Environmental Development 31 (2019) 97–109

Contents lists available at ScienceDirect

Environmental Development

journal homepage: www.elsevier.com/locate/envdev

Perceptions of climate shocks and gender vulnerabilities in the Upper Ganga Basin

Neha Khandekar[a], Ganesh Gorti[b], Suruchi Bhadwal[b,*], Vani Rijhwani[b]

[a] Ashoka Trust For Research In Ecology And The Environment, Karnataka 560064, India
[b] The Energy and Resources Institute, New Delhi, India

ARTICLE INFO

Keywords:
Climate shocks
Gender
Vulnerabilities
Strata
Upper Ganga

ABSTRACT

Mountain ecosystems, owing to their skewed development trends and amplified climatic perturbations, are extremely vulnerable to climate change. Existing developmental challenges manifested as limited access to basic services and over reliance on weather sensitive livelihoods further amplify the vulnerability of communities. This study, using empirical evidence from sites in Uttarakhand, establishes an understanding on how place-based vulnerabilities influence the livelihoods – analyzed through the sustainable livelihoods frameworks. The research also highlights the gender differentiated impacts that arise due to existing social norms and practices evident in the study sites. The study further identifies an emerging narrative of socio-cultural norms determining access to resources and influencing an individual's vulnerability. Moreover, existing social norms differentially impact women by limiting their access to land ownership, decision making powers, amongst others, and subsequently negatively influencing their adaptive capacities. These present as critical challenges that influence gender based vulnerabilities in the mountains and plains of Uttarakhand.

1. Introduction

In the discourse of development theory and practice, "gender mainstreaming" has evolved to be a regular parlance (Clisby, 2005). This can be witnessed from the proliferation of gender mainstreaming, to attain equality, being entrenched within the larger development goals (Millennium Development Goals) (Kabeer, 2005), and the subsequent Sustainable Development Goals. This mainstreaming has thus evolved to entail re-organising formal structures of decision making and institutional process to acknowledge gender as a centrality rather than an add-on issue (Chant and Gutmann, 2002) to ensure developmental policies do not perpetuate conditions of social marginalization and thus resulting in inequality.

This literature has since percolated into climate change research, more specifically in the vulnerability and adaptation research, over the years, highlighting the need to mainstream gender in climate change research. Studies, such as Denton (2002), point towards the role of women, more particularly rural women, play in environmental and natural resource management, which has large intersectionality with climate change adaptation and sustainable development. However, such notions of women's agency in climate action are often limited due to existing socio-cultural norms that inhibit women's role and access to tangible and intangible resources, and more often than not perpetuate existing vulnerabilities.

Vulnerabilities, a complex manifestation resulting from the interactions between exposure, sensitivity and adaptive capacity (Adger, 2006; IPCC, 2014), are largely determined by the shocks and stressors that a system faces. These shocks and stressors can

* Corresponding author.
E-mail address: suruchib@teri.res.in (S. Bhadwal).

https://doi.org/10.1016/j.envdev.2019.02.001
Received 7 August 2018; Accepted 13 February 2019
2211-4645/ © 2019 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/BY-NC-ND/4.0/).

either be climatic or non-climatic (Mohan and Sinha, 2016), which are embedded within the society and endogenous to a system, or can be factors that are exogenous (Fussel, 2006). However, these endogenous shocks/stressors are influenced by a range of socio-economic factors, that include one's social identity (age, caste, gender and other factors) (Carr and Thompson, 2013), and issues such as lower assets, social marginalization, and lack of mobility (Yadav and Lal, 2018). Research also identifies that gender inequality amongst other factors determine inherent vulnerability of communities (Rajesh et al., 2014). Reinforcing this, it has been noted that amongst other factors, financial, physical and human capital, play an important role in adaptive capacity and therefore in alleviating vulnerabilities (Lockwood et al., 2015). Adaptive capacity and its determinants thus: "relate to the economic, social, institutional, and technological conditions that facilitate or constrain the development and deployment of adaptive measures" (Smit et al., 2001).

This literature finds similarities with Amartya Sen's capability approach (Sen, 1984) which highlights the role of access to resources (or assets) in vulnerability alleviation. However, it is often noted that women in rural India generally lack (or have a lesser) rights and access to assets (Roy and Venema, 2002), and this thereby impede the capability to adapt and reduce their vulnerabilities. Moreover, socially constructed notions of roles and responsibilities of men and women have a bearing on access and control of resources, and subsequently on their vulnerabilities (Roy and Venema, 2002), and more often than not this leads to vulnerabilities that are skewed towards the women, more than men. However, previous research has identified the limited evidence that has been generated in this context leading to limited understanding on the differential impact climate change has on the agency of both men and women (Goh, 2012; Jerneck, 2018). Our research situates itself at the intersection of these existing theories, notions and needs, and builds on the understanding they establish in the gender discourse and that of climate change vulnerabilities through a case-study from the Hindu Kush Himalayan region. Mountainous regions are considered to be amongst the most fragile ecosystems on Earth (Tsering et al., 2010) and climate change impact is said to be pronounced in these ecosystems (Mountain Research Initiative EDW Working Group, 2015). These impacts would significantly influence the lives and livelihoods of communities with low socio-economic capacities (Rajesh et al., 2014). However, mountain specific geographic and social conditions which are characterised by accessibility and fragility of both geographical and human systems (Pandey and Jha, 2012). The Hindu Kush Himalayan (HKH) region which constitutes a major proportion of the world's mountain ecosystems is no exception to this narrative of exacerbated and differentiated impact of climate change. The HKH has, in the recent past, witnessed rapid socio-economic and demographic changes (Gerlitz et al., 2017) along with environmental changes and disasters leading to socio-ecological fragility and vulnerability that has and will significantly influence lives and livelihoods

Operationalizing these concepts in the Upper Ganga Basin, more specifically the Himalayan state of Uttarakhand, this paper dissects the information by gender differentiated vulnerabilities that construe given the perceptions on exposure to climate shocks. Therefore, this paper analyses and contributes to the body of knowledge on gendered vulnerability to climate change in terms of exposure and impacts, and how these impacts affect different gender groups. The broad research questions guiding the research include the following;

1. What are these extremes in the context of the Upper Ganga Basin? How are these likely to change in future time periods?
2. What are the perceptions of men and women about the risks and how they are affected?
3. How does this vary by factors including elevation, social strata viz., gender, caste, class?

Our research provides insights into differential impacts of climate change on day to day roles and activities of men and women involved in various spheres of livelihoods. This analysis is carried out within existing social norms of various ethnic communities existent within the case study sites. However, the study does not touch upon the intra-household dynamics and how these roles might evolve in future.

