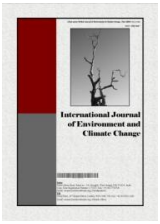

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Climate Change Vulnerability Assessment in the High Mountain Region of Nepal: A Case Study of Lamjung District

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Authors' contributions

This work was carried out in collaboration among all authors. Author KR had the original idea for this paper. Author BKN had written this manuscript. Author RKP had collected the data. All authors have read and approved the final manuscript.

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ABSTRACT

Climate change vulnerability has need access to targeted scientific information about the impacts of climate change in order to adapt to its effects. Awareness can be measured through three different parameters-conceptualization, engagement and experimental. This research has conduct in Lamjung district where people are victimize from climate change. Primary and secondary sources of data are used. This study used household surveys and focus group discussions to assess people perceptions of these changes and identify the climate change vulnerability. Thus, the present study aimed to evaluate the Lamjung districts, vulnerable in the context of the climate change. This result is useful for policymaker, local government and different stockholder who are working on climate change sector. It is also important for long term changes in climate variables and occurrences of natural disasters is the most important component to determine the overall vulnerability. Climate change vulnerability had been decreased considerably in this study area. Meanwhile, long-term research in Nepal is required for extensive work on climate change and primary data collection for climate change vulnerability assessment.

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Keywords: Climate change; adaptive capacity; awareness; vulnerability; Lamjung.

1. INTRODUCTION

Climate change is currently a global issue, which has been mount as a hot issue in the present world. Scientists and policy makers across the world have a due concern in climate change, its affects and vulnerability [1-3]. It is well known fact that climate change affects livelihood as well as environment [4]. The average surface temperature of the earth has been increasing since the end of the Little Ice Age [5,6]. Over the past few decades, human activities have significantly altered the atmospheric composition [7]. The average surface temperature of the earth has increased between 0.3ºC and 0.6ºC over the past hundred years and it likely to continue in future [8,9].

The extent of the impact depends on the magnitude of climatic changes affecting a particular system (exposure), the characteristics of the system (sensitivity), and the ability of people and ecosystems to deal with the resulting effects (adaptive capacities of the system) [10]. It is crucial that future methods are developed around the specific environmental and socioeconomic context of the study area to ensure policy guidance and management recommendations to meet the needs of local stakeholders [11]. The differences in vulnerability are attributable to substantial variations in orography, climate conditions, and ecosystems, as well as differences in the social structures, economic status and requirements of different communities [12].

Many studies have predicted for strong increase in temperature in future. The approach used to produce the metric for the development of a composite indicator called “Index of Human Vulnerability” [13]. For example, temperature likely increased between 3.5 and 5.5ºC by 2100 in the Indian subcontinent [14]. And an even greater increase is predicted for the Tibetan Plateau [15,16]. It was estimated that a 1ºC rise in temperature will cause alpine glaciers worldwide to shrink as much as 40 per cent in area and more than 50 percent in volume as compared to 1850 [14,17]. The extent to which global precipitation changed over the same time is more variable and uncertain [18]. Though warming has not been uniformed across the planet, the upward trend in the globally averaged temperature shows that more areas are warming than cooling [19]. Since 1880, surface temperature has risen at an average pace of 0.07°C every 10 years for a net warming of 0.94°C through 2016 [20].

Over this 137-year period, average temperature over land areas has warmed faster than ocean temperatures: i.e. 0.10°C per decade compared to 0.06°C per decade [21]. According to United Nations Framework Convention on Climate Change, Climate change can be defined as change of climate that is attributed directly or indirectly to human activity which alters composition of the global atmosphere and that is in addition to natural climate variability observed over comparable times [22,23]. Female, old age people, child and marginalized group are likely to be more sensitive to negative impact of climate change [24]. The high degree of sensitivity and low adaptive capacity of the people are responsible for such a high vulnerability to climate change [25–27]. The adaptive capacity to cope with the negative impact of climate change among stakeholders is highly dependent on the awareness. Most of the people in this area are engaged in agriculture, which is significantly affected sector from climate change [28–30].

Nepal is mountainous country with huge diversity in geographical and climatic phenomena. Country experiences tropical hot monsoon (in lowland Terai Plain) to alpine tundra (in High Mountain and High Himalayan regions) types of climate. Peoples’ perception of climate change, covering all the ecological regions of Nepal, is not well documented, and most previous studies have concentrated on specific locations in Hill and Mountain regions, with limited attention given to the Terai region [31,32]. The recorded rates of warming in the Himalaya are significantly higher than the global average [33]. In Nepal, the indicator method had applied for assessing the vulnerability to climate change [34–36]. Studies have related the impacts of climate change to increased vulnerability to hydro meteorological events at the national level. Nepal has an extremely varied and complex climate, driven by the uneven terrain and regional weather systems. Nepal is experiencing higher rate of climate change [37–39]. The analysis of temperature shows a trend of warming by 0.4°C–0.6°C per decade [33,40]. Climate change had been observe more severely in Hindu Kush Himalayan region including Nepal [41–43]. Different sectors such as socio-economic, biodiversity, livelihood, water resources and

energy are already experiencing negative impact of climate change in the country [44–46].

