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# Growing social vulnerability in the river basins: Evidence from the Hindu Kush Himalaya (HKH) Region

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## ABSTRACT

Vulnerability is a set of conditions of people that is derived from the historical and prevailing socio-economic, cultural, environmental and political contexts along with understanding future scenarios, especially for climate change. This study aimed at better understanding the nature and types of socio-economic drivers and social vulnerabilities in the context of increasing climatic stresses in four river basins in the Hindu Kush Himalaya (HKH) region. A multidimensional, contextual and integrated approach has been applied using participatory qualitative tools and techniques to identify major socio-economic drivers and conditions along with climatic factors in upstream, midstream and downstream of the river basins. In upstream and midstream region, people's livelihood is dependent on subsistent agriculture, horticulture, pastoralism and tourism while in downstream, agriculture and fisheries are the major livelihood options. Climate sensitive natural resources based livelihoods are severely affected across the river basins. Poor and marginal population are not able to take adequate adaptation measures due to lack of capacities, poor access to resources, services, information, which push them into greater vulnerability. The vulnerable groups in all four river basins are marginalized sections who are conditioned by economic classes, gender and social norms and living in geographically underdeveloped areas. For instance, poor, women, religious/ ethnic minorities, subordinate caste groups, char dwellers. Poor governance and the lack of access to resources and services have made the situation worse. All these factors are enhancing social vulnerability across the basins and study sites. Social protection measures, enhancement of human capitals and livelihood diversification with pro-poor and gender responsive adaptation and socially inclusive policy are needed to address growing social vulnerability.

## 1. Introduction

Hindu Kush Himalaya (HKH) is as described in articles 1 and 2 of this special issue, has diverse geography as well as population.

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High rate of poverty and marginalization is prevalent in the region. Impact of climate change is obvious with fragile natural environment (You et al., 2017). The impact of changing climate varies among people in HKH due to differential socioeconomic status. The HKH is an emblematic case of compounded impact from socio-economic inequalities, developmental challenges and environmental challenges. Absolute poverty, based on a unidimensional poverty analysis of national living standards, across the eight regional member countries of HKH, is as high as one-third of its total population (Gerlitz et al., 2014). In addition, people in the mountains are confronted with lower access to basic facilities, poor physical access to services and institutions, higher dependency ratios (Hunzai et al., 2011; Gerlitz et al., 2014). Patriarchy being prominent among the majority in HKH, gender disparities on resource ownership is high, which shapes the gendered impact of changing climate (Goodrich et al., 2017). These socio-economic conditions add to the growing vulnerabilities of people in the region. Though geophysical conditions of a locality and severity of climate change stresses are the primary causes of risks, the socio-cultural setting plays crucial role on multiplying the effect of climatic stressors and shaping vulnerability (IPCC, 2007). Vulnerabilities emerging from climatic stressor like natural disaster are thus the result of a complex set of drivers and interactions of conditions (IIPCC, 2012).

The IPCC (2014) suggests that differences in vulnerability and exposure arise from many non-climatic factors. There is general consensus within the social science community about some of the major factors that influence social vulnerability (Cutter et al., 2003). Factors like lack of access to resources including information, knowledge, and technology; limited access to political power and representation; social capital, including social networks and connections; beliefs and customs; age; health; and type and density of infrastructure and networks are identified as factors shaping vulnerabilities (Cutter et al., 2003). Though, there is a general consensus about some of the major factors that influence social vulnerability, this study observed that context specific multidimensional understanding in the Indus, Ganga, Gandaki and Brahmaputra river basins of HKH is limited. Nevertheless, review of literature on social vulnerability in three climate hotspots (deltas, semi-arid regions and snowpack- or glacier-fed river basins) in Africa, Central Asia and South Asia concludes that there are gaps on understanding the underlying drivers of vulnerability and how and why they change over time (Tucker et al., 2015). This includes a need to capture the interaction of multiple stressors (Bunce et al., 2010a, 2010b; Cruz et al., 2007; Westerhoff and Smit, 2009: cited in Tucker et al., 2015) and incorporate longer-term socio-economic trends into vulnerability analysis (Gain et al., 2012: cited in Tucker et al., 2015). Moreover, there are gaps on knowledge related to the role of 'social stratifies' (gender, class, caste, ethnicity age, etc.) in social vulnerability studies, which are important for preparing context specific adaptation programs and policies targeted to the most vulnerable in particular space and time.

A study by Jones and Boyd (2011) on social aspects to adaptation and vulnerability provides valuable insights from Nepal and explores the complex relationship between social process, drivers of vulnerability and adaptation. Lynn et al. (2011) concludes that some segments of society are expected to be effected due to climate change than others because of geographic location, degree of the association with climate sensitive environments and unique social, cultural, economic, or political characteristics of particular landscapes and human populations. Mishra et al. (2016) examined the climate change impacts on livelihoods in South Asian countries and found that most vulnerable livelihoods are those of the subsistence farmers, sharecroppers and landless wage earners. Nepal et al. (2014) studied the linkages between the changes in the physical environment of upstream areas and of climate change on the downstream water availability.

However, among all those studies, comprehensive assessment of social dimension in the HKH region within number of river basins is limited. As water is the element affected by changing climate, river basin as a unit of study provide more realistic understanding of vulnerabilities, considering upstream and downstream dependency and linkages with focus on social dynamics and dimension

Considering this research gap on social dimension with upstream and downstream linkages of river basins, this study under the aegis of the Himalayan Adaptation, Water and Resilience (HI-AWARE) Research on Glacier and Snowpack Dependent River Basins for Improving Livelihoods aims at improved understanding of multiple socio-economic drivers and conditions which are determining the social vulnerability of the communities across four river basins of Indus, Upper Ganges, Gandaki and Teesta in the HKH region. The study has been conducted in twelve sites in these four river basins covering upstream, midstream and down-stream ecosystems.

## 2. Approach, methods and tools

### 2.1. A contextual, multidimensional and integrated approach

The study adopts contextual approaches to understand social vulnerabilities. Contextual approaches envision vulnerability and adaptive capacity as highly contextualized within social, political, economic and ecological contexts at multiple scales from local to global. In particular, a contextual approach examines institutional constraints, social and economic barriers, and underlying historical processes and the differential capacities and sensitivities these induce (Murphy et al., 2015). Contextual approach allows to explore the multidimensional nature of vulnerabilities emerging from gender issues at individual level to political dimensions on resource allocation to environmental degradation and climatic stressors (Fig. 1).

The methodology on data collection was developed through a number of consultations among multidisciplinary research team involved in four river basins after field testing. The approach adopted for field data collection was a Participatory Rural Assessment that considered multidimensional and contextual aspects of vulnerabilities during the field inquiry. The blend of quantitative data available through secondary sources is used as much as possible with qualitative data collected to interpret vulnerabilities in a location and context. The study further integrated biophysical information on climate change trends, impacts and risks with local perceptions, experiences, insights of the community to get a comprehensive understanding of multiple drivers (like population, poverty, inequality, marginalization, lack of economic and infrastructural development, market technology, urbanization, push and pull factor of migration) and conditions that determine differentiated vulnerability for the communities living in the study areas.

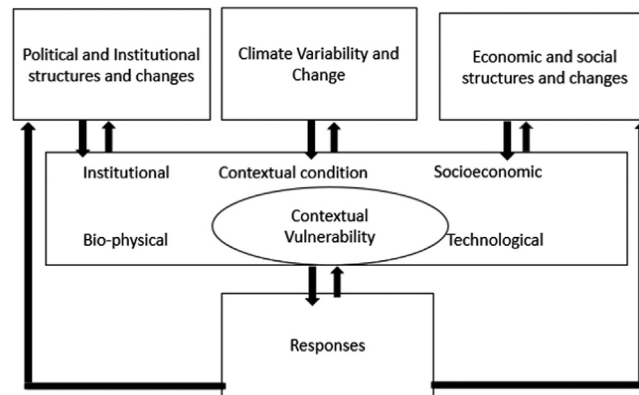


Fig. 1. Contextual approach to social vulnerabilities. Source: Murphy et al. (2015).