2. Methodology

2.1. Conceptual framework

A livelihood comprises of people, their capabilities and their means of living, including food, income and assets (Chambers and Conway, 1991). DFID's sustainable livelihoods framework provides the means to understand the vulnerabilities of a given system with livelihood capabilities central to the entire framework. Capabilities here are defined by the livelihoods asset base that exists and further defines the vulnerabilities of the livelihoods and has the potential to transform livelihood outcomes.

This is further defined as the potential to overcome vulnerabilities in livelihoods and transform the outcomes. It is used to understand the underlying vulnerabilities of population, given that the framework seeks to define livelihoods from capabilities, assets and means of living, point of view. It assists in defining how people operate within a vulnerability context, shaped by different factors, and the assets or capitals they draw on. It further defines that to be sustainable a livelihood should be able to cope with and recover from stress and shocks, maintain or enhance its capabilities and assets in the present day context and for the future without undermining the natural resource base (DFID, 2000).

The word capability has a wide span and has been used in diverse contexts by different people in different places (Jodha, 1998). Sen et al. refer to it as what a person is capable of doing and being adequately nourished, comfortably clothed, to avoid escapable morbidity and prevent mortality etc., while others include aspects of well-being and quality of life attached to it (Sen, 1984, 1987; Dreze and Sen, 1989). Within this definition of capabilities there is a component that looks at livelihood capabilities that include being able to cope with stress and shocks and being able to look at the possible opportunities. Vulnerability has two aspects, one is external, stresses and shocks and the other internal, how to cope (IDS, 1989). This further consists of having access to services and

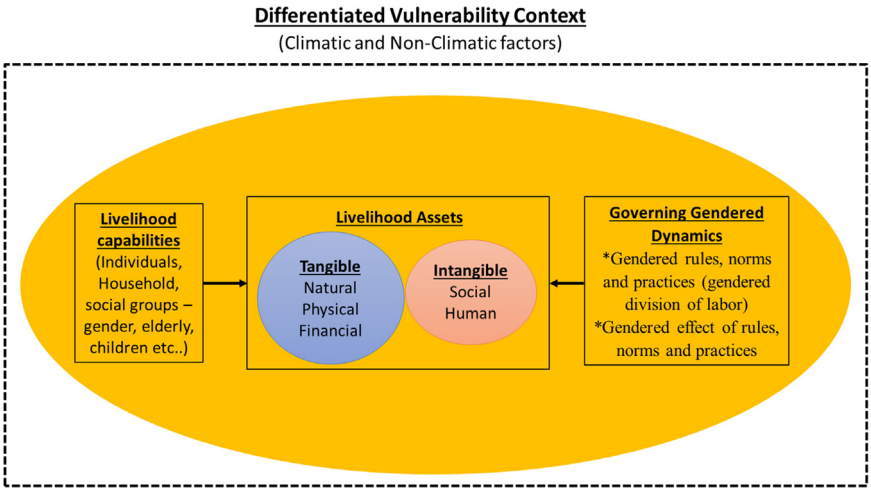

Fig. 1. Conceptual Framework Used for the Study (adapted from the SLF).

information, ability to fully participate and explore new opportunities and resources.

The framework used for this study attempts to capture how the changing climate is affecting livelihoods of the locals by connecting different elements which determine the living gained by the individual. These elements include the access to and activities associated with the five assets (natural, physical, human, financial and social). This process is dynamic in nature and is facilitated through social relations, institutional and organizational networks (Ellis, 2000).

Through various elements of the framework, this paper seeks to focus on the vulnerability context, which frames the environment in which people exist. People herein are defined as individuals, within the existing social groups by gender, children, elderly etc. These relate to elements wherein people have limited or no control, have a great influence on their livelihoods and on the wider availability of assets. The vulnerabilities emerge when livelihoods are exposed to shocks or threats to which they are not able to respond effectively. The livelihood assets further help define the response capabilities (Fig. 1).

While livelihoods are studied extensively with households as a focus, individual or intra-household dynamics that cover well-being aspects of household members are ignored. Having said that, this study attempts to place gender explicitly in the framework by going beyond the roles and responsibilities assigned to men and women in order to bring in depth analysis of their experiences that have shaped the existing social realities. The framework suggested above aims to capture some of these shades based on findings from the case study sites.

2.2. Study area

To be able to address the research questions, information was gathered across different locations in the Hindu Kush Himalayan region of India. This paper draws on insights from our work done in the Northern Himalayan Stretch in India largely spread out in the State of Uttarakhand. To be able to locate our sites, a river basin approach has been followed and for the purpose of the study our work has been confined to the Upper Ganga Basin (UGB) (Fig. 2).

The State, a central Himalayan state nestled in the northern part of India, has an elevation ranging from 300 to 7000 m above the mean sea level (Chauhan, 2010). Given the large topographical variations resulting from the elevations, the climate in the state varies from the valleys to the slopes, from subtropical to temperate climate (Chauhan, 2010). Moreover, Uttarakhand also witnesses a stark inequality between its plains and hilly districts, and is characterised by a strong participation from women in its rural economy, a trend substantiated by the growing out-migration of men from the hilly districts, leaving the females of the households (Mittal et al., 2008). Communities in these regions are also predominantly involved in agriculture which constitutes their predominant livelihood source (Pandeya et al., 2017). We employ this understanding to our field sites (Table 1) that are spread across the Garhwal region (and administrative region of the state) of Uttarakhand, across elevations. These villages represent regions which have witnessed climatic aberrations in the past. Nestled within this context, we explore the gendered vulnerabilities that communities are currently facing. The study sites under the HI-AWARE project have been chosen in three different elevations of the Upper Ganga Basin viz., high, mid and low.

