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Local Perceptions and Trends of Climate Change in the Sikkim Himalaya, North-East India

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Abstract: The Himalayan high mountain areas are more vulnerable to climate change and the awareness of its impacts among the natives is very crucial as well as beneficial to stakeholders and policymakers. The impacts of climate change via food security, water availability, natural hazards, agriculture, and livelihoods have a direct relation or threat to the lives of high mountain communities, as these areas are experiencing the immediate and greatest impacts of climate change. Although the tourism industry has become the backbone of the economy in these areas, a significant increase in tourist footfall has also impacted the environment, livelihoods, culture and food habits. To understand the local perceptions of climate change, a binary question-based survey (interview) was conducted in six main subdivisions of North Sikkim, which is a biodiversity and tourism hotspot. The data revealed that irrespective of the locality (urban/rural) people are aware of climate change. Significant coherence in the responses among gender and age groups, and between remote and developed areas exist. The transhumant herder populations are also well aware of climate change (80%). Peoples' perception about temperature change and the meteorological data are also consistent, however, a misperception is observed with the precipitation data. Decreasing snowfall patterns and increasing landslides in the higher altitudes are major concerns among the natives. The majority of people have denied any positive outcome of climate change and around 85% of the respondents are willing to participate at the community level in mitigation efforts to help curb climate change.

Keywords: Climate change; Local perception; Increasing temperature; Tourism.

Introduction

Climate change refers to systematic changes in the average weather patterns, which are difficult to experience directly or detect accurately (Weber, 2010; Blennow et al., 2012). Nevertheless, the information about the local temperature and precipitation variability in an area, acquired from the experiences and perceptions of the people living there, has been shown to correlate strongly with responses to climate change (Blennow et al., 2012). Understanding the climate change perception of any native community becomes crucial as it lays the foundation for environmentalists and governments to frame effective climate policies by including the native community as stakeholders. It is important to have societal participation to curb climate change because until the public recognises its responsibility and becomes aware of the anthropogenic contribution to global warming; policies to cut short the emissions of greenhouse gases are unlikely to happen. Hence, without civic engagement, developing effective communication strategies becomes quite critical (Hansen et al., 2012; Whitmarsh and Capstick, 2018). Moreover, civic concern increases the chance of people's willingness to change their behaviours and accept policy measures (Von Borgstede et al., 2013;

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Shi et al., 2015). This becomes more relevant under the ongoing unequivocal warming scenario that has emerged as a global challenge (Watson et al., 1998; Fraser et al., 2011; IPCC, 2014).

Although the effects of changing climate have been observed on a global scale, the complexity in terms of topography, climate, and ecological gradient in the high mountain areas make them even more sensitive towards climate change (Ives and Messerli, 1989; Beniston, 2003; Bellwood, 2013). The potential impacts of climate change on the high mountain ecosystems are enormous, as the rate of temperature and precipitation variability is significantly higher (Mathison et al., 2013). The situation in the Himalayan region is more worrisome because the rate of temperature increase has been reported to be more than the global average (Shreshtha et al., 1999; Bhutiyani et al., 2010). Along with that, the repercussions of climate change are differential in nature at the local/community level and generally depend on the occupation and economic status of the people (Aryal et al., 2014). Therefore, the perception of climate change at a local scale helps in framing localised climate policies and also serves as a proxy to know the percentage of people willing to change their behaviour/activities to minimise the adverse effects of climate change (Niles and Muller, 2016).

The Eastern Himalaya comprises some of the most remote and spectacular mountain landscapes and is widely considered as a biodiversity hotspot with fragile ecosystems that are sensitive to the slightest variation in climate (Lama and Devkota, 2009). Sikkim is a transitional zone between the Indian Summer Monsoon (ISM) dominated (wet/moist) low lands of India and the cold and dry highlands of Tibet and is characterised by high biodiversity, which is a consequence of topography-climate interaction. People living in this area have limited livelihood options, low adaptive capacity and are more vulnerable to the effects of climate change (Gentle and Maraseni, 2012). Our current understanding of peoples' perception towards the ongoing climate change in these remote high mountain areas is very limited. Keeping this in view, the present research investigates the public perceptions of climate change and related issues in high mountain areas of Sikkim (Figure 1). The study compares the perceptions and impacts on the people from North and South districts and further explores the possibilities through peoples' participation to minimise the effects of climate change and follow an environment-friendly lifestyle.

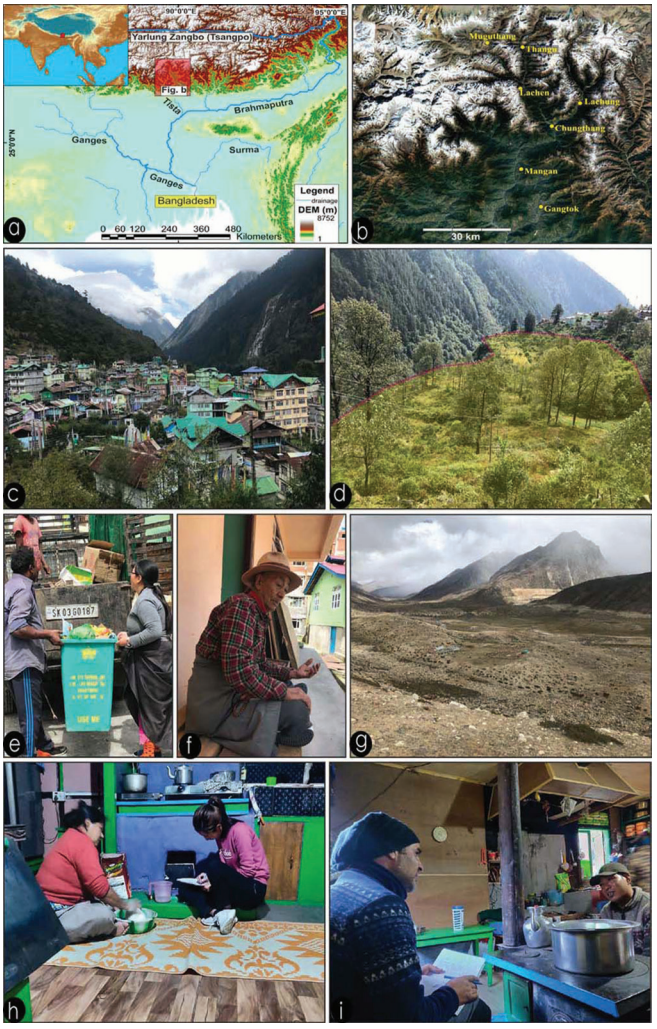

Figure 1: (a) Shuttle Radar Topography Mission (SRTM) digital elevation map of north-east India with major drainages and location of Sikkim (red rectangle). Inset: Regional map of South-east Asia showing the geographical setup of India and the study area (Sikkim; red rectangle). (b) Google Earth imagery of Sikkim showing the studied locations and their corresponding topography (c) Field photograph of Lachen showing dense settlements. (d) A piece of abundant agricultural land (highlighted within the red dashed line) in Lachen. (e) Garbage collection vans and local participation. (f) One of the oldest persons interviewed during the present survey. (g) Synoptic view of Muguthang valley where the trans-herder communities graze their herds during summer. (h-i) Field photograph showing the interactions with natives.

Study Area and Data Collection

Sikkim, a small state (~7,299 km^2) in the eastern Himalaya was ruled by monarchy till 1975. The state bears an important strategic and political position as it

shares its border with Bhutan, Tibet, and Nepal (Figure 1a). The altitudinal gradient of Sikkim is very steep (~8,300 m of elevation difference over just 100 km of horizontal distance). The higher Sikkim Himalaya is covered by permanent snowfields and ice and forms an important component of the state's hydrology (Bahuguna et al., 2001; Krishna, 2005). A significant influence of ISM and steep altitudinal gradient entails diverse micro-climatic conditions ranging from sub-tropical humid environments at <1,800 m asl (towards south) to tundra type environments above ~4,500 m asl (towards north). This complex geomorphological setup has resulted in different meteorological conditions with higher temperatures and precipitation towards the south followed by a significant declining trend towards the north. The state has a spectacular and mesmerising natural beauty from lush green valleys to snow-capped mountains and several high altitude glacial lakes attracting thousands of domestic and international tourists every year. The gradual strengthening of the tourism industry has been attributed to scenic beauty, diverse culture and ethnicity, etc. and has significantly contributed to the state's GDP (Chakrabarti, 2001, 2009; Joshi and Dhyani, 2009).