Tools and techniques of Participatory Rural appraisal were utilized where application with a focus that people were put in the center of participatory learning and sharing. A combination of tools from participatory appraisal exercises were used along with focused group discussions (total 111 FGDs) and key informant interviews (total 68 KIIs) and multi-stakeholder workshop (3 multi-stakeholder at Teesta downstream) workshop were done among different groups of men and women, occupational groups to capture the differential vulnerabilities across four river basins. Visualizations of spatial aspects (through maps) and temporal analysis and capturing the insights of local people, their experiential knowledge and perspectives into analysis were done for this study. Fig. 2 shows the methods and participatory tools used for data collection.

## 2.2. Study sites

Fig. 3 shows the twelve study sites in four river basins namely Indus, Upper Ganga, Gandaki and Teesta of Brahmaputra. Study sites of Indus basin include Hunza at upstream, Soan at midstream and Chaj Doab at downstream area; sites of Upper Ganga include Rudraprayag (upstream), Tehri Garhwal midstream, and Haridwar, Dehradun and Tehri Garhwal at downstream. All sites in Indus and Upper Ganga basins are situated in Pakistan and India, respectively. Rasuwa (Nepal) at upstream, Nuwakot (Nepal at midstream), Chitwan (Nepal) and West Champaran (India) at downstream are study sites in Gandaki basin. North and West Sikkim (India) at

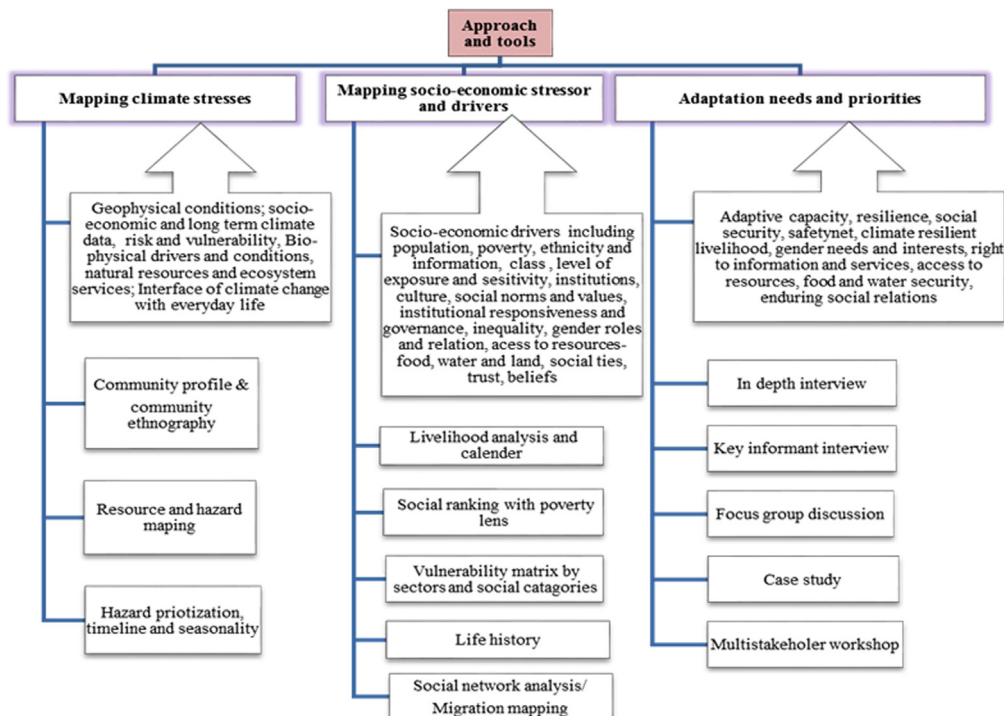


Fig. 2. Approaches and tools for data collection.

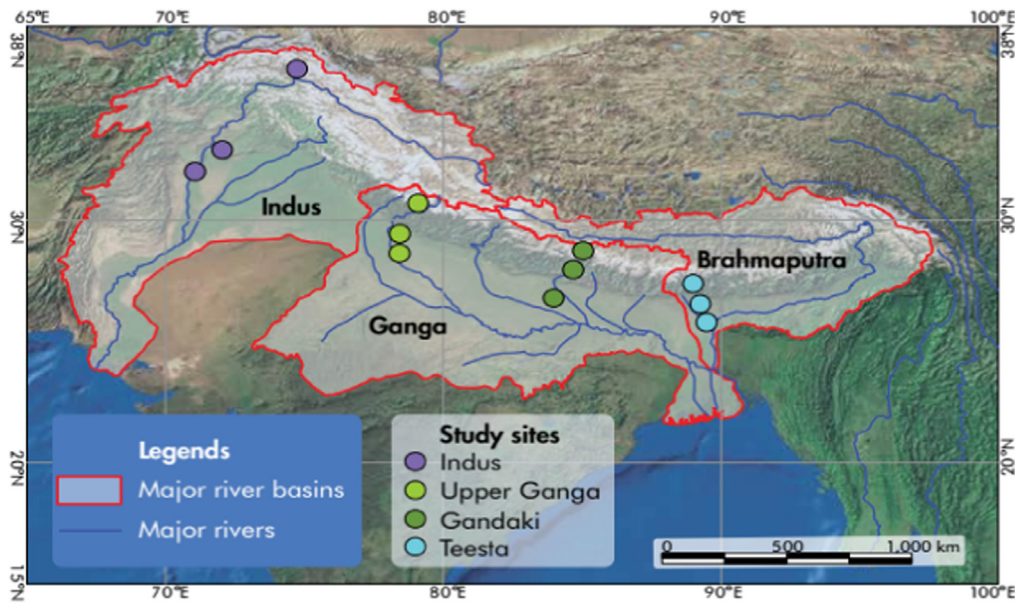


Fig. 3. Study sites in four river basins.

upstream, Pandem, Melli (Sikkim, India), and Poshyor and Teesta valley (West Bengal, India) at midstream, and Jalpaiguri (West Bengal, India) and Nilphamari, Rangpur and Lalmonirhat (Bangladesh) at downstream are the study sites in Teesta basin.

The upstream essentially includes the high mountains of the trans-Himalaya and higher Himalaya with wide variation in elevation and climate. Upstream is characterized by an abrupt rise of topography, extremely rugged terrain, steep slopes and deeply incised cut valleys. The land cover varies from glaciers, snow, bare soil and rock at the highest elevations, through shrubs, grass and coniferous forest at the lower elevations. The study sites in midstream comprise the lesser Himalayan (middle mountains/ mid hills) zone. This area is characterized by hills with large areas of dense broad-leaved mixed forest and extensive agriculture, often on cascaded terraced slopes. The study sites in the downstream are mostly flat and characterized by vast floodplains and prone to flood and riverbank erosion. Table 1 summarizes the study sites in four river basins and reason behind for selecting those sites.

### 3. Results and discussion

#### 3.1. Socio-economic conditions of the people

In Indus basin, upstream population along Hunza sub-basin depend mainly on natural resources and traditionally live in an agro-pastoral life (Abbasi et al., 2017). In midstream, the Soan basin extends across two of the four districts on the plateau. Livestock forms an important component of rural livelihoods in this area. The villages in the Soan sub-basin are all well established and well

Table 1

List of study sites in the four river basins and reason for selecting.