2.3. Data collection and analysis

The research employed a range of data collection techniques in each of the study sites to build a narrative on perceived change in climatic and weather parameters and understand the current roles and responsibilities and access regimes associated with both men and women across communities. These techniques include participatory rural appraisal (PRA) tools; semi structured household interviews, focus group discussions and key informant interviews. The SLF framework proved to be a useful analytical tool to both

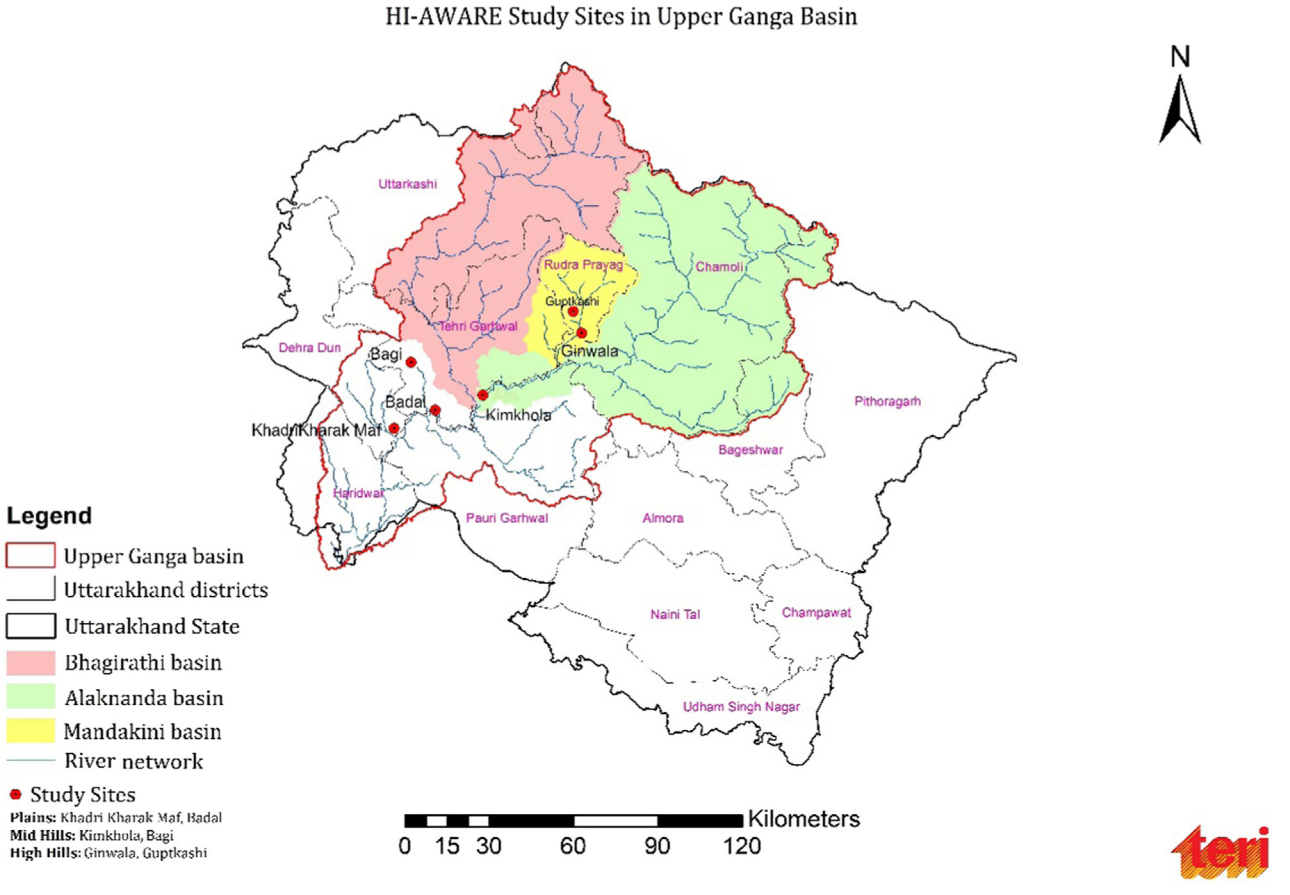

Fig. 2. Study locations in the Upper Ganga Basin.

Table 1
Identified study sites and elevations, *Low elevation < 500 m, Mid elevation 500–1500 m and High elevations 1500 m and above (SC: Scheduled Caste; ST: Scheduled Tribe; OBC: Other Backward Caste; OC: Other Caste). Source: Government of India, 2011; *estimates gathered on study population within Khadri Kharak Maaf and Badal.

Village	District	Elevation Category*	Average Elevation (masl)	Number of households	Total Population	Female population	Social Groups	Main River
Khadri Kharak Maaf	Haridwar	Low elevation	318	200*	1000*	500*	OC (Rajputs); ST (Buksa)	Song and Upper Ganga
Badal	Haridwar	Low elevation	441	40*	200*	100*	OC (Rajputs)	Upper Ganga
Kim Khola	Tehri Garhwal	Mid elevation	1329	87	378	221	OC (Rajputs); SC (Harijan)	Upper Ganga
Bagi	Tehri Garhwal	Mid elevation	1382	95	413	243	OC (Rajputs); OBC (Muslims); SC (Harijan)	Upper Ganga
Ginwala	Rudraprayag	High elevation	1953	76	379	207	OC (Rajputs); SC (Harijan)	Mandakini
Guptakashi	Rudraprayag	High elevation	1511	277	1130	507	eOC (Rajputs); SC (Harijan)	Mandakini

collect and analyse the data to understand gender mediated vulnerability. Using the structure of SLF framework, attributes to be analyzed under each asset were defined and gendered interplay among the various attributes (i.e., Natural, Physical, Financial, Social and Human attributes) in terms of differential access and control was recorded. This approach resonates with an earlier study that assesses climate change vulnerability and adaptation using sustainable livelihoods framework based indicators (see Pandeya et al. (2017)). The study identifies, amongst others, determinants of adaptive capacity against the five capitals postulated by the sustainable livelihoods framework. These include social networks, remittances, loss of property associated with disasters or other weather events, insufficiency of food from farms (Pandeya et al., 2017). The research builds on this framework to derive a qualitative narrative, through a place based study, on regional manifestations of vulnerability analyzed through a gendered lens.

2.3.1. PRA tools

Participatory Rural Appraisal tools were employed extensively in the study villages. In the first instance, transect walk was carried out to build community rapport. During the walk across the villages, information pertaining to distribution of household settlement belonging to various ethnic groups and resources (natural, physical, financial, human) in the landscape were recorded. Further, wherever possible, seasonal calendars along with activity calendars were prepared with both men and women of different communities to understand the key livelihood activities they were involved in. Further, list of livelihood as well as reproductive activities where men and women engage in study sites was noted down and roles and responsibilities of men and women under each of these activities was discussed and documented. This was further augmented with data from semi structured household interviews.

2.3.2. Semi structured household interviews

To understand the changes in the climatic parameters as perceived by men and women of local communities in the study region extensive semi structured household interviews were carried out in each of the six study sites. Respondents were asked to identify the changes in climate (temperature, precipitation) and other environmental parameters (non-timber forest products, water availability, forest cover) over the past thirty years. Respondents were also asked about changes in extreme weather events such as hailstorms, cloudbursts, and floods within the span of their lifetimes or a generation back in terms of their intensity, frequency and duration. Over an approximately four month period in 2017, 18 field interviews with men and women were carried out across the study sites.