This paper provides a systematic quantitative analysis of the academic literature on the impacts of climate change and vulnerability assessment in study area. We found there are many effects of climate change and people have strong adaptive capacity. Nowadays, people are using many indigenous knowledges for decreasing the subsequent effects of climate change. The occurrence of natural disasters such as flash floods, landslides and drought and its losses and damages are increasing because of climate change in Lamjung. Further study is necessary to find out the impacts of climate change and people's adaptive capacity for sustainable development of rural area. People's livelihood is highly vulnerable at this study area. The aim of this study is to assess the vulnerability in the context of the climate change. The findings of the study will be utilize to formulate climate change adaptation strategy in Nepal, as well as to increase the adaptive capacity of rural people. Climate change vulnerability is a global phenomenon; this research has followed climate change vulnerability approach based on IPCC's framework of vulnerability.

2. MATERIALS AND METHODS

2.1 Study Area

This study area covers the two locations of Lamjung District in Gandaki Province of Nepal, Site 1 Chiti and Site 2 Jita and Taskar (Fig. 1). Site 1 which lies on central part of Lamjung district, whereas Site2 lies on the south western part. The watershed area of Marshyangdi River in Chiti consists of 12 sub-watersheds. Chiti lies in Besishahar Municipality. Similarly, Taksar lies in Madhya Nepal Municipality and consists of 34 sub watersheds. The study area Site1 covers a total area of 1761.58 ha. Geographically, the study area lies in between 28°9′55.42″ to 28°13′50.7″ N and 84°24′21.41″ to 84°27′30.70″ E. The dominant soil type indicated by Land Resource Maping Project (LRMP) report is Entisols and Inceptisols. The dominant soil texture is loamy skeletal and drainage condition ranged from well to moderately well. The Land use of the Site2 classified as agricultural, forest, grassland, pasture and open area. Total area of

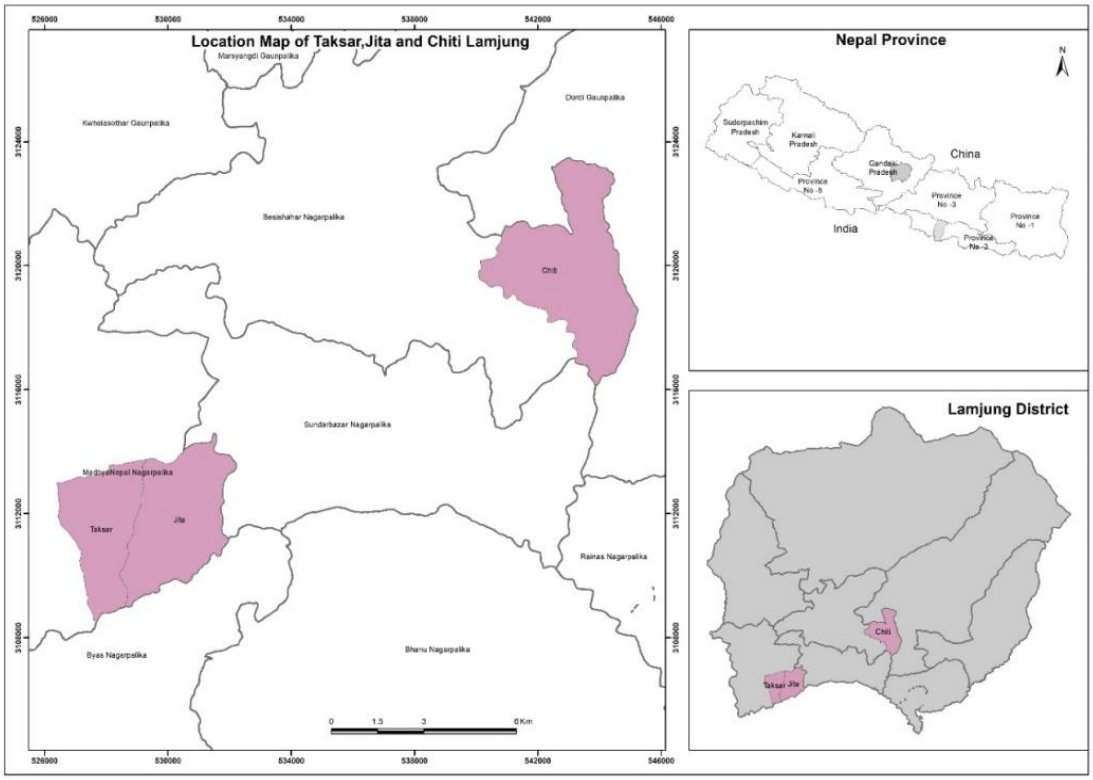

Fig. 1. Location map of study areas

the study site2 is 2079.761 ha. The longitudes and latitudes of the area is within 84°16′6.89″ E to 84°19′40.45″ E and 28°5′43.86″ N to 28°9′1.84″ N. The slope in the area ranges from less than 1° to more than 30°. The dominant soil type indicated by Land Resource Mapping Project (LRMP) report is ENT sols and Inceptisols. The dominant soil texture is loamy skeletal and drainage condition ranged from well to moderately well. The elevation of the area ranges from 420 meters to 1480 meters above the sea level. The special climate change fund project (EbA SSC) determined this study areas as suitable because Lamjung and Mugu districts were found to be more vulnerable in terms of climate change among other districts in Nepal [44].