River basin	Upstream	Midstream	Downstream
<b>Indus</b>	Hunza	Soan	Chaj Doab
<b>Reason</b>	Agro-pastoral livelihood	Pastoralism, irrigated agriculture, prolonged period of canal closure	Densely populated, irrigated agriculture, ground water depletion
<b>Upper Ganga</b>	Rudraprayagh	Tehri and Devprayag	Haridwar and Rishikesh
<b>Reason</b>	Land loss during the 2013 floods, religious tourism, changes in weather and adversely affected by human-wildlife conflict, caste discrimination	Heavy out migration, rain-fed agriculture, caste system	Differential water access and land holding, caste system, rain-fed agriculture, migration, tourism, caste system
<b>Gandaki</b>	Rasuwa	Nuwakot	Chitwan and West Champaran
<b>Reason</b>	Pasture land, farming based on snow and rain, tourism, benefit sharing from hydro-power	Rain-fed and irrigated agriculture with presence of co-operatives	Flood and human-wildlife conflict, rice-duck farming, commercial farming
<b>Teesta</b>	North and West Sikkim	Pandem, Melli, Poshyor, and Teesta Valley	Jalpaiguri, Nilphamari, Rangpur, and Lalmonirhat
<b>Reason</b>	Mixed agriculture, traditional agro-pastoralist and tourism	Eco-tourism, mixed farming, intensive cardamom agriculture, issue of land document, migration, impact of development and market, issue of water scarcity	Left and right bank of Teesta river, agriculture, fisheries, issue of flood, river erosion and water.

connected with road and railway infrastructure, while there is no seasonal migration for work except for transhumance. In downstream of Indus in Chaj Doab, agriculture (irrigated mostly) is the single largest sector in rural areas, which provides direct or indirect employment to the majority of the labour force. Large, medium and small scale industry, business, and trade dominate the urban areas, as the plains are characterized by gentle slopes, facilitating transportation and the process of transporting goods from farm to market (Abbasi et al., 2017).

In Upper Ganga basin, the overall socio-economic condition in the higher elevation district of Rudraprayag is low, with 37% of the population below the poverty line and road connectivity is poor. Mid-hill has a high proportion (32%) of marginal workers (those who have worked for less than three months of the year) compared to the state average of 26% (Bhadwal et al., 2017). Other sources of livelihoods include cottage industry, casual employment and tourism-related activities such as shop-keeping, running catering and providing accommodation. Haridwar district in the plains is agriculturally rich with high agricultural productivity due to its location in the fertile Terai region (Bhadwal et al., 2017). Haridwar has high degree of urbanization (ibid) and famous destination for Hindus and tourists.

In Gandaki basin, the topographical differences have led to different population densities: low in the upstream ( $9/\text{km}^2$ ) and gradually increasing in midstream ( $183/\text{km}^2$ ) with the highest density in downstream ( $278/\text{km}^2$ ) (Dandekhya et al., 2017). Across the basin, women have lower levels of literacy (male 78% & female 62% literacy rate) and except in the hills are less likely to be economically active, indicating a lower status and cultural barriers to women working outside the home (Dandekhya et al., 2017). The downstream of basin, though is fertile face and economic prosperity is high, yet unequal land distribution and historical bias towards ownership to land remain one of the reason diverse socioeconomic status of people in downstream.

In Teesta basin, the socio-economic regime may be summarized as - the high elevation villages are inhabited by indigenous groups; mid-hills by mixed Nepali ethnic communities, other scheduled tribes and migrants from Assam, Bhutan and Nepal; while the downstream floodplains are inhabited by mainly Bengalis in West Bengal and Bangladesh (Syed et al., 2017). The majority of population depends on natural resources and subsistent agriculture for their livelihood and living standard is generally lower middle to low. In downstream Indian part, Jalpaiguri and Siliguri are the largest townships; however, subsistence agriculture is the main economic activity in the rural parts where average size of landholdings is 1.3 ha. In Bangladesh part, 54% of 14 million people is involved in subsistence agriculture. Of these, 84% are marginal farmers with less than 1 ha of cultivable land, where people in chars (sand bars) are the most vulnerable in this area (BBS-GOB, 2010; Syed et al., 2017; Syed and Al Amin, 2016; Tacoli, 2011).

### 3.2. People's perception of major climatic and natural hazards

Overall in four basins of the HKH region, there is a generic trend towards rising temperatures and increased variability in precipitation, but the specific trends vary slightly in the different areas from the mountains to the flood plains (Table 2). Similar study done by Maharjan et al. (2018), included that majority of the households (91%) in four river basins stated about perceiving changes in the climate and experiencing environmental shocks over the last decade.

Snowfall decrease is observed in upstream, of all the four basins, whereas seasonal and flash flood is reported in mid and downstream of the basins. In addition increase incidence of hailstorm is also reported as problem in mostly in mid and downstream of the basins.

Narratives of upstream, midstream and downstream communities do confirm that there is variation on climatic patterns observed. For instance in Jalpaiguri Teesta, people also reported that there is increase in climate extremes such as windstorm, thunderstorm, floods, droughts and heavy precipitation (Tables 3 and 4), and in Bangladesh, people reported that there is increase in erratic rainfall which resulted in increased river bank erosion, seasonal flood as well as increased incidences of drought (Tables 3 and 4). However, people in his area defined water scarcity as drought like condition. Though there is variation on extreme climate events in different

**Table 2**  
climate extreme and natural hazards in study sites. Source: Field survey (Identification of climatic extreme and hazards), 2017.

Climate extreme event	SF/FF	DR	RE	ER/CB	LL/LE	CW	Fog	Frost	HW	TS	HS	ST	SFD	WS
Upstream														
Indus	x			x	x					x		x	x	
Upper Ganga	x		x	x	x						x		x	x
Gandaki		x		x	x		x		x			x	x	x
Teesta				x	x			x			x		x	x
Midstream														
Indus		x		x		x	x				x			x
Upper Ganga	x	x		x					x					x
Gandaki	x				x	x	x	x			x			x
Teesta	x	x		x	x			x	x		x	x		x
Downstream														
Indus			x	x	x	x	x					x		
Upper Ganga	x			x					x		x			x
Gandaki	x		x				x		x	x	x			
Teesta	x	x	x	x		x	x				x	x		

Note: SF/FF – Seasonal flood/flash flood; DR – drought; RE – riverbank erosion; ER/CB – erratic rainfall/cloud burst; LL/LE- landslide/land erosion; CW-cold wave; HW-heavy wind; HS – hailstorm; TS – thunderstorm; ST – storm; SFD -snowfall decrease, WS-water scarcity.



**Table 3**

Variation on climatic parameters at Shardapally, Kharia-II GP, Jalpaiguri district (Teesta plains Jalpaiguri). Source: FGD findings (Climatic Stressor analysis), 2017.

Events	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<i>Temperature</i>												
Hotness		+	+	++	+++	+++	+++	++	++	+	+	
Coldness	—	—									—	—
<i>Rainfall</i>												
Pattern	—	—	—	—	—	+	+++	+++	++	—	—	—
Rainstorms					+	+		++	++	+++		
<i>Wind</i>												
Wind storms				+	++					+	+	
Hail storms							++	++				
Hot winds			++	+++	+++	++						

Temperature: hotness: + normal ++ hot, +++ very hot; coldness: — normal, — cold, — — very cold; Rainfall: + sometimes rainfall occur, + + normal rainfall, +++ heavy/ erratic rainfall, — no rainfall period; rainstorms: + normal, ++ destructive rainstorms; Wind/hail storms: + normal, ++ destructive; hot winds: +++ very hot

**Table 4**

People's perception about trend of climate extreme events and hazards in lower Teesta basin in Bangladesh. Source: Field data, hazard trend analysis, 2017.

