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Index measurement of climate variability and household vulnerability: A case of western Nepal

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Abstract
This study examines the relationship between the magnitude of climate variability and household vulnerability in the catchment areas of Sot Khola sub water basin in the western mountainous Surkhet, Nepal by constructing theoretical climate vulnerability index based on household level data collected from 642 Household covering adaptive, sensitive and exposure. Its result is climate vulnerability index (CVI) of households living in Sot Khola sub water basin's catchment areas, which provides sufficient evidence of heterogeneity in climate variability and vulnerability of household across location and altitude of the catchment areas. In all clusters, all households are vulnerable at different level. Households have heterogeneous adaptive capacity in which about 40 percent household have less adaptive capacity indicating potential vulnerable households, although 60 percent household have higher adaptive capacity. Majority households (52.7%) are sensitive to Climate induced disasters: landslide and flood due to their socio-economic status and food insufficiency. But about 47.4 percent households are less sensitive. Since households' locations are far from flood and landslides patches, about 4.4 percent households are higher exposure but 95.6 percent households are in less exposure. The composite index of climate vulnerability index shows 50 percent moderate and higher vulnerable household from climate induced disaster: landslide and flood. It was supplemented by additional 17.0 percent moderate vulnerable housheolds. Thus, in total, about 67 percent household is vulnerable at different level from moderate to extremely higher vulnerable. The remaining (33 percent) is least vulnerable.

Keywords: climate change, vulnerability, water basin, water-induced disasters, flood etc

1. Introduction

The intensity of climate variability and vulnerability distributes unevenly with respect to geographical location and altitude. In Nepal, fact sheets of metrological data base (2019) provides a strong evidence, like as live experiences and observations. Empirical and theoretical literatures show unilateral directional relationship. Still, its relationship at household level seems to be relevant. When we talk about the catchment areas of water basin and its socio-economic dimensions (income, literacy, awareness etc.), there is a sufficient room to be observed. We assume climate variability induces vulnerability but its magnitude depends on locations of the catchment areas and also income level of household because of the different magnitude of climate vulnerability. Therefore, there should be some extent correlation between climate vulnerability, location and income level of the household to increase the magnitude of climate vulnerability at household level. Therefore, this study estimates empirically this relationship in the catchment areas of water basin.

Climate vulnerability in the world is widely accepted as a big threat. UNFCCC (2007) [37] provides scientific evidence of extreme and gradual changes of climate variables such as increasing temperature, declining rainfall, severe drought, forest fire and diseases and its impacts at households.

It is due to extremely and gradually changes of climatic variables such as increasing temperature, declining rainfall, severe drought, forest fire and diseases (UNFCCC, 2007) [37]. Theoretical Literatures have observed theoretically dimensions, elements, characteristics of climate vulnerability in which UNFCCC (2007) [37] and Fussel and Klein (2006) [12] mention the susceptible, inability of geo physical, biological, socio economic systems to cope with, and adverse impacts of climate change. It just mentions trade off situation between resilience and climate change's effect. If it increases at local areas, there will make higher vulnerable to the community. In another words, this is vulnerable situation of geo physical, biological and socio economic systems. Its examples are low lying of water basin, coastal areas and islands. Such vulnerabilities depend on key impacts of climate change. Watts and Bohle (1993) [39], Blaikie *et al*, (1994) [4] and Kelly and Adger (2000) [1] highlighted social and environmental vulnerability. Theoretical and empirical literatures (Smit *et al*., 2001; Corfee-Morlot and Höhne, 2003; Hare, 2003; Oppenheimer and Petsonk, 2003, 2005; ECF, 2004; Hitz and Smith, 2004; Leemans and Eickhout, 2004; Schellnhuber *et al*., 2006) [34, 6, 16, 26, 32] have mentioned key impacts on social, economic, biological and geophysical systems, like as the literatures of IPCC (2001a) and UNFCCC(2007) [37]. Its vulnerabilities associate with climate sensitive systems including food supply, infrastructure, health, water resources, coastal systems, ecosystems, global biogeochemical cycles, ice sheets, and modes of oceanic and atmospheric circulation.

There are large literatures on Magnitude and timing of climate impacts and vulnerability distribution across regions, sectors and population such as (Corfee-Morlot and Agrawala, 2004; Schneider and Mastrandrea, 2005; Yamin *et al*., 2005; Rayner and Malone, 1998; Adger, 2001 and Gupta *et al*., 2003) [7, 31, 40, 29, 14]. These literatures argue the magnitude of climate change and its vulnerability determined by its scale (e.g., the area or number of people affected) and its intensity (e.g., the degree of damage caused).

