Economics of Climate Change and its Vulnerability all over Nepal for Adaptation and Mitigation

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Abstract

Nepal has *climate variability* in which temperature has slow and gradual growth over time period and the pattern, intensity and distribution of rainfall and precipitation have instable and fluctuation. Its distribution and impact all over the country is different in accordance with altitude, geography and resilience of the community. Climate vulnerability and its effects have heterogeneous pattern across altitude, geography and resilience of the community.

This paper estimated climate vulnerability in the different parts of Nepal through Index Method for finding its rank and distribution by using the secondary data sets of indicators. The estimation result of climate vulnerability of Nepal rank was 0.43. It shows the variation of temperature and rainfall. In its distribution, Kathmandu had 0.61. It was the highest vulnerable district categorized into the Ist Rank. However, Dolpa had 0.18. It was the lowest vulnerable district categorized into 27th Rank. Lamjung District had 0.43. Its rank was 14th. Thus, climate vulnerability occurs heterogeneously all over the country. Therefore, economic policy should be adaptative and mitigative to address climate induced vulnerability and poverty.

Key Words: Climate Variability, Vulnerability, Index Method, Nepal, etc.

1. INTRODUCTION

Climate change is an important global issue and now local issue of developing countries like of Nepal in which in depth theoretical and empirical research is going on to design proper alternative measures of adaptation and mitigation for stabilizing climate change and improving human security, development and welfare. Horizontally, this issue has been making catch up areas to all countries including developed and developing countries. Its impact distribution can be found vertical among countries including developed and developing countries. There are arguments about variation of adaptation capacity and behavior as well as mitigation activities among countries (Stern, 2006). For example: developed countries have strong adaptive capacity with developed resources, advance knowledge and technology, specialized human capacity, infrastructure, institution, etc. Those countries have minimized risk of climate change vulnerability. However, differently, developing countries have weak adaptive capacity with traditional and indigenous knowledge and technology, non-specialized human capacity, poor infrastructure, weak institution etc. In simple, those countries could not minimize risk of climate change vulnerability. In almost literatures (Stern (2006), IPCC (2001a)), developing countries are more vulnerable socio economically than developed countries.

There are studies about vulnerability conducting in different countries. African and Asian countries are more vulnerable in the absence of adaptive capacity and behavior in these studies. At household level survey and studies (Bista, 2007, Bista, 2008, Bista, 2011, Bista, 2011a, Bista, 2011b, Bista, 2011c, Bista, 2013, & Bista, 2016), there are strong observations with arguments that the poor households are more vulnerable than the rich households from climate change because of different assets, literacy, money, information, mobility, physical access etc. Therefore, climate vulnerability has become massive impactful issue in developing countries.

The paper examines climate vulnerability in the different places of Nepal by building climate vulnerability index (CVI) and analyzes extremity of climate vulnerability.

This paper is organized into the following sections: Section 2: Literature Review, Section 3: Theoretical Framework and Section 4: Data sets and Descriptive, Section 5: Results and Discussions, Section 6: Conclusions.

2. LITERATURE REVIEW

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). The application of inductive approach was specific climate sensitive systems in which deductive approach couldn't 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 also mitigation.

Sullivan and Meigh (2005) 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) have assessed vulnerability level of countries in 2007 in the context of the Adaptation Fund under the United Nations Framework Convention on Climate Change 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" (p. 377).

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).

3. THEORETICAL FRAMEWORK

3.1. Concept of Index

Index is a quantitative measure having different meanings and concepts. In simple, it gives numerical value of qualitative information. It is a single indicator as representative group of individual data and information. In another words, it is explained as composite measure presented in the range between 0 and 1 or in percentage. The value of Index provides ranks of regions to compare intra region, intra community, intra country and intra time periods for understanding changes. For example: *Human Development Index (HDI), Poverty Index (PI), Corruption Index (CI), Consumer Price Index (CPI), Market Performance Index (MPI), Climate Vulnerability Index (CVI)* etc.

In economics and finance, this tool is widely applied to measure performance of different sectors, institutions, markets, company and programs. The Consumer Price Index (CPI) is used by the Central Bank, Nepal Rastra Bank as tool to track the

variation in prices for the selected different consumer goods and services over time in a constant geographical location for adopting proper fiscal and monetary policy and also to calculate adjustment salaries, bond interest rates, and tax thresholds for inflation (NRB, 2014). Similarly, there are practices of GDP deflator Index, Job Market Index, Stock Market Index etc. Therefore, Index is very effective statistical tool in economics, finance, climate change economics and other disciplines.

When we talk about Climate Vulnerability Index (CVI), the Index provides composite value of the selected indicators of regions in the range between 0 and 1. The value provides us rank. The rank will be comparable to trace out change of vulnerability situation between intra regions or intra time periods. The measure will be valuable input for the policy measures.