Hazards	1980–1990	1990–2000	2000–2015
Riverbank erosion	+++	+++	+++
Heavy fog	++++	+++	++
Erratic rainfall (irregular)	++	++	+++
Seasonal flood	++	+++	++++
Flash flood	+	++	+++
Drought	++	+++	++++
Cold wave	+	++	+++
Heat wave	+	++	+++

places, the common is more incidence of floods, landslides triggered by heavy rain during monsoon and more drought in winter. For instance, Women respondents of Upper Gandaki reported that there is increase rate of nose bleeding among children during summer due to increase warmness.

### 3.3. Socio-economic drivers of vulnerabilities

Vulnerability of a community is determined by a series of factors which are not limited to just the exposure to a climate stressor; but also a multitude of other socio-economic factors or drivers—that couple-up with climatic risks to determine the degree of vulnerability of an individual and the community. The major indicators of this contextual vulnerability identified by [Adger \(1999\)](#) are poverty and resource dependence at the individual level and inequality and institutional adaptation at the collective level (Cited in: [Senapati and Gupta, 2016](#)). This observation holds true in all of our study river basins. It is found that the most vulnerable people in the face to climatic hazards are often found to belong to poor and marginal group, having limited access to resources and ecosystem services and most often with no access to existing government supports and services. Social exclusion and caste-based inequalities were reported in the up-streams of Upper Ganga, upstream and midstream of Teesta and in Gandaki basin. However, in up-stream and midstream Indus and in midstream Sikkim, good communication facilities and well established infrastructures were found which reduced the poverty level and social vulnerability there.

The greater vulnerability, as stated by the people, arises from a multitude of reasons including but not limited to, lack of information, knowledge and awareness about climate change impacts and responses, low level of technology transfer and local innovation, lack of access of the poor to institutional supports and services limit the adaptive capacity of the people, particularly those belonging to socially disadvantaged groups and communities, which increases their vulnerability. It was also felt that caste systems increased social inequity, deprivation and differentiation, particularly in Nepal and India, which has again limited the capacity of individuals, families and communities to face and cope with the externality like climate change.

Again, increases in unemployment, state and local political insecurity (for example: in Upper Ganga and Teesta) (poor governance in disaster management, issue of land ownership (issue of tea-workers in Teesta Valley and situation of char-dwellers in lower Teesta), breaking up of traditional and communal institution (found in Teesta upstream), lack of quality education (in Teesta downstream, literacy rate has found less than 35% in all study villages) etc. are key drivers and conditions that affect the lives and livelihoods. Increasing out migration (in Hunza Valley of Indus, Teesta and Gandaki basin) and social insecurity, increasing cost of food items and production equipment, community conflict and human-wildlife conflict (reported in Gandaki and Upper Ganga basin) etc. were reported during field survey across the river basins which are drivers for social vulnerability.

In all the study sites, gender discrimination (in case of decision-making power, land ownership, discriminated wage, lower level of

education compared to men, religious and cultural practices) has been found to be a major socio-economic factor, which makes the poor women more vulnerable to the effects of climate change. Thus, the impacts of climate change coupled with the socio-economic drivers and conditions, institutional arrangement, governance and responsiveness as well as the cultural norms, values and practices that are embedded in the society, often determine the nature and level of vulnerability. All these issues can be summarized in five major categories of socio-economic stressors like geophysical condition of the locality, socio-economic status, access to resources and services, marginality-inequality-caste discrimination and issues of gender.

### 3.4. Climatic and non-climatic factors and livelihoods

Livelihoods rarely face only one stressor or shock at a time (Olsson et al., 2014) i.e., the synergistic relationship between climate extreme events and a variety of other social, economic, and political stressors impinge on livelihoods and reinforce each other in the process, often negatively (Cited in: Olsson et al., 2014). Shifts in livelihoods often occur due to changing climate trends, linked to a series of environmental, socioeconomic, and political stressors (ibid).

In the HKH region, upstream and midstream livelihoods are characterized by agriculture, horticulture, floriculture, pastoralism, small business, wage earning and tourism. Agriculture in upstream region is mostly subsistence and has high significance for food and nutritional security of the people living in the harsh mountain terrain. However, farmers across the mountain region of HKH gradually shifting towards subsistence to high value agriculture due to growing recognition of the products, market access, remittance flow, expansion of cooperatives etc (Gioli et al., 2018). Agriculture is also of the main livelihood for majority of the households in downstream of four river basins, combined with fisheries. Some livelihood practices more climate sensitive, such as rain-fed smallholder subsistence agriculture, seasonal employment in agriculture (e.g., tea, coffee, sugar plantations), fishing, pastoralism and tourism (Olsson et al., 2014). Climate change also affects households dependent on informal livelihoods or wage labour in poor urban settlements, directly through unsafe settlement structures or indirectly through rises in food prices or migration (Olsson et al., 2014). In addition, livelihoods are also affected by non-climatic factors like infrastructure development. The massive road construction in mid and upstream of Gandaki has also a reason for increase landslide causing siltation in river downstream affecting water system like water mills. Climate stressors coupled with socio-economic factor increases the impacts in key livelihood sector and increase the differential vulnerabilities among different group.

In Indus basin, agriculture sector is vulnerable due to flood and drought in all river basin. In Upper Indus basin, Attabad lake disaster was significant to note. That landslide washed away lowlying village and agricultural land. Farmers reported that around 10 years back the farmers used to cultivate wheat in Oct- Nov but now a days the wheat crop is sown in Dec due to changes in weather patterns. The winter rains that appeared in January and February are now shift to March. Similarly, the summer monsoon has shifted from July to almost August and September which changed their farming pattern. The livestock health is also effected due to fodder crop that gets damaged during rains in March. Fodder crop also gets effected during the cold waves in start of winter spell. In lower Indus, farmers reported 100% of crop loss during last three years due to un-wanted rain spell in March.

In higher altitude of Upper Ganga, there has been a considerable drop in the productivity of key horticultural crops like peaches, apricots, plums, and apples as the required chilling cannot be obtained due to decrease in snowfall. Similarly at mid-hill of Upper Ganga, production gone down from 100 quintal to 10 quintal which is the cash crop in this area. Apart from an increase in temperature, human wildlife conflict has affected the agricultural productivity in the high elevation sites of the Upper Ganga Basin. Similarly in Indus, the reduction in snowfall has severely affected agriculture and fruit production. For those who have access to market, in Gandaki upstream, reduced snowfall has led to a shift away from the traditional cereal farming to cash generating vegetable and organic farming in poly-tunnels. The traditional communities from Lachen and Thangu, Sikkim in Teesta upstream grow crops in the summer after the snow melts. As an alternative livelihood, in Gandaki upstream, villagers started rural tourism in Tatopani. However, the drying or shifting of sulphur rich hot springs has created severe livelihoods difficulties for people who were earning some income from such eco-tourism as tourists arrivals have dropped drastically. In upstream of Upper Ganga, heavy precipitation, GLOF (glacial lake outburst flood) events followed by landslide caused massive destruction in Ram Bara and Gauri Kaund area. Many people adjoining villages died as it was tourist season. Climate extreme events have increased the vulnerability of the herders as yak and sheep populations have reduced in recent years due to inadequate grazing lands in the trans-Himalayan zones as well as climatic hazards such as heavy snowfall causing deaths of yaks, sheep, and goats.

