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Climate Change Vulnerability Mapping for Central Development Region of Nepal

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Abstract

The climate change is real and happening now. The Intergovernmental Panel on Climate Change have already concluded that there is increased global temperature since the twentieth century and it is very likely due to increased anthropogenic Greenhouse Gas (GHG) emissions. As climate change involves complex interactions it has diverse impact. It is now apparent that dealing with climate change is unavoidable and the ongoing climate change, and changes projected to occur are likely to have impacts on different sectors of Nepal. The risks associated with these changes are real and vulnerability to these risks may exacerbate ongoing social and economic challenges. The paper assesses the vulnerability of the Central Development Region, Nepal. Vulnerability index is calculated as the function of adaptation capacity, sensitivity and exposure which were calculated using different indicators. The vulnerability index is mapped for different districts of the region using GIS. The most vulnerable district in the region is Kathmandu along with four other districts, Dhading, Makwanpur, Mahottarai and Dhanusha marked as highly vulnerable districts. Chitwan, Parsa, Bara, Rautahat, Sarlahi, Sindhuli, Ramchhap, Dolkha and Sindhupalchok are ranked having moderate vulnerability index. Lalitpur district along with Kavre, Bhaktapur, Nuwakot and Rasuwa districts are ranked with low vulnerability index.

Keywords

Climate Change – Vulnerability – Mapping

1. Introduction

The Intergovernmental Panel on Climate Change have already concluded that there is increase in global temperature since the twentieth century and it is very likely due to increased anthropogenic Greenhouse Gas (GHG) emissions from burning of fossil fuel and forest conversion [1]. Climate change, the greatest threat of the 21st century, has hammered almost all processes of earth. Either it be on land or ocean or the atmosphere. As climate change involves complex interactions it has diverse impact. Risks are unevenly distributed and are generally greater for disadvantaged people and communities in countries at all level of development[1].

The climate change is real and happening now. The planet is already experiencing its impact on biodiversity, freshwater resources and local livelihood. It is now apparent that dealing with climate change is unavoidable. And our country, Nepal cannot remain unscathed by this global phenomenon [2]. Nepal's temperature is rising faster than the global average, and rainfall is becoming unpredictable. Although Nepal is responsible for only about 0.025% of the total annual GHG emissions of the world [3], it is already experiencing an increasing trend and the associated effects of climate warming.

Being a developing country, Nepal is even more vulnerable to the effects of climate change due to its high dependence on climate-sensitive sectors such as glaciers, agriculture and forestry, and its low financial adaptive capacity [3]. The country's ability to adapt to the adversities has direct implications in its strategies on the sectoral and overall development of the nation.

Adaptation to climate change has emerged as a challenge to achieving and sustaining the development outcomes as mitigation is not taking place as needed [4]. However, adaptation is becoming complicated in practice as climate change and its impacts are faster than the natural process can sustain and they are interlinked with and

embedded into a range of social, economic and political processes [5].
Our case study mainly focus to learn about the vulnerabilities posed by climate change in Central Development Region. The paper assesses the vulnerability of a Central Development Region. The vulnerability index is calculated as the function of exposure, sensitivity and adaptive capacity.

1.1 Study site

Central Development Region is chosen as our study site. The Central Development Region (CDR), one of the five development regions of Nepal, spans all three eco zones – mountain, hill and plains. The Central Region comprises three administrative zones (Bagmati, Narayani and Janakpur) and 19 districts. The population density in the Central Region is 293 inhabitants per square kilometer, which is the highest among all five development regions and significantly above the national average of 157 inhabitants per square kilometer [6]. The Human Development Index (HDI) of the Central Region, 0.531 is higher than the national average of 0.509.

2. Methodology

The general methodology adopted in this study is that of the [7] applied for the vulnerability mapping of Southeast Asia. Their concept was further based on the Third Assessment Report of the IPCC. Vulnerability according to IPCC is defined as, "The degree to which a system is susceptible to, or unable to cope with the 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, its sensitivity, and its adaptive capacity" [8]. Vulnerability can thus be defined as a function of exposure, sensitivity, and adaptive capacity, or: Vulnerability = f (exposure, sensitivity, adaptive capacity)

3. Results

3.1 Adaptation Capacity

Adaptation is defined as adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits bene-