2.2 Data Collection

A well-structured household questionnaire was use to obtain information about household socio-economic information, climate change impact, perception about climate change, as well as indigenous knowledge/strategy to cope for climate change. Since household questionnaire forms were too long so it consumed more time (> an hour per respondent) at household survey. The survey was pilot from April to May in 2018. The sample size was composed of 150 households. Stratified random sampling method is use for household survey. All data recorded and analyzed in Microsoft Excel.

We conduct eight (8) focus group discussion (FGD) and 15 key informants interview (KII) at study areas to gain in-depth information and elicit subjective experiences on climate change, changing livelihood activities, socio-cultural activities, social festivals, traditional institutions, as well as status and problems initiated due to climate change. Prior to conducting an interview and the focus group discussions, all participants and respondents briefed about the type of questions, the main purpose of the study and the discussion procedures. The participants of both activities were mainly adult, local government leaders, teachers, social mobilizers, farmers and women group.

2.3 Conceptual Framework

This study based on primary and secondary sources of data. In order to gather primary data and other information, household survey, key informant interviews (KIIs), focus group discussion (FGD) and observation methods adopted as mentioned in above section and secondary information was collect from various sources. The households selected with purposive sampling method from different settlement sites of within study areas.

It is divided into three main groups of indicators, it is categorized in “exposure,” “sensibility,” and “adaptive capacity”. As a result, it is necessary to identify proxy variables or indicators used to construct them transparent and understandable variable of vulnerability. Participatory Rural Appraisal (PRA) tools, such as Focus Group Discussion (FGD), key informant survey, household survey and transact walk were used to collect the information for this study. To analyze the collected data, SPSS and MS Excel used. This present survey followed the guidelines developed by the project on concept of vulnerability, methods of data collection and calculation of vulnerability index that was also use in baseline survey.

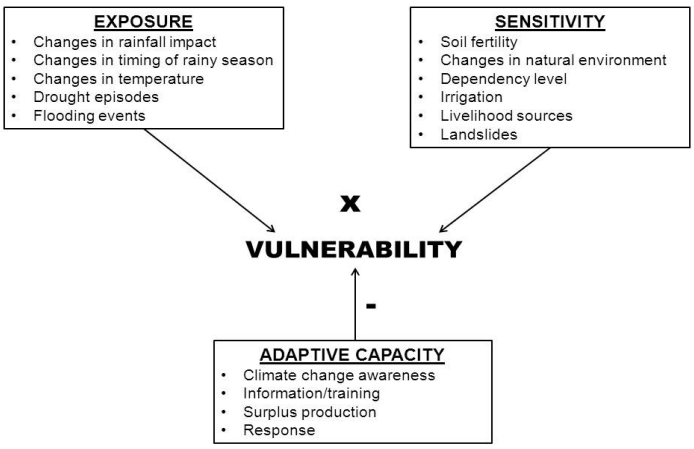

Fig. 2. Indicators of climate change vulnerability

Major indicators and their scoring methods used under three different vulnerability components given in table. Similarly, the indicators and their scoring methods for preparing awareness index given in table.

The vulnerability index calculated by using the following equations:

- The exposure index was calculate as the sum of five indicator scores (i–iv).

$$Exposure = \left(\sum_{i}^{iv} score\_indicator \right)$$

- The sensitivity index was expresse as the sum of six indicator scores (v–x).

$$Sensitivity = \left(\sum_{v}^{x} score\_indicator \right)$$

- The adaptive capacity index was expresse as the sum of four indicator scores (xi–xiv).

$$Adaptive\ capacity = \left(\sum_{xi}^{xiv} score\_indicator \right)$$

- The vulnerability index was expresse as the product of sensitivity and exposure minus adaptive capacity.

Vulnerability = (Exposure x Sensitivity) – Adaptive capacity

Similarly, the climate change awareness was calculate as a composite index of three indicators:

i) Conceptual awareness
ii) Experiential awareness
iii) Engagement

Scores for climate change awareness are further normalize to range between 0–100 percent by dividing the scores with the largest possible score (9) and multiplying the quotient by 100.

$$Awareness\ (\%) = \frac{\text{climate change awareness score}}{9} \times 100$$

3. RESULTS

3.1 Exposure

At the time of baseline survey in three just write village of Lamjung district, out of 150 household the average household index value of three VDC was in variation. The exposure index value in Fig. 3 was rising in all three VDCs. The average value of Chiti 0.86 was seen higher than among them i.e Jita was 0.79 and Tandrang Takasar was 0.81. The minimum value of Chiti and Taksar was seen equal 0.50. However, the index value of Jita was seen low 0.20, whereas, Chiti and Jita were equal value 1.00 as well as higher than Taksar was 0.90. The Fig. 4 shows that there were compared the exposure index value of 2017 to 2018.

3.2 Sensitivity

Sensitivity is the degree to which a given community or ecosystem is affected by climate stresses the household index value of vulnerability components Sensitivity has index value in all three VDCs was rising it has rang from Fig. 5. The average index value of Takshar 0.55 was see higher than other two VDCs i.e Jita was 0.54 and Chiti was 0.51. Minimum index value of Takshar 0.35was seen the highest and the lowest was seen in chiti i.e. 0.13. The maximum index value of Chiti i.e. 0.79 was seen higher than other two i.e. Takshar was 0.77 and Jita was 0.69.