Sikkim has four districts and the North Sikkim district is known for its scenic beauty and receives the maximum footfall of tourists. The present investigation is focussed on the North Sikkim which is the sampling universe for this study. The residents of six main localities from this district including the capital city 'Gangtok' were randomly interviewed using a binary question-based survey (Figure 1). The purpose of working with a binary scale was to make the interview easier and quicker for respondents, to increase the number of respondents and to reduce their fatigue; without compromising on the quality of the data (Dolnicar et al., 2011). A total of 215 people within the age range of ~15-80 years were interviewed, representing most of the settlement areas and age groups (Table S1). Individual responses to the questions through direct interviews with locals (with the help of some local friends for language interpretation wherever needed) were obtained (Figure 1). Out of the seven locations, two localities (Mangan and Gangtok) represent developed areas, while the rest four localities are relatively remote of which Muguthang represents the transhumant community. To obtain a wider range of perceptions, the respondents were chosen from different gender and age groups. The tally of respondents from each location (north to south; Figure 1b) is as follows: Muguthang - 10, Thangu - 37, Lachung - 31, Lachen - 44, Chungthang - 24, Mangan - 42, Gangtok - 27. Out of these, there were 79 female and 136 male respondents. The data consists of individuals from different age groups with a count of 15, 115, 58 and 27 from young (< 20 years old), adult (20 – 40 years), mature (40 – 60 years) and old (60 – 80 years), respectively.

Interviewees were not identified earlier and the prerequisite rule was to interview one member of a family which enabled us to cover general perceptions at the household level. However, in Muguthang—a transhumant area—we disregarded the "one member" rule as the population was very low. For the interview, a binary scale questionnaire was formulated after intensive literature review and discussions that focussed mainly on long-term changes in mean temperature, precipitation, and its impact on the health and lifestyle of the native communities over the last two decades (Tables 1 and S2). Since the historical or instrumental meteorological data in the Indian Himalayan region is sparse (Shrestha et al., 1999; Ali et al., 2019), therefore, the Climate research unit time series (CRU-TS 4.04; Harris et al., 2020), has been used to analyse the temperature and precipitation data from 1988 to 2018. The data acquired from the interview has been validated for internal consistency before any inferences from the responses are drawn (see Section Testing Consistency Among Responses). Furthermore, it was used to understand the response of remote versus developed communities to climate change and examine its effects on the individuals (Figures 2 and 3). All the analyses were done using the *Performance Analytics* package in R platform version 3.6.1 (Peterson and Carl, 2019; R Core Team, 2019).

Results

Testing Consistency Among Responses

Five categories (Table 2) were made from the questions and the consistencies in the responses within the categories were tested by linear correlation and corresponding *p*-values. It is observed that the responses were consistent and the respondents have carefully given their responses and hence reliable. Correlation among categories and their correlation coefficients are shown in Figure 4. Further, we have categorised the respondents based on gender (1-sM and 2-sF), age (3-aY, 4-aA, 5-aM and 6-aO) and the region they belonged to (7-rMU, 8-rT, 9-rU, 10-rE, 11-rC, 12-rM and 13-rG), and thus there are 13 categories. All the responses from each category are given in Figures 2 and 3. Figure 5 depicts the gender, age, and location-based correlations (for Yes) and their coherence.

Table 1: Interview questions asked for the present study

Qn. 1	Are you a resident of Sikkim?
Qn. 2	Have you heard about “climate change” or "global warming"?
Qn. 3	Do you feel that the pattern of weather is changing in last few years?
Qn. 4	Do you have any idea that climate is changing compared to earlier times past?
Qn. 5	Experienced any change in the summer temperature over the past 15-20 years?
Qn. 6	Any change in the winter temperature of your region over the past 15-20 years?
Qn. 7	Is annual snowfall decreasing over the past 15-20 years?
Qn. 8	Is the rainfall increasing over the past 15-20 years?
Qn. 9	Do you think that climate change will cause natural disasters?
Qn. 10	Do you think that the affects of climate change are going to be catastrophic?
Qn. 11	Have you noticed any seasonality changes in cultivation pattern over the years?
Qn. 12	In your village, have you noticed any change in food habits of people?
Qn. 13	Is agriculture productivity increased in last 20 years?
Qn. 14	Based on the experience, has air pollution affected you, your family or friend’s health?
Qn. 15	Do you believe that the effects of climate change can be mitigated?
Qn. 16	Is there any link between energy consumption pattern and climate change?
Qn. 17	Do you believe that it is already too late to meet challenges of climate change?
Qn. 18	In your opinion, is biodiversity decreasing with increasing global warming?
Qn. 19	Do you believe that the impact of climate change can be addressed by applying science and technology?
Qn. 20	Do you think that climate change can bring some positive change in our life?
Qn. 21	Would you like to help in some way or the other for this cause?
Qn. 22	Are the private agencies helping the locals to combat climate change issue?
Qn. 23	Does the government have some schemes to combat climate change issue?

Table 2: List of five categories based on the similarity of questions

Category No.	*Question Number*	*Description*
1	Qn. No. 2, 3, 4, 16	Climate change
2	Qn. No. 5, 6, 7, 8	Temperature and precipitation
3	Qn. No. 9, 10, 11, 12, 14, 18	Possible consequences
4	Qn. No. 15, 17, 19	Mitigation efforts
5	Qn. No. 20, 21, 22, 23	Govt/Pvt/Individual actions

The gender and age-based consistency test reveals maximum coherency among the adult males (r^2=0.99) followed by the mature males (r^2=0.98), while the coherency among the adult and mature females is 0.96 followed by young and old females (r^2=0.84). The responses of male and female candidates are quite consistent (r^2=0.95), while the least consistency is observed among young and old individuals (r^2=0.66; Figure 5). Similarly, in the locality-based consistency test, maximum coherency has been observed in the two urban localities (Chungthang-Mangan and Mangan-Gangtok; r^2=0.92). It is also interesting to notice that good coherency exists among the remotest and developed urban areas (Muguthang-Gangtok, r^2=0.86; Muguthang-Mangan, r^2=0.66). However, the least coherency is observed between Muguthang and Chungthang (r^2=0.59). Comparisons based on relative development/remoteness of the localities show the highest coherence among the developed/urban areas viz. Mangan-Gangtok (r^2=0.92), while a low coherence (r^2=0.62) is recorded among Lachen-Lachung and Muguthang-Thangu rural areas (Figure 5). The climate perception data revealed that the majority of the respondents from both rural and urban areas, ages, and genders have heard about climate change or global warming except for a few old people (Qn. 2; Figure 2). The perceptions related to weather (Qn. 3) and climates (Qn. 4) are dominantly consistent and people claim that they have experienced significant changes in them. One of the most important meteorological parameters influencing people is temperature. The perception of the summer temperature variations and the satellite/ instrumental data (Climate Research Unit, CRU-TS 4.04) is consistent. CRU data shows that the average

summer temperature from 1988 to 2018 has increased and people have correctly perceived it (Qn. 5). Similarly, the winter temperature data also shows an increasing trend; on contrary to this, over 50% of the respondents feel that the winter temperature does not show any significant change (Qn. 6). The annual precipitation data (CRU-TS 4.04) does not show any significant variation although an overall slightly decreasing trend for the whole Sikkim is observed. The respondents' perception contradicts this trend as more than half of the interviewees believe that rainfall has been increasing (Qn. 8). A significant decrease in the snowfall has been observed by the respondents living in higher altitudes (Qn. 7). Thus, it is safe to say that the people living in this region have correctly perceived the changing weather/climate and hence their perception is critically important to strategise appropriate adaptation measures (Hein et al., 2019). Almost all agreed to the point that agricultural productivity is declining (Qn. 13; Figure 3). A significant number of the respondents, irrespective