Midstream agriculture practices in Indus, Upper Ganga and Gandaki basins are influenced by uneven rainfall. In mid-stream of Teesta, agriculture is the main source of livelihood. However, agriculture that previously flourished has become vulnerable to frequent hailstorms during March and April every year. Hailstorms are affecting the cultivation of maize, damaging fruit, vegetables and large cardamom (GoS, 2011). Oranges are no longer being cultivated in West Pendam (Sikkim), Posyur (Kalimpong, West Bengal), and Teesta Valley (Darjeeling, West Bengal), in the mid hill so the Teesta. In 40% households, family income are affected due to hailstorm in Pendem. According to people of Teesta midstream, 70–98% loss of spring discharges has resulted in water scarcity and drought, leading to 60–90% crop failure. Cloudburst event in Bagi in Upper Ganga caused 60% damage of agricultural fields and 95% of people are engaged in other forms of livelihood. Agriculture has become less profitable in the region leading to unemployment and migration, which in turn has created a shortage of agricultural labour force, with additional laborers often brought in from the plains. Outmigration of men in Posyur and Teesta Valley has left women and older people more stressed as they have to manage agricultural activities as well as the home. Outmigration is also reported in Gandaki, Teesta, mid and lower Indus basin as well. On an average about 39% household in four river basins reported that they have at least one migrant member in their family (Maharjan et al., 2018).

Downstream communities engaged in agricultural activities are more vulnerable to the impact of flash floods and other water-induced disasters. Riverbank erosion (80% people mentioned in downstream Teesta) is the most crucial form of climatic hazards in

downstream Teesta that made them poor by grabbing their lands, properties and livelihoods. In Dahagram (Lalmonirhat, Bangladesh), the villagers told that they had their lands and properties which are now under water due to riverbank erosion because of leaving the area with no protection like embankment or spurs. Extreme climate events and climatic variability affect natural assets on which certain livelihoods depend directly, such as rivers, lakes and fish stocks (cited in: [Olsson et al., 2014](#)). In Jalpaiguri, (West Bengal, India) in downstream Teesta site, fishermen mentioned that the unpredictable heavy rainfall brings with it excessive siltation and high turbidity in the river water and with its unpredictable river runoff and water levels which has disturbed the breeding of fish. The availability of fish has now declined into almost half as stated by the fishermen after the construction of upstream Barrage. Again in downstream site in Bangladesh side of Teesta, dependency on fishing is severely impacted due to decreased water level after the construction of dam in the river. According to the villagers, now-a-days, Teesta has become ineffective during dry period which is responsible for shortage of fish and vulnerability of fishermen. Fishermen stated in FGD that previously they could catch 3–5 kg fish within two hours whereas now it is difficult to get 1 kg of fish from morning till noon. They catch fish only three months in a year (June–August). Due to unfavorable condition, fishermen forced to change their livelihood. FGD participants mentioned, fishermen have to struggle a lot when they work as agricultural labour as they are not good at this work. Sometimes it becomes difficult to get their work in this unknown track which makes their lives miserable and difficult.

The political environment plays a significant role to diversify livelihood options for adaptation. For instance, in the study sites of Sikkim where the political environment is stable significant resources are being spent by the government on infrastructure and capacity development, tourism and enterprises have been promoted as alternative to farm based livelihoods. Community of Lachen and Thangu have shifted their livelihood from traditional farming and agro-pastoralism to tourism. Again, with better access to roads, new markets for Yak Cheese have been developed. On the other hand, in adjacent sites in West Bengal where there is political instability with spurts of violence, with ongoing demand for a separate state of Gorkhaland, the situation seems deteriorating with frequent strikes, clashes between the government forces and opponents, resulting in hardly any infrastructure as well as other development work. This has curtailed people's opportunities to alternate livelihoods.

Infrastructure development also shows its negative impacts on people's vulnerabilities'. For instance in Sikkim where hydropower is being rapidly developed with construction of a series of dams, has led to major controversies. Interviews in both North and West Sikkim bring out a strong community perception that building large hydropower dams will have negative impacts on their water resources and agricultural livelihoods. People point out that such impacts are already being seen in the drying up to streams, and decrease of productivity of crops, particularly of cardamom. (Figs. 4 and 5)

### 3.5. Nature and types of vulnerabilities by social categories

Vulnerability is driven by various drivers and conditions which are defined by socio-economic factors ([Wisner et al., 2003](#)) and varies among different groups. According to Pastuer (2011) (Cited in [Goodrich et al. \(2017\)](#)), poverty, living in marginal and fragile environments, having limited access to material, social, economic and political resources (including skills and technologies), few income earning possibilities and limited ability to diversify or adapt in difficult circumstances, infirmities and conditions of disability and life cycle positions contribute to make some people less resilient and less able to cope with and adapt to crisis situations ([Pasteur, 2011](#): cited in [Goodrich et al., 2017](#)). Poor and marginal farmers, day laborers, women, lower caste people, people who have less political affiliation, migrant families, who do not have access to and control over resources (like tea garden workers in Teesta Valley)-are found to be the most vulnerable considering their socio-economic stresses along with climate extreme events. Both the social drivers and climate stresses leave unequal and higher impacts on the health, working potential and employment, incomes, agriculture, horticulture, pastoral activity, tourism, fisheries, food and nutrition, particularly of the poor and marginal groups in all the



Fig. 4. Conditions leading to vulnerabilities. Source: Field Study: findings from Upper Ganga study basin, 2017.



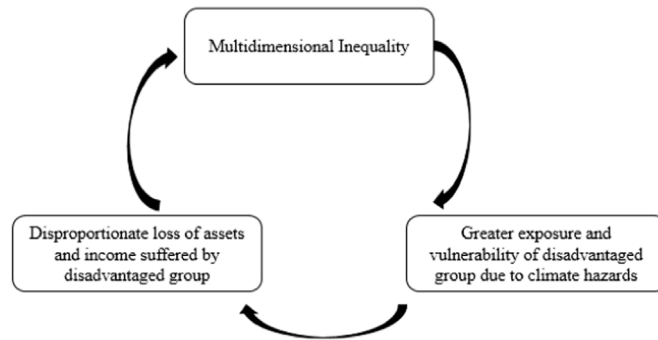


Fig. 5. Inequality and climate change vicious cycle. Source: [Islam and Winkle \(2017\)](#).

river basins. In this section, various cases of different vulnerable groups have been presented across four river basins. We classify these groups based on economy, caste, political context, geographical location and gender.

### 3.5.1. Economic class

Frequent effects of major climatic stressor such as floods, erratic rainfall, drought cause huge loss of production for the farmers. Rich and mediocre farmers can recover the loss, as they have alternative resources to cope with the loss. However, for poor and marginal farmers belonging to low economic class such event comes as an unbearable loss, which leads to secondary effects such as disparities in intra-household consumption affecting women and men of same class differently. Due to their dependence on shared cropping and daily wages, they are left with no reserves that could help mitigate any losses arising extreme weather. The villagers frequently pointed out to how the prevailing weather patterns have changed over the years and how this has been affecting their farming system and creating unfavorable conditions for marginal farmers. For example, in the floodplains of West Champaran in Bihar (India), communities living near the river or inside the embankments are unable to carry out any agricultural activities for 3–4 months a year, as their fields are either eroded by the river or completely inundated due to floods ([Udas, et. al, 2018](#)). This is similar to the case of downstream Teesta study sites in Bangladesh. Similarly, in the floodplains of Jalpaiguri (India, Teesta downstream), farming is limited as the river does not provide irrigation water, except where there are leakages from the canal while *chars* (riverine islands) are becoming less ideal locations for agriculture. In mid-hills of Upper Ganga, in Bagi village, people were practicing subsistence agriculture and even selling their surplus produce in local markets of Chamba. But since the cloudburst event occurred in 2014 and triggered landslide and flash floods in the area; the irrigation canals have been damaged, fields have now been deposited by debris and people have lost their livelihood. In the upstream regions of the Upper Ganga basin, floods in 2013 and 2014 had resulted in river bank erosion and land loss, impacting the landholding of farmers who already have low landholding.

