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Inherent vulnerability of agricultural communities in Himalaya: A village-level hotspot analysis in the Uttarakhand state of India

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ABSTRACT

Mountain regions are characterized by complex biophysical and marginal socio-economic conditions that contribute to the vulnerability of agricultural communities. Owing to the extremely heterogeneous conditions in mountains, it becomes imperative to understand the spatial distribution of vulnerability at fine-scale. This study assesses the inherent vulnerability of agricultural communities at village level for the entire state of Uttarakhand. Inherent vulnerability, conceptualized as an internal property of agriculture dependent communities, is measured as a function of sensitivity and adaptive capacity. Data on 36 indicators, reflecting the social and ecological dimensions of sensitivity and adaptive capacity, was collected from secondary sources for 15,285 villages. Each indicator was weighed according to its importance in determining vulnerability using Analytical Hierarchical Process (AHP) and finally aggregated to map the spatial distribution of inherent vulnerability under five classes. To enable more effective adaptation planning, identification of vulnerability hotspots was done using local Moran's I. Our analysis reveals that majority of the villages have very low (36.1%) and low (19.6%) adaptive capacity characterized by the poor developmental and high agricultural constraints. Overall the state observes high vulnerability (0.66 ± 0.15), with about 23.6% and 24.7% villages classified under very high and high vulnerability class respectively. The spatial pattern of inherent vulnerability shows significant altitudinal gradient with most of the vulnerability hotspots villages located in middle altitudinal zone. The outcomes of the study assist the policy interventions in prioritizing allocation of resources to enhance the capacities of agricultural communities inhabiting the identified inherent vulnerability hotspots.

1. Introduction

Mountains are complex socio-ecological systems characterized by geological instability, ecological fragility and economic backwardness (Ning, Rawat, & Sharma, 2014; Singh & Thadani, 2015; Wymann, Ott, Klaey, & Stillhardt, 2006). Mountain communities, highly dependent on natural resources, face numerous livelihood bottlenecks (Aryal, Cockfield, & Maraseni, 2014; Kollmair, Gurung, Hurni, & Maselli, 2005; Kreutzmann, 1998; Tiwari & Joshi, 2015). In the Indian Himalayan Region (IHR), about 80% of rural communities are dependent on agriculture and allied activities (GoI, 2010). Agriculture forms the main source of livelihood and is mainly subsistence in nature (Barua, Katyaini, Mili, & Gooch, 2014; Pandey & Bardsley, 2015). However, immense heterogeneity exists in the bio-physical and socio-economic conditions conducive of agriculture production (Sati, 2005; Chhetri, 2011). Agriculture productivity in the region is limited by fragile natural resources and rugged topography that also affects the region's soil and climate (Jodha, 1989; Kuniyal, 2003; Sati, 2005). Further, wide regional imbalances exist in the availability of modern inputs, infrastructures and accessibility to markets (Chopra, 2014). Such impediments, though generally topography-linked, are more often a result of fragmented and alienating nature of developmental policies to mountain specificities (Jodha, 1989; Singh, 2006; Rueff, Kohler, Jung, & Ariza, 2014).

Additionally, the external changes operating at different scales severely impact agriculture production in the mountains. For instance, the ongoing environmental degradation (Dangwal, 2005; Maikhuri, Rao, & Semwal, 2001; Shrestha, Gautam, & Bawa, 2012), socio-economic changes (Badola & Hussain, 2003; Banerjee, Black, Kniveton, & Kollmair, 2014), occurrence of natural disasters (Gardner & Dekens, 2006; Valdiya, 2014; Sarkar, Kanungo, &

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Sharma, 2015), and changes in climate (Basistha, Arya, & Goel, 2009; Dimri et al., 2013; Madhura, Krishnan, Revadekar, Mujumdar, & Goswami, 2014; Xu et al., 2009) interact in a cascading manner leading to pronounced and unanticipated impacts. The increasing centrality of discussions on disproportionate impacts of these external changes highlights that vulnerability differs within communities. Vulnerability to any external changes is mediated through certain inherent preconditions, like those of resource availability, infrastructure availability and institutional access, and hence varies within any community (Holand, Lujala, & Rød, 2011; Cutter, Ash, & Emrich, 2014; Bennett, Blythe, Tyler, & Ban, 2015).

Vulnerability assessment, a tool to assess the vulnerability of a valued attribute of a system, usually aims to identify vulnerable hotspots and gain insights into factors that make an identified system vulnerable (Ford et al., 2010; Preston, Yuen, & Westaway, 2011). Assessment of vulnerability begins with its conceptualization based on the context and locale rationales (Ciurean and Schroter, 2013; Pamungkas, Bekessy, & Lane, 2014). However, vulnerability being a multidisciplinary concept is often conceived differently by researchers (Adger, 2006; Fussel, 2007; Kok et al., 2015). Broadly two approaches for conceptualizing vulnerability exist namely 'outcome vulnerability' and 'contextual vulnerability', parallel to 'end point' and 'starting point' concepts of vulnerability, respectively (Brooks, 2003; O'Brien et al., 2009; Füssel, 2009). These approaches differ in their attribution of vulnerability to either be an endogenous characteristic or a residual outcome of an exogenous hazard.