3.2. Theoretical Framework of Climate Vulnerability Index (CVI)

Climate Vulnerability Index (CVI) is an important approach for quantitative assessment of vulnerability to climate change in the present context of global climate change. Vulnerability concept was endorsed as a key category by the IPCC in 2001. In 2002, Wu et. al. (2002) applied first time index approach to measure vulnerability of coastal communities to sea level rise for US coastal communities of Cape May County, New Jersey. It was a beginning of vulnerability index in the research of environment and climate change. Further, it became Climate Vulnerability Index when the Climate Vulnerability Index was presented at Capacity Building Seminar organized at Oxford in 2008. Thus, Climate Change Vulnerability Index (CVI) was established as tool to track out impact performance of climate change in different regions.

Climate Vulnerability Index (CVI) is a holistic and interdisciplinary tool developed to provide a clearer understanding of how climate and other global impacts on water resources are likely to influence human populations (Sullivan and Meigh, 2005; Sullivan and Huntingford, 2009). In other words, the approach measures to the exposure of a

population to some hazards like as flooding, landslides, soil erosion etc. In simple, the index carries a composite of multiple quantitative variables including physical, climatic and capacity and standardized framework. McCarthy et. al. (2001) mentions three components of vulnerability: exposure, sensitivity and adaptive capacity (as per theoretical concept of vulnerability as the degree to which a system is susceptible to or unable to cope with, adverse effects of climate change including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed). These three components as follows:

- Exposure is a direct stressor i.e. climatic variable (temperature, rainfall and precipitation)
- Sensitivity is a human-environmental condition.
- Adaptive capacity is capacity to minimize the impact of exposure i.e. asset, literacy, technology etc.

  It can be presented mathematically as follows:

$$V=f(I-AC)$$

Climate Vulnerability Index (CVI) is theoretically based on three sets of indicators i.e. exposure, sensitivity and adaptive capacity. In this study, under the three sets of indicators, there are inclusive of nine sets of indicators such as temperature, rainfall, HH average size, population density, per capita income, average land holding, irrigated land, average production per unit land, milk production etc. It produces a single number in the range between "0" and "1", which can provide vulnerability rank of the selected 42 regions will be comparable among the selected 42 district regions for understanding the level of climate vulnerability index for developing appropriate climate change policy. This method was also used by Briguglio (1992; 1993; 1995; 1997), Chander (1996) and Crowads (1997)

The selected indicators of the CVI are often measured in different units which may be in Degree, Percent, number, etc. In the course of Index construction, the information and data is standardized or normalized to get average and then get composite index.

A normalization procedure commonly used is that which adjusts the observation to take a value of between 0 and 1, using the formula:

$$V_{ij} = (X_{ij} - MinX_i) / (MaxX_i - MinX_i)$$

where:

V_{ij} = the standardized vulnerability score of $_i$th indicator of CVI for district j;

X_{ij} = the observed value of ith indicator of CVI and $_j$th district;

Max X_i and Min X_i = maximum and minimum value of the observed range of values of $_i^{th}$ indicator of CVI and $_j^{th}$ districts.

4. DATA SET AND DESCRIPTIVES

The data set in this study is the cross-sectional data collected in 2012 and published by Center Bureau of Statistics (CBS) based on Metrology Department, Nepal Government and Environmental Statistics representing all parts of the country. In the construction of Climate Vulnerability Index (CVI), there was selected purposive sampling. Out of 75 districts, only 42 districts were selected purposively. Its reason was availability and reliability of data published by CBS.

There were three climatic data variables: temperature and rainfall recorded by the stations of Metrology Departments all over the country were published by CBS. In addition, the data of the remaining variables such as HH average size, population density, per capita income, average land holding, irrigated land, average production per unit land, milk production were collected from Population Census, 2011 and Agricultural Census, 2011 published by CBS.

5. EMIPIRICAL RESULTS AND DISCUSSIONS

5.1. Climate Vulnerability Index

Climate Vulnerability Index results 0.43 score to Nepal. In other words, Nepal's national Climate Vulnerability Index CVI is 0.43. The result shows variation of temperature and rainfall

Table No 1 shows Index value from minimum (0.18) to maximum (0.61). Minimum index value indicates lowest vulnerability level meanwhile maximum index value indicates highest vulnerability level in the case of two climatic variables: temperature and rainfall variations. Thus, Kathmandu with 0.61 that Ist Rank can be explained as highest vulnerable district meanwhile Dolpa with 0.18 that is 27th rank is lowest vulnerable district in Nepal.