Literatures are large talking about its measurements to understand the magnitude of climate impacts. There are quantitative literatures (Nordhaus and Boyer, 2000; and Nicholls *et al*. 2005) providing different monetary units such welfare, income or revenue loss, cost of adaptation and willingness to pay to avoid. In addition, Indicator and qualitative literatures (Barnett, 2003; Arnell, 2004; Parry *et al*., 2004; Van Lieshout *et al*., 2004; Schär and Jendritzky, 2004; Stott *et al*., 2004) [3, 2, 28, 30, 35] have also explored their space to measure the magnitude of climate impacts by measuring food and water shortages, morbidity and mortality from diseases and forced migration, along with heritage and biodiversity loss. Thus, vulnerability is measured by magnitude and timing of impacts, system at risk, uncertainty of impacts and potentiality to adapt.

Indicator Method to assess Climate Vulnerability is widely employed by including heterogeneous indicators as per requirement and availability in the different locations, geographical setting and income groups. Therefore, there are available diverse indicators based Index of vulnerability. Whatever, Kelly and Adger(2000) [19] and Eriksen and Kelly (2007) [10] believe it as source of reference point for evaluating framework for development, as provider of information for developing adaptation and mitigation plans and as standard of measures. Indicator measurement is one of qualitative and quantitative measures to measure vulnerability to climate change for understanding its status, nature, process, distributional pattern and intensity over time, location, income and geographical setting and also the impacts of climate change, along with understanding the effectiveness of development and climate resilient policy and programs in across locations, geography and income groups.

Literatures show two approaches in vulnerability Index construction and application in climate change and environmental disciplines. They are deductive and inductive approach in the construction of Climate Vulnerability Index (CVI). In large literatures, theory driven (deductive) conceptual framework was constructed and followed to identify relevant indicators for determining their relationships through construction of Index. Similarly, in many cases, data driven approach (inductive) was used to select vulnerability indicators based on their statistical relationship with observed vulnerability outcomes (Eriksen and Kelly, 2007) [10]. The application of inductive approach was specific climate sensitive systems in which deductive approach could not be applied in the absence of well-defined vulnerability outcome. In general, for urgency of coping climate change vulnerability, the inductive approach was popular to be used.

Literatures reveal three types of indices in practice such as global, national and regional for different objectives: rank of vulnerability and areas and priority of adaptation strategy and finance and mitigation. Sullivan and Meigh (2005) [36] developed a Climate Vulnerability Index comprised of six indicators encompassing resource, access, capacity, use, environment, and geospatial dimensions to assess CVI of water to Mongolia for analyzing large data sets. They suggest their index has applicability and comparability across various scales of analysis from small island developing nations (SIDs) to the national level. However, there is no theoretical discussion of indicator choice or the specific indicators.

Eriksen and Kelly (2007) [10] have assessed the vulnerability level across countries in 2007 under the United Nations Framework Convention on Climate Change (UNFCCC) by developing five quantitative national level indices of social vulnerability to climate change: vulnerability resilience indicators (VRI), Environmental Sustainability Index (ESI), Dimensions of Vulnerability (DV), Index of Human Insecurity (IHI) and Predictive Indicators of Vulnerability (PIV). The study finds that "a lack of a clear theoretical and conceptual framework for the selection of indicators has hampered the robustness, transparency and policy relevance" of these indicator studies, and they note "a serious deficiency in existing studies, the limited testing and verification of indicators and of the validity of underlying conceptual frameworks" (p. 504). As a result, the three indices that provide a ranking of countries show "relatively little agreement regarding which particular countries are the most vulnerable, with only five countries ranked among the 20 most vulnerable in two or more of the studies and only one country ranked among the 20 most vulnerable in all three. This finding […] firmly underlines the challenge in making objective judgments about which countries are more vulnerable than others as a basis for allocating of funding" (p. 502). Kim (2010) evaluated climate vulnerability index (CVI) of 16 local governments in South Korea by identify local scale 36 sub indicators to measure performance of water management. The study seems to be inductive approach based on availability of data, although there is a lack of theoretical framework. In addition, the study has not provided strong judgments in selecting sub indicators. In the selected sub indicators, there is a missing of data. However, it has higher possibility of policy implication.

Eakin and Luers (2006) express serious concerns regarding the validity of national-scale vulnerability assessments noting that "Ranking and comparing vulnerability across countries […] is challenged by everything from the quality of the available data, to the selection and creation of indicators, to the assumptions used in weighting of variables and the mathematics of aggregation. There are also problems in the interpretation of indices".