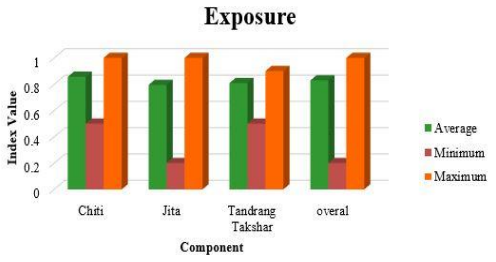

Fig. 3. Household index value of vulnerability components VDC wise exposure

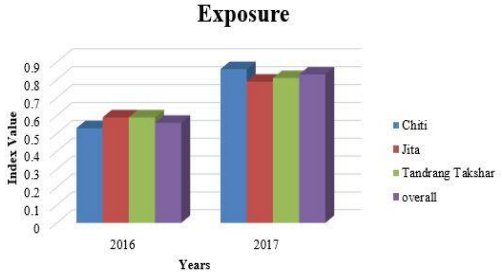

Fig. 4. Household level index value exposure

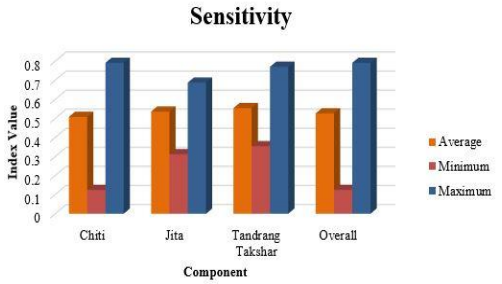

Fig. 5. VDC wise household index value of vulnerability components sensitivity

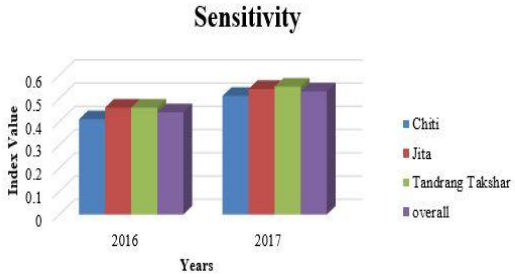

Fig. 6. Average household level index value of sensitivity in different period

3.3 Adaptive Capacity

Adaptive capacity is the ability of a system to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences [47]. The Fig. 7 shows that the average value of adaptive capacity of Chiti was 0.60, which was higher, and adaptive capacity of Jita was 0.57, which was see, quit higher than Takshar 0.56. The minimum value of Chiti, Jita and Takshar were seen equal value 0.25. On the other side, the maximum value of Chiti and Takshar were seen equal i.e. 1.00 and 0.88 respectively. We can see that the index value of adaptive capacity of Chiti/Jita/ Tandrang Takshar which was higher in 2017 than in 2016. The index value of adaptive capacity of Chiti/Jita/Takshar was see equal in 2016 that shown in Fig. 8.

Therefore, from Ministry of Environment, when the researcher was attempt the comparison of this index with their report publish was normal but in study area all the parameters of climate change vulnerability component i.e. adaptive capacity are higher.

3.3.1 Awareness

Climate change awareness is most closely associated with education. Improving basic education on climate and public understanding of the local dimensions of climate change are vital for public engagement and support for climate action [48].

People of Lamjung district are more experience, they engaged in this type of program, they have conceptual idea and they experimental all the awareness activities.

3.3.2 Vulnerability

Vulnerability is defined as the extent to which a natural or social system is susceptible to sustaining damage from climate change [49,50]. Vulnerability is a function of the sensitivity of a system to change in climate and ability to cope up with the circumstances change in climate [51].

VDC level index value of vulnerability obtained through surveyed carried out data in 2017 in three pilot sites. The VDC wise vulnerability index value of Takshar, which was 0.37, and Jita

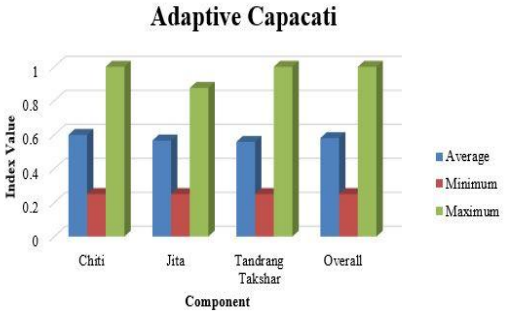

Fig. 7. VDC wises household level index value of vulnerability components adaptive capacity

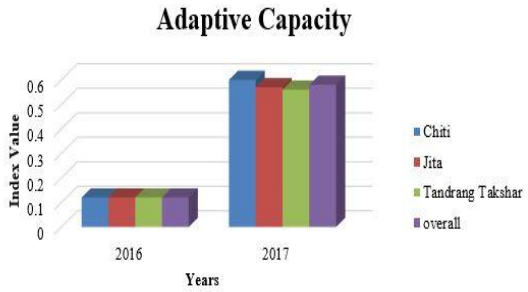

Fig. 8. Average household level index value of adaptive capacity in different period

