Inherent vulnerability assessment of rural households based on socio-economic indicators using categorical principal component analysis: A case study of Kimsar region, Uttarakhand

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A B S T R A C T

The recent trend of shifting focus from hazard centric drivers of vulnerability towards the social and economic drivers of vulnerability has led to a number of conceptual frameworks for social vulnerability assessment. Contributing towards this growing trend of social vulnerability assessment, this study proposes a framework to measure inherent vulnerability, which is centered on hazard generic and livelihood oriented socioeconomic factors of vulnerability. Inherent vulnerability is defined as the predisposition of a household to suffer harm. The study focuses on the mountainous communities in Kimsar region, located in Uttarakhand state, India. The communities in the region suffer from multiple stressors including extreme precipitation, drought, landslides, cloudbursts and flash floods. Vulnerability indicators with mixed scaling are used, to capture household’s perception and other socio-economic attributes, which contribute towards its inherent vulnerability. Data was collected by conducting household surveys in nine villages of Kimsar region. In order to process the indicators with mixed scaling, and obtain an empirical summary of the data set, the method of Non-Linear Principal Component Analysis was used for computing a household level Inherent Vulnerability Index. Results obtained revealed that principal components explaining a major variance in the data set were — access to employment opportunities, effectiveness of local government, access to food, occupational diversity, access to resources, educational attainment and access to water. It was observed that the villages of Dharkot, Kandakhal and Bhumiyakisar have the highest percentage of households, which were relatively less vulnerable to environmental stressors. Higher vulnerability was observed in majority of households in the village Kimsar, Ramjeewala and Malla Banas. A majority of households in Talla Banas, Jogiyana and Kasan were moderately vulnerable. Inherent vulnerability assessment has the potential to predict the future harm a household might suffer due to hazard events.

1. Introduction

The climate change will adversely and disproportionately impact the rural communities by affecting the availability of water, food, agricultural produce, and aggravating poverty (Senapati and Gupta, 2017). These impacts will particularly have an increased effect on the poor and marginalized, such as female-headed households and people with limited access to resources (IPCC, 2014; Rajesh et al., 2014; Tanner et al., 2015; Atapattu, 2015). Socio-economic factors like income, land ownership, social networks are important determinants of a community’s vulnerability to environmental stressors (Phillipo et al., 2015; Senapati and Gupta, 2017). Some of the factors which make rural communities more vulnerable to climate change when compared to their urban counterparts include poor infrastructure, fewer transportation options, lower education rate and slower emergency response time (Houghton et al., 2017). Vulnerability assessment is essential to get an insight into the presence of differential vulnerabilities among households within a community. This information will help in reducing the future harm that a household can suffer due to climate extremities and other stressors.

Traditional hazard centric view of vulnerability focused on assessment of hazard impacts to estimate a system’s vulnerability (Dwyer et al., 2004). Vulnerability is not caused due to a single factor; it results from interplay of various socio-economic processes which results in unequal distribution of vulnerability within a community (Rajesh et al., 2014; Tanner et al., 2015; Atapattu, 2015; Maiti et al., 2017). There is a...
growing awareness to analyse the multiple socio-economic stressors that influences a community’s vulnerability (Räsänen et al., 2016; McDowell et al., 2016; Maiti et al., 2017). The recent paradigm shift in vulnerability assessment views vulnerability as a complex interaction of various social, economic, political, institutional and technological factors (Leary et al., 2008). This approach considers people to be vulnerable from “lack of entitlements” and focuses on vulnerability analysis at household level (Sen, 1981; Adger, 2006; Ribot, 2009). Entitlements are the “total set of rights and opportunities with which a household can obtain different commodities and resources” (Ribot, 2009).

Many studies focusing on computing vulnerability indices for rural mountainous communities have been conducted in the past. Pandey et al. (2017) used a sustainable livelihood framework to assess vulnerability of Himalayan communities, and developed a climate vulnerability index based on integrated vulnerability assessment. In another study by Pandey et al. (2015), climate related water vulnerability was assessed using indicator based aggregation method for the households in mountainous region of Uttarakhand State in India. Likewise, Pandey et al. (2016) also developed Adaptation Capability Index to examine the household level adaptation to climate change in mountainous region using indicator aggregation method. Gerlitz et al. (2017) assessed multidimensional livelihood vulnerability to climatic, socio-economic and environmental changes for rural mountainous Himal Kush Himalayan region. Multidimensional Livelihood Vulnerability Index (MLVI) combines the LVI developed by Hahn et al. (2009), which uses indicator aggregation method, along with Alkire-Foster method for identifying vulnerable households.