Other studies found that several aggregated vulnerability indices express strong sensitivity to the selection of specific proxy variables as well as to variations in the mathematics of index construction (Moss *et al*. 2001, Gall 2007, Schmidtlein *et al*. 2008) [22, 33]. Hahn *et al*., (2009) employed the LVI to understand livelihood and climatic vulnerability in small island developing states (SIDS).

Despite available international literatures on Climate Vulnerability and Climate Vulnerability Index (CVI), the literatures on Nepalese context are handfuls, which have not focused in the western mountainous Nepal, have not applied indicator method including CVI. In this context, this study estimates climate vulnerability level in the catchment community and locations of Sot Khola Sub water basin in Surkhet, Nepal, where climate variability particularly rainfall was recorded in the rainfall stations of Surkhet and its induced heavy disastrous flood disaster event were badly experienced by the catchment areas and the community in 2014. Available literatures have not covered such issue, except the correlation between climate variability and vulnerability. Still, there is a query whether heterogeneous level of disasters in the catchment areas occur or not, whether heterogeneous level of vulnerability in the catchment areas occur or not and whether the correlation between disaster and vulnerability occur or not.

The paper examines climate vulnerability in the western mountainous Nepal by building climate vulnerability index (CVI) and analyzes extremity of climate vulnerability and its distribution across altitude and geographical setting.

This paper is organized into the following sections: Section 1: Introduction, Section 2: Life threating climate vulnerability in Nepal, Section 3: Method and Data, 4: Results and Section 5: Discussions and Conclusion.

2. Life Thratening Climte Vulnerability in Nepal

Nepal is the fourth most vulnerable country in terms of Climate risks and 30th in terms of water-induced disaster (UNFCCC, 2007) [37], although her GHG emission share is only about 0.025 percent of total annual GHG emissions of the world(Karki, 2007). There are climate risks: increasing dry periods, intense rainfall, floods, landslides, forest fires, glacier outburst flood etc. among which about 13 cases of Glacier Outburst Flood (GLOF) have damaged substantially to the people's lives, livestock, land, environment and infrastructure. Further, National Adaptation Program of Action (NAPA) (2010) is the national policy document of climate change adaptation verifies it by explaining Nepal as highly vulnerable to climate change. Further, it projects 10 million populations in climate risk. Out of such population, about 1.9 million populations are in highly vulnerable to climate change. It finds its higher intensity in mid and far western regions. For example, Surkhet, where water induced disasters, flood happened in 2014. The flood unexpectedly and severely damaged house, asset, crops, bridge, road and life all over Surkhet (DDC, 2015). MOH (2015) estimated10 billion in Rs worth loss of physical assets, along with 37 deaths and 3867 household affected.

In Surkhet, the flood of Sot Khola sub water basin with 10 feet's wild and high-sounding water level unexpectedly happened due to the heavy and intense rainfall continuously in three days and three nights. It carried everything in its course. It had affected its catchment areas (Gadhi, Lekhagaon and Kunathari) from the upper catchment areas to the downward catchment areas. Since the settlement of the community was the top hilly areas, the flood had not swept houses, except crops, banks of the river, agricultural land, water wheel, life and infrastructure (road, clean drinking water, irrigation drainage, bridge etc.). The estimated loss of the catchment areas of Sot Khola was 1, 33, 44,000 in Rs of house and asset, which was 0.13 percent of total loss of Surkhet (MOH, 2015). In addition, there was a loss of crop, income and life. Thus, there was about 67 percent household vulnerable from the upper catchment areas to the downward catchment areas. Therefore, the higher intensity of the flood disaster occurs in the catchment areas of Sot Khola sub water basin in the different locations and altitude.

3. Methodology and Data

3.1. Theoretical Framework of Climate Vulnerability Index (CVI)

Climate vulnerability index (CVI) is a quite popular method to calculate socio economic vulnerability due to climatic variation. Hahn *et al*. (2009) developed this approach covering three indicators of livelihood vulnerability (i.e., exposure, sensitivity and adaptive capacity) to risk from climate vulnerability. Shah *et al*. (2013) and Turton (2000), Knutsson (2006) applied in Climate Change Vulnerability (CVI). Its basic assumption was IPCC's definition of vulnerability as a function of exposure, sensitivity and adaptive capacity (IPCC, 2001) [13]. It is called as balanced approach because it covers 1) the level of exposure of livelihoods to climate variability 2) socio economic characteristics influencing their ability to adapt and 3) the sensitivity of household to climate change. Its mathematical form is as follows