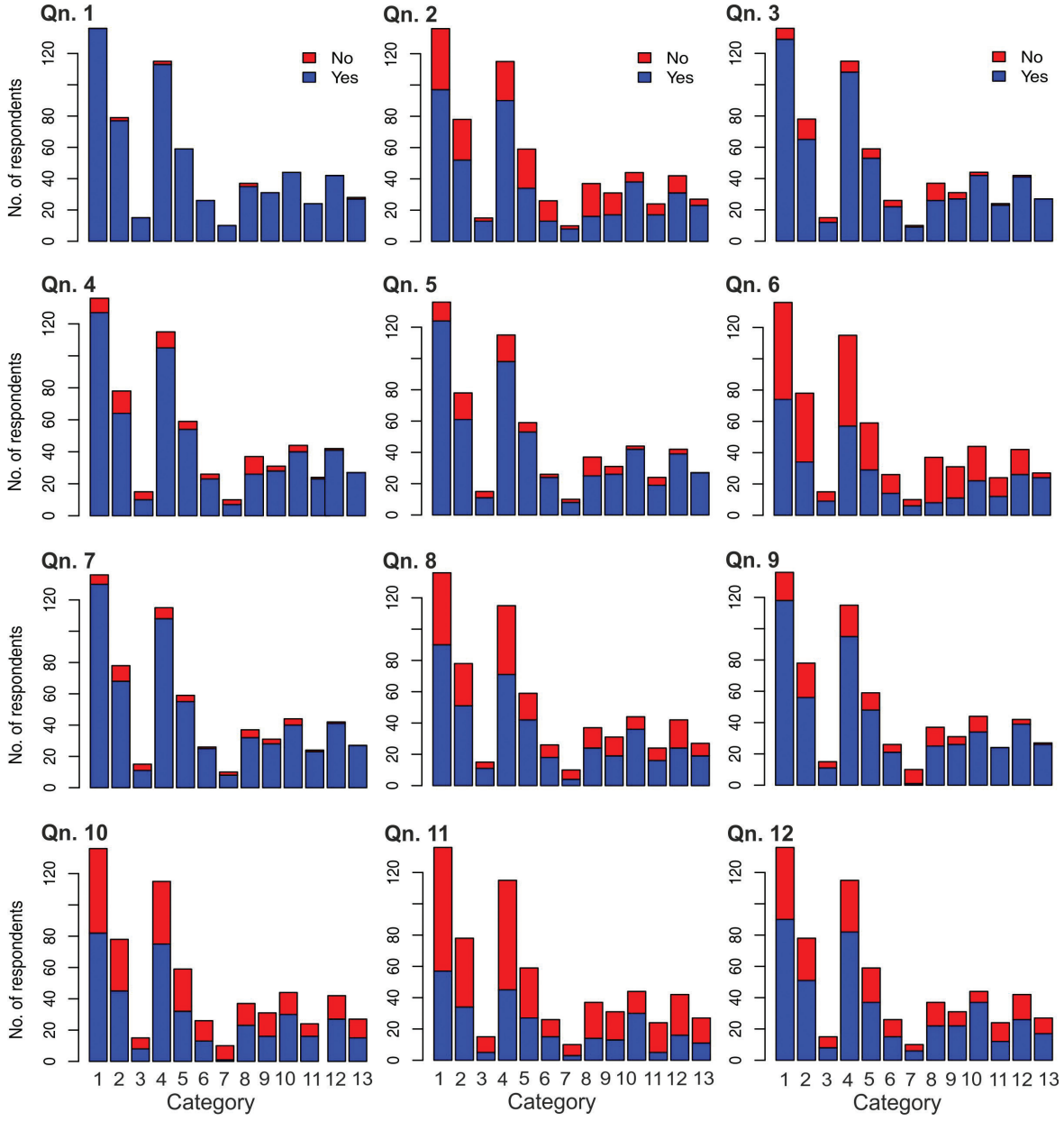

Figure 2: Category (1-sM-Male; 2-sF-Female; 3-aY-Young; 4-aA-Adult; 5-aM-Mature; 6-aO-Old; 7-rMU-Muguthang; 8-rT-Thangu; 9-rU-Lachung; 10-rE-Lachen; 11-rC-Chungthang; 12-rM-Mangan and 13-rG-Gangtok) wise responses of the natives from 7 locations of Qn. 1-12.

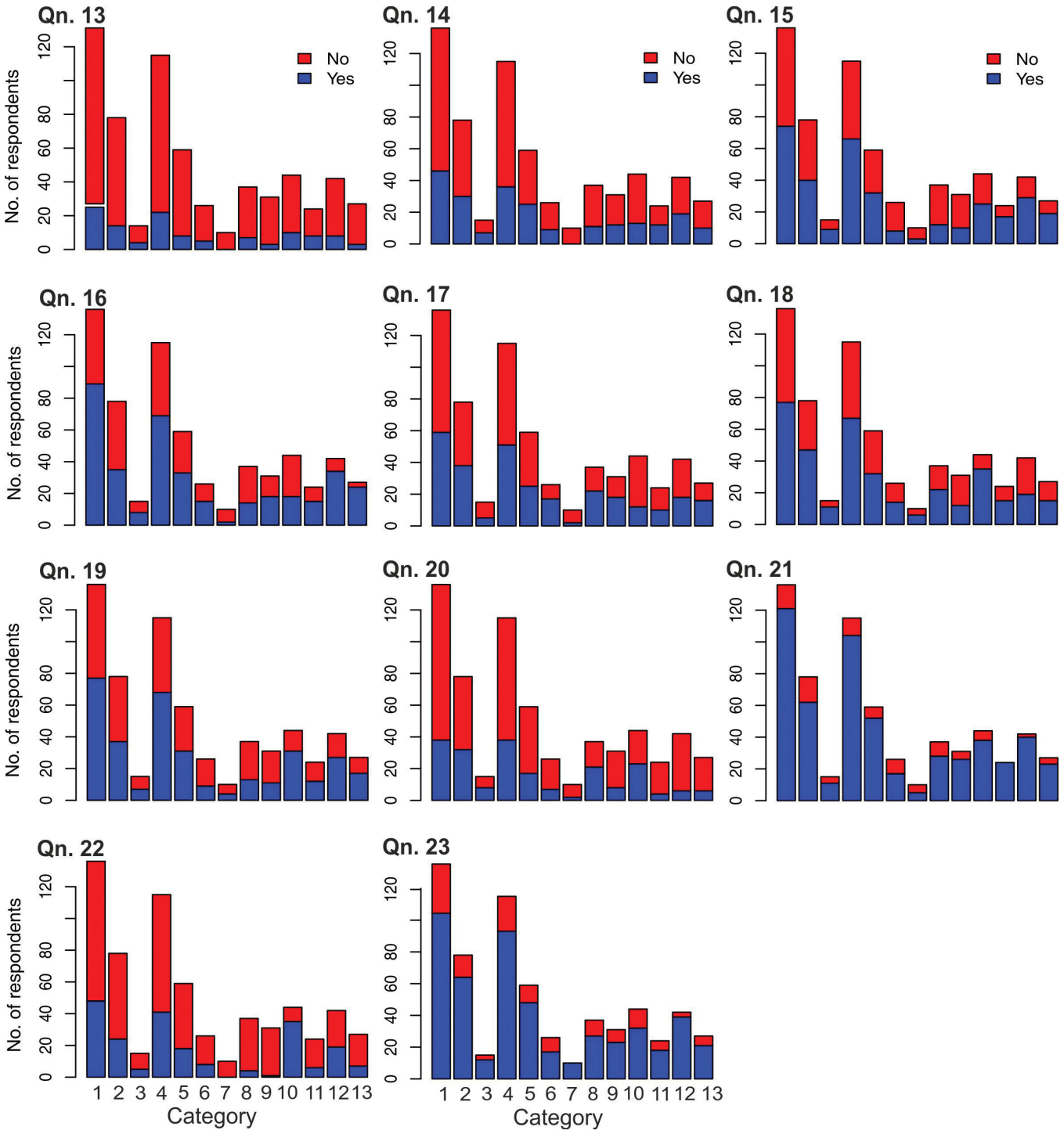

Figure 3: Category (1-sM-Male; 2-sF-Female; 3-aY-Young; 4-aA-Adult; 5-aM-Mature; 6-aO-Old; 7-rMU-Muguthang; 8-rT-Thangu; 9-rU-Lachung; 10-rE-Lachen; 11-rC-Chungthang; 12-rM-Mangan and 13-rG-Gangtok) wise responses of the natives from 7 locations of Qn. 13-23.

of localities, gender, and ages, feel that it is not too late to curb the problem of ongoing climate change and by using science and technology we can achieve it (Qns. 17 [54%], 19 [53%]; Figures 2 and 3). It is also evident from the data that 81% of the respondents from Muguthang, 44% from Thangu, 74% from Lachung, 47% from Lachen, 77% from Gangtok and more than 80% from Chungthang and Mangan have denied any