Farmers depending on diesel pumps for irrigation are sometimes responsible for groundwater overexploitation which causes declining of water table in Teesta plains in Bangladesh. However, poor farmers who cannot afford pump, face burden of water scarcity, especially increase work load among women to fetch water and forced migration for men due to crop failure. Just over half (54%) of households in the Teesta floodplains in Bangladesh are primarily engaged in farming, of these 84% are marginal farmers with less than 1 ha of cultivable land ([BBS-GOB, 2010](#)). Riverbank erosion is the major reason for poverty as farmers lose their agricultural land and livelihood and forced to get into labour work and further became poor and marginalized in the society due to loss of assets like land. Again, people who were forced to change their livelihood face unfavorable condition with new occupation; sometimes it becomes difficult to get their work in this unknown track which makes their lives miserable and difficult. Due to unavailability of fish resources, Fishermen communities in Teesta basin are forced to change their livelihood and struggle in new track to get work and to get accustomed with new livelihood.

The trend of men leaving the village to work abroad has drastically increased in Nepal part of Gandaki basin. In some case even women have started to go abroad. Respondents realized this trend also as a socioeconomic stressor, especially for those households who take loan to send family members abroad and bear the burden of absentee family member to perform farming and provide household labour work, as well as high interest rate to pay loans. 21% of the head of household in Nuwakot (midstream of Gandaki) is headed by female in 2011. The stories of migrant families indicate that family has to go through number of cycles of migrations experiences and expanding skills as well as social capital in destination for economic gain. For economically poor families who take loan to bear the processing cost to go abroad, became more vulnerable than before.

However, scenario is comparatively better for communities living in Upper Indus basin. Findings from social ranking analysis showed that average monthly income of community people living here nearly 148 USD. Findings from hazard ranking and prioritization shows that people living here less disaster-prone area and less vulnerable due to climatic hazards. Agriculture, business and jobs are full year activities for the people of this area while day labour has 9 months activity for the study area. Income opportunities for longer time, making them less vulnerable. Around 96% of households in Hunza-Nagar (upper Indus) have access to agricultural land and cultivate both staple and cash. 95% of households owning more than one type of livestock such as yak, sheep, and goat.

During socio-economic factor analysis, people mentioned here that agricultural development, technological innovation, group formation and women empowerment are positively affecting the economic activity in this study area. But in midstream Soan basin, according FGD discussion conducted in six villages, small scale crop farming and livestock management are severely effected due to

erratic rainfall and snowfall pattern. Male members of their family migrate to other places in search of livelihood. Absence of male members increase the work burden and social insecurity of women.

### 3.5.2. Category based on caste and other social stratifiers

Caste is a common social category among Hindu communities in HKH. Among Muslims, racial categories are observed. Marginality, inequality and vulnerabilities are directly linked with each other based on caste and racial categories depending on who is placed high in social hierarchy. The field evidences conclude that marginal population belonging lower caste and racial categories possess less power, have less access to resources and services and are socially excluded, making them more vulnerable to cope and respond to climatic stressors. This phenomenon resonates with established theory of vicious cycle of inequalities and climate change vulnerabilities (Islam and Winkle, 2017), resulting in reinforcing and perpetuating existing vulnerabilities, and undermining communities' adaptive capacities. The caste system observed in Hakimpur village of downstream of Upper Ganga where large section of land are mostly owned by the affluent caste and class, the lower castes work as agricultural laborers or off farm laborers. The ownership of private water body connections lay largely with the same groups while others rent water from neighbors at fixed rate. This makes the lower caste groups vulnerable during the period of water scarcity. Event of flood in 2013 highlighted as extreme caused damage to lives and properties of people especially the Buska tribal communities in Khadri Kharak Maf town of Upper Ganga. As they do not possess any land legally, they were not awarded any compensation. However, due to lower share of and less income generated from agriculture, lower caste families have more working hands and are engaged in different forms of livelihood activities. Field evidence showed that diversification of livelihood is more evident among scheduled caste communities as they are not tied up with land. So they are able to be less dependent on agriculture and work more as hired labour with a fix wage. They, could be less vulnerable due to climate induced agricultural vulnerabilities. In lower Teesta basin, char dwellers are more vulnerable than the people living in mainland. Char-lands are badly exposed to river erosion, floods, sand deposition. Respondents in FGD discussion mentioned that they are socially excluded and cannot get strong role in decision-making process. Even people of mainland do not want to make marital relationship with char dwellers as they do not possess social security as well as environmental security.

Dalits caste category in Gandaki basin are historically deprived of land ownership, hence possess almost no land or homestead. Similarly Buksa tribal community in Gandaki basin and tea-pickers at Teesta valley do not possess any land legally. Though in past, not having land for this caste category is related to other skilled services they used to provide to agrarian families, with change on availability of technologies such as farm tools, their livelihood is dependent on labour work either for farming or other. These farm labourer bear double burden of climate risk of losing labour work in case of farm failure or double loss as tenant while facing climatic stressor.

### 3.5.3. Institutional dimension

In mid- stream Indus basin, people reported the collaboration between stakeholder and community as not effective in the area compared to others. This scenario is similar for Gandaki basin. Initiatives in the far downstream part of the basin have been extremely limited, although the grassroots organization Megh Pyne Abhiyan has been working hard with other local organizations to provide support to people in the flood affected districts of north Bihar (Dandekhya et al., 2017). In downstream Teesta, Union Council is one of the nearest government service institution for Dimla, Kaunia, Hatibandha and Patgram Upazilla. Each of the villages has one Union council and it does not have enough resources to provide the community with necessary services according to the villagers' opinion. According to villagers, remoteness of the villages, underdeveloped road communication systems are the leading causes of getting poor supports from the institutions particularly during flood and river bank erosion. Stakeholder mapping and findings from FGD discussion revealed that although there are various institutions working in vulnerable areas but collaboration among them are very little. Each government and non-government institutions take their initiatives individually.

However, Developmental and welfare initiatives undertaken by the Government of Sikkim in the rural areas have been further strengthened over the years. This has brought about a perceptible change in the lives of the people in the village. The Government of Sikkim has also developed "Village Development Action Plan (VDAP)" which is an innovative initiative to usher in democratic decentralization, need based planning and empowerment of the Panchayati Raj Institution.

The political situation in the area are very significant in the field sites which are cut off from the dominant development discourse lie much at the mercy and dictates of the political parties. Like in the Darjeeling hills which is set against the backdrop for the demand of autonomy in the name of Gorkhaland. Many a times the macro development ideals do not trickle down to these areas and residents here are left with little opinion but to local level political influences. Similar scenario is for the char dwellers in lower Teesta basin. Hence, these vulnerable groups end up becoming the 'vote banks' to the political parties. For example, the MGNREGA (Mahatma Gandhi National Rural Employment Guarantee Act, 2005), also popularly known as 100 days as it provides 100 days of wage employment to unskilled labour, is distributed by local political party leaders and local government employees. These political parties often use the scheme to win vote banks by distributing these schemes to those who show their allegiance to them. Another example is the establishment of ethnicity based development boards by the state government and providing financial support and various types of schemes for education, employment, housing, etc. to these groups. This has helped certain groups in reducing their vulnerabilities but has also made them more dependent on these political parties.

### 3.5.4. Geographical location

The location in which people are placed is another reason for vulnerabilities. Geographical location and proximity to hazard sources are another reason making people vulnerable reported by all four river basin. In Indus, people of Chaj Doab region sated that land erosion near Jehlum River bed is increasing in summers due to excessive rains in the upper part where most of the communities

have land holding near the river bed. The major settlement of Gulmit (Upper Indus) was severely damaged by water after the Attabad lake disaster (in which a landslide dam across the Hunza River in 2010 led to formation of a 20 km long lake along the Gojal valley)

For Buksa tribal community in downstream upper Ganga, most of their standing crop were destroyed and they had to evacuate their houses as water from Ganga inundated their area during 2013 extreme flood event in Uttarakhand. However, being inherently nomadic in nature and since they do not own the land legally, they were not awarded any compensation amounts and had to face the losses. Their settlement was not closer to the river until Garhwali community was allotted land in the region and river channel itself shifted its course due to construction of barrage. Due to their present day settlement being closest to river among other communities residing in the area, this renders them vulnerability due to location but inherently because of caste discrimination, marginality and inequality. In midstream of Upper Ganga, the village Amni has a main spring source which is perennial and the oldest spring in their area. As per people, it has been there since almost 100 years. Due to certain natural events such as Uttarkashi earthquake in 1991 and reduced rainfall, it has shifted its position time and again but had always remained as the primary source of water, until it almost dried up.