2.3.3. Key-informant interviews

Interviews with current village heads, former village heads and school masters were also carried out to capture climatic perceptions, changes in agricultural patterns, if any, and understand the changes in resource access. Wherever possible, government officials from the district/block were also interviewed. Across the study villages, 12 interviews were carried out.

2.3.4. Focus group discussions

Wherever possible, gender disaggregated focus group discussions were organized for men and women belonging to different communities exposed to different climatic hazards. Participants first discussed perceptions of differentiated impacts arising out of various climatic risks along with asset ownership, social roles and relations within community. Taking clues from the household interviews, information was tabulated for different activities to understand their differential access to various attributes and resource maps for water access were made in different study sites. In total 20 FGDs were conducted across the study sites.

3. Research findings

3.1. Incidence of extreme events in the Upper Ganga catchment

Apart from being prone to geo-hazards and lying in the highest seismic zone of the country, the State of Uttarakhand by virtue of its geography is exposed to many forms of hydro meteorological extremes. Floods, cloud bursts, flash floods, glacial lake outburst floods, hailstorms, drought induced by water scarcity, rock falls, landslides, mud flows and forest fires are frequent incidences reported within one or the other part of the state. The National Disaster Management Authority claims the State to be prone to disasters. The region also has, in the past, faced frequent deluges and other disasters (Kala, 2014). Moreover, such disasters, induced due to either anthropogenic or natural sources have increased in the entire Himalayan region, including Uttarakhand (Maikhuri et al., 2017), making it an extremely fragile region.

Vast extensive stretches of land with rivers flowing down the mountains constitutes the geography of the region. Most of these rivers have a perennial nature and are fed by glaciers, snow and rain. The Mandakini river is located far up in the district of Rudraprayag where it originates from the Chorabari glacier near Kedarnath. As a tributary of the Alaknanda river, river Mandakini forms a confluence at Rudraprayag. The combined river further joins the Bhagirathi river at Devprayag to form the Ganga and further flows downstream with many other tributaries small and big contributing to the flows in the main stem of the river Ganga. As part of the study while many locations were covered in the State, there were specific locations where exposure to these extremes were quite prominent given the occurrence of these events and their intensities. While the nature of the extremes varied as we moved from one site to the other, these locations were found to be not restricted by elevation and occurred across all elevations wherein the exposure to one or the other event was observed to be high. In the recent past, floods in rivers originating in Uttarakhand, in 2010 (Bhatt and Rao, 2016) and 2013 (Sati and Gahalaut, 2013) have induced hardships to communities living both in the upstream and downstream regions. The disaster in 2013 affected many people and had serious implications on local economies and livelihoods. A combination of these external stressors, combined with marginality of sections of communities induces conditions of vulnerability that perpetuate

hardships for the communities within.

Locations covered in the study in the high elevation regions prone to occurrence of these events include sites of Ginwala and Guptakashi, all situated within the Rudraprayag district. These locations are sensitive to spells of high rainfall and occurrence of flash floods, floods, landslides, rock fall and mudflows. The glacier feeding the river is located quite close to these sites. The mid elevation locations largely comprises of a cluster of sites experiencing incidence of heavy precipitation, for instance Bagi. On the other hand in another block in the mid elevation, cluster of sites experience water scarcity conditions. Village KimKhola is situated in the Devprayag block and experiences water shortage. The low-elevation sites include villages that are located near the riverside and get affected as the river expands when flows increase. These includes sites of Khadri Kahrak Maf and Badal.

There is a clear trend of warming manifesting through increase in the temperatures at all altitudinal locations of the Upper Ganga Basin. Impacts on glaciers and glacial melt including contributions to river run-off are high. The Glacial Lake Outburst Flood (GLOF) in 2013 in the Mandakini catchment had drained a voluminous amount of water downstream with huge implications with damage to life and property (IIRS, 2014). While there are no clear trends in precipitation, erraticity has been reported to have increased from all the elevations with reduced rainfall in the monsoon season. In certain cases increase in intensities have also been reported. Increase in incidences of cloud bursts, flash floods and floods have been observed over the years. Landslides and mud flows have also increased over the years.

3.2. People's perception about climate change and its associated risks and impacts

The literature stresses that environmental and climatic perceptions of issues are constructed by people who define threats and risks according to how they experience them (Hopkins et al., 2001). White (1988) notes that 'unless a risk analysis comprehends the social structure within which individual decisions are made, it may fall short of understanding either the process or the consequences of those decisions'. Douglas and Wildavsky (1982) note that risk perception is a social process of shared threats and fears which is influenced by social relations. Social and cultural factors help to identify and construct risk (Kasperson et al., 1988). Wolfe (1988) states that the perception of risk is related to social factors at least as much as to its quantified estimates. 'Gender is a major axis of difference in the society' (Hopkins et al., 2001) and thus is a major factor that affects perceptions and experiences of vulnerability to livelihood stresses, including climate-related ones.

Due to the differences in socioeconomic backgrounds, the exposure to risks varies considerably in each site across the elevations where the study focused. Overall, communities pointed out to changing trends in climatic parameters that have been witnessed in the recent past. Tables 2 and 3 provide a gender disaggregated overview of the highlighted changes in extreme weather conditions based on community perceptions. The frequency and intensity of rainfall is being manifested in the form of changing water availability in the region. Khadri Khark Maf in the floodplains (low elevation) has issues of flooding during the monsoon period. Quality of water has been an issue for the communities during the monsoons. Kimkhola has water scarcity emerging as a prominent issue. Bagi is subject to heavy precipitation and Ginwala and Guptakashi affected by floods.

Besides, increase in rainfall intensities communities in mid elevation sites have highlighted the issue of lower discharge in springs and drying up of springs. They attribute it to multiple factors including the cutting down of Oak and Rhododendron forests that had a large water retentive potential and assisted in recharging of ground aquifers. This also has implications on increased run-off and soil erosion. The availability of water in turn affects livelihoods with impacts on agriculture and forests.

The land is largely fragmented and scattered with very small landholdings and therefore presents challenges for producing enough for the markets. Agricultural dependence and farming is largely subsistence. Majority of the cultivated land is rainfed. Field narratives highlighted that the changing climate was affecting agriculture adversely in the study site. Locals attributed this to the erratic rainfall which is perceived to also be declining over the last few years. Though compared to other elevations, agriculture lands in the low elevation were found to be more productive and certain crops like red kidney beans, vegetables resulted in good yields. Challenges to be able produce at economies of scale and target markets have rendered agriculture largely to be subsistence in the mid and high elevations. A large part of the agricultural land is left fallow and is uncultivated. Falling productivities and damage to crops by wildlife has been highlighted as a major reason for discarding agriculture that was largely subsistence. These reasons have also been a trigger for outmigration in many cases and shortage of labour. Mostly men including young boys have out-migrated. Due to a combination of the many factors highlighted above women reported that there is an increased dependence of households on market-based products which was not the case earlier.