Components	Direct Indicators	Proxy Indicators
Sensitivity		
Human		Population Area
Ecology		Forest Cover Agriculture Area
Exposure		
Temperature and Precipitation	Annual temperature trend Annual rainfall trend	
Landslide	Occurrence Death Injured Affected Property loss Positive rainfall trend	
Flood	Occurrence Death Injured Affected Property loss Positive rainfall trend	
Drought	Negative rainfall trend	Food production
	Mean annual temperature trend	food requirement Population at risk due to food shortages
GlOF	Location of potential GLOF	Distance from potential GLOF
Others climate induced disasters	Occurance Death Injured Affected Property loss	
Ecology		Population pressure on forest land Human poverty index Road density
Adaptation Capacity		
Socio-economic	Literate population above 5 yrs. HDI HPI Population per doctor	
Technology	Landlines Mobile Electricity	
Infrastructure	Road density Irrigation HHs with RCC pillars Drinking water	

Table 1: Methodological framework

Figure 1: Central Development Region

ficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation and autonomous and planned adaptation. Adaptive capacity is defined as the degree to which adjustments in practices, processes, or structures can moderate or offset potential damage or take advantage of opportunities (from climate change). It can be written in equation form as follows: Adaptive capacity = f (socio-economic factors, technology, infrastructure) Through literature review literate population, HDI, HPI, population per doctor, landlines, mobile, electricity, road density, irrigation, HHs with RCC pillars and drinking water are taken as the indicators of adaptation capacity.

Socio-economic adaptation capacity

Human Development Index (HDI), Human Poverty Index (HPI), literacy rate and population per doctors are used to calculate the socio-economic adaptation capacity. Equal weight was assigned to each indices and socio-economic adaptation capacity map was prepared.

Kathmandu, Bhaktapur, Lalitpur and Chitwan are placed as highest socio-economic adaptive capacity and Bara, Rautahat, Sarlahi and Mahottari are the district with least socio-economic adaptive capacity. Urban areas are the one with higher socio-economic adaptation capacity as per the result obtained.

Technology adaptation capacity

Mobile, landlines and electricity were taken as the indicators for the technology adaptation capacity calculation. Each of the indicators was assigned equal weight and technology adaptation capacity map was prepared.

Infrastructure adaptation capacity

Road density, irrigation, water supply and HHs with RCC pillars were taken as the indicators for the infrastructure adaptation capacity. Each of the indicators was assigned equal weight and infrastructure adaptation capacity map was prepared.

Combined adaptation capacity

The combined adaptation capacity map was prepared by adding the weighted values of socio-economic, technology and infrastructure sub-indices. Socio-economic, technology and infrastructure are weighted 0.5, 0.25 and 0.25 respectively.

3.2 Sensitivity

According to IPCC recent reports, humans as well as natural ecosystem are highly affected by climate change. Sensitivity is the degree to which a given community or ecosystem is affected by climatic stresses. For example, a community dependent on rain-fed agriculture is much more sensitive to changing rainfall patterns than one where mining is the dominant livelihood. Likewise, a fragile, arid or semi-arid ecosystem will be more sensitive than a tropical one to a decrease in rainfall, due to the subsequent impact on water flows.

The exposure and sensitivity of a system (e.g. a community) to an environmental change risk (e.g. drought) reflect the likelihood of the system experiencing the particular conditions and the occupancy and livelihood characteristics of the system which influence its sensitivity to such exposure [9]. Human and the ecosystem are both taken as the indicator of the sensitivity.