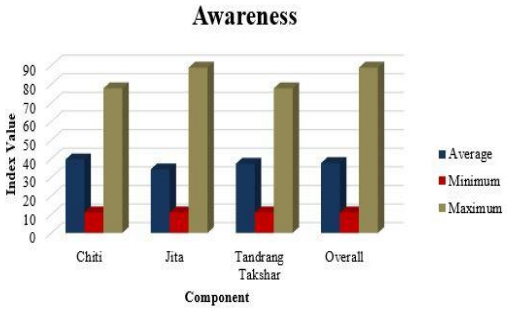

Fig. 9. VDC wise household index value of awareness

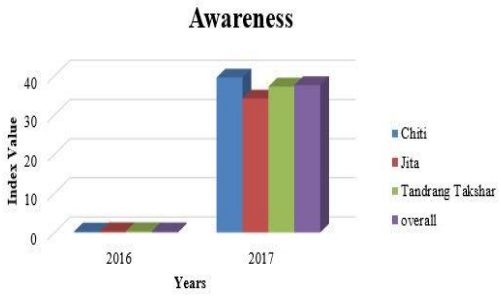

Fig. 10. Household level index value of awareness in different period

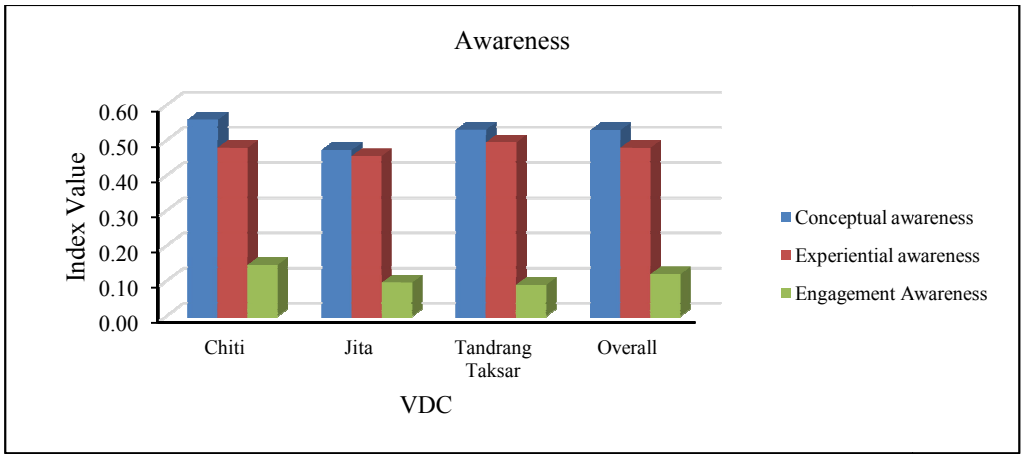

Fig. 11. Conceptual level in awareness household level index value

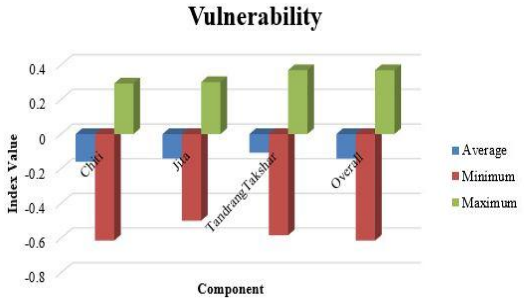

Fig. 12. VDC wises household level index value of vulnerability

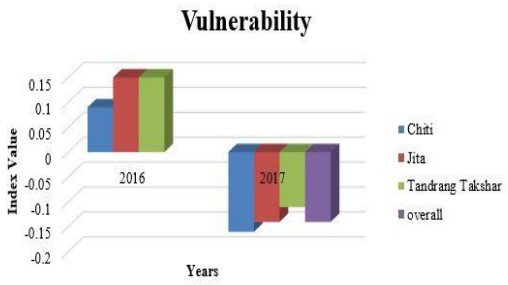

Fig. 13. Household level index value of vulnerability in different period

by 0.30, which was maximum vulnerability ratio. Similarly, Chiti was 0.29, which was maximum vulnerability, but it seems to be lower than two other maximum vulnerability ration.

4. DISCUSSION

This framework was prepared to provide decision-makers and adaptation implementers such as (local) government officials, development experts and civil society representatives with a structured approach and a source book for assessing vulnerability to climate change. Furthermore, it provides a selection of methods and tools to assess the different components that contribute to a system's vulnerability to climate change. The spatial distribution of people and other assets of human value on the landscape determines the level of human exposure to climate variability and climate change [52–54].

The index value of Chita/Jita/and Takshar VDCs had seen high in 2017 than in 2016. As we can see that other two VDC. I.e. Jita and Tandrang Takshar seen equal in 2016. Exposure of a locality to long-term changes in climate variables and occurrences of natural disasters is the most important component to determine the overall vulnerability of the locality [33]. However, biophysical elements determining the exposure like temperature, rainfall and natural disasters are beyond the immediate influence of the policy makers. The researcher was attempt the comparison of this index with their report publish by National Adaptation Program for Action to climate change [55], which was higher but in study area all, the parameters of climate change vulnerability are normal.

Climate change expected to have a significant impact on food and water security in the Mountainous Region [40]. Although data on the effects of climate change and particularly on glacial melting is conflicting, it is evident that changes in precipitation and temperature increases are leading to increased vulnerability in the region. Climate change is affecting the seasonality of rainfall, which affects agricultural productivity, health, water and food and security [56-58].