In Bihar, Gandaki, most vulnerable are located inside embankment which has been constructed. The land of these people fall inside the embankment. Without proper resettlement plan they are at higher risk. In midstream and upstream, where water drains because of the steep slope, rain-fed farmers are at higher risk of climatic variability.

In Teesta basin, Poshyor in Kalimpong is located in a land-slide prone area. Not only this, the only bridge that connects the village to the main road is gets washed away every year during the monsoon. As a result these people become more vulnerable during monsoon due to landslides and lack of connectivity for essential supplies. People have reported that the incidences of landslide have been increasing since the last 5–7 years. People living in char land of Teesta and flood prone area of downstream Gandaki possess higher vulnerabilities due to their location.

### 3.5.5. Gender

Gendered practices also determine vulnerability. Women are disproportionately vulnerable to climatic hazards and socio-economic drivers within the households and community due to unequal gender relation in the society. Women's position in the family and society is subordinate to men in terms of decision making and access to resources and opportunities. Gender based division of labour is another cause behind women's inequity leading to greater vulnerability. Wage inequality, cultural and religious norms regarding women's mobility, social practices, child marriage, dowry, unequal opportunity for women, unequal resource distribution are the major social factors leading them to be in vulnerable situation, which get worse during and after disaster period.

Women in HKH do not have equal power to make decision, secure rights to land and have access to resources like men and their burden of work in agriculture, natural resource management including household have increased their vulnerabilities (Goodrich et al., 2017). Farming is a woman centric activity in mountainous regions and demands a major contribution from females throughout the year.

In Indus basin, women support their male members in agriculture sector. In livestock management women role is very significant. 60–70% activities are performed by female family members. However, compared to up-stream and mid-stream Indus, male and female both gender are found to migrate for job purposes.

With regards to high mountain villages, people face severe water scarcity which has increased women time to travel more distant places to collect drinking water and fodder for their cattle. The burden of collecting water, fuelwood, fodder and forage falls to women. However, during their tasks they face differential vulnerabilities. Like in Upper Ganga, Women of lower caste tend to depend more on the hand-pump (far away) as there is differential access of water from the tank on the basis of caste. There is heavy male out-migration in the area. So it's the women who mostly engage in farm related activities. This leads to feminization of agriculture putting most burden of agricultural annual cycle on women. This scenario is similar to Gandkai basin.

In upstream and midstream of Gandaki, agriculture is heavily feminized as men migrate for jobs outside the village. In Nuwakot (midstream Gandaki) even women have started to go abroad. Women are overburdened with work. The hardship in chauri transhumance livestock management is apparent even as more farmers take to livestock activities to meet their household coping needs. Like agriculture, this sector is also becoming feminized due to lack of male labour. Women have to frequently support their men in order to successfully carry out transhumance livestock management with yak, chauri, cows, sheep and goats.

In Teesta valley women tea-pickers are burdened with the work of tea-picking while they are working from morning to evening, also have to go back home to fetch water. Burden of work also remain on women in Teesta downstream when their male counterpart migrate in search of livelihood during lean period. Women are equally affected by flooding and landslides especially in times of maternity emergency. It was seen in the monsoon period of 2015 when a pregnant woman in times of emergency failed to be transported to a medical center and succumbed to her pregnancy immediately. Such incidents of delayed access to health during the flooding in monsoons are common to Poshyor, in which the women and children are found to be more vulnerable. It was reflected in FGDs and interviews (in downstream Teesta Bangladesh part) that Riverbank erosion put their family in hardcore poverty by destroying the land and other livelihood assets very badly. When a family becomes poor it affects women in those families in many ways. If there is food shortage, women take less food, which affect their health. It affects girls' education and increases threat of early marriage, encourages dowry system.

A quick linear analysis of the trend on amount of loan taken by a household and male to female ratio of family member as per baseline data collected by partner for pilot activities in Chharke in downstream of Gandaki basin shows that the higher the number of daughters in a family, the higher is the loan burden of the family. Further case analysis of some of the houses indicated that for most of the families the loan is taken during marriage of the daughter, except in some cases where in addition to dowry, loan is taken for medical purpose. During the FGD, loud voice for the reason of taking loan echoed for dowry (Udas et al., 2018).

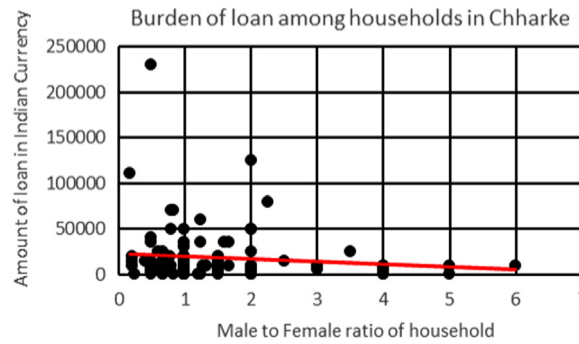


Fig. 6. Burden of loan among households in Chharke, downstream Gandaki Basin.

Fig. 6 shows burden of loan among household in downstream Gandaki basin. In this Fig. 1 indicates equal male to female in a households. Less than 1 indicates more females and more than 1 indicates more males.

In Upper Indus basin, ten years back women were not considered for important decisions but now in many family matters women's are considered for financial and other important family decisions. Agricultural activities were dominantly done by women but currently mostly people hire labour force which ultimately reduced women work load. This is happening due to increased literacy late in this district. Average literacy rate for women is equal to or above 70% in the study district. In Teesta downstream, women told that they give their opinion in family decision making to some extent nowadays compare to the past as various NGOs worked with women. However, it has found that although NGOs have intervened in the issues related to women, in terms of spending money it always male member of the family who take decision. Women have very restricted access in social sphere. Ayesha Begum, one of the members of Purbo Chatnai Union Council (Teesta plains, Bangladesh) has shared her experience about the changes in gender role of her village and claimed that although she has opportunity to contribute as an active member in Union Council, but most of the time the role of women member in union council is just to maintain the rule of the government. They have limited or almost no power to influence decision at the Union Council that might benefit women and the poor. In terms of decision making and spending money, scenario is similar for other study basin as well.

### 3.5.6. Trans-boundary Issues and vulnerabilities in peoples' livelihood

In Teesta and Gandaki basin area, trans-boundary water sharing issue is one of the major issues to increase the vulnerability of community. Conflicts among farmers for water sharing arise between the borders of Nepal and India in Gandaki basin. In Teesta, after the construction of Gajoldobba barrage in Jalpaiguri (India), it has limited the availability of irrigation water in Bangladesh. This further reduces the flow of the river in the floodplains and responsible for changing river hydrology and ecosystem and ultimately creating impacts on peoples' livelihood. This trans-boundary issues were most of the time remain unaddressed or unresolved in these study areas. According to Vij et al. (2017), transboundary issues are not properly focused between two countries in adaptation policies while addressed at national and sub-national scale. Except for the Climate Change Policy of Nepal, none of the policies discusses trans-boundary scale adaptation approaches (Vij et al., 2017). This trans-boundary issue is one of the major issue need to be resolved to reduce vulnerabilities of people.