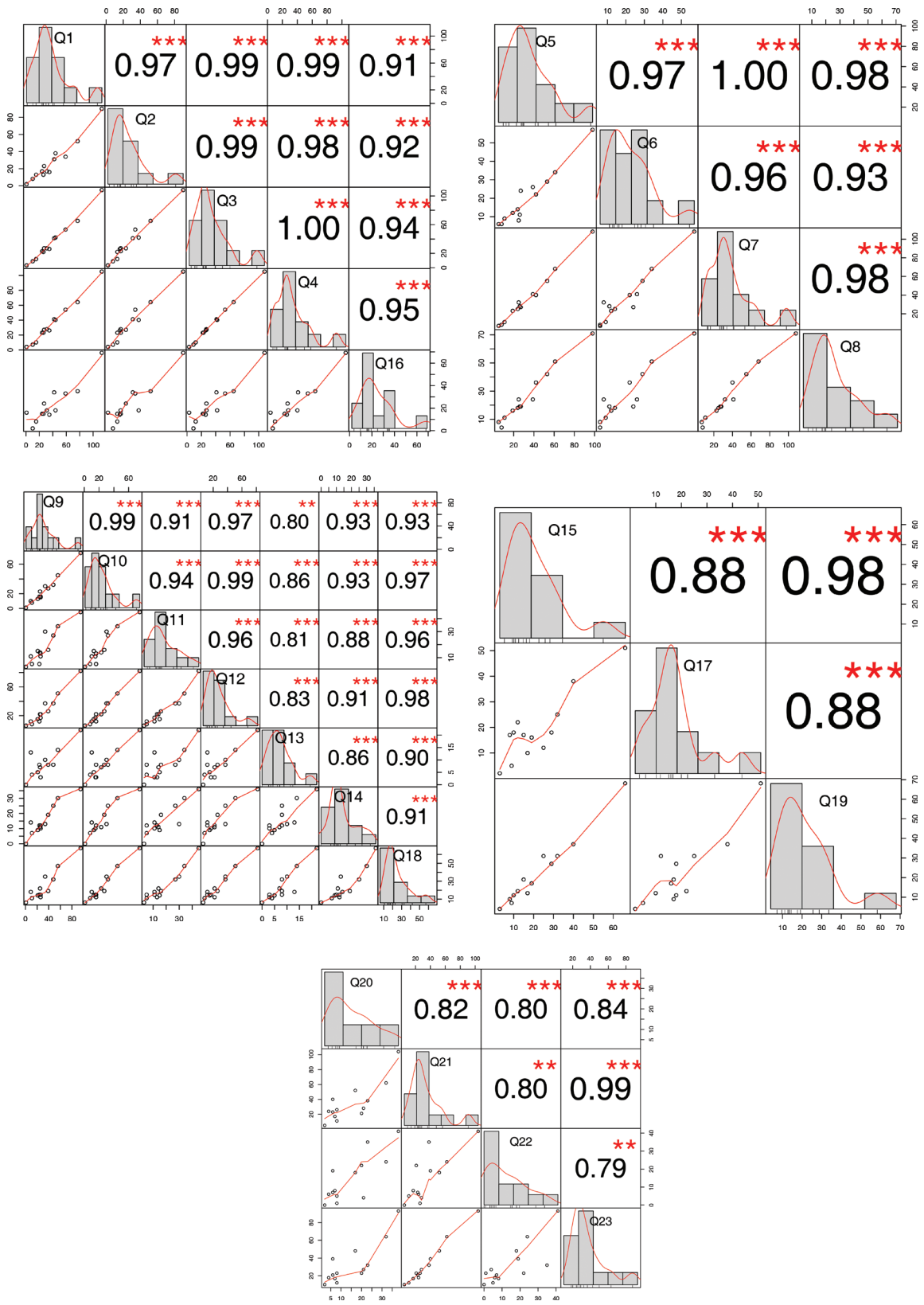

Figure 4: Correlation diagram based on the responses to a certain categorization of questions (Table 1) with the correlation coefficients (in numbers) and p-values (stars superscripted every correlation coefficient). Each star corresponds to a zero in the denominator. For example, one star is one-tenth (1/10) of the P-value and three stars mean the P-value is 1/1000, i.e. 0.001.

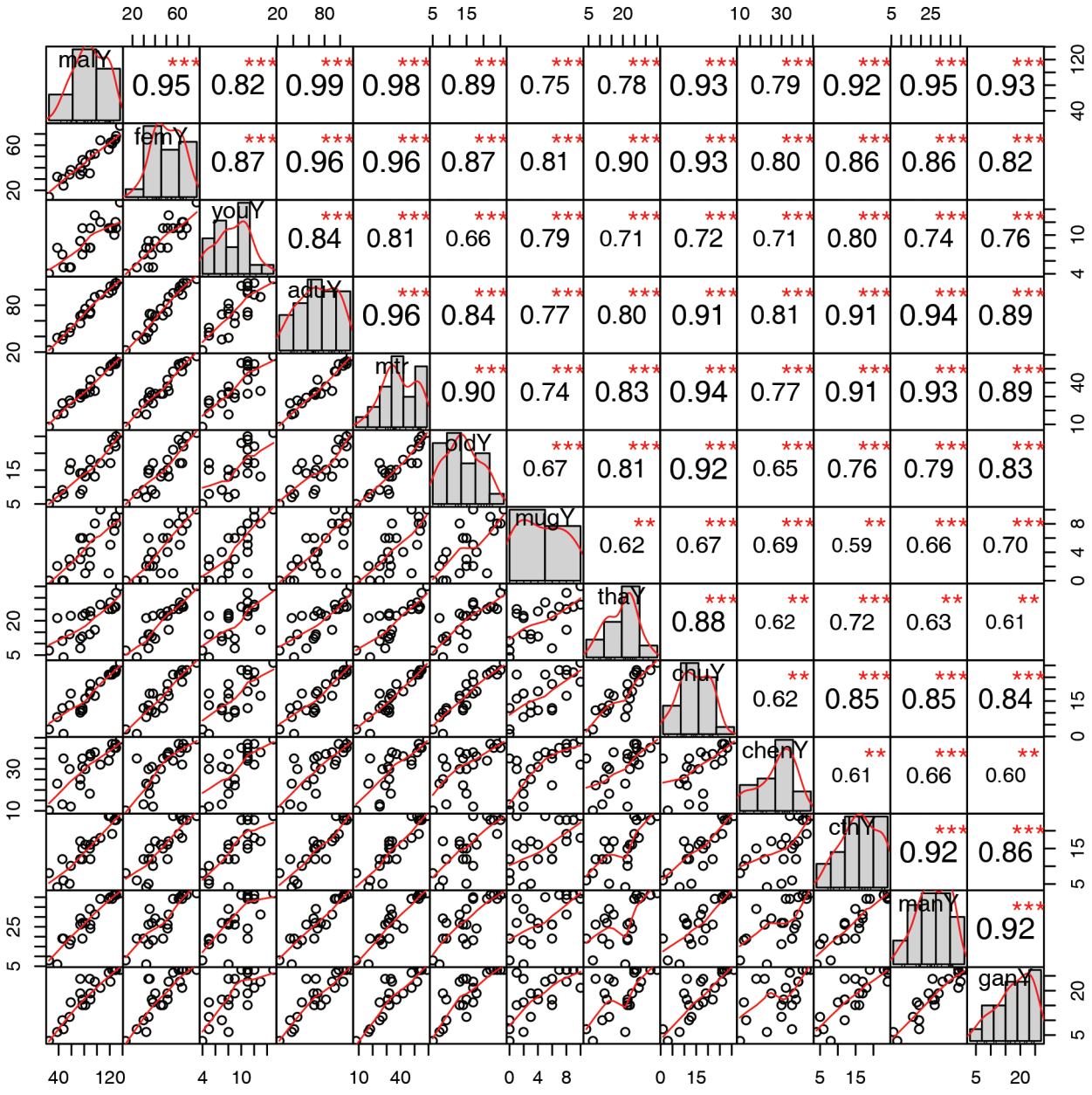

Figure 5: Correlations among the responses (Yes only) from each category that is mentioned along the diagonal. Numbers and stars are the correlation coefficients and P-values, respectively.

positive outcome of climate change in their lives (Qn. 20). However, it was surprising to see a significant number of adults feel that climate change has a positive outcome in their lives. Around 57% of the respondents agree with the fact that biodiversity is declining as a consequence of global warming (Qn. 18). Furthermore, the majority of the respondents (58%) agreed to the point that there is a link between energy consumption (anthropogenic contribution) and climate change (Qn. 16). It is also well noted that the people living in urban areas agree to it (84%). It was overwhelming to observe that 85% of respondents from this region irrespective of age or gender agreed to take initiatives at an individual as well as community level to help curb climate change (Qn. 21). It was also interesting to see that people appreciate and acknowledge government policies for knowledge transfer and remedial measures (Qn. 23; Figure 1). Most of the respondents expressed their satisfaction with the questionnaire-based interview/ survey and showed a willingness to know more about climate change issues and possible remedial practices (Figure 3).

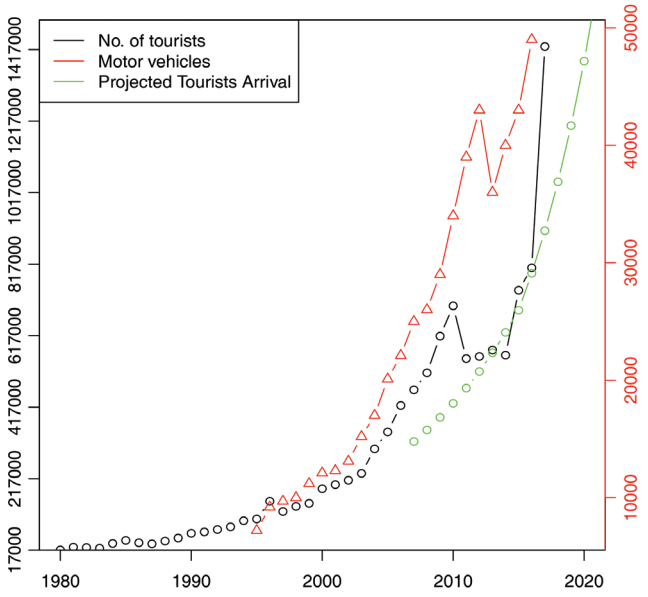

Figure 6: Comparative diagram between annual tourist footfall, number of vehicles, and the projected tourist influx.

