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Assessing Climate Variability in Langtang Valley Using Livelihood Vulnerability Index

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ABSTRACT

Himalaya of Nepal is highly vulnerable to climate change as well as one of the disaster prone zone in the world. The research regarding livelihood vulnerability of Langtang which is remote settlement within Langtang National Park of central Himalaya of Nepal has not been assessed regarding the impacts of climate change. Tamang are the indigenous communities of Langtang who primarily depend on natural resources for subsistence livelihoods are among the first and most affected due to climate change impacts. This research was objectively carried out to assess the livelihood vulnerability index in response to climate change and trends of climate variables of Langtang. The livelihood vulnerability index (LVI) by Hahn and LVI-IPCC of Langtang Valley were analysed. The study area was categorized on the basis of altitudinal variation as well as on the base of distance from 2015 earthquake induced avalanche impact zone, specifying Lower, Mid and Upper Valley to analyze livelihood Vulnerability Index. Whole enumeration process was applied as only 112 households are remained after the 2015 earthquake. The collected data were analyzed using People's perception was studied through questionnaire survey while KII and FGD were also conducted. As per finding, the overall LVI of Langtang was 0.334. The Lower Valley Settlements has LVI of 0.352 while Upper Valley Settlements has 0.340. Comparatively Mid Valley Settlements has higher LVI and LVI-IPCC i.e. 0.377 and 0.098 respectively which is also direct impact zone of 2015 earthquake induced avalanche.

Keywords: *Climate change, Indigenous Communities, Avalanche, Livelihood Vulnerability Index, Adaptations Practices*

INTRODUCTION

Climate Change is becoming one of the major threats to the fragile Himalayan ecosystem including the Langtang area (ICIMOD 2010). Glaciers of the Himalayas are retreating at the fast rate than expected resulting to the formation of glacier lakes. This may lead to disaster events like Glacier Lake Out Burst (GLOF) and avalanche making local people and biodiversity in great threat from its impact (WWF 2012).In the 2015 earthquake, more than 300 people were die when the entire village of Langtang was wiped away by a massive avalanche and landslide from Langtang Mountain (ICIMOD 2017). The disaster impact on agriculture-based livelihoods and food security is particularly worrying as it had damaged people's houses, as well as their productive resources, health, employment sources, and means of living. Climate change increases risk of livelihood from various aspects of vulnerability such as physical, socio-economic and environmental. People, whose subsistence livelihood is based on the direct utilization of natural resources are most affected by climate change and have different but accurate perceptions of climate change than those people following modern lifestyles (Aryal *et al*. 2014). Indigenous adaptation strategies practiced by local communities, in response to changing climate, are worth to analyze since they are inseparable to local culture and complement in subsidizing CO_2 emissions.

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 (Hahn 2008). Recognizing the limitations of secondary analysis, the LVI and LVI-IPCC utilize household level primary data to measure the chosen sub components. 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).

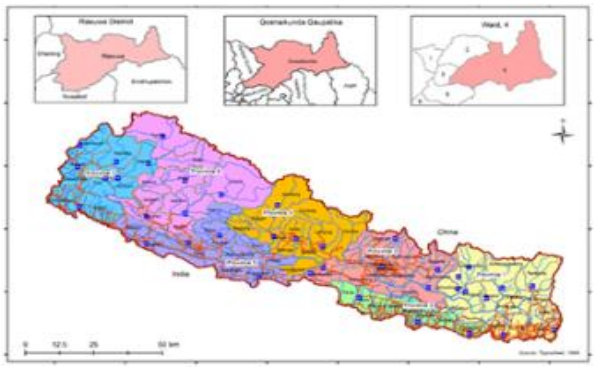
The LVI and LVI-IPCC was first developed by Hahn *et al* in 2009 and implemented in two villages in Mozambique with differing socio-economic and environmental conditions where it proved insightful in capturing differentials in community-level climate vulnerability. In terms of Nepal, the study was conducted in Lete and Kunjo VDC of Mustangby Urothody and Larsen in 2010. Similarly, Aryal *et al* (2014) has compared the three VDCs of Solukhumbu, Dolakha and Bajhang district representing Eastern, Central and far-Western mountainous areas of Nepal respectively to explore their perceptions about climate change and other observed changes in biophysical indicators.