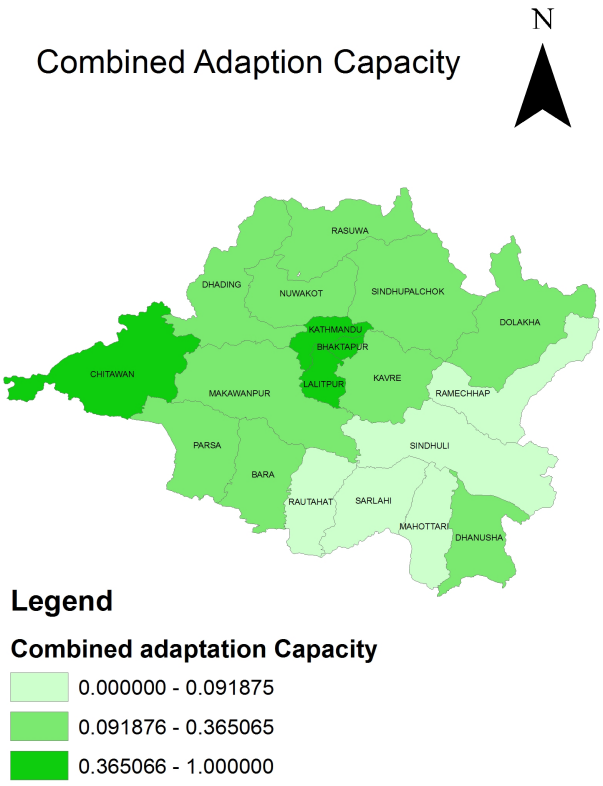

Figure 2: Combined adaptation capacity

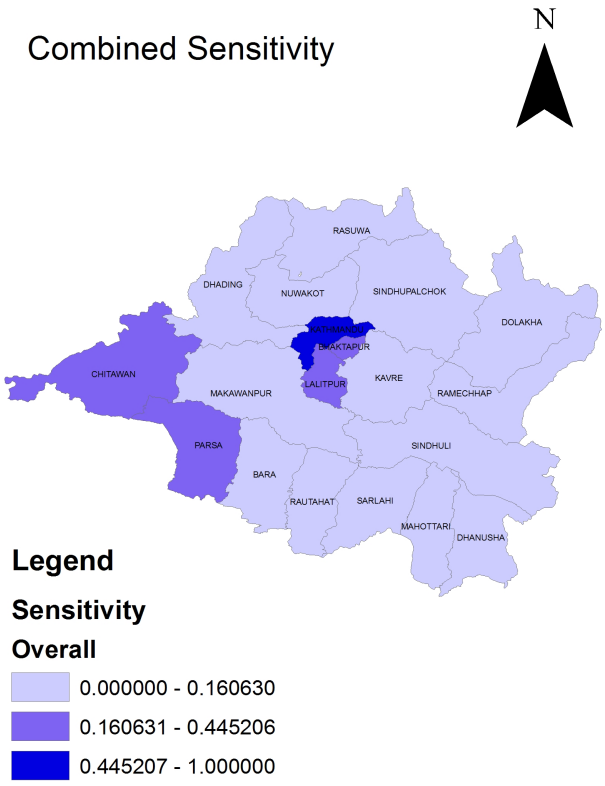

Figure 3: Combined sensitivity

Human Sensitivity

For the calculation of human sensitivity population density was taken as indicator. Population data was obtained from the latest census report. Kathmandu and Bhaktapur are the districts with high human sensitivity.

Ecological Sensitivity

Forest area coverage and agriculture and grass land coverage are taken as the indicators for the calculation of ecological sensitivity.

Combined Sensitivity

Human sensitivity and ecological sensitivity are the indicators for the calculation of the combined sensitivity with weighting of 0.7 and 0.3 respectively. Kathmandu district is the most sensitive district as per the calculation.

3.3 Climate Risk/Exposure

In the context of CDR climate risks/exposure envisaged are annual temperature and rainfall trends, ecology, landslide and floods in Mountain and Hill Zone, flood in Terai, droughts, other climate induced disasters and Glacier Lake Outburst Floods(GLOF). These sub-indices are explained below.

Temperature and Rainfall Risk/Exposure

Annual average rainfall and temperature trend were taken from Practical Action (2009). Giving equal weight to annual average rainfall trend and temperature trend and normalizing them sub-indices for temperature and rainfall risk/exposure was calculated. Negative/positive rainfall trend were denoted by (n) and (p) respectively.

Ecological Risk/Exposure

Sub-indices for Ecological Risk/Exposure were taken from the Climate Change Vulnerability Mapping for Nepal [10].

Landslide Risk/Exposure

Database on landslide in CDR since 1971 is available at UNDP Disinventer. It was in compatible format for variables such as occurrence, numbers of people dead, injured and property loss. Along with these variables, positive rainfall trend were used to develop landslide Risk/Exposure sub indices as shown in figure. Number inside parenthesis indicates weight assigned.

Flood Risk/Exposure

Sub-indices for Flood risk/exposure were calculated as in case of landslide risk/exposure.

Drought Risk/Exposure

Database of drought were used from Practical Action (2009). It was normalized then to develop sub-indices for Drought risk/exposure.