Discussion

According to the Intergovernmental Panel on Climate Change (IPCC, 2001a), weather and climate have a profound influence on life on the earth and have become a spotlight of environmentalists, socialists as well as politics. With an unequivocal warming scenario and insufficient mitigation measures to curb climate change, the adaptation of eco-friendly lifestyles and participation at the community level even from the remotest locations may reduce its adverse effects (IPCC, 2001b). People living in high mountain areas of developing countries show marginalized behaviour (physically and economically) and solely depend upon natural resources and any change in environmental conditions hence may impact their food security as well as the economy (Kohler et al., 2014). These regions sheltering the most sensitive ecosystems are experiencing the wrath of extreme weather and catastrophic events and are forebears of conflicting interests between economic development and environmental conservation (Beniston and Haeberli, 2001). Furthermore, with the growing tourism industry, these areas are showing the accelerated progression of urbanisation with rapid degradation of biodiversity and water resources and giving up their traditional grazing and agricultural activities due to ease of life. Hence, the above-discussed facts demand necessary studies aiming at understanding the native perceptions of climate change to implement successful mitigation and adaptation strategies in high mountain regions.

Peoples' Perception of Changing Weather Patterns and Climate

Despite the widespread recognition of the legitimacy and importance of climate change, there is a scarcity of records that could give important insights into the peoples' perceptions of climate change in India and more specifically in the higher Himalaya (Capstick, 2013). The importance of this comes into play for any initiatives aiming for policymaking, sustainable natural resource management, biodiversity conservation, or climate change adaptation and mitigation. Climate change has been roasting the Himalayas, making it warmer by 0.06°C per year (1982 to 2006; Shreshtha et al., 2012). It has been reported by Sharma et al. (2009) that the overall temperature in Eastern Himalayas has increased by 0.01–0.04°C per year (from 1928 to 2007). This increasing trend in temperature is characterised by significant warming in both summer and winter leading to a prominent shift in seasons, changes in precipitation (rain and snow) and affects on the hydrological cycle, thereby having a multitude of impacts on local populations (Sharma et al., 2009; Chaudhary et al., 2011; Chettri, 2011). The perception of diverse mountain populations thus acts as a bridge in connecting the biophysical and social realms and is an important tool to assess changes in the local and regional weather patterns (Fort, 2015). The present study demonstrates that the people of Sikkim are familiar with the phenomenon of 'Climate change', especially those living in relatively urban locations. It is interesting to see that even though a lot of respondents were not familiar with the scientific terms and processes, they shared their essential perspectives and experiences on the changing weather patterns and their direct and indirect impact on their livelihood.

Temperature and Precipitation (Local Perceptions vs. Scientific Data)

The two main climatic parameters that have the most significant and visible impact on any population are temperature and precipitation. Changes in these can be monitored scientifically but their impacts can only be verified by the locals' experience. The temperature and precipitation data for Sikkim (CRU-TS 4.04; 1988-2018) show an increasing trend of summer temperature. The perception results also show that irrespective of the geographic location, the majority of the respondents have experienced gradual warming during the summers.

Our results are in agreement with the earlier study carried out by Sharma and Shreshtha (2016), wherein 89% of respondents have experienced an increase in temperature from the southern part of Sikkim. As far as the winter temperature is concerned, a fifty-fifty opinion among the people who have perceived an increase in winter temperatures to the people to claim no significant changes is observed. However, an overall increasing trend in the winter temperatures is revealed by CRU TS 4.04 data. These results are consistent with the observations from Nepal (Shreshtha et al., 1999; Kattel and Yao, 2013; Mishra, 2017), western Himalaya (Shekhar et al., 2010) and north-western Himalaya (Bhutiyani et al., 2010). As far as the precipitation data is concerned, the people of Sikkim seem to be inconsistent with their experience and response to precipitation change. The meteorological data suggest a slight decrease in precipitation over the past 30 years which conforms with the results of Rahman et al. (2012), Seetharam (2012) and Das et al. (2017).

Perception of Extreme Events

In Sikkim, extreme weather events are usually manifested by heavy precipitation or flash floods and winter snowstorms in the higher altitudes. Extreme rainfall events and flash floods are a major concern of people living below 3000 m asl, where landslides, debris flows, and riverbank erosion adversely affects the local populations (SAPCC, 2011; Mukherjee et al., 2017). With the ongoing changes in the meteorological parameters, people believe (81%; Qn. 9) that the frequency of natural disasters (floods, landslides, snowstorms) will increase and will be more catastrophic (~60%; Qn. 10). During the monsoon months, Sikkim Himalaya experiences numerous landslides, resulting in thousands of fatalities and property damage. Reports of various rainfall-induced landslides from the region over the last three decades show an increasing trend, causing massive damage and loss of property, as well as negatively impacting people's livelihoods (Bhasin et al., 2002; Ghosh et al., 2016; Kaur et al., 2019). (In terms of occurrences of floods and landslides, the Tista basin is one of the most vulnerable river basins in the Himalayas. The 1968 cloudburst caused catastrophic floods in the region, destroying numerous bridges and causing major disruption. Following the 1968 flood, many other major floods occurred in 1973, 1975, 1976, 1993, 1996, and 2000, and the trend has been increasing over the last two decades. (Bhattacharya, 2015; Pal et al., 2016; Kaur et al., 2019). It is to be mentioned here that the Northern Sikkim has steep valleys and the effects of flooding are relatively insignificant to those of landslides. The higher mountainous transhumant herder communities, however, are more vulnerable to glacial lake outbursts floods and snowstorms. Snowstorms in the higher Himalayas are associated with terrain-locked low-pressure systems caused by the midlatitude westerlies (Lang and Barros, 2004). Furthermore, the development and expansion of glacier lakes under regional climate warming make the Himalayan region vulnerable to devastating glacial lake outbursts floods or GLOFs (Carrivick and Tweed, 2016; Shukla et al., 2018; Zhang et al., 2019; Pandey et al., 2020). Hence, regular monitoring of the large glacial lakes and looking out for the possibilities of GLOFs to initiate prior mitigation is needed in the region (Allen et al., 2016; Linsbauer et al., 2016; Pandey et al., 2020). Peoples' perception of climate change and its consequences with adverse effects on their day-to-day lives, are synchronous and need full consideration for strengthening the infrastructure and mitigation measures are required.

Biodiversity Changes

The cascading effects of the climate crisis on the biodiversity of the area have drawn people's attention. Extinction of endemic species due to little or no upward shift, physiological body changes, and changes in the seasonality of breeding or breeding failure are the most prominent effects (Acharya, 2008; Wormworth and Sekercioğlu, 2011). The upward shifting of the snow line in the Himalayan region has led to the uphill shifting of both alpine and mid-level elevation species in Sikkim (Xu et al., 2009; Acharya and Chhettri, 2012). As the climate is changing, the adaptation of the non-migratory species to the higher elevation climate and ecological conditions has led to an increase in the risk of extinction (Pounds et al., 2006; Kannan and James, 2009; Xu et al., 2009). The influx of exotic species might lead to a disproportion in prey-predator relationships thereby disturbing the entire food chain (Pianka, 2000). Even though a lot of wildlife species have adapted to the changing situation, some of them are pushed to near extinctions (Acharya and Chhettri, 2012). The majority of people agree with the fact that biodiversity is decreasing with the increase in global warming.

Impacts on Agricultural Productivity and Food Habits on Locals

Alterations in the climatic parameters have a direct impact on food security. An increase in temperatures, changes in precipitation, and an increase in atmospheric

carbon dioxide can affect crop yields, growth rates, and photosynthesis and transpiration rates (Kimball and Idso, 1983). In the harsh environment of high mountain regions, where agricultural productivity is already low, climate change will further minimise the crop yields (Mahato, 2014; Ali et al., 2017; Palomo, 2017). In the present survey, the majority of the respondents agree with the fact that the agricultural productivity in Sikkim is on a declining trend. These observations are in agreement with the previous study suggesting reduced crop yields as compared to 10 years before (Sharma and Shrestha, 2016). Apart from decreasing agricultural productivity, some people are also concerned about decreasing agricultural practices (Figure 1). This has been attributed to changing lifestyles and the availability of job opportunities through growing tourism. In Sikkim, more than 50% of the people feel that their dietary habits have changed during the last 15-20 years and may be attributed to the easy accessibility of goods and are in conformity with other Hindu Kush Himalayan regions (Rasul et al., 2017). The changing food habits and decrease in agricultural practices have resulted in the deterioration of traditional mountain food systems with a decline in agro biodiversity (Rasul et al., 2017).

Tourism Industry

Uncontrolled tourism in the Himalayas has resulted in unplanned constructions and together they have adverse effects on the local ecosystem. Attempts have been made by the government agencies to plan controlled tourism at some places like Rohtang, Himachal Pradesh, wherein only a fixed number of vehicles are allowed in these places every day. However, such policies have not been formulated for other similar regions because of the dependencies of locals on the tourism industry.