Resembling patterns in other mountain states, women in this region are heavily involved in agriculture, and have been

Table 2
Perceived climatic changes in low elevation sites.

Low Elevation	Perceptions Khadri Kharak Maf		Perceptions Badal	
	Men	Women	Men	Women
Erraticity in rainfall	Increased	Increased	Increased	Increased
Hailstorms	Increased	Increased	Don't know/ can't say	Increased
Frequency of flash floods/ Flooding	Downstream of Barrage- flood flows restricted; 2013 flood memory overshadows other events	Downstream of Barrage- flood flows restricted; 2013 flood memory overshadows other events	2013 flood memory overshadows other events	2013 flood memory overshadows other events

Table 3
Perceived climatic changes in mid elevation and high elevation sites.

Mid & High Elevation	Perceptions Kimkhola		Perceptions Ginwala, Bagi, Guptkashi	
	Men	Women	Men	Women
Spring Discharge	Significantly Reduced	Significantly Reduced	No change	No change
Erraticity in rainfall	Increased	Increased	Increased	Increased
Snowfall	Decreased, almost negligible	Decreased, almost negligible	Decrease	Decrease
Frequency of extreme events	Don't know/ Can't say	Increased (drought)	Don't know/ Can't say	Increased (extreme precipitation, floods)

predominantly involved in all activities of agricultural practice except for ploughing of the fields, which was culturally associated with men. However, with growing outmigration (of predominantly men) witnessed in the villages of Uttarakhand (Ghosh et al., 2007) this activity is also performed by women now. The study villages also indicated outmigration mostly in the mid and high elevation sites and most agriculture being undertaken by women. Fodder collection, is one of the primary activities of the women and a considerable amount of time is spent by them doing so during the course of the day.

3.3. Differentiated impacts by various factors including elevation, social strata viz., gender, and caste

Gender structures and deeply entrenched socio-cultural ideologies that marginalize women's work make women more vulnerable than men. Mountain women, who have great resilience and the knowledge to adapt are often left out of key decision-making processes and are marginalized further, even though they are likely to suffer more in the future. Climate change is bound to increase these gender inequalities further in many ways. These vulnerabilities are often linked to the skewed division of labour. Focus group discussions that were conducted separately with men and women, revealed clear gendered division of labour in their daily livelihood activities. Further, it was informally observed that this division of labour varied between different communities. The dynamics of each community was complex and discreet in the nature of work performed by them. The different roles within the household were shaped by several factors that in certain cases restricts the role played by women and hence has an impact on the vulnerabilities. In this section the gendered dynamics observed in the study villages are analyzed through the lens of the five capitals under the sustainable livelihoods framework.

3.3.1. Natural resources

In all the elevations, it was observed that women have limited access to land as ownership of land is restricted to men. In the low elevation sites, locals perceive increased uncertainty in flood flow regime and thus are at constant risk of losing produce sowed on the farm lands. Here tribal communities living in closer proximity of river are at higher risk in terms of loss of harvest and coverage under compensation for the same. These are largely the marginalized and poor communities living in the floodplain areas (low elevation). Moreover, women are normally associated with the responsibility for carrying and using water at home, which exemplifies aspects of a universal patriarchy which results in certain structural and symbolic inequalities between women and men (Joshi and Fawcett, 2005).

Mid elevation sites are affected by water scarcity and reduced number of rainy days which increases the vulnerability of the communities. Moreover, there are variations in water access across different communities namely the upper and lower castes. An overhead tank is used in the villages in the Devprayag cluster and in case there is any problem with the piped supply, handpumps are used. Women from lower castes rely on the community water tank which is separate from the tank serving the upper castes. In case piped water supplies are affected, these women need to travel for nearly 4 km to collect water, spending nearly 4–5 h in water collection in the entire day. The sources from where water is collected varies in most cases and therefore reflects on differential vulnerabilities across the social strata. Women reported that the task for collection of water from handpumps is very exhaustive to meet the requirements of the whole family since the yields are less during summer months. More than half of the agricultural land in the mid and high elevation regions in the mountains is left fallow with agricultural productivities having declined considerably. Difficult terrain, fragmentation of land and decreased rainfall in the region has affected croplands. In addition to this, wild life conflicts and poor market connectivities have further restrained the abilities of the communities to benefit from agriculture. In the high elevation sites, due to this differential access, people belonging to a certain community had to access water of poor quality, at times affecting the health of the people. Moreover, due to changing water availability, especially during the summers, women had to walk further to access water, increasing the drudgery of women. Another task usually associated with women in this region is firewood collection. With growing villages, forests close to the villages have reduced forcing women to walk further in search of firewood for use in the households. The decreasing forest cover, as noted by the field interviews, and spring shed impacts have further added to the drudgery of women, negatively affecting firewood and water availability respectively. Issues of land loss due to streams which grow bigger during the monsoons have been highlighted, and often lead to issues of accessibility. This inundation associated with swelling streams also affects stored firewood, by dampening them, and negatively affects the women's workload as they now have to look for dry firewood. Land loss due to landslides also has been reported. Both men and women are affected due to these losses. Elderly women and children are the most affected and exposed to the risks. In the high elevation sites, the dependency on agriculture and forest produce is high in certain cases, on the other hand religious tourism, small businesses and service constitutes

means of living. Land loss has been an issue due to flash floods and flood incidences. The loss of land has an impact at the household scale with both men and women affected as their assets get destructed.

3.3.2. Physical resources

Most land/property/asset ownership was with men, with women only ownership in case widowed. The high and mid elevation sites, where men have migrated, women involved in agricultural activities make decisions if needed on crops to be grown, the sowing and harvesting time of crops, amongst other decisions. Unequal access to and control over resources however limits their abilities at times. For instance, women are less able to diversify or utilize improved varieties of crops and small livestock because of limited access to credit or control over productive resources. Livestock is owned by the head of the family or the sons so the decision making in terms of selling it, is with them. The milk is sold within the village. Selling of the milk is a women's job. Decision related to renting and exchange of land was also made by men with the women engaged in the decision process. In the mid-elevation locations, some of the sites were located high up on the mountains (some 7 km away from the nearest motorable road) with access only by an arduous climb. In the absence of a motorable route, women had to carry huge loads uphill which added to their deprivation. This includes carrying water, fuel, wood, fodder from long distances on head, back, shoulders. Besides increasing their work load, amount of physical pressure that women have to go through is additional. Majority of people depend on agriculture as main livelihood along with construction and labour work. Agriculture is mainly Rainfed. Farming is a woman centric activity, especially in mountainous regions and demands a major contribution from women throughout the year. Men were only engaged in land preparation activities. While agriculture is restrained due to natural factors, poor market connectivity has further restrained the abilities of the communities. In such a case, men have migrated largely whereas women have remained and continue with agriculture to sustain. Livestock was once a steady source of income. However, due to out-migration and reduced availability of fodder, families have reduced number of domesticated animals. Reduction in agricultural yield and male out migration, stress and workload among women has seemingly increased over the years. Lower caste communities were found to have less land holding and therefore families mostly engage in off farm livelihood like labour work, masonry. Some also work as agricultural labourers.