The present study focuses on vulnerability assessment based on the socio-economic aspects of a household, such as poverty, access to resources like water, electricity, cooking fuel, transportation, social networking, etc. Such an analysis of vulnerability, which depends upon the inherent socio-economic and livelihood characteristics of a household, is termed as “inherent vulnerability” in this study (Rajesh et al., 2014). Owing to lack of entitlements, inaccessibility, and poor socioeconomic conditions communities become devoid of basic amenities, and are more prone to suffering. Inherent vulnerability assessment is useful in categorizing the households into different vulnerability categories for appropriate government interventions (Shukla et al., 2016). Inherent vulnerability assessment will provide a deeper insight into the variations in vulnerability across different households within a community. Such information will aid decision makers to develop strategies and policies targeting pertinent socio-economic issues at the grass root level. Gerlitz et al. (2017) measured the variation in multi-dimensional livelihood vulnerability for communities in Hindu-Kush Himalayan region in order to identify intervention areas and guide policy measures to reduce vulnerability. The Intergovernmental Panel on Climate Change (IPCC) report highlights the significance of people’s perception of risk, their view of community and environment, and their indigenous knowledge in implementing effective adaptation strategies (IPCC, 2014). One of the salient features of the study is that it incorporates a household’s perception of risk and its views on issues such as various government policies, environmental resources, along with other hazard generic socio-economic aspects, to assess its inherent vulnerability. It is not possible to obtain a continuous measure for all the socio-economic attributes of a household, therefore measurement of indicators were not restricted to continuous scale. Many attributes depicting a household’s perception and livelihood conditions were measured in categorical scale. Incorporating an exhaustive list of inherent vulnerability indicators with different measurement levels to compute the inherent vulnerability of a household is another salient feature of the paper.

This study aims to identify the variation in inherent vulnerability among the households located in rural communities of Kimsar region of Uttrakhand in India, by computing household level Inherent Vulnerability Index (IVI). A household’s inherent vulnerability is defined as its intrinsic predisposition to suffer harm due to climate extremes and other stresses. It is viewed as an ‘inherent’ property or attribute of a community, irrespective of presence of external stressors. The socio-economic conditions of a household determine its inherent vulnerability (Rajesh et al., 2014). A conceptual framework is developed, and hazard generic indicators are identified to assess inherent vulnerability of rural households. It should be noted that the current study incorporates starting point vulnerability or social vulnerability approach, wherein exposure is not seen as a part of vulnerability. In this study exposure is seen as a precondition for a hazardous situation instead of a component of vulnerability. This approach of vulnerability assessment has been adapted in Pressure and Release Model by Blaikie et al. (1994) and elaborated by Ribot (2009), Adger (2006), and Gallopín (2006). Adding on to this growing field of vulnerability assessment the current study proposes a novel methodology which incorporates the Nonlinear Principal Component Analysis (NLPCA) for assessing inherent vulnerability of mountainous rural communities. The methodology incorporates social vulnerability approach, and makes use of both qualitative and quantitative indicators. The description of the study area, the conceptual framework and the methodology for computing household level IVI is provided in the following sections.

2. Materials and methods

2.1. Site description

Kimsar region (latitude 30.02°N, longitude 78.40°E) 40°E is located in the Yamkeshwar Developmental Block of the Pauri Garhwal District of Uttarakhand (Rajesh et al., 2014). Situated in the Shivaliks range, the region is characterized by mountainous and rugged landscape. The region is located in close proximity of Chilla Wildlife Sanctuary (Rajaji National Park) and is prone to frequent attacks by wild animals. Nine villages from Kimsar region, (as shown in Fig. 1), were selected for the study as these villages were exposed to multiple hazards, and showed lack of access to resources such as water, electricity, educational institutions etc. People residing in these villages depended on labour work and agricultural activities for sustaining their livelihood. Lack of employment opportunities had forced many people to move out of the villages in search of jobs to support their families still residing in the village. As mentioned previously the villages suffered from social impediments such as lack of basic amenities like health care, access to water, irrigational facilities, commuting facilities, high dependence on environmental resources etc. The region is also plagued by frequent occurrences of hazards like landslides, cloudburst, extreme precipitation and wild animal attacks (Rajesh et al., 2014).

2.2. Data collection

Inherent vulnerability indicators were finalized using a triangulation approach involving survey, literature survey, and expert discussions. List of these indicators along with their explanation is provided in Table 1. Questionnaire forms were developed to capture these indicators. Two questionnaire forms were developed:

- A village-level questionnaire, which focused on the collection of general information about the village.
- A household level questionnaire, which focused on the collection of specific information about each household.

Both the questionnaire forms were tested during the pilot field survey, conducted in February 2013, in the five villages of Malla Banas, Talla Banas, Kimsar, Dharkot and Bhumiyakisar, located in Kimsar region. Detailed field survey for gathering information on the identified inherent vulnerability indicators was conducted from March 2013 to June 2013. Households from the nine villages in the Kimsar region were selected (Fig. 1), and sample size for each village was calculated at 95% confidence level.

Apart from the information on the inherent vulnerability indicators,
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