Fig. 6 shows that the index value of sensitivity of Takshar and Jita was shown equal 0.46 and Chiti 0.41 in 2016. The index value of sensitivity of Takshar was 0.55, Jita was 0.53 and Chiti was 0.51 in 2017. While comparing the vulnerability ratio with the data published by MoE, 2010, the sensitivity index of all study areas is increasing. As climate change infested high vulnerability in the study areas, people are compelled to adopt secondary occupation for their need.

The household index value of awareness by respective Study areas where the average value of awareness of Chiti was 39.56, which is higher than other two VDCs i.e. Tandrang Takshar was 37.24 and Jita, was 34.21. The minimum value of awareness of Chiti, Jita and Takshar were equal i.e. 11.11. The maximum value of Jita was 88.89, whereas Chita/ Takshar were maintain equal position of awareness i.e. 77.78 as well which shown in Fig. 9. The average household level index value of awareness in different period. Awareness index value was seen lower in 2016 with compare to 2017 shown in Fig. 10. The index value of awareness was drastically increase in 2017.

The minimum vulnerability all three VDC were (-) value in Chiti by -0.61 which was high, Takshar by -0.58 and last Jita was secured -0.50 which was VDCs low and minimum Index value of vulnerability. In average index value we can see in the figure also (-) value in Chiti -0.15, -0.14 Jita second and -0.11Tandrang Takshar third rank of index value which is described in Fig. 12. Average household level index value of sensitivity in different period presented in Fig. 13. The value of vulnerability in 2016 was higher than in 2017. The average household level index value of Tandrang, Takshar was lowest in 2017 than in 2016.

However, the exposure and sensitivity were increased slightly, but the vulnerability was dropped from 0.12 in 2016 to -0.14in 2017. Such a drop in the vulnerability index was due to enhanced awareness and adaptive capacity of the people. At the last compare district label, ministry of environment (MoE), survey district was more vulnerable, but in the particular area, it was found that awareness and adaptive capacity was high. Hence, people residing there were less vulnerable as indicated by 2017 survey.

Out of the three components of vulnerability, adaptive capacity is the component having direct policy implications. Improving the adaptive capacity also has indirect implications on improving the sensitivity of the community. By getting the result of the whole data of study area. The exposure and sensitivity value of all study area have increased slightly and at the same time, the awareness among people and their adaptive capacity is increase faster. Because of this and as compared to the results obtained in 2017 and 2018, it shows the value of vulnerability has decreased. The main reason behind the decrease in value of vulnerability is rapid increase in awareness and adaptive capacity. The results obtained provide a basis for the decision makers concerning the need for the targeting of public policies to specific sectors in order to improve the adaptive capacity of Lamjung district, Nepal.

5. CONCLUSION

Our research establishes noticeable information on vulnerability assessments. The results imply that exposure of a locality to long term changes in climate variables and occurrences of natural disasters is the most important component to determine the overall vulnerability of the locality. Our paper establishes foundational knowledge

on vulnerability assessments. This area of practice is evolving and will remain important a support unity for the application of vulnerability assessments. In addition, adaptation decision-making increasingly present themselves. However, biophysical elements were determining exposure like temperature, rainfall and natural disasters are beyond the immediate influence of the policy makers. As a result, in 2017 the average value of vulnerability has dropped significantly as compared to the results obtained in 2016. In addition, Value of Awareness and Adaptive Capacity is rapid increase.

Climate change has several impact. It affect livelihoods of the people in mountainous region more than other region. It has some positive impacts but negative impacts is high. In order to minimize the risk, communities need to understand the climate change patterns, the likely impacts on livelihoods and measures to moderate the negative impacts. This study was able to show that communities can assess the climate change vulnerability, assess the level of associated risk and map it, prepare the adaptation plan to moderate the likely negative impacts and access resources from the local government to implement their plan. In light of the findings of this study, we recommended that the local government should use the climate change vulnerability assessment in their regular planning to address the climate change issues at the community level.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Scheraga JD, Ebi KL, Furlow J, Moreno R. From science to policy: Developing responses to climate change. Clim. Chang. Hum. Heal. - Risks responses. 2003;237–266.
2. Mertz O, Halsnæs K, Olesen JE, Rasmussen K. Adaptation to climate change in developing countries. Environ. Manage. 2009;43(5):743–752.
   DOI: 10.1007/s00267-008-9259-3
3. Pralle SB. Agenda-setting and climate change. Env. Polit. 2009;18(5):781–799.
   DOI: 10.1080/09644010903157115.
4. Ford ND, Patel SA, Narayan KMV. Obesity in low and middle-income countries: Burden, drivers and emerging challenges, Annu. Rev. Public Health. 2017;38(1):145–164.
   DOI: 10.1146/annurev-publhealth-031816-044604
5. Camuffo D, Bertolin C, Craievich A, Schenal P, Granziero R. The little ice age in Italy from documentary proxies and early instrumental records. Mediterranee. 2014; 122(1):17–30.
   DOI: 10.4000/mediterranee.7005
6. Tang L, Zhou J, Bobojonov I, Zhang Y, Glauben T. Induce or reduce? The crowding-in effects of farmers’ perceptions of climate risk on chemical use in China. Clim. Risk Manag. 2018;20:27–37.
   DOI: 10.1016/j.crm.2018.02.001
7. Le Treut H, Cubasch U, Allen M. Historical overview of climate change science. 2005; 16.
8. Riaz S, Ali A, Baig MN. Increasing risk of glacial lake outburst floods as a consequence of climate change in the Himalayan region; 2015.
9. Lockwood JG. Impact of global warming on evapotranspiration. Weather. 1993;48(9): 291–299.
   DOI: 10.1002/j.1477-8696.1993.tb05914.x
10. Tonmoy FN, El-Zein A, Hinkel J. Assessment of vulnerability to climate change using indicators: A meta-analysis of the literature. Wiley Interdiscip. Rev. Clim. Chang. 2014;5(6):775–792.
    DOI: 10.1002/wcc.314
11. Bitsura-Meszaros K, Seekamp E, Davenport M, Smith JW. A PGIS-based climate change risk assessment process for outdoor recreation and tourism dependent communities. Sustain. 2019;11 (12).
    DOI: 10.3390/su10023300
12. Yadava RN, Sinha B. Vulnerability assessment of forest fringe villages of

