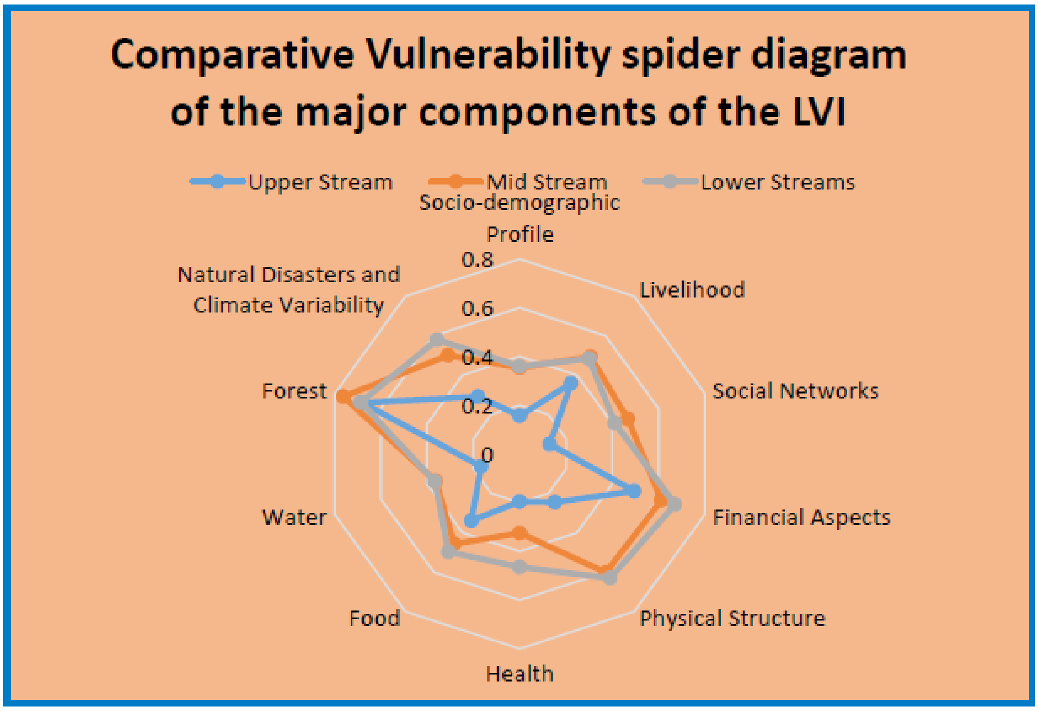

Figure 3 Comparative Vulnerability spider diagram of the major components of the LVI for three belts.