After its union with the Republic of India in 1975 as the 22nd state, Sikkim, especially the Northern district has seen consistent growth in tourist footfall (Figure 6). The booming tourism industry witnessed sluggishness during 2011-2013. This may be due to the earthquakes in the richter scale of 6.9 and 4.1 magnitude that struck the region. Heavy rainfall followed the earthquake, which prompted landslides, further complicating rescue and relief plans, making the situation much worse. After 2013, the tourism industry again retained its positive course and saw exponential growth in tourist influx. With this phenomenal increase in the tourism industry, a similar trend has been observed in motor vehicle data (Bhagwat, 2013; Figure 6). The overall data clearly shows that with an increase in tourism, the vehicular pollution in these regions is also increasing. It is further disturbing to see that the tourist projections made (Anonymous, 2007) for the year 2017 (Figure 6) have been underestimated and the current trend advocates for a more exponential increase. As mentioned earlier, increasing tourism, unplanned constructions, and ecosystem degradation will also increase if necessary steps are not taken.

Community and Government Initiatives

Mitigating the effects of climate change requires an eclectic approach and personal sacrifice is not enough. In developing countries like India, the government plays a greater role in setting up the framework for initiating change (Young and Dhanda, 2013). The government of Sikkim has proven to be one of the finest environmental leaders across the country by formulating green policies to combat and adapt to the ongoing climate change scenario. One of the first steps taken by the state was banning disposable plastic bags in 1998. In the same year, the state imposed a ban on grazing in reserved forest areas, plantation areas, and water source areas, and the affected herders were provided with financial aid. In its 'Total Sanitation Campaign, the government intended to eliminate open defecation to minimise contamination of the environment and spread of diseases (State of Environment Report, 2007). In 2016, the state government took two drastic decisions of banning the use of packaged drinking water in government offices and the use of Styrofoam and thermocol disposables (cutlery) in the entire state. Along with this, the state is one of its kind to undertake a project on "Climate Change Related Vulnerability Assessment of the Rural Communities at the Gram Panchayat Level" sponsored by National Adaptation Fund on Climate Change (NAFCC; MoEFCC, 2018). Other initiatives concerning climate change include protection and management of forests, reforestation, water bodies, and restoration of biodiversity and environment amelioration. Monitoring of glaciers, glacier lakes and snow cover, and effective implementation of various climate change adaptation policies and mitigation programmes have also been the prime focus of the Government over the last several years (Tambe and Arrawatia, 2012; Singh, 2018). As a part of its Tourism Master Plan, Sikkim encourages eco-tourism and nature tourism with strict measures to maintain the ecological balance in conjunction with generating revenue, however, limitation on tourist footfall has not been implicated. The people of Sikkim are sensitive to the emerging threats of climate change and are aware of the conservation of natural resources. For instance, the Lachung Dzomsa

(a traditional administrative institution of the villages of Lachen and Lachung in North Sikkim) banned the use of packed drinking water and encourage the use of reusable materials in both districts. The local community and NGOs confiscate any plastic items carried by tourists and also impose a fine if caught a second time (Shreshtha and Kaushik, 2016; Wangchuk, 2019). By imposing penalties, organising mass awareness programmes, and formulating eco-friendly state-level policies, Sikkim is on its way to become free of the scourge of plastic pollution. Despite that, with an increasing number of tourists and the current climate situation, Sikkim has a long way to go in winning the battle against climate change. Keeping this in mind, we suggest some possible recommendations that would help the state in completely eradicating or adapting to the effects of climate change.

Possible Recommendations

1. Focussed research on climate change in high mountain ecosystems and its integration with decision and policymaking.
2. Increasing climate change awareness among the stakeholders through public outreach programmes and using their feedbacks in adaptation and mitigation.
3. Controlled tourism and vehicular movement along with promotion and encouragement for planned infrastructural development with eco-friendly practices.
4. Protecting biodiversity by promoting conservation measures like the protection of endangered species.
5. Promoting agricultural activities and reviving animal husbandry with insurance schemes and subsidies in the high mountain regions.
6. Early warning systems for glacial lake outbursts floods and bunds for riverbank erosions in critical areas for example settlement sites and roads.

Conclusion

Our study has explored how changes in climatic parameters have been perceived by the local communities of higher Sikkim Himalaya. Although the natives are more or less familiar with the term ‘climate change’, the effects/consequences of climate change have been largely recognised. The study reveals that the perception of increasing temperature is in agreement with the meteorological data, while the same is not true for precipitation. Overall people’s perception of climate change and its impacts show negative consequences on the local environment and traditional lifestyles. On one hand, people believe that the boom in the tourism industry during the last few decades has benefited them economically as well as logistically. While on the other hand, the respondents feel that increased tourism may further degrade (pollute) the environment. It is observed that the number of tourists is significantly higher than the projected estimates and the progressive trend implies further acceleration. Hence, controlled tourism may be one of the main policies to be followed. Waste disposal sites are altogether missing in these high mountain regions; thus, proper waste management plants should be installed. To fulfil these adaptation and mitigation measures, cooperation among locals and policymakers must be developed. More detailed perception studies, especially from the high-risk regions, must be carried out to form a uniformity of views among natives and stakeholders for better formulation and implementation of climate change policies and actions.

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Conflict of Interest

The authors have no conflict of interest.

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Table S1: Details of the respondents used to understand the perception of climate change

S. No.	*Name*	*Sex*	*Age Group*	*Age*	*Locality*	*Date*
1	Lhamo	F	M	52	Muguthang	10-10-2019
2	Norpu Tsering	M	A	37	Muguthang	10-10-2019
3	Topgyal	M	A	37	Muguthang	10-10-2019
4	Tenzing Lhendup	M	A	23	Muguthang	10-10-2019
5	Phurba	F	A	26	Muguthang	10-10-2019
6	Tashi Bhutia	F	O	66	Muguthang	10-10-2019
7	Tsering	F	A	26	Muguthang	10-10-2019
8	Sonam Chhunchhun	M	M	52	Muguthang	10-10-2019
9	Passang Chokey	F	M	43	Muguthang	10-10-2019
10	Tamning Lachenpa	M	A	30	Muguthang	10-10-2019
11	Tenzing Roma	M	A	37	Thangu	10-12-2019
12	Neysang Lachenpa	M	M	53	Thangu	10-12-2019
13	Napso Lachenpa	M	A	38	Thangu	10-12-2019
14	Sonam Thargay	M	M	58	Thangu	10-12-2019
15	Jhonki Lachenpa	F	M	60	Thangu	10-12-2019
16	Kandu Lachenpa	F	O	67	Thangu	10-12-2019
17	Naong Lachenpa	M	O	73	Thangu	10-12-2019
18	Tsering Keeden	F	A	27	Thangu	10-12-2019
19	Diki Lachenpa	F	M	48	Thangu	10-12-2019
20	Kichung Lachenpa	F	A	33	Thangu	10-12-2019
21	Lhamo	F	O	73	Thangu	10-12-2019
22	Lhamu Lachenpa	F	M	54	Thangu	10-12-2019
23	Pachung Lachenpa	M	M	50	Thangu	10-12-2019
24	Yangchin Lachenpa	F	A	26	Thangu	10-12-2019
25	Phurba T. Lachungpa	F	M	43	Thangu	10-12-2019
26	Maya Lachenpa	F	Y	17	Thangu	10-12-2019
27	Sonam Choden	F	A	27	Thangu	10-12-2019
28	Karma Doma	F	M	43	Thangu	13/10/2019
29	Tshering	F	Y	17	Thangu	13/10/2019
30	Doma Lachenpa	F	Y	20	Thangu	13/10/2019
31	Saden Lachenpa	F	A	28	Thangu	13/10/2019
32	Bol Bahadur	M	M	52	Thangu	13/10/2019
33	Dila Thapa	M	A	40	Thangu	13/10/2019
34	Passang Sherpa	M	A	40	Thangu	13/10/2019
35	Tushing Lachenpa	F	M	58	Thangu	13/10/2019
36	Keden Lachenpa	F	A	30	Thangu	13/10/2019
37	Prema Bhutia	F	A	26	Thangu	13/10/2019
38	Bannkey Lachenpa	F	A	26	Thangu	13/10/2019
39	Chemiladen Lachenpa	F	A	30	Thangu	13/10/2019
40	Dhonay Limboo	M	A	38	Thangu	13/10/2019
41	Paghu Lachenpa	M	O	75	Thangu	13/10/2019
42	Andol Lachenpa	F	O	73	Thangu	13/10/2019