In the low elevation regions, the division of labour assigned women to the reproductive sphere of the home and everyday farm work while men were allocated to the public sphere of the production and employment. This allocation of duties was mostly due to the land holding and economic need of the household. A distinct nature of this division was seen in different communities resulting in the lack of skill development of females in few communities. In the lower caste households due to less land holding and major economic need, females also assisted male members in the field and worked as labourers. This resulted in higher workload but acquiring better skills for productive activity along with household duties. Similar results were found in a study conducted by Djoudi and Brockhaus (2011). Due to higher involvement of the male in agricultural activities, they had higher decision power in the household. Discussions with the locals clearly depicted that women were associated with all on farm and off farm work, while men were associated with religious tourism, wage labour or short-term employment. Site popular for adventure tourism indicates, the activity is handled by men and young boys. Added to it are decisions related to vehicle procurement, registration which are also handled by men.

3.3.3. Financial resources

It was clearly noted that the land tenure was always associated with men. The land/property/asset was in the name of a female only if she was widowed. In the low elevation sites, several economic activities were handled by men and young boys. Family expenditure decisions are taken care by men of the family. Variation in labour rates for men and women is observed contingent upon the nature of tasks performed. Females are largely dependent on financial matters as expenditure is largely controlled by men with decision making largely in their hands. Men were observed to have a choice of diversifying their income by actively participating and allied livelihoods but due to cultural norms women were wedged to agricultural and household activities. Floods affected agriculture in the plains (low elevation), and businesses in the mid and high elevation region including adventure tourism and religious tourism, with the number of tourists showing a sharp decline after the massive floods in 2013. Incomes were affected and many men were also unemployed affecting many households. Land loss in areas reported from the mid elevation and high elevation sites resulted in a precarious situation. Accounting for such land losses in land records is unclear. There is no insurance coverage and the compensation for the losses has been quite minimal or negligible in most cases. On losing land, land ownership of the land lost is also presumed to be lost. Both men and women in this case struggle with these conditions that surround them.

3.3.4. Human resources

In certain cases where the men have migrated the mid elevation and high elevation sites, it is perceived that the direct risks due to hydro-meteorological events to them may have reduced as they have moved from the hotspot areas to other areas where comparatively the risks may be lower. In many of the flood affected areas, mortality and morbidity rates of the people living in these locations were quite high. But with the movement of men this risk has been reduced. However, the entire families have not moved and the women, children and the elderly have remained thereby classifying these strata of the society to be highly vulnerable to the risks caused by these events in the identified hotspots. Also men who have migrated have diversified their income by actively participating in construction and allied livelihoods but due to cultural norms women were found to be wedged to agricultural and household activities.

3.3.5. Social resources

Nazneen and Tasneem (2010) suggest that the gendered division of labour limits women's time and ability to participate in formal

Table 4
Livelihood Assets and Implications by Gender.

Livelihood Assets	Ownership/responsibilities and implications
Forests/Fuelwood	*Current regime:* Women in the high and mid elevation sites are societally responsible to collect fuel wood from forests *Implications:* Reduced forest cover as a result of climate variation means that women have to travel more for fuel wood and fodder.
Water sources	*Current regime:* Women across all elevations are responsible for collecting water *Implications:* Differential Water Access is a major barrier for lower caste women. ● Enhances drudgery in case of scarcity
Farm land	*Current regime:* Decreased land productivity, changing cropping pattern, ● In absence of diverse cropping practices, household's dependency increased on food (often low quality) procured from market ● Land tenure associated with men. Few women with land title. *(In 2011, female agricultural workforce was 70%, yet only 9.5% own land (FAO data cited in* Kapoor, 2011*).* Only widowed women have ownership of assets – land, livestock etc., *Implications: Impact on capabilities and capacities of individuals to cope with climatic aberations and access finance*
Livestock	*Current regime:* Mostly owned by men but taken care of by women *Implications: Reduced ownership negative influences decision making powers and ability to make financial decisions when necessary*
Bank, informal financial institutions	*Current regime:* Cash flows controlled by men. Access to credit and collateral favors men. Although several schemes for women have been launched, most women are not aware of them (like low interest on loan taken in the name of women) *Implications: Lower access to financial institutions, thereby reducing their objective adaptive capacity*
Labour wages	*Current regime:* Unequal wages, women paid less for both farm and off farm labour activities *Implications: Negatively influences adaptive capacities of women due to lower financial resources*
Institutions	*Current regime*: Comparatively lower literacy rates, empowerment and socio-cultural norms restrict the ability of women and their participation for decision making purposes. *Implications:* Do not see women in decision making positions
Village level statutory (Panchayat) and customary institutions	*Current regime:* Institutional networks favor men and presume male heads of household in spite of quotas for women participation ● Women's organization not empowered to make any major decisions. Where cash is involved, men make the decisions. ● Women have more say in SHGs and closed knit networks for socio-cultural engagements *Implications*: Reduced say in decision making, negatively influencing adaptive behavior.
On and Off Farm Labour	*Current regime:* Division of labour within the wider economy assigned women to the reproductive sphere of the home and everyday farm work while men were allocated to the public sphere of the production and employment. But in marginalized communities, both men and women take up equal roles for income generation. *Implications:* Unequal division of labour exacerbating drudgery and vulnerabilities of women who interact more closely with climate-sensitive assets.
Education	*Current regime:* In low elevation sites, in general literacy rate is lower, with female literacy rate at 44%. For the mid and high elevation sites, both men and women have equal access to primary education and women have higher literacy rates as compared to low elevation sites (48%). For mid and high elevation sites, it is also a function of remoteness. It is lower for sites with difficulty in accessing motorable roads. (Census, 2011) *Implications:* Possible impact in decision making systems and asset ownership

political and planning activities. While institution norms and practices engage both gender, men are seen to lead normally, even in cases where the woman holds a decision making position. For instance, in the sites where adventure tourism is prominent, mostly women do not engage in adventure tourism livelihood activities and women have expressed security concerns and cultural intrusion. Interestingly, however, strong community based institutions and local self-help groups (SHGs) in one of the study sites in the high elevation has positively influenced the lives and livelihoods of women. With external help, women SHGs have been reshaping lives by imparting livelihood training for juice preparation and packaging, weaving and stitching, amongst other activities. However, a lack of such institutions was felt in the in few of the middle elevation sites. Comparatively lower literacy rates, empowerment and socio-cultural norms restrict the ability of women and their participation for decision making purposes (Tables 4 and 5).