$$CVI_c=(e_c+s_c)-a_c\ldots\ldots(1)$$

However, we followed model applied by Dressa *et al*.(2008) to measure climate vulnerability index(CVI). In this model, the sum of sensitivity(S) and exposure (E) provides us the impact of climate-induced disaster. When it is higher, vulnerability is higher. If adaptive capacity (AC) is higher, vulnerability (V) will be lower. It is

$$V=(E+S)/AC\ldots\ldots..(2)$$

Where, e_c =the calculated exposure of the household
a_c =the calculated adaptive capacity of the household
s_c =the calculated sensitivity score of the household

To analyze vulnerability level of household and VDCs, we employed the factors of the **cat**chment areas: Gadhi, Lekhagaon and Kunathari for adaptive capacity of household, sensitivity of household and exposure of household as follows: 1) Adaptive capacity has the following factors: proportion of economically active population, Proportion of literate people, Proportion of people employed in off farm activity, Proportion of household having more than one member involved in off farm activity, 2) Sensitivity has the following factors: Gini coefficient of inequality in income of the communities, Proportion of household having less than 6 months food sufficiency in a year, Proportion of household having not access to clean drinking water, Proportion of household having less than 3 km distance to access health post and Proportion of household with old age people, 3) Exposure has the following factors: Per household crop loss (in kg), Per household livestock damage (in number), Proportion of land loss in the community in kata and Proportion of house damage in the community. Above factors were calculated by using actual values and then using standardized method for calculating scores of exposure, sensitivity and adaptive capacity separately. In CVI, each component was computed after getting standardized value from actual value by using standardized value method given below. Secondly, all standardized value of adaptive capacity, like sensitivity and exposure were sum and divided by total component. It gave the score of adaptive capacity, sensitivity and exposure separately. Finally, values of these three were kept above equation for getting CVI.

3.2. Data sets

The data set for the construction of CVI were primary nature collected from Household Survey 2015 through the structured questionnaire. Its sample size was 642 household. The collected and proceeded data were computed in accordance with three indices and their bundle indicators (13). Based on the above indicators mentioned in the factors of CVI, three indices (adaptive index, sensitive index and exposure index) were computed to measure their respect level of household of the catchment VDCs (Gadhi, Lekhagaon and Kunathari) by cluster and household level as follows.

4. Results and Discussion

4.1. Adaptive Capacity Index

This Index tool measures adaptive capacity of household level in the sub watershed basin and catchment areas (Gadhi, Kunathari and Lekhagaon) to climate change induced natural disaster including flood and landslide. This household capacity is comprised of individual capacity, institutional capacity and resources. In this index study, there were employed four factors: literacy rate, economically active population, proportion of people engaging in off farm activity and proportion of people more than one engaging in off farm activity. The analysis for the construction of the index was to measure coping capacity of climate change induced disaster: flood and landslide.

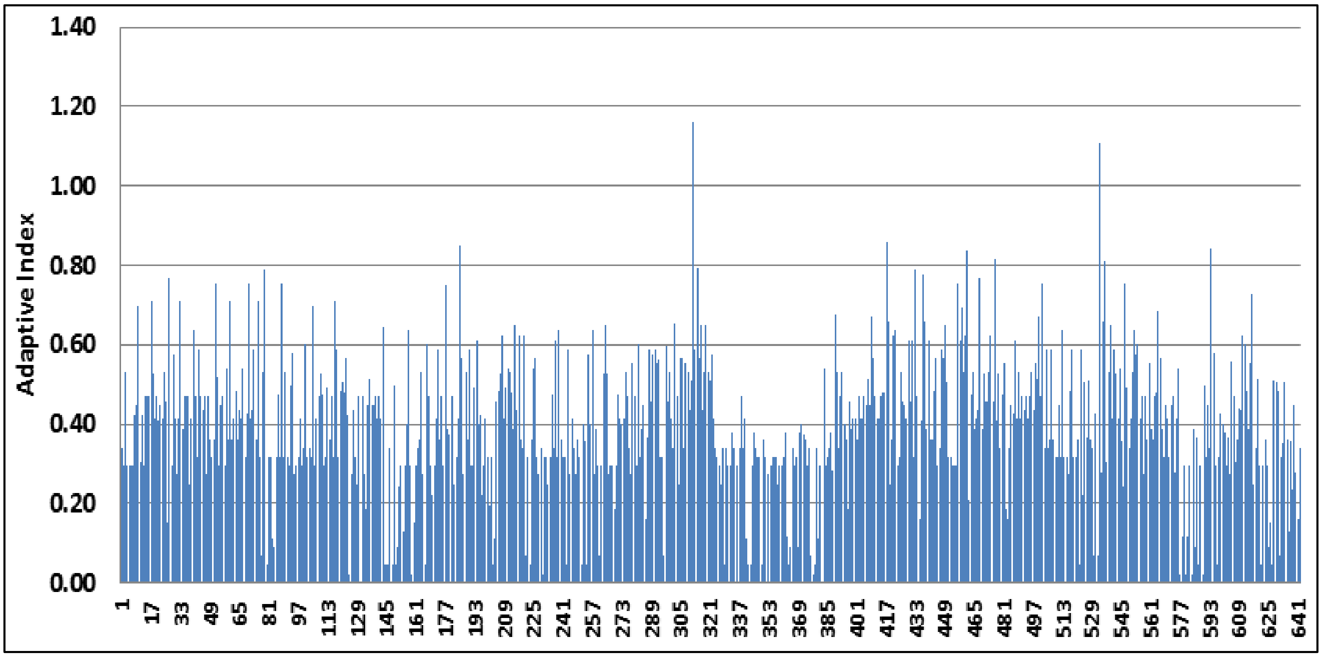
Adaptive index Figure 16 shows adaptive capacity of household as the composite index of already mentioned four factors: literacy rate, economically active population, proportion of people engaging in off farm activity and proportion of people more than one engaging in off farm activity. Household of the study areas had their heterogeneous character and status.