Madhya Pradesh, India for Planning Adaptation Strategies. Sustainability. 2020;12(3):1253.
DOI: 10.3390/su12031253

13. Adger WN. Vulnerability, Glob. Environ. Chang. 2016;16(3):268–281.
DOI: 10.1016/j.gloenvcha.2006.02.006
14. IPCC, Climate Change 2001: Impacts, adaptation and vulnerability. IPCC Third Assessment Report; 2001.
15. Goyal MK, Surampalli RY. Impact of climate change on water resources in India. J. Environ. Eng. (United States). 2018;144(7).
DOI:10.1061/(ASCE)EE.1943-7870.0001394.
16. Darrow M. Climate change and the right to water. Hum. Right to Water Theory, Pract. Prospect. 2017;174–222.
DOI: 10.1017/9780511862601.008
17. Wang Y, Wang J, Li S, Qin D. Vulnerability of the Tibetan pastoral systems to climate and global change. Ecol. Soc. 2014;19(4).
DOI: 10.5751/ES-06803-190408
18. Fischer AP. Forest landscapes as social-ecological systems and implications for management. Landsc. Urban Plan. 2018;177:138–147.
DOI: 10.1016/j.landurbplan.2018.05.001
19. Yanik T, Aslan I. Impact of global warming on aquatic animals. Pak. J. Zool. 2018; 50(1):353–363.
DOI:10.17582/journal.pjz/2018.50.1.353.363.
20. Chaulagain NP. Impacts of climate change on water resources of Nepal: The physical and socio-economic dimensions. IOP Conf. Ser. Earth Environ. Sci. 2009;6(29): 292029.
DOI: 10.1088/1755-1307/6/9/292029
21. Przybylak R, Wyszyński P. Air temperature changes in the Arctic in the period 1951–2015 in the light of observational and reanalysis data. Theor. Appl. Climatol. 2020;139:(1–2):75–94.
DOI: 10.1007/s00704-019-02952-3
22. Ravindranath NH, Sathaye JA. Climate Change: Vulnerability, Impacts and Adaptation. 2002;63–95.
23. Critto A. Climate change: impacts, adaptation and vulnerability. Clim. Chang. Impacts, Adapt. Vulnerability Approaches. 2009;8(3):419–429.
24. Rylander C, Odland JØ, Sandanger TM. Review article. Int. J. Soc. Lang. 2009;140 (1):1–10.
DOI: 10.1515/ijsl.1999.140.149
25. Regmi BR, Bhandari D. Climate change adaptation in Nepal: Exploring ways to overcome the barriers. J. For. Livelihood. 2013;11(1):43–61.
DOI: 10.3126/jfl.v11i1.8612
26. Dhungana N, Khadka C, Bhatta B, Regmi S. Barriers in local climate change adaptation planning in Nepal. J. Law, Policy Glob. 2017;62:20–24.
27. Ober K, Sakdapolrak P. Whose climate change adaptation 'barriers'? Exploring the coloniality of climate change adaptation policy assemblages in Thailand and beyond. Singap. J. Trop. Geogr. 2020;41 (1):86–104.
DOI: 10.1111/sjtg.12309
28. Thapa S, Joshi G. A Ricardian analysis of the climate change impact on Nepalese agriculture. MPRA Pap., no. 29785; 2010.
29. Malla G. Climate change and its impact on Nepalese agriculture. J. Agric. Environ. 2009;9:62–71.
DOI: 10.3126/aej.v9i0.2119
30. Shrestha AB, Aryal R. Climate change in Nepal and its impact on Himalayan glaciers. Reg. Environ. Chang. 2011;11(SUPPL. 1):65–77.
DOI: 10.1007/s10113-010-0174-9
31. Neupane BK, Acharya A, Thapa L. Local People's perception on climate change at Kamalamai Municipality, Sindhuli. Geogr. Base. 2019;6:21–31.
DOI: 10.3126/tgb.v6i0.26164
32. Paudel B, et al. Farmers' understanding of climate change in Nepal Himalayas: Important determinants and implications for developing adaptation strategies. Clim. Change; 2019.
DOI: 10.1007/s10584-019-02607-2
33. Karki M, Mool P, Shrestha A. The initiation, Acta Otolaryngol. 1966;61(S215):8–15.
DOI: 10.3109/00016486609121828
34. Acharya K, Tiwari KR, Timilsina YP, PC S. Assessing vulnerability and adaptation strategies of forest dependent people to climate change in the Mid-hills of Nepal. Banko Janakari. 2015;25(1): 55–62.
DOI: 10.3126/banko.v25i1.13475