Materials and Methods

Study Area

Langtang valley within Langtang National Park is one of the U shaped inner Himalayan valleys of Nepal fed by big glaciers (Stainton, 1972; Chhetri & Gautam 2015) located north of Kathmandu in Gosainkunda Rural Municipality Ward no: 4 of Rasuwa District, Province 3 within Langtang National Park. Langtang Valley lies on the geographical coordinates of 28° 12' 59" N, 85° 30' 22" E (Wikipedia) at the altitude of 3430m. As a popular tourist trekking area, no roads existed within the valley. Primary access to and within the valley was provided through trails, normally used by porters and mules. According to Langtang National Park Annual Progress Report (2073/74), Langtang Valley has total household of 112 with population of 455(M-219, F-236). The overall Langtang Valley was divided on the basis of altitudinal variation as well as on the base of distance from 2015 earthquake induced avalanche impact zone, specifying lower, mid and Upper Valley to compare livelihood Vulnerability Index. Lower Valley has villages like Rimche, Lama Hotel, Gumnachowk with few households along the way. Similarly, the Mid Valley has settlements like Godatabela, Thangshyarp, Gumba and Langtang whereas Upper Valley has settlements like Mundu, Sindhum and Kyanjing. The largest settlement in the valley is also called Langtang, but multiple small villages, the trekking routes both above and below the eponymous village. Langtang is inhabited by a Tibetan-speaking people whose means of subsistence has depended on animal husbandry for at least three hundred years (McVeigh 2004).

The household questionnaire was prepared and conducted for overall households as only 112 households are remained after the 2015 earthquake. One FGD was conducted in each study division while overall 6 KII was conducted, 2 in each study division. During the field research period covert and overt observation were made. Photographs and simple notes were taken during meetings, and during the walking tours. The data published by Central bureau of Statistics, relevant researches, papers journals, relevant national policies, available data from Rural Municipality, ancillary data sources including available maps were studied.



Livelihood Vulnerability Index (LVI) Using Hahn Et Al. 2009

The LVI includes seven major components; Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Networks (SN), Health (H), Food (F), Water (W) 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 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:

Index $S = \frac{S - S_{min}}{S_{max} - S_{min}}$

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.

$M_i = \frac{\sum_{i=1}^{n} indexS_i}{n}$

Here,

M_i = 0ne of the seven major components

S_i = sub components, indexed by *i*

n = number of sub components 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 = $\frac{\sum_{I=1}^{n} W_{m_i} M_i}{\sum_{i=1}^{8} W_{m_i}}$ which can be expressed as

LVI= $\frac{W_{SDP}\,SDP + W_{LS}\,LS + W_{SN}\,SN + W_H\,H + W_F\,F + W_W\,W + W_{NDCV}\,NDCV}{W_{SDP} + W_{LS} + W_H + W_{SN} + W_F + W_W + W_{NDCV}}$

Where,

LVI = Livelihood Vulnerability Index

W_{m_i}= Weights of each major components

M_i =Each major component

The weights of each major component,W_{m_i}, 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).

LVI–IPCC Framework Approach

After the calculation of LVI, an alternative method for calculating the LVI was incorporated as IPCC vulnerability definition. The table below shows the organization of the seven components in the LVI-IPCC framework. They are Natural disasters and climate variability under Exposure; Socio-demographic Profile, Livelihood Strategies and Social Networks under Adaptive Capacity while health, food and water is under Sensitivity.

Following equation used to calculate Contributing Factor:

CF = $\frac{\sum_{i=1}^{n} W_M M_i}{\sum_{i=1}^{n} W_M}$

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:

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).

RESULTS AND DISCUSSION

Livelihood Vulnerability Index (Lvi)

The overall LVI value of Langtang was 0.334. Total seven major components were evaluated to find the LVI of this site. The highest value was 0.599 of Natural Disasters and Climate Variability and lowest value was 0.238 of livelihood component (Table 1).

Table 1: *Livelihood Vulnerability Index (LVI) sub-component values and minimum and maximum sub-Component values, Indexed of Subcomponents and averaged value of Components for Langtang Valley.*

Major Component	Sub-Components	LVI Sub-component Value	Max. Value	Min. Value	Index of Sub component	Average of Sub Component
Socio-demographic Profile	Dependency Ratio(<15 years and >65 years)	0.42	1	0	0.420	0.311
	Percent of female-headed households	17.9%	100	0	0.179	
	Percent of households where head of household has not attended school	59.8%	100	0	0.598	
	Percent of households with	4.5%	100	0	0.045	