Table 1: Adaptive Capacity by Household

Adaptive Capacity category	Household Situation	Adaptive Capacity Index	% of Household
Extremely higher capacity	Extremely higher ability to cope	>1 to 0.8	34.9
Higher capacity	Higher ability to cope	0.8 to 0. 5	24.1
Moderate capacity	Moderate ability to cope	0.5-0.2	29.9
Less capacity	Less ability to cope	0.2 to 0/(-)	11.1
Total			100

***Source*:** Field Survey, 2015

In Table 1, adaptive capacity of household was heterogeneous. In Table 1, about 34.9 percent household laid the highest adapative capacity between 0.8 and > 1. It was followed by about 24.1 percent household lying higher adapative capacity between 0.5 and 0.8, about 29.9 percent household lying moderate adapative capacity between 0.2 and 0.5 and about 11.1 percent household lying least adapative capacity. It indicated 11.1 percent household having no capacity to cope vulnerability. It is followed by 29.9 percent household having moderate capacity (the details in Annex-VII). Thus, about 40 percent housheold would be potential vulnerable housheold (Figure 1).



***Source*:** Field Survey, 2015(the details in Annex-VII)

Fig 1: Adaptive Index by Household

4.2. Sensitive Index

Household are in the different level of sensitive in climate induced disaster-prone areas. Sensitivity index measures its degree in the study areas.

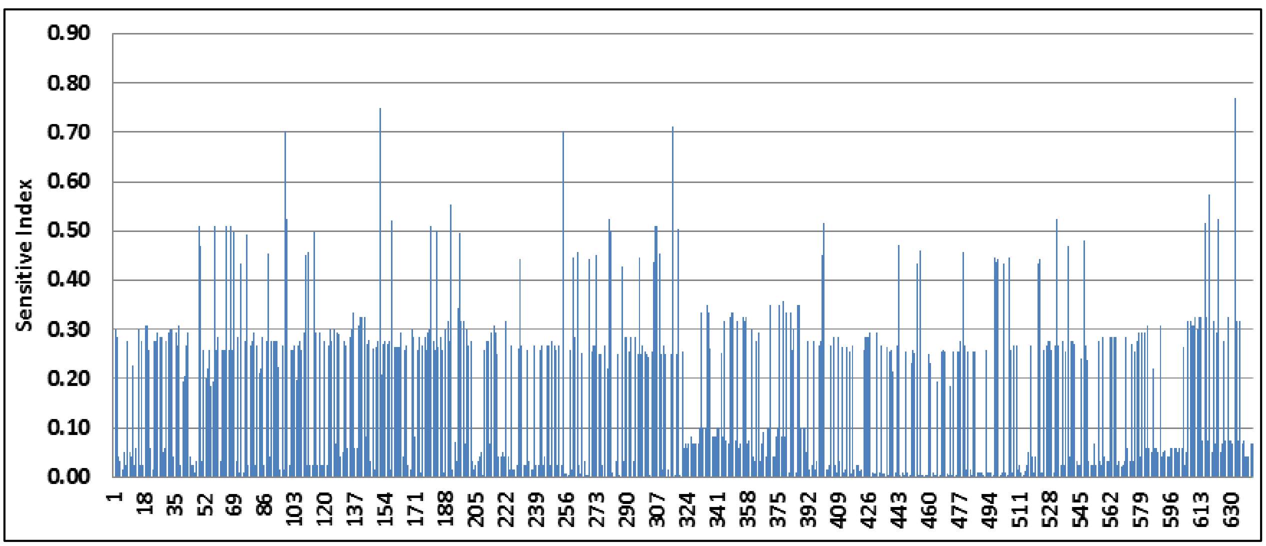
Based on that four factors (proportion of household (HH) with food sufficiency for less than 6 months, proportion of HH without piped water, distance to health facility and proportion of old aged people), sensitive index of the study area could be constructed (the details in Annex-VII). It analyzes household sensitive level. Average standardized value of individual four factors contribute to its composite score (Figure-2).