43	Minma Lachenpa	F	M	60	Thangu	13/10/2019
44	Choten Lachenpa	M	A	34	Thangu	13/10/2019
45	Chong Norbu	M	A	27	Thangu	13/10/2019
46	Doma Lachenpa	F	A	32	Thangu	13/10/2019
47	Jeet Kumar	M	M	50	Thangu	13/10/2019
48	Tendup Bhutia	M	O	70	Lachung	15/10/2019
49	Wongchuk Lachungpa	M	A	30	Lachung	15/10/2019
50	Passang Sherpa	M	M	60	Lachung	15/10/2019
51	Nimdiki Sherpa	F	M	50	Lachung	15/10/2019
52	Samten Bhutia	M	A	28	Lachung	15/10/2019
53	Dawa Bhutia	M	O	70	Lachung	15/10/2019
54	Gyatso Lachungpa	F	A	27	Lachung	15/10/2019
55	Ongmu Lachungpa	M	A	23	Lachung	15/10/2019
56	Chewng Thinlay Lachunpa	M	A	36	Lachung	15/10/2019
57	Sachin Rai	M	M	43	Lachung	15/10/2019
58	Doma Bhutia	F	M	53	Lachung	15/10/2019
59	Amu Bhutia	F	A	37	Lachung	15/10/2019
60	Nima Bhutia	F	A	37	Lachung	15/10/2019
61	Kezang Lachungpa	M	A	38	Lachung	16/10/2019
62	Prema Choden Lachungpa	F	M	44	Lachung	16/10/2019
63	Chering Lachungpa	F	A	24	Lachung	16/10/2019
64	Khedup Lachungpa	M	A	37	Lachung	16/10/2019
65	Dorjee Tanzin	M	O	80	Lachung	16/10/2019
66	Kesary Lachungpa	F	A	32	Lachung	16/10/2019
67	N. Bhutia	M	M	52	Lachung	16/10/2019
68	Kessang Lachungpa	M	A	33	Lachung	16/10/2019
69	Wongchuk Lachungpa	M	A	32	Lachung	16/10/2019
70	Zagmu Bhutia	M	A	38	Lachung	16/10/2019
71	Sonam Lachungpa	M	A	35	Lachung	16/10/2019
72	Karma Lachungpa	F	A	32	Lachung	16/10/2019
73	Tibik Lachungpa	M	O	67	Lachung	16/10/2019
74	Chomu Lachungpa	M	A	32	Lachung	16/10/2019
75	Dawa Lachungpa	M	A	25	Lachung	16/10/2019
76	Dhonshe Bhutia	M	M	45	Lachung	16/10/2019
77	Shanti Sherpa	F	M	41	Lachung	16/10/2019
78	Norzom Lachungpa	M	A	35	Lachung	16/10/2019
79	Zigdol Lachenpa	M	A	33	Lachen	10-05-2019
80	Tenzing Dorjee	M	A	32	Lachen	10-05-2019
81	Tshering Lachenpa	M	A	27	Lachen	10-05-2019
82	Gyenchen Lhamo Lachenpa	F	M	50	Lachen	10-05-2019
83	Tshering Dorjee Lachenpa	M	A	29	Lachen	10-05-2019
84	Rinzing Chewang Kazi	M	M	52	Lachen	10-05-2019
85	Thupden Lachenpa	M	A	23	Lachen	10-05-2019

(*Contd*.)

Table S1: (*Contd.*)

S. No.	*Name*	*Sex*	*Age Group*	*Age*	*Locality*	*Date*
86	Bhaichung Lachenpa	M	A	33	Lachen	10-05-2019
87	Tshering Namgyal	M	A	25	Lachen	10-05-2019
88	Kessang Lachenpa	M	A	30	Lachen	10-05-2019
89	Sonam Lachenpa	M	Y	20	Lachen	10-05-2019
90	Chong Kasang	M	A	31	Lachen	10-05-2019
91	Uden Bhutia	M	A	21	Lachen	10-05-2019
92	Sonam Wang	M	M	53	Lachen	10-05-2019
93	Chungden Lachenpa	F	A	37	Lachen	10-05-2019
94	Nawang Pintso Lachenpa	M	A	26	Lachen	10-05-2019
95	Botkay Lachenpa	F	O	68	Lachen	10-06-2019
96	Kaszang Lachenpa	F	A	38	Lachen	10-06-2019
97	Lapzay Lachenpa	F	M	41	Lachen	10-06-2019
98	Dazang Lachenpa	M	M	50	Lachen	10-06-2019
99	Sonam Wangchur	M	Y	17	Lachen	10-06-2019
100	Samten Choden	F	A	40	Lachen	10-06-2019
101	Tashin Lachenpa	F	M	47	Lachen	10-06-2019
102	Palmu Lachenpa	F	A	27	Lachen	10-06-2019
103	Rinzing Ongmu Lachenpa	F	Y	17	Lachen	10-06-2019
104	Tenzing Dolker	F	Y	19	Lachen	10-06-2019
105	Tsheten Zangmu	F	Y	17	Lachen	10-06-2019
106	Dorjee Wangdi	F	A	22	Lachen	10-06-2019
107	Tamchok Lachenpa	M	O	88	Lachen	10-06-2019
108	Keeden Lachenpa	F	A	24	Lachen	10-06-2019
109	Zekden Ongmu	F	Y	15	Lachen	10-06-2019
110	Sonam Lachenpa	M	Y	16	Lachen	10-06-2019
111	Dorjee Lachenpa	M	M	42	Lachen	10-06-2019
112	Chola Lachenpa	M	O	68	Lachen	10-06-2019
113	Ishyang	F	Y	18	Lachen	10-06-2019
114	Nazen Lachenpa	M	A	32	Lachen	10-06-2019
115	Anzing Lachenpa	F	O	66	Lachen	10-06-2019
116	Phensung Dorjee	M	A	40	Lachen	10-07-2019
117	Gopal Lama	M	O	68	Lachen	10-07-2019
118	Dikidoma Lachenpa	F	A	28	Lachen	10-07-2019
119	Khatuk Lachenpa	M	M	43	Lachen	10-07-2019
120	Kunthub	M	A	34	Lachen	10-07-2019
121	Sangay Dorjee	M	A	32	Lachen	10-07-2019
122	Hissey Lachenpa	M	A	25	Lachen	10-07-2019
123	Bhaichung Sherpa	M	Y	18	Chungthang	14/10/2019
124	Chumee Sherpa	M	A	35	Chungthang	14/10/2019
125	Tshering Sherpa	M	A	26	Chungthang	14/10/2019
126	Rinzin Bhutia	M	A	37	Chungthang	14/10/2019
127	Tashi Bhutia	F	A	28	Chungthang	14/10/2019

128	Selena Subba	F	A	34	Chungthang	14/10/2019
129	B. D. Lama	M	M	42	Chungthang	14/10/2019
130	Dr. Sonam Diki Lepcha	F	A	32	Chungthang	14/10/2019
131	Mingma Bhutia	F	A	25	Chungthang	14/10/2019
132	Migma Lepcha	F	A	21	Chungthang	14/10/2019
133	Andrew Tamang	M	A	24	Chungthang	14/10/2019
134	Sotomi Tamang	M	A	26	Chungthang	14/10/2019
135	Tsewang Lepcha	M	A	34	Chungthang	14/10/2019
136	Sonam Jhonka	F	M	45	Chungthang	14/10/2019
137	Paden Lepcha	M	O	65	Chungthang	14/10/2019
138	Pedon Lepcha	F	M	60	Chungthang	14/10/2019
139	Sita Rai	F	A	35	Chungthang	14/10/2019
140	Tshering Ongmu	F	A	40	Chungthang	14/10/2019
141	Tseten Tashi lachungpa	M	M	44	Chungthang	14/10/2019
142	Yengi Lachungpa	F	O	75	Chungthang	14/10/2019
143	Karma Choden	F	A	40	Chungthang	14/10/2019
144	Pintso Wangchuk	M	A	36	Chungthang	14/10/2019
145	Passang Sherpa	F	A	25	Chungthang	14/10/2019
146	Pandela Bhutia	M	A	25	Chungthang	14/10/2019
147	Jagat Joshi	M	M	45	Mangan	14/10/2019
148	Padam Subba	M	M	54	Mangan	14/10/2019
149	Gelek Thendup	M	M	49	Mangan	14/10/2019
150	Lobsang Bhutia	M	M	44	Mangan	14/10/2019
151	Uden Bhutia	M	O	73	Mangan	14/10/2019
152	Saraswati Chhetri	F	M	44	Mangan	14/10/2019
153	Samten Bhutia	M	O	75	Mangan	14/10/2019
154	Reena pradhan	F	A	40	Mangan	14/10/2019
155	Bhaichung Lepcha	M	Y	16	Mangan	14/10/2019
156	Sangit Pradhan	M	A	35	Mangan	14/10/2019
157	Inderlal Sharma	M	M	50	Mangan	14/10/2019
158	C. K. Pradhan	M	O	63	Mangan	14/10/2019
159	Suresh Kumar	M	M	45	Mangan	14/10/2019
160	Naku Tshering	M	A	38	Mangan	14/10/2019
161	Shyam rai	M	M	52	Mangan	14/10/2019
162	Harish Joshi	M	M	52	Mangan	14/10/2019
163	Tek Bahadur	M	M	41	Mangan	14/10/2019
164	P. B. Basnet	M	O	84	Mangan	16/10/2019
165	Dukhchung	M	A	40	Mangan	16/10/2019
166	Man Kumar Garg	M	M	55	Mangan	16/10/2019
167	Manish Kumar Malakae	M	A	26	Mangan	16/10/2019
168	Binu Chetri	F	Y	20	Mangan	16/10/2019
169	Manoj Kumar	M	A	33	Mangan	16/10/2019
170	Tenzing Bhutia	M	A	39	Mangan	16/10/2019

(*Contd*.)