35. Chitale VS, et al. Forest climate change vulnerability and adaptation assessment in himalayas. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives. 2014;1291–1294.
DOI:10.5194/isprsarchives-XL-8-1291-2014

36. Biggs EM, Tompkins EL, Allen J, Moon C, Allen R. Agricultural adaptation to climate change: Observations from the Mid-Hills of Nepal," Clim. Dev. 2013;5(2): 165–173.
DOI: 10.1080/17565529.2013.789791

37. Joshi A, Farquhar S, Assareh N, Dahlet L, Landahl E. Climate change in Lamjung District, Nepal: Meteorological evidence, community perceptions, and responses," *Environ.* Res. Commun. 2019;1(3): 031004.
DOI: 10.1088/2515-7620/ab1762

38. Sharma AR. Climate Change and Community Perceptions in the Khudi Watershed, Lamjung, Nepal. Hydro Nepal J. Water, Energy Environ. 2015;17:49–54.
DOI: 10.3126/hn.v17i0.13275

39. Macchi M, Gurung AM, Hoermann B. Community perceptions and responses to climate variability and change in the Himalayas, Clim. Dev. 2015;7(5):414–425.
DOI: 10.1080/17565529.2014.966046

40. Khanal U, Wilson C, Hoang VN, Lee B. Farmers' adaptation to climate change, its determinants and impacts on rice yield in Nepal. Ecol. Econ. 2018;144:139–147.
DOI: 10.1016/j.ecolecon.2017.08.006

41. Krishnan R, et al. The Hindu Kush Himalaya Assessment. Springer International Publishing; 2019.

42. Sharma E, et al. Introduction to the Hindu Kush Himalaya Assessment," in The Hindu Kush Himalaya Assessment. 2019;1–16.

43. Misra A, et al. Diabetes in developing countries. J. Diabetes. 2019;11(7):522–539.
DOI: 10.1111/1753-0407.12913

44. Bista RB, Dahal KR, Gyawali RP. A review of climate change and its effects in the Western Mountainous Water Basin of Nepal. Hydro Nepal J. Water, Energy Environ. 2018;23:79–85.
DOI: 10.3126/hn.v23i0.20829

45. Metternicht G, Sabelli A, Spensley J. Climate change vulnerability, impact and adaptation assessment. Int. J. Clim. Chang. Strateg. Manag. 2014;6(4):442–476.
DOI: 10.1108/ijccsm-06-2013-0076

46. Shrestha B, Ye Q, Khadka N. Assessment of ecosystemservices value based on land use and land cover changes in the transboundary Karnali River Basin, Central Himalayas. Sustain. 2019;11(11).
DOI: 10.3390/su11113183

47. Diane Pruneau, A Khattabi, M Demers. Challenges and possibilities in climate change education. Online Submiss. 2010;7(9):15–24.

48. Reid A. Climate change education and research: possibilities and potentials versus problems and perils? Environ. Educ. Res. 2019;25(6):767–790.
DOI: 10.1080/13504622.2019.1664075

49. Gizachew L, Shimelis A. Analysis and mapping of climate change risk and vulnerability in Central Rift Valley of Ethiopia climate change is one of the current issues that severely impact all climate sensitive sectors like agriculture. The Manifestation of Climate Change. 2014;22(6):807–818.

50. Bitew AM. Strategies to adapt to climate change in the Central Rift Valley of Ethiopia: Landscape impact assessment for on-farm adaptation. Strategies to Adapt to Climate Change in the Central Rift Valley of Ethiopia: Landscape Impact Assessment for on-farm Adaptation. 2015; 170.

51. Malone EL. Vulnerability and resilience in the face of climate change: Current research and needs for population information. Popul. Action Int. 2009;55849.

52. Tsering K, Sharma E, Chettri N, Shrestha A. Climate change impact and vulnerability in the Eastern Himalayas – Synthesis Report. ICIMOD; 2010.

53. Shrestha AB, Devkota LP. Climate change in the Eastern Himalayas: Observed trends and model projections; Climate change impact and vulnerability in the Eastern Himalayas - Technical report 1; 2010.

54. Eriksson M, Jianchu X, Shrestha S, Arun Bhakta Vaidya, Ramesh Ananda Nepal, K Sandström. The changing Himalayas-impact of climate change on water resources and livelihoods in the Greater Himalayas. International Centre for Integrated Mountain Development (ICIMOD); 2009.

55. "Napa," Gov. Nepal. 2010;6(1):96.
DOI: 10.2307/1497461

56. Hatfield JL, et al. Indicators of climate change in agricultural systems. Clim. Change. 2018;1–14.
DOI: 10.1007/s10584-018-2222-2

57. Fuhrer J. Agricultural systems: Sensitivity to climate change. CAB reviews: Perspectives in agriculture, veterinary science. Nutrition and Natural Resources; 2006.
DOI: 10.1079/PAVSNNR20061052

58. Panda A. Transformational adaptation of agricultural systems to climate change. Wiley Interdisciplinary Reviews: Climate Change. 2018;9 (4).
DOI: 10.1002/wcc.520

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