Table 1: Sensitive Index by Household

Sensitive category	Household Situation	Sensitive Index	% of Household
Extremely higher Sensitive	Extremely higher sensitive	>1 to 0.8	0
Higher Sensitive	Higher sensitive	0.8 to 0. 5	3.3
Moderate Sensitive	Moderate sensitive	0.5-0.2	49.4
Less Sensitive	Less sensitive	0.2 to 0/(-)	47.4
total			100

***Source*:** Field Survey, 2015

Figure 2 shows sensitive index calculated as composite index of above mentioned factors through the use of above mentioned methods. The result of sensitive index is presented in Table 2. The result is the evidence of different household sensitivity level. About 3.3 percent household was at higher sensitive between 0.5 and 0.8. It was followed by about 49.4 percent moderately sensitive household lying between 0.2 and 0.5, about 47.4 percent less sensitive household lying between 0.0 and 0.2. It indicated 52.7 percent moderate and higher sensitive household from climate induced disaster: landslide and flood (the details in Annex-VII). It is followed by 47.4 percent less sensitive household (Table 2).



***Source*:** Field Survey, 2015

Fig 2: Sensitive Index by Household

4.3. Exposure Index

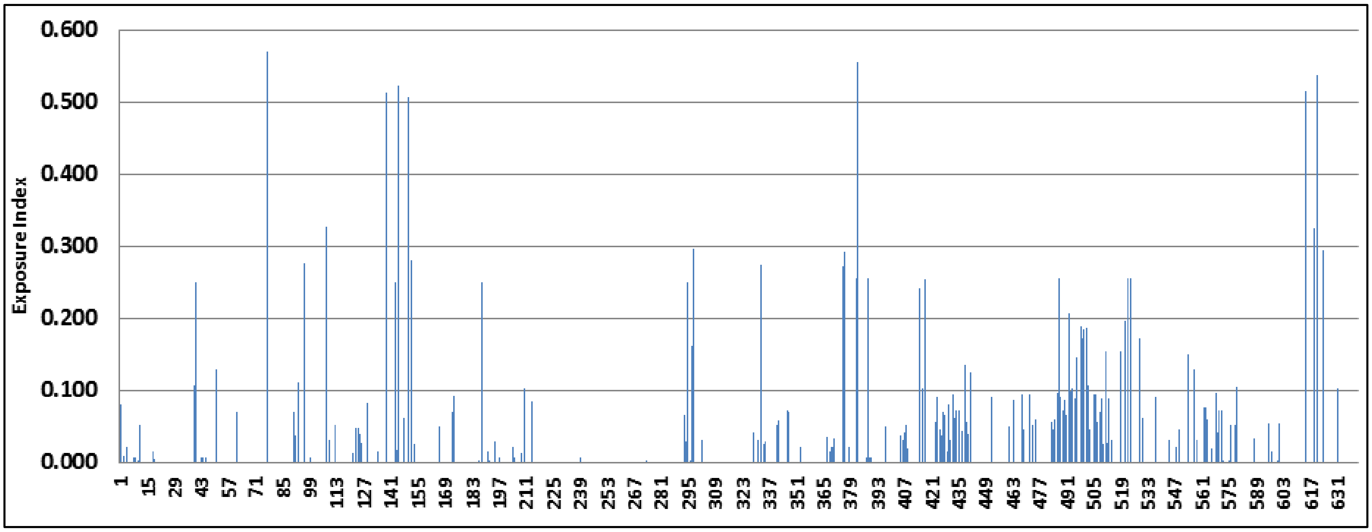
In climate induced disaster, household is in the different exposure level. Exposure index measures its degree. In this study area, there was a loss and damage of household as exposure in different level. Based on four factors (crop loss, livestock loss, household damaged, and land loss), the exposure index was constructed. Its value analyzes exposure level of household. Average standardized value of individual four factors contribute to the composite score of exposure index and rank. The index provides exposure level of different household in the areas of the watershed.