Other Climate Induced Disaster Risk/Exposure

Information about variables such as death, injured and occurrence of other climate induced disaster (avalanches, forest fire, heat waves, thunderstorms, hailstorms, snowfall, cold waves etc.) were obtained from Disinventer(UNDP). Equal weight was assigned to number of deaths, injured and occurrence of the event and then normalized to calculate sub-indices for other climate induced disaster risk/exposure

Glacier Lake Outburst Flood

GLOF risk/exposure data in terms of distance from Glacier Lake were taken from Climate Change Vulnerability Mapping for Nepal (2010). Then by normalizing we developed sub-indices for Glacier Lake outburst flood risk/exposure.

Combined/multiple exposure index

After calculating sub-indices for temperature/rainfall exposure, ecological exposure, flood, landslide, GLOF, drought and other climate induced disaster risk exposure as explained above, combined/multiple exposure index is developed by assigning equal weight to all 7 sub-indices and normalizing them. According to multiple exposure index districts are stratified into high, moderate and low exposed as follows.

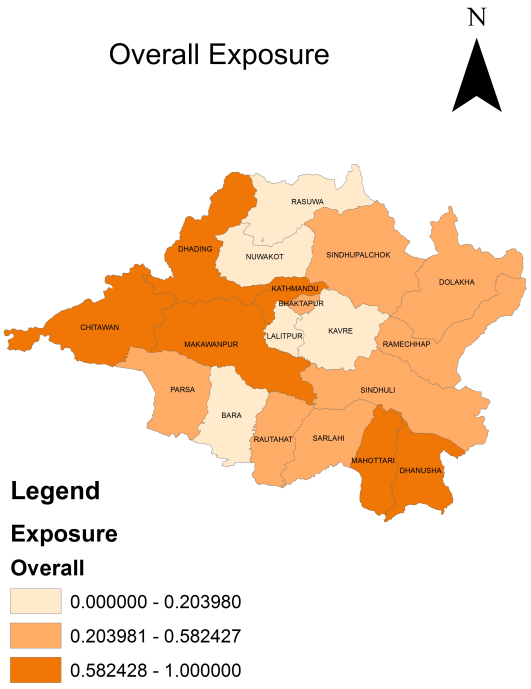

Figure 4: Combined Exposure

3.4 Overall Vulnerability

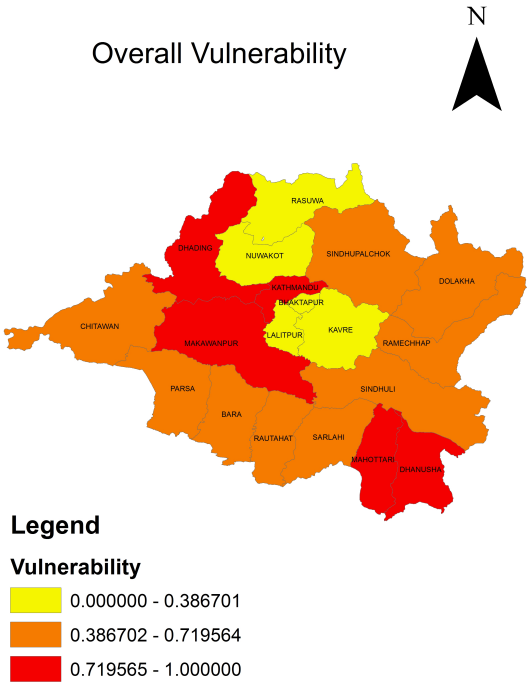

Figure 5: Overall Vulnerability

Kathmandu, Makwanpur, Mahottari, Dhanusa,and Dhading are found to be highly vulnerable districts of central development region and among them aslso Kathmandu is the most vulnerable while rasuwa district as least vulnerable.

Overall Vulnerability	Districts
High(0.72-1.00)	Kathmandu, Makwanpur, Mahottari, Dhanusa, Dhading
Moderate(0.38-0.72)	Chitwan, Parsa, Bara, Rautahat, Sarlahi, Sindhuli, Ramechhap, Dolkha, Sindhupalchowk
Low(0.00-0.38)	Bhaktapur, Lalitpur, Kavre, Nuwakot, Rasuwa

Table 2: Overall Vulnerability

4. Conclusions

Following conclusions were drawn from this project.

- Kathmandu district is the most vulnerable district of central development region with higher exposure, higher sensitivity along with higher adaptation capacity.
- Hilly regions are higher vulnerable due to higher exposer to landslide and food security while terai belt face floods. So adaptation solutions are not similar in all the region and they vary according to time and place.
- Vulnerability changes with time. Districts which are listed as higher vulnerable in MOE "Climate change vulnerability mapping" report are also listed in other categories in this report concluding vulnerability changes with time.

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