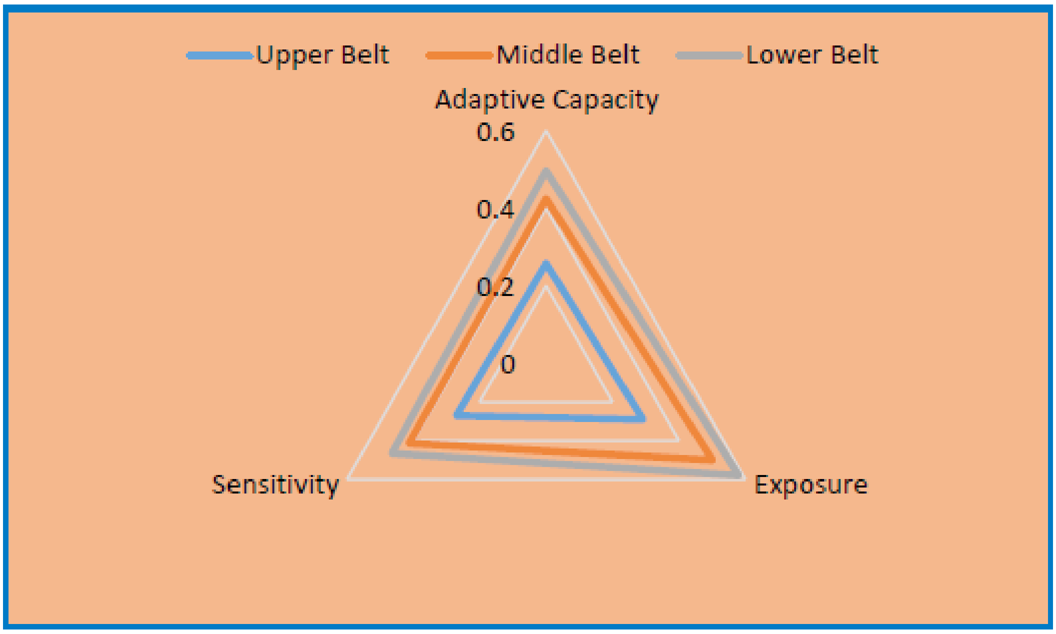

Figure 4 Vulnerability triangle Diagrams of three belts according to LVI-IPCC.

Citation: Shreevastav BB, Tiwari KR, Mandal RA, et al. Assessing flood vulnerability on livelihood of the local community: a case from Southern Bagmati corridor of Nepal. *MOJ Eco Environ Sci.* 2021;6(4):139–154. DOI: 10.15406/mojes.2021.06.00227

Table 12 Calculation of LVI-IPCC values of all belts

Contributing Factors	Major Components	No. of Sub-Components	Upper Belt/Up-Stream			Middle Belt/ Mid-Stream			Lower Belt/ Low-Stream		
			Major Component Values	Contributing Factor Values	LVI-IPCC Value	Major Component Values	Contributing Factor Values	LVI-IPCC Value	Major Component Values	Contributing Factor Values	LVI-IPCC Value
	Socio-demographic Profile	7	0.157			0.354			0.359		
Adaptive Capacity	Livelihood	7	0.358			0.493			0.483		
	Social Networks	5	0.129	0.257		0.466	0.424		0.411	0.496	
	Financial Aspects	3	0.495			0.612			0.671		
	Physical Structure and Facilities	7	0.245		0.009	0.602		0.031	0.631		0.038
Sensitivity	Health	7	0.196			0.325			0.413		
	Food	5	0.339	0.271		0.457	0.464		0.498	0.465	
	Water	6	0.167			0.362			0.366		
	Forest	2	0.68			0.762			0.687		
Exposure	Natural Disasters and climate variability	6	0.291	0.291		0.5	0.5		0.579	0.579	

The LVI-IPCC is an implementation of the Sustainable Livelihoods Approach to development analysis (Chambers and Conway 1992), according to which communities are described in terms of their natural capital, social capital, financial capital, physical capital, and human capital. Stresses related to climate change map onto each of these capitals, but climate exposures and adaptation actions are typically not explicitly considered in the approach. This reorganizes the Sustainability Livelihoods Approach into new categories, which includes an explicit climate component, and is framed in a manner amenable to the use of household survey data. The LVI-IPCC, also developed by Hahn et al.,[1] maps the LVI components onto the three IPCC contributing factors to vulnerability—exposure, adaptive capacity, and sensitivity.

The LVI and LVI-IPCC can also be used to assess the impact of a program or policy shift by substituting the value of the indicator that is expected to change and recalculating the overall index. For example, if the goal of a water project is to decrease the travel time to a community's primary water source or increase the amount of water that households are storing, these sub-components could be adjusted and the new LVI and LVI-IPCC can be compared with baseline indices calculated using the survey data to predict the potential impact of the intervention on the vulnerability of a community (Hahn 2008).

Recognizing the limitations of secondary analysis, the LVI and LVI-IPCC utilize household level primary data to measure the chosen subcomponents. This method therefore does not suffer from the limitations of most vulnerability assessments to date, namely the possible consequences of combining data collected in different years, at varying spatial scales and for different purposes. Reliance on secondary data, on the other hand, means that researchers combining these datasets must attempt to interpret results without insight into errors that occurred before they accessed the data. Because the survey instrument was created for particular vulnerability assessment, the researcher was free to choose indicators that were most appropriate for measuring the selected major components rather than structuring the study framework around available data (Hahn 2008).

Regarding weighting, because of LVI and LVI-IPCC employ no weighting in their calculation, the methods and results from this study will be easy to compare with future LVI assessments in other contexts whereas other vulnerability assessments to date have relied on either idiosyncratic or complicated methods for weighting that could be difficult to reproduce. This will also be beneficial if an assessment is carried out in the same population over time to compare the transformation of livelihood vulnerability (Hahn 2008).