Table 2: Exposure Index by Household

Exposure category	Household Situation	Exposure Index	Percent of Household
Extremely higher Exposure	Extremely higher exposure	>1 to 0.8	0
Higher exposure	Higher exposure	0.8 to 0. 5	1.1
Moderate exposure	Moderate exposure	0.5-0.2	3.3
Less exposure	Less exposure	0.2 to 0/(-)	95.6
Total			100

Source: Field Survey, 2015

Figure-18 shows exposure index calculated as composite index of above-mentioned factors through the use of above methods. The result of sensitive index is presented in Table 3. The result is the evidence of different household sensitivity level. In Table 20, about 1.1 percent household was higher exposure between 0.5 and 0.8. It was followed by about 3.3 percent moderately exposure household lying between 0.2 and 0.5, about 95.6 percent less exposure household lying between 0.0 and 0.2. It indicated 4.4 percent moderate and higher exposure household from climate induced disaster: landslide and flood.



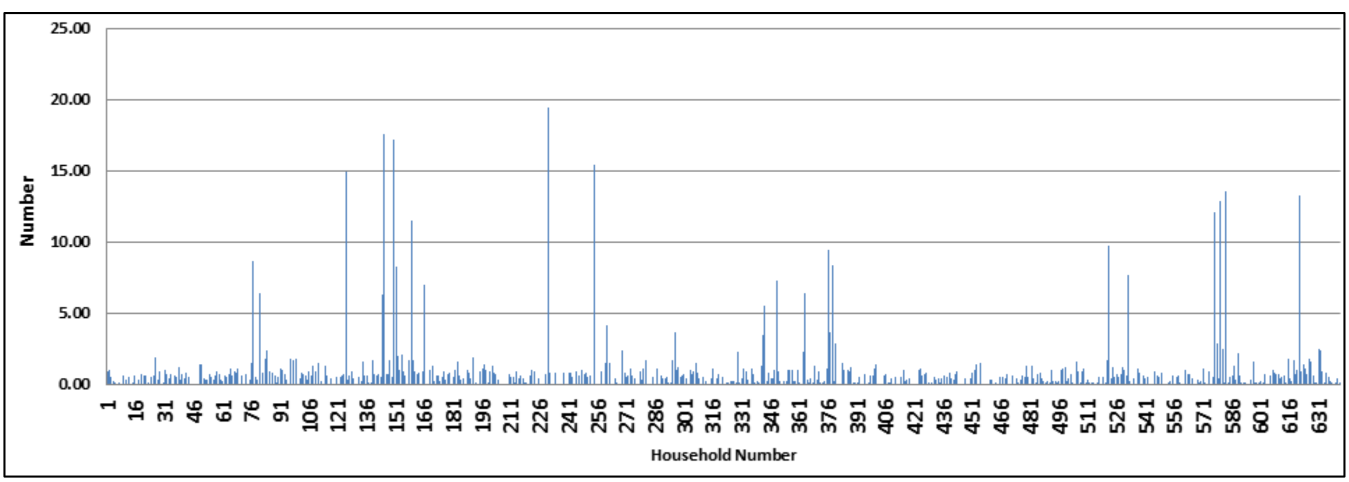
***Source*:** Field Survey, 2015

Fig 3: Exposure Index by Household

4.4. Vulnerability Index of Household level

Based on above three indices: adaptive capacity index, exposure index and sensitive index, climate vulnerability index (CVI) at household level is calculated as a composite index. In general, the composite index is constructed by the sum of exposure and sensitivity divided by adaptive capacity. The result of the composite index is the evidence of higher and lower vulnerability of household due to climate induced disaster. If composite index has higher score, its vulnerability level will be higher. If it has lower score, its vulnerability will be lower.