4. Conclusions

These existing trends of underlying vulnerabilities, resulting in skewed access to resources, services and institutions, will only see a rise with future climatic changes, and as extreme weather events are predicted to increase so will the implications on water availability, health and livelihood opportunities of the people living in mountain regions. These implications coupled with changes in demographic and socioeconomic changes might further aggravate the underlying vulnerabilities (Gorti, 2015). Against this backdrop, this study set in the Upper Ganga Basin explores gender roles and responsibilities that shape women and men's differential access, ownership and control over resources that influence their capacities and capabilities to adapt to climate change.

The findings demonstrate how social barriers influence an individual's adaptive capacity and restrict behavior and entitlement.

Table 5
Climate Change Hazards and Impacts on women and communities.

Extreme event Incidence/ Natural Hazard	Elevation	Household level Impact	Impact on women	Further Differentiated impact
Extreme rainfall and, Floods, Hail	Low, mid, high Low, mid high Low, mid high	crop loss; Less food available for subsistence cultivators; Income loss in cash crop cultivation; loss of HH (land, house/ cattle shed) and community level infrastructure (road/ panchayat ghar, water supply)	● Since women are involved in domestic work and prepare food for all household members, are often the last to eat and consume the least.	● Male outmigration increased hardship for women of marginalized community's households
Land slides	High	Reduced productive top soil cover	● Outmigration of the male members leads to stress and hardship for women who become the heads of household	
Drying waterways and forest springs; reduced stream flow	High, Mid	Reduced clean water availability for small-scale irrigation and drinking water	● More time and energy is required for women to fetch water for domestic consumption and livelihood requirements	● Restricted entitlement for Scheduled caste and tribal community households makes them vulnerable.

Field narratives pointed out that men and women interpret experience and respond to climatic and non-climatic changes concurrently. The drivers of household vulnerability were an ensemble of highly localized and individual factors (intra-household dynamics and local socio-cultural norms). The roles and responsibilities assigned to men and women were largely due to the societal norms and conceptions that have allocated productive activities such as production and employment to men while the reproductive activities such as domestic work and everyday farm work to women.

Access to resources and power of decision, play a major role in shaping the vulnerabilities Women are more dependent on natural resources for their livelihoods; they often lack access to information, and decision-making power to adapt to climate change impacts and further conserve natural resources. They also face numerous barriers in accessing education.

Further the societal norms determine land inheritance laws (which exclude women) and involvement in agriculture which limits the potential for them to diversify their income. The differential access to water resource was seen prominently in all elevation which creates a barrier to adaptation for certain people in a community. Similarly, when women are members of a landowning or powerful family, they are generally able to command their say in decisions at village level pertaining to water resources. But in terms of skill sets, women from scheduled caste and tribal communities have more experience due to more involvement in income generation activities. This trend was observed in all the elevations. Furthermore, men had the ability to migrate and which reduces their vulnerabilities in the nature of reduced exposure to the risks existing in the study sites which increases stress and hardship for women who were still exposed to the risks adding to their vulnerabilities.

Acknowledgements

This work was carried out by the Himalayan Adaptation, Water and Resilience Research (HI-AWARE) consortium, under the Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA), with financial support from the UK Government's Department for International Development and the International Development Research Centre, Ottawa, Canada.