The outcome vulnerability approach is built on risk-hazard impact models and describes vulnerability as an outcome of an external hazard (Fussel and Klein, 2006; Eriksen & Kelly, 2006). On the other hand, the contextual vulnerability approach considers vulnerability to be a pre-existing state that exists within a system irrespective of any external exposure (Adger et al., 2009; Cutter et al., 2014; Ellis, 2006). In contextual vulnerability construct, where vulnerability arises purely from social inequality, rooted deeply in the idea of unequal access to economic assets and demographic profile, is referred as social vulnerability (Cutter, 2003). However, the usage of term 'social' is inappropriate when vulnerability cannot be merely determined by intrinsic socio-economic characteristics of communities but is equally dependent on physical and ecological characteristics of a region. In such cases, the term 'inherent' vulnerability might be more appropriate (Brooks, 2003; Sharma, Chaturvedi, Bala, & Ravindranath, 2013). Inherent vulnerability of communities thus measures the predisposition of a community to be affected by any harm shaped by intrinsic social and ecological attributes (Rajesh, Jain, Sharma, & Bhahuguna, 2014). It represents an antecedent condition, determining the ability of a system to prepare, respond and recover when exposed to an external stress (Cutter et al., 2014).

By conceptualizing vulnerability as an intrinsic characteristic of mountain agricultural communities, the present research aims to assess the inherent vulnerability of agricultural communities for the state of Uttarakhand. The research considers the social as well as the ecological factors that interact to determine the sensitivity and adaptive capacity of agricultural communities. As there exist high spatial heterogeneity in the demographic, economic and bio-physical conditions, the scale of analysis becomes extremely important to capture the associated spatial dynamics in inherent vulnerability. Therefore, the present assessment is done at village level, which is the lowest administrative scale in India, using mountain specific indicators. Such holistic and fine-scale assessments of vulnerability are necessary for the entire state of Uttarakhand, though presently limited in number, given the multitude of drivers that are continuously challenging the livelihood and food security of the communities (GoU, 2014). The specific objectives of the study are (i) to understand the distribution of inherent vulnerability and its components i.e. sensitivity and adaptive capacity for the entire state of Uttarakhand; and (ii) to detect the spatial distribution and location of inherent vulnerability hotspots.

2. Study area

Uttarakhand, located between 28°43′24″ to 31°27′50″ N latitude and 77°34′27″ to 81°02′22″E longitude, is a mountainous state present in the western part of IHR. It occupies about 16.27% of India's total land area with a total population of 10.11 million (Census, 2011). Kumaun (in south east) and Garhwal (in north east) represent the two broad regions in the state. Administratively, the state is divided into 13 districts (basic unit of administration under state), 78 tehsils (consists of villages and municipalities, often described as a sub-district), and 16,826 villages (smallest administrative zone in rural area consisting of one or more habitations) (Census, 2011) (Fig. 1). The state is affixed by complex geographical setting, with mountains and hills accounting for about 97.75% of the total area. Based on elevation gradient, three broad altitudinal zones are identified in the region (Sati, 2012; GoU, 2014). The lower zone (up to 1200 m) represents valleys and plains, middle zone extend from 1200 to 1700 m represent mid hills and upper zone (above 1700 m) covers high hill region. Table 1 lists the tehsils of each district under the three altitudinal zones.

Uttarakhand is predominantly a rural state with 69.45% of population living in rural areas. Out of the 16,826 villages, 81% have a population of less than 500 inhabitants and only 2.7% of the villages have a population above 2000, exhibiting sparse and fragmented distribution of population (UHFWS, n.d.). About 70% of the state's population is dependent on agriculture (Negi & Maikhuri, 2013). In spite of the high dependence on agriculture, only 14% of the total area of the state is under cultivation (GoU, 2014). Agriculture in the region has mainly been subsistence based, but intensification of agriculture is being observed in few plain areas in the recent years (Nichols, 2015; Tiwari, 2000; Singh & Rao, 2002). Overall, agricultural development in the state is impeded by largely unfavorable bio-physical, complex agro-climatic and poor socio-economic factors (Rais, Pazderka, & Gary, 2009; ICIMOD 2011; Sati, 2012). The state's geography poses additional challenges in the availability of resources (like land and water) required for maintaining agriculture productivity. Small (70% of the total land holdings less than 1 ha) and fragmented land holding, excessive soil erosion, high dependence on rainfall for irrigation (55% of the total net sown area), limited irrigation facilities and low investment are a few major issues found to result in the low agriculture yields (Negi & Maikhuri, 2013; Sati, 2012). The wide variation in environmental conditions (edaphic, topographic and climatic) augmented with significant regional imbalances in development across the three altitudinal zones have led to a dichotomous pattern in agriculture in the state (GoU, 2014; Chopra, 2014). Table 2 highlights these differences across the three altitudinal zones. Each zone is further characterized by complex social and ecological interactions at local-scales, generating differential conditions of vulnerability for the agricultural communities inhabiting these zones.

3. Methodology

The inherent vulnerability of agricultural communities of Uttarakhand state was assessed at the most disaggregated administrative level i.e. the village level. 15,285 villages from the total of 16,826 (excluding the forest villages and uninhabited villages) were considered for the analysis. For the assessment of inherent vulnerability the study uses an indicator-based approach, which