Figure-2 shows climate vulnerability index (CVI) calculated as composite index of above-mentioned factors through the use of above mentioned methods (the details in Annex-VII). The result of CVI is presented in Table 4 below. The result is the evidence of different household vulnerability level of household. In Table 21, about 29.1 percent household was extremely higher vulnerable lying between 0.8 and >1. It is followed by 20.9 percent household higher vulnerable between 0.5 and 0.8. about 17.0 percent moderately vulnerable household lying between 0.2 and 0.5, about 33.0 percent less vulnerable household lying between 0.0 and 0.2. It indicated 50 percent moderate and higher vulnerable household from climate induced disaster: landslide and flood. It was supplemented by additional 17.0 percent moderate vulnerable housheolds. Thus, in total, about 67 percent household is vulnerable at different level from moderate to extremely higher vulnerable. The remaining (33 percent) is least vulnerable.



***Source*:** Field Survey, 2015

Fig 4: Vulnerability Index by Household

Table 4: Vulnerability Index by Household

Vulnerability category	Household Situation	Vulnerability Index	% of Household
Extremely higher vulnerable	Extremely higher urgency level	>1 to 0.8	29.1
Higher vulnerable	Higher Urgent level	0.8 to 0. 5	20.9
Moderate vulnerable	Urgent level but temporary external assistance to recover	0.5-0.2	17.0
Less vulnerable	Vulnerable situation but still able to cope	0.2 to 0/(-)	33.0
Total			100

***Source*:** Field Survey, 2015

4.5. Discussion and Conclusion

Above result provides strong evidence on the status and rank of adaptive capacity of household lying from zero score to nearly 1 (100 percent) score. It provides the evidence of heterogeneity at household adaptive capacity based on the selected its four indicators: literacy rate, economically active population, proportion of people engaging in off farm activity and proportion of people more than one engaging in off farm activity. In the range from 0 to 1, how much score moves towards zero, so much adaptive capacity will be lower. In reverse, how much score moves towards 1, so much adaptive capacity will be higher. Its lower score means poor effectiveness of development policy and initiation of the government and need to external assistance. It further shows ineffectiveness of development policy and initiation of the government. In other words, these household are poor. If not, it further shows the effectiveness of development policy and initiation of the government. In other words, these household are well off.

Above result provides the evidence of heterogeneous adaptive capacity of household in which about 40 percent households (Table 19) have lowering adaptive capacity. It means nothing household having poor capacity in terms of literacy and resource. Thus, these household can be considered as potential vulnerable household in the absence of coping capacity. This is a critical issue to minimize the impact of climate induced disaster. It indicates need of urgency short- and long-term support of the government to improve their adaptive capacity as preparedness to adapt climate vulnerability. In case of the higher score of adaptive capacity of 60 percent (Table 2), it indicates households having coping capacity to vulnerability and occurance of lower vulnerability. Still, it needs only short term support for temporary management.

Above result of sensitive index of household in the study area provides evidence of heterogeneity to climate induced natural disaster: flood and landslide. All household are sensitive to vulnerability above lower level. In Table 2, about 52.7 percent households is higher and moderately sensitive. Highly and moderately sensitive household have higher threat of vulnerability. If these household are not responded urgently, there will be a problem of safety of household and population. Meanwhile, as Table 19 shows 47.4 percent households of the study area as less sensitive. They do not need its urgent response for improving the safety of household and population.

Similarly, above result provides the evidence of heterogeneous exposure index of household in the study area due to climate induced natural disaster: flood and landslide. All households are exposure to vulnerability above lower level. In Table 20, about 1.1 percent households were at higher exposure. It was followed by about 3.3 percent moderately exposure households. It indicates these households having higher vulnerability level. If these household are not responded urgently, there will be a problem of recovery of household and population. Meanwhile, 95.6 percent households of the study area is less exposure. They need not urgent response for recovering household and population.

Based on heterogeneity of adaptive capacity, sensitivity and exposure and based on above result of climate vulnerability index (CVI) in the study area, there is a sufficient evidence of heterogeneous household vulnerability level. The characters of all households are vulnerable at different level. Except less vulnerable household (33.0 percent), about 67 percent households (Table 4) are vulnerable households in which extremely higher and higher vulnerable households (50 percent) has dominated. Majority of vulnerable household indicates their occurrence of unusual climate induced natural disaster: flood and landslide in the study area due to changing pattern and intensity of annual rainfall, particularly changing monsoon rainfall and also increasing temperature. Household sensitivity and exposure level are greater than adaptive capacity of household because of lower literacy and poor resources. In addition, the development policy and program of the government along with terrible preparedness and management are ineffective. Thus, annual frequency of disaster has contributed to increase in depth poverty and inequality in the study area. In the absence of proper responding resilient local governance and resource, the vulnerability level is still as it is. Its negative contribution may be in HDI and GDI of the study area. Based on above findings, alternative hypothesis for objective 2 is accepted.

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