Table 1 shows middle score of vulnerability index that is 0.43. It indicates neither higher nor lower score in Vulnerability Index. Lamjung is such good

Table-1: Climate Vulnerability Index 2014

Vulnerability Rank	Districts	Index Value
1	Kathmandu	0.61
2	Rupandehi	0.60
3	Bara	0.58
4	Morong	0.57
4	Nawalparashi	0.57
5	Sunsari	0.56
5	Bhaktapur	0.56
6	Kaski	0.55
6	Jhapa	0.55
6	Chitawan	0.55
7	Rautahat	0.52
8	Kailali	0.51
9	Syangjia	0.50
9	Ilam	0.50
9	Dhanusha	0.50
10	Dang, Ghorahi	0.48
10	Darchula	0.48
11	Saptari	0.47
12	Kanchanpur	0.46
13	Banke	0.45
13	Dhankuta	0.45
13	Makwanpur	0.45
14	Lamjung	0.43
15	Bhojpur	0.42
15	Tanahaun	0.42
16	Nuwakot	0.40
17	Okhaldhunga	0.38
17	Surkhet	0.38
18	Palpa	0.37
19	Gulmi	0.36
19	Dailekh	0.34
20	Samkhuwasabha	0.33
21	Doti	0.31
22	Gorkha	0.29
22	Taplejung	0.29
22	Dolakha, Jiri	0.29
23	Dadeldhura	0.28
24	Manang	0.24
25	Mustang	0.22
26	Jumla	0.19
27	Dolpa, Dunai	0.18

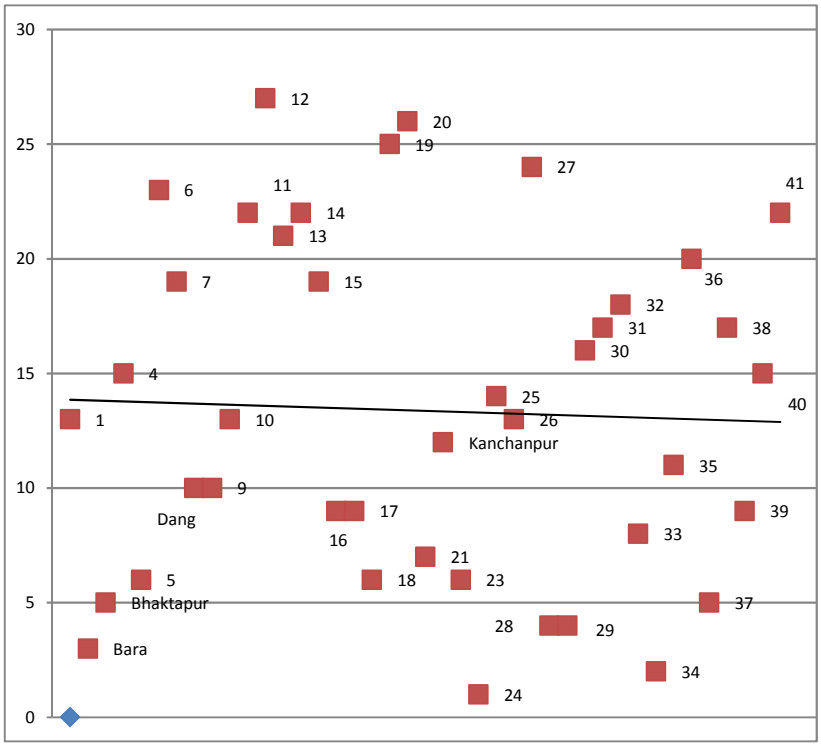
district having 0.43. Its rank is 14th.

Quintile distribution of vulnerability index can be presented and discussed as below. In Top ten highest score, there are Kathmandu (0.61), Rupendehi(0.60), Bara(0.58), Morong(0.57), Nawalparashi(0.57), Sunsari(0.56), Bhaktapur(0.56), Kaski(0.55), Jhapa(0.55) and Chitwan(0.55). Similarly, in Top ten lowest scores, there are Dolpa(0.18), Jumla(0.19), Mustang(0.22), Manang(0.24), Dadeldhura(0.28), Dolkha(0.29),Taplejung(0.29), Gorkha(0.29), Doti(0.31) and Sankhuwasabha(0.33).

5.2. Vulnerability Characteristics and Distribution

Figure -1 shows distribution of districts with Climate Vulnerability Index.

Figure 1: District Distribution and Vulnerability Index



Trend line divides two groups of vulnerable districts. Kathmandu is located at bottom that means highest vulnerability index but Dolpa is at top that means lowest vulnerability index. The Trend line is declining trend explaining inclining vulnerability to climate change in different parts of Nepal.

6. Conclusions

Different climate variability has different effects and vulnerabilities in the different parts of the country, Nepal. The index results 0.43 score to Nepal. The result shows variation of temperature and rainfall. Thus, Kathmandu with 0.61 that Ist Rank can be explained as highest vulnerable district meanwhile Dolpa with 0.18 that is 27th rank is lowest vulnerable district in Nepal. Lamjung is such good district having 0.43. Its rank is 14th. CVI results depend on different variables along with climatic variables. Therefore, CVI could be valuable information to understand climate variability and its vulnerability for economic policy implication and building adaptive and mitigating behavior at institutional and individual level so that the socio economic stress of climate induced vulnerability could be minimized.

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