References

Adger, W.N., 2006. Vulnerability. Glob. Environ. Change 16 (3), 268–281.
Bhatt, C.M., Rao, G.S., 2016. Ganga floods of 2010 in Uttar Pradesh, north India: a perspective analysis using satellite remote sensing data. Geomatics, Natural Hazards and Risk 7. Taylor & Francis, pp. 747–763. https://doi.org/10.1080/19475705.2014.949877.
Carr, E.R., Thompson, M.C., 2013. Gender and climate change adaptation in Agrarian settings. Geogr. Compass 8 (3), 182–197.
Chambers, R., Conway, G., 1991. Sustainable rural livelihoods: practical concepts for the 21st century. IDS Discussion Paper 296, 296 (Brighton: Institute of Development Studies, University of Sussex), 29. Retrieved from http://opendocs.ids.ac.uk/opendocs/handle/123456789/775.
Chant, S., Gutmann, M.C., 2002. "Men-streaming" gender? Questions for gender and development policy in the twenty-first century. Prog. Dev. Stud. 2 (4), 269–282.
Chauhan, M., 2010. A perspective on watershed development in the Central Himalayan State of Uttarakhand, India. Int. J. Ecol. Environ. Sci. 36 (4), 253–269.
Clisby, S., 2005. Gender mainstreaming or just more male-streaming? (Retrieved from http://ezproxy.library.nyu.edu:2452/doi/abs/). Gend. Dev. 13 (2), 23–35. https://doi.org/10.1080/13552070512331332284.
Denton, F., 2002. Climate change vulnerability, impacts, and adaptation: Why does gender matter? Gend. Dev. 10 (2), 10–20.
DFID (2000): Sustainable Livelihoods Guidance Sheets. Department for International Development.
Djoudi, H., Brockhaus, M., 2011. Is adaptation to climate change gender neutral? Lesson from communities dependent on livestock and forest in northern Mali. Int. For. Rev. 13 (2), 123–135.
Douglas, M., Wildavsky, A., 1982. Risk and Culture. University of California Press, Berkeley; Los Angeles; London.
Dreze, J., Sen, A., 1989. Hunger and Public Action. Clarendon Press, Oxford.
Ellis, F., 2000. Rural Livelihoods and Diversity in Developing Countries. Oxford University Press, Oxford.
Fussel, H.M., 2006. Vulnerability: a generally applicable conceptual framework for climate change research. Glob. Environ. Change May, 1–27.
Goh, A.H.X., 2012. A Literature Review of the Gender-differentiated Impacts of Climate Change on Women's and Men's Assets and Well-being in Developing Countries. International Food Policy Research Institute.
Gerlitz, J.Y., Macchi, M., Brooks, N., Pandey, R., Banerjee, S., Jha, S.K., 2017. The Multidimensional Livelihood Vulnerability Index—an instrument to measure livelihood vulnerability to change in the Hindu Kush Himalayas. Clim. Dev. 124–140.
Ghosh, N., Kar, S., & Sharma, S. (2007). Inequalities of Income Opportunity in a Hilly State: A Study of Uttarakhand. IEG Working Paper Series No. E/287/2007.
Gorti, G., 2015. Understanding Differential Vulnerability to Climate Change: A Case Study Approach. TERI University.
Hopkins, W.D., Fernandez-Carriba, S., Wesley, M.J., Hostetter, A., Pilcher, D., Poss, S., 2001. The use of bouts and frequencies in the evaluation of hand preferences for a coordinated bimanual task in chimpanzees (Pan troglodytes): an empirical study comparing two different indices of laterality. J. Comp. Psychol. 115, 294–299.
IDS, 1989. Vulnerability: how the poor cope, IDS Bulletin, Volume 20, Issue 2.
IIRS, 2014. Glacial Lake Outburst Flood Hazard Assessment in a Part of Uttarakhand, India (Thesis). pp. 42 Amit Anand.
IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1132.
Jerneck, A., 2018. What about gender in climate change? Twelve feminist lessons from development. Sustainability 10 (3).
Kabeer, N., 2005. Gender equality and women's empowerment: a critical analysis of the third millennium development goal. Gend. Dev. 13 (1), 13–24.
Jodha, N.S., 1998. Reviving the social system-ecosystem links in the Himalayas. In: Berkes, F., Folke, C. (Eds.), Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge University Press, Cambridge.
Joshi, D., Fawcett, B., 2005. The role of water in an unequal social order in India. In: Coles, A., Wallace, T. (Eds.), Gender, Water and Development. Berg.
Kala, C.P., 2014. Deluge, disaster and development in Uttarakhand Himalayan region of India: challenges and lessons for disaster management. Int. J. Disaster Risk Reduct. 143–152. https://doi.org/10.1016/j.ijdrr.2014.03.002.
Kapoor, A., 2011. Engendering the Climate for Change: Policies and Practices for Gender-Just Adaptation. Alternative Futures and Heinrich Böll Foundation, New Delhi, India.
Kasperson, R., Renn, O., Slovic, P., Brown, H., Emel, J., 1988. Social amplification of risk: a conceptual framework. Risk Anal. 8 (2), 177–187.
Lockwood, M., Raymond, C.M., Oczkowski, E., Morrison, M., 2015. Measuring the dimensions of adaptive capacity: a psychometric approach. Ecol. Soc. 20 (1).
Maikhuri, R.K., Nautiyal, A., Jha, N.K., Rawat, L.S., Maletha, A., Phondani, P.C., Bahuguna, Y.M., et al., 2017. Int. J. Disaster Risk Reduct. 111–124. https://doi.org/10.1016/j.ijdrr.2017.09.002.
Mittal, S., Tripathi, G., & Sethi, D. (2008). Development Strategy for the Hill Districts of Uttarakhand. Indian Council for Research on International Economic Relations

Working Paper.
Mohan, D., Sinha, S., 2016. Assessing vulnerability to climate change in the Ganges Basin using a combined macro- and micro-level approach. Clim. Dev. 312–323.
Mountain Research Initiative EDW Working Group, 2015. Elevation-dependent warming in mountain regions of the world. Nat. Clim. Change 424. https://doi.org/10.1038/nclimate2563. Nature Publishing Group, a division of Macmillan Publishers Limited.
Nazneen, S., Tasneem, S., 2010. A silver lining: women in reserved seats in local government in Bangladesh. IDS Bull. 41 (5), 35–42. https://doi.org/10.1111/j.1759-5436.2010.00164.x.
Pandey, R., Jha, S.K., 2012. Climate vulnerability index – measure of climate change vulnerability to communities: a case of rural Lower Himalaya, India. Mitig. Adapt. Strateg. Glob. Change 17 (5), 487–506.
Pandeya, R., Jhab, S.K., Alataloc, J.M., Archied, K.M., Guptaa, A.K., 2017. Sustainable livelihood framework-based indicators for assessing climate change vulnerability and adaptation for Himalayan communities. Ecol. Indic. 338–346. https://doi.org/10.1016/j.ecolind.2017.03.047.
Rajesh, S., Jain, S., Sharma, P., Bhahuguna, R., 2014. Assessment of inherent vulnerability of rural communities to environmental hazards in Kimsar region of Uttarakhand, India. Environ. Dev. 16–36. https://doi.org/10.1016/j.envdev.2014.06.003.
Roy, M., Venema, H.D., 2002. Reducing risk and vulnerability to climate change in India: the capabilities approach. Gend. Dev. 10 (2), 78–83.
Sati, S.P., Gahalaut, V.K., 2013. The fury of the floods in the north-west Himalayan region: The Kedarnath tragedy. Geomat., Nat. Hazards Risk 193–201. https://doi.org/10.1080/19475705.2013.827135.
Sen, A., 1987. The Standard of Living. Cambridge University Press, Cambridge.
Sen, A., 1984. Rights and capabilities. In: Sen, A. (Ed.), Resources, Values and Development. Basil Blackwell, Oxford (Retrieved from). 〈http://www.amazon.com/Resources-Values-Development-Professor-Amartya/dp/0674765265/ref=sr_1_1?s=books&ie=UTF8&qid=1310679109&sr=1-1〉.
Smit, B., Pilfosova, O., Burton, I., Challenger, B., Huq, S., Klein, R. J. T., & Yohe, G. (2001). Adaptation to Climate Change in the Context of Sustainable Development and Equity. McCarthy, J.J., Canziani, O., Leary, N.A., Dokken, D.J., White, K.S. (Eds.), Climate Change 2001: Impacts, Adaptation and Vulnerability. IPCC Working Group II, Cambridge University Press, pp. 879–906.
Tsering, K., Sharma, E., Chettri, N., & Shrestha, A. (2010). Climate Change Impact and Vulnerability in the Eastern Himalayas – Synthesis Report. ICIMOD. ICIMOD.
White, G.F., 1988. Paths to risk analysis (Reprinted in) In: Cutter, S.L. (Ed.), Risk Analysis: Environmental Risks and Hazards 8. Prentice Hall, New Jersey, pp. 171–175 (1988).
Yadav, S.S., Lal, R., 2018. Vulnerability of women to climate change in arid and semi-arid regions: the case of India and South Asia. J. Arid Environ. 149, 4–17 (Elsevier Ltd. Retrieved from https://doi.org/10.1016/j.jaridenv.2017.08.001).
Wolfe, Amy K., 1988. Environmental risk and anthropology. Pract. Anthropol. 10 (4), 4.