	orphans					
Livelihood	Percent of households with family member working in a different community	42.9%	100	0	0.429	0.238
	Percent of households dependent solely on agriculture as a source of income	7.1%	100	0	0.071	
	Average Agricultural Livelihood Diversification Index	0.37	1	0.20	0.213	
Health	Average time to health facility	67.1	255	5	0.248	0.296
	Percent of households with family member with chronic illness	27.7%	100	0	0.277	
	Percent of households where a family member had to miss work or school in the last 2 weeks due to illness	19.6%	100	0	0.196	
	Average Common cold Exposure*Prevention Index	5.571	12	0	0.464	
Social Networks	Average Receive: Give ratio	0.985	15	0	0.066	0.400
	Average Borrow: Lend Money ratio	1.102	2	0.5	0.401	
	Percent of households that have not gone to their local government for assistance in the past 12 months	73.2%	100	0	0.732	
Food	Percent of households dependent on family farm for food	0%	100	0	0	0.463
	Average number of months households struggle to find food	0.52	12	0	0.043	
	Average Crop Diversity Index	0.62	1	0	0.620	
	Percent of households that do not save crops	86.6%	100	0	0.866	
	Percent of households that do not save seeds	78.6%	100	0	0.786	
Water	Percent of households reporting water conflicts	0%	100	0	0	0.031
	Percent of households that utilize a natural water source	0%	100	0	0	
	Average time to water source (minutes)	1.30	3	1	0.150	
	Percent of households that do not have a consistent water supply	0%	100	0	0	
	Inverse of the average number of liters of water stored per household	0.005	1	0	0.005	
Natural Disasters and Climate Variability	Average number of flood, drought, and cyclone events in the past 6 years	2.87	7	0	0.410	0.599
	Percent of households that did not receive a warning about the pending natural disasters	100%	100	0	1	
	Percent of households with an injury or death as a result of the most severe natural disaster in the past 6 years	59.8%	100	0	0.559	

	Mean standard deviation of the daily average maximum temperature by month	2.168	2.737	1.141	0.643	
	Mean standard deviation of the daily average minimum temperature by month	2.356	2.887	1.418	0.638	
	Mean standard deviation of average precipitation by month	28.455	75.455	3.386	0.349	

Table 2. *Average Indexed Values at Upper, Mid and Lower Valley*

Major Components	Average Indexed value		
	Upper Valley	Mid Valley	Lower Valley
Socio-demographic Profile	0.28	0.284	0.328
Livelihood	0.255	0.199	0.245
Health	0.375	0.357	0.353
Social Networks	0.39	0.402	0.374
Food	0.458	0.491	0.564
Water	0.081	0.098	0.079
Natural Disasters and Climate Variability	0.545	0.626	0.563

LVI-IPCC Value of Langtang

The overall LVI-IPCC Value was 0.078. The average values of Adaptive Capacity, Sensitivity and Exposure were 0.316, 0.261 and 0.617 respectively (Table 3).

Table 3: *LVI-IPCC Values for Langtang Valley*

Contributing Factors	Major Components	Major Component Values	No. of Sub-Components	Contributing Factor Values	LVI-IPCC Value
Adaptive Capacity	Socio-demographic Profile	0.311	4	0.316	0.078
	Livelihood Strategies	0.238	3		
	Social Networks	0.400	3		
Sensitivity	Health	0.296	4	0.261	
	Food	0.463	5		
	Water	0.031	5		
Exposure	Natural Disasters and climate variability	0.617	6	0.617	

The LVI-IPCC Values of were 0.097, 0.098 and 0.086 at upper, mid and lower valley respectively (Table 4).

Table 4: *Value of Contributing factors in Upper, Mid and Lower Valleys*

Contributing factor	Contributing Factor Values		
	Upper valley	Mid Valley	Lower valley
Adaptive Capacity	0.306	0.308	0.303
Sensitivity	0.299	0.307	0.331
Exposure	0.631	0.626	0.563
LVI-IPCC Value	0.097	0.098	0.086

The LVI-IPCC Values were varied according to different part of valleys. The values were the lowest **0.**086 at lower valley which were about similar in upper and mid valley with 0.097 and 0.098 respectively. The overall LVI of Langtang was 0.334. According to the study conducted in Khumjung by Aryal et.al. (2013), LVI of Khumjung is 0.406.

The earthquake induced avalanche in 2015 showed that people of Mid Valley are more chronic illness like hypertension, depression etc. According to the study conducted in by Panthi and team in 2010 found that exposure value of Dhading, Syangja and Kapilvastu is found to be much low than Langtang ((Shah *Et. al* 2013, Panthi *et. al* 2015).

Conclusion and Recommendation

These indices could be used as a practical tool for the governments, policy makers and developmental organizations to identify

vulnerable communities, understand the factors contributing to vulnerability at district or community level and also to prioritize the potential areas of intervention. Thus, climate change occur as a challenging threat so there is need of impact identification and adaptation to cope with vulnerabilities in livelihood, agriculture, and many other sectors.

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