There are some limitations of the LVI approach such as place-specific indicators used based on review of available data is highly subjective and may not be applicable to other areas due to some particular assessment; indicators and indices obtained are used to oversimplify a complex reality and inherently, there is no direct way to validate indices which consist of very different indicators. Considering the limitations of the Hahn et al.,[1] index, the strengths far outweighs the limitation hence its use is credible. It is also important to note that all subcomponent indicators have been standardized using the maximum and minimum values in this study population to facilitate integration into the overall LVI. As pointed out by Vincent in 2007, this means that subcomponent indices and the overall LVI are not comparable across future studies. The comparison of two components can be differing with time (Hahn 2008).[6–30]

Conclusion

The prime purpose of this study was to assess and analyze the impact of floods on livelihood and explore the process of vulnerability, adaptive capacity and risk sensitivity. In addition, status of preparedness and preventive measures from floods at communities within Southern Bagmati Corridor of Nepal was also observed. The study focused community and household-level factors most likely to influence flood vulnerability. It further developed and applied different quantitative vulnerability indices to explore the socio-economic factors anticipated determined vulnerability. This has been proved to be virtuous approach which allows a better understanding of the flood vulnerability status communities and households studied.

Looking to the overall indexed value of the different components like socio-demographic profile, livelihood component, social network component, financial component , physical structure, access to health facility, availability of food component, availability of water resource component, forest resource, natural disasters and climate variability, the findings showed that the highest value was at down-stream while it was the lowest at up-stream. Thus, the livelihood vulnerability index was the also the highest at down-stream and lowest at up-stream. This indicated that the community living in down-stream is most vulnerable in terms of overall floods and its impacts. It can be argued that policy needs to address to this issue. It is essential consider the livelihood vulnerable index to act accordingly for benefit of community living at down-stream and middle & up-stream. The result has been supported by various findings (Manandhar 2011).

Vulnerability assessment showed that lower belt/downstream was found to be most vulnerable (with highest LVI value 0.528), followed by Middle belt/mid-stream with medium LVI value 0.506. The least vulnerable is upper belt/upstream which has low LVI value 0.323. Similarly, The results of LVI-IPCC showed that the lower belt (with highest LVI-IPCC Value 0.038) was found the most vulnerable followed by Middle belt (with mid LVI-IPCC Value 0.031)and upper-belt (least LIV-IPCC value 0.009). All of the three major contributing factors; the adaptive capacity, exposure and sensitivity) provisioned by IPCC vulnerability approach value were found to be higher in lower belt. The least vulnerable was observed in Upper belt (0.009).

Aggregating major components such as Socio-demographic Profile, Financial Aspects, Physical Structure, Health, Food, Water and Natural Disasters and Climate Vulnerability); lower belt (0.515) was most vulnerable, followed by Middle belt (0.493) and least vulnerable was the Upper belt with value 0.306. Similarly, Middle belt had highest value in remaining 3 major components (livelihood, Social Networks and Forest). The upper belt had no major components with highest value leading them to least vulnerable. A significant correlation was observed between contributing factors such as: vulnerability, contributing factors-exposure, sensitivity and adaptive capacity. The multivariate analysis shows that households' having better preparedness and mitigation measures was influenced by their ability to responds to floods vulnerability. The analysis of this study can be prepared to identify and access vulnerability of all households with potential multiple prospective of livelihood that need to strengthen to overcome the challenges posed by disasters and climate variability. The study shows that livelihood diversification is a very effective way to reduce vulnerability.

LVI can be a vital tool to analyze vulnerability and implement livelihood activities. It can provide basic requirements and access to resources in accordance with their needs as they can develop mitigating programs to strengthen the vulnerable sectors and heighten adaptive capacity and sensitivity. It should be used in development research context, by development and humanitarian organizations, governments and policymakers, in order to advance to the application of remedial measures, and therefore purpose to improve communities' adaptive capacity and increase their resilience to floods and water induced disasters. The results of the study can be used as a benchmark study to be compared with forthcoming research literatures.

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Conflicts of interest

Authors declare that there is no conflict of interest.

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