## 4. Summary and conclusions

Vulnerability is often conceived as a compounded manifestation of various biophysical and socioeconomic factors that interact leading to an intertwined impact (Ford et al., 2008). More often than not, these socioeconomic factors tend to be underlying factors that interact with and influence exposure and sensitivity to a hazard, and their ability to cope with them. The ability to cope or adaptive capacity is greatly influenced by how actors, across levels, perceive what their level of adaptive capacity is (Bhadwal et al., 2013). This perceived level is in turn influenced by the "objective adaptive capacity" (Grothmann and Patt, 2005) of people which relates back to resources (including natural, financial, human, social and physical) available that can help aide in adapting or coping. However, the availability of these resources brings in an additional layer of "who has what" (or who has access and control), and interacts with exposure and sensitivity, eventually being realized as "conditions of vulnerability."

This narrative of "who has what/who has access and control" is grounded extensively in the political economy that is witnessed within a scale. (Ribot and Peluso, 2003) define this access as the "ability to derive benefits from things". This understanding is also deeply engraved in existing social theory notions of entitlements and, capacities and capabilities approach (Sen, 1981, 1984), which suggest that context-contingent causalities lead to deprivation and vulnerabilities. Our findings presented above, analyze these context specific causalities mediated through climatic factors, conclude that poor and marginalized are more likely to face the greatest vulnerabilities owing to structural inequalities arising from low land holding, in-ability to shift livelihoods and eventually translating into fewer resources to cope/adapt and enabling vicious cycles of vulnerabilities. Moreover, an over dependence on weather sensitive livelihoods, like farming and fishing are likely to be impacted due to the perturbations arising from climatic changes. We have also observed marginal communities, like the char dwellers and the Buksa community, having a greater exposure to hazards, owing to their inability to access "safer lands". The series of climatic pressure points that communities in each of these

river basins further aggravate issues arising from socio-economic drivers of contextual vulnerability, mediating and negatively influencing livelihoods.

In this light, we find an immediate need to address these structural inequalities through targeted policy and institutional measures, directly addressing the vulnerabilities the poor and the most vulnerable face. There is a need for inclusive policies that seek to address the developmental needs, and enhance livelihood capabilities in this climate hotspot. A participatory assessment has been done, by following an integrated and contextual approach to understand the nature and level of vulnerability in the interface of social drivers and climate change stress. The study has been carried out in twelve sites in four river basins (Indus, Upper Ganga, Gandaki and Teesta) in the HKH region, covering upstream, midstream and down-stream ecosystems. The combined effects of social drivers and climate stresses are affecting livelihoods of people, among which socially excluded and marginalized groups are more vulnerable across the river basins due to their weak social conditions, powerbase, structural inequity, lack of access to resources and services.

In the up-streams, the wage earners, women, tourism workers, small traders, pastoral groups and lower caste people (in Upper Ganges, Gandaki and Teesta) have been found highly vulnerable to both climate change and social stresses. In the mid-streams, horticulturists, tea workers, wage earners, subsistence farmers, women and socially excluded groups have been identified as the most vulnerable sections. In the down-streams, small farmers, seasonal migrants, traditional fishers, women, char-dwellers and temporary settlers on embankments are the most vulnerable groups. Study findings revealed that people who are poor and marginalized and people who are depending on natural resources for their livelihood are more vulnerable compared to others. Again, in upstream region due to geophysical condition diversity of livelihood (particularly non-farm and non-land based option) is less compared to downstream region and they are most vulnerable during and after the climate extreme. Outmigration is a constant demographic driver in the mountainous regions. A fall in hill agricultural productivity stemming out from a range of climatic and non-climatic factors has been negatively impacting people's livelihoods in the region. Tourism is another affected sector due to climatic stress in upstream areas. With no other source of income, and a dearth of alternate livelihoods, outmigration has become rampant in these villages. However, it is to be noted that the degree of outmigration varies according to the social context of the village and the availability of resources that would assist in the process of outmigration. This scenario is also been observed in downstream Teesta basin. During flood or because of riverbank erosion, people have to migrate to other places in search of livelihood. In downstream region, marginalized farmers or who possess less land, or whose livelihood depends on agro-based labour, during unfavorable condition they cannot earn their income and their family suffers miserably. Again, institutional response or access towards various institutions to help people during critical condition is minimal. Sometimes it depends on the good political alliance or good relation with bureaucrat. Moreover, geographical remoteness determines and drives access to essential resources, whether physical or natural. A different narrative emerges, where-in access to services is not limited by mere geographical remoteness, but is also determined by the state of awareness and level of motivation.

The gendered difference in terms of vulnerability is significant to note. Along with this issue inter-sectionality is important to take into account as it is noticed that the section of women are affected by climatic variability and disasters whether women are engaged exclusively in agriculture and farming from lower income households. Climate change, increase in disasters and growing economic burdens have pushed the women into public spaces. Where in the need for an alternative source of income other than agriculture has put a lot more pressure on women to ensure the smooth running of their respective households. The women are eventually burdened by the pressure of both the intra-household activities and additional burden due to climate change impacts on their lives, livelihood, water, agriculture, sanitation, food and nutrition, childcare etc.

The growing social vulnerability across the basins and study sites in the four rivers would necessitate policy and institutional measures for sectoral as well as community based local adaptation considering the social drivers, conditions, climate stresses and upstream-downstream linkages. The community people and vulnerable groups are coping with the stresses and are undertaking limited adaptation measures particularly in the areas of agriculture, home gardening, horticulture, livestock and fisheries, tourism, small trading and business. In few cases, government departments and development agencies like NGOs are supporting the local adaptations. These are reducing some level of risk and vulnerability, but planned adaptations would be required in all the river basins considering the long term climate change and impacts on the society, population and their livelihoods. Again, community people also raise the issue regarding trans-boundary river water sharing and their vulnerabilities which needs to be resolved by addressing in climate policy. Hence, the structural and root causes of vulnerability are to be addressed through policy and institutional measures. Adaptation policies and plans should address differential needs and priorities of the vulnerable groups. Findings reveal that there are many solutions which are practiced in HKH region. Many of these solutions could be upscale with contextualization and configuration. In Indus basin people have started initiative for drip and sprinkler irrigation. Off farm activities are also effective adaptation in this region. In upper Ganga, to maintain recharge of springs in the region, nearby villages had collectively prepared a traditional recharge structure in 1960s. This is locally known as *Chahal*, has proven to be very effective in recharging their springs. Micro-enterprise within the village - diversifying livelihood without migration. In downstream Teesta, people of the villages are practicing maize, potato, chili and pumpkin farming in the sandy land and it becomes very popular coping and adaptation practices in the villages. Shared livestock or adhi system is a popular adaptation and source of income for poor people. The initiative on springshed management is also worth mentioning, where Sikkim is leading by example both from policy and practice perspectives.

At the end, we feel we would like to emphasize five points for policy uptake. First, the pro-poor and gender responsive adaptation and socially inclusive policy are needed to address growing social vulnerability of the poor, women and marginalized communities. Second, social protection measures, enhancement of human capitals and livelihoods diversification are needed for reducing vulnerability, which may also contribute to socially inclusive development as well as achieving SDGs. Third, adaptation and livelihood measures are to be designed along with cross-sectoral collaboration amongst the government, NGOs, CBOs (community based organization) and research communities. Fourth, Community's vulnerability can be reduced by reviving traditional knowledge



repository for locally effective adaptation. Finally, inter-country cooperation in the context of up-stream and down-stream linkages have to be enhanced for building resilience, addressing disaster impacts and reducing vulnerability.

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## Declaration

The authors whose names are listed immediately below certify that they have affiliations with or involvement in any organization or entity with all financial and material support for the conduct of this study and/or preparation of this manuscript is clearly described in the Compliance with Ethical Standards section of the manuscript.

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