Table S1: (Contd.)

S.No.	*Name*	*Sex*	*Age Group*	*Age*	*Locality*	*Date*
171	D. B. Chetri	M	A	35	Mangan	16/10/2019
172	Shiv Kumar Prasad	M	M	55	Mangan	16/10/2019
173	Anita Chettri	F	A	23	Mangan	16/10/2019
174	Joy	M	A	37	Mangan	16/10/2019
175	Om Prakash	M	M	50	Mangan	16/10/2019
176	Ravi Kant Bihari	M	A	32	Mangan	16/10/2019
177	Chandan K. Gupta	M	A	26	Mangan	16/10/2019
178	Amit kumar Gupta	M	A	25	Mangan	16/10/2019
179	Rakar Chelin	M	A	27	Mangan	16/10/2019
180	K. Yangchen Bhutia	M	A	23	Mangan	16/10/2019
181	Kalden Chettri	M	A	36	Mangan	16/10/2019
182	Rinzing Wangdi	M	A	32	Mangan	16/10/2019
183	Tshering Doma Bhutia	F	A	29	Mangan	16/10/2019
184	Asmu Munsoori	M	M	43	Mangan	16/10/2019
185	Meera Devi	F	A	38	Mangan	16/10/2019
186	Maan Bahud…	M	M	45	Mangan	16/10/2019
187	Phurmil	M	A	26	Mangan	16/10/2019
188	Keeden Lepcha	F	A	28	Mangan	16/10/2019
189	Tshering	M	A	40	Gangtok	10-03-2019
190	P. T. Sherpa	M	M	45	Gangtok	10-03-2019
191	Anu Sharma	F	A	24	Gangtok	10-03-2019
192	Binoy Mukhia	M	A	40	Gangtok	10-03-2019
193	Phurba Lepcha	F	A	23	Gangtok	10-03-2019
194	Sunil Choudhary	M	A	32	Gangtok	10-03-2019
195	M. K. Sherpa	M	O	70	Gangtok	10-03-2019
196	Anil Saha	M	M	60	Gangtok	10-03-2019
197	Sangeeta Pradhan	F	M	50	Gangtok	10-03-2019
198	Apeshya Rai	F	Y	18	Gangtok	10-03-2019
199	Geeta Rai	F	M	45	Gangtok	10-03-2019
200	Sangeye Sherpa	M	M	43	Gangtok	10-03-2019
201	Dr. S.T. Bhutia	M	O	62	Gangtok	10-04-2019
202	M. K. Agarwal	M	O	64	Gangtok	10-04-2019
203	Anuj Agarwal	M	A	35	Gangtok	10-04-2019
204	Ramesh Mittal	M	M	48	Gangtok	10-04-2019
205	Abit Kumar Singh	M	A	37	Gangtok	10-04-2019
206	Yash Raj	M	M	49	Gangtok	10-04-2019
207	Vicky agarwal	M	A	36	Gangtok	10-04-2019
208	Biswa Rai	M	A	27	Gangtok	10-04-2019
209	D. D. Lakhotia	M	O	67	Gangtok	10-04-2019
210	Uden Subba	M	M	47	Gangtok	10-04-2019

211	Chirag Kumar Goyal	M	A	35	Gangtok	10-04-2019
212	Suresh Kumar	M	M	58	Gangtok	10-04-2019
213	Mohd. Wazer	M	O	68	Gangtok	10-04-2019
214	Afzal Rehman	M	A	22	Gangtok	10-04-2019
215	Satish Agarwal	M	A	32	Gangtok	10-04-2019

Table S2: Responses of 215 people from the interview (R= Number of respondents, Q= Number of questions, 1=Yes, 0=No)

R/Q	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*
1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1
2	1	1	1	0	1	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	1
3	1	1	1	1	1	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1
4	1	1	1	1	1	1	1	0	0	0	1	1	0	0	0	1	1	1	1	0	1	0	1
5	1	0	1	0	1	1	1	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	1
6	1	1	1	1	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1
7	1	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	1
8	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1
9	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
10	1	0	1	1	1	0	1	1	1	1	0	0	0	0	1	1	0	0	1	0	1	0	1
11	1	0	1	1	1	0	1	0	1	1	0	1	1	1	0	1	1	1	0	1	1	0	1
12	1	0	1	1	1	0	1	0	1	1	0	1	0	1	0	1	1	0	1	1	1	0	1
13	1	1	1	1	1	0	1	1	1	1	0	1	0	1	1	1	0	1	1	0	1	0	1
14	1	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0
15	1	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1
16	1	0	0	0	1	0	1	1	1	1	1	0	0	0	0	0	1	1	0	1	0	0	0
17	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
18	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	1	1	1	0	1	0	1
19	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1
20	1	0	1	1	0	0	1	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0
21	1	0	1	1	1	0	1	0	1	1	0	1	0	1	1	1	0	1	0	1	1	0	1
22	1	0	1	1	1	0	0	1	1	1	0	1	0	0	1	1	0	1	1	1	1	0	1
23	1	0	1	1	0	0	1	1	1	1	1	0	0	0	1	0	0	1	1	1	1	0	1
24	1	1	1	1	0	0	1	0	1	1	1	1	0	0	1	0	0	1	1	0	1	0	1
25	1	1	0	0	1	0	1	1	1	1	0	0	1	0	1	0	0	1	1	0	1	0	1
26	1	0	0	0	1	0	1	1	1	1	0	1	0	0	0	0	1	0	0	1	0	0	1
27	1	1	1	1	1	0	1	1	1	1	0	1	1	0	0	1	1	1	1	1	1	0	1
28	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	0	1	1	0	1
29	1	1	1	1	1	0	0	1	1	1	0	1	0	0	1	1	0	1	1	1	1	0	1
30	1	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	0	0	1	0	0
31	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	0	1	1	0	1	1	0	1
32	1	0	0	0	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	0	1
33	1	1	1	1	0	0	1	1	1	0	0	1	0	1	0	1	0	0	0	1	1	0	1
34	1	0	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	0	1	1	0	1
35	1	1	1	1	1	0	1	0	0	0	1	0	1	1	0	1	1	0	0	0	1	0	1
36	1	1	1	1	1	1	1	0	0	0	1	0	0	1	0	0	1	1	0	1	1	0	0
37	1	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1

Table S2:(*Contd.*)

R/Q	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*
38	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	1
39	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0
40	1	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1	0	1	0	0	1	1	1
41	1	0	0	0	1	0	1	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	1
42	1	1	1	1	1	0	1	1	1	0	1	0	0	1	0	1	1	0	0	0	0	0	1
43	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
44	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	1	0	1	1	1	0
45	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1	1	1	1	0	1	1	1
46	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	0	1	1	0	0
47	1	1	1	1	1	0	1	1	1	0	1	1	0	0	0	0	0	0	1	1	1	1	1
48	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	1	1	0	1	0	1	0	1
49	1	1	1	1	1	0	1	1	1	1	0	0	0	0	1	1	0	0	0	0	1	0	1
50	1	1	1	1	1	0	1	1	1	1	1	1	0	0	0	1	0	1	0	1	1	0	1
51	1	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	0	1	1	0	1	1	1
52	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	0	1	1	0	1	0	1
53	1	0	1	1	1	1	1	0	1	0	1	1	0	0	0	0	1	1	0	0	0	0	1
54	1	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1
55	1	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1
56	1	1	1	1	1	0	1	1	1	1	1	0	1	1	0	0	0	0	0	0	1	0	1
57	1	1	1	1	1	1	1	0	1	0	0	1	0	0	1	0	1	1	1	0	1	0	1
58	1	1	1	1	1	1	1	1	1	0	1	1	0	0	1	0	0	0	0	0	1	0	1
59	1	1	1	1	0	0	1	1	1	0	0	0	0	0	0	1	1	0	0	0	1	0	1
60	1	1	1	1	1	0	1	0	1	0	1	1	0	1	0	1	1	1	0	1	1	0	1
61	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	1	0	1
62	1	0	1	1	1	0	1	1	1	1	0	1	0	1	0	1	0	0	0	0	1	0	0
63	1	1	1	1	1	1	1	0	1	1	1	1	0	0	1	1	1	0	1	1	1	0	1
64	1	1	1	1	1	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	1	0	0
65	1	0	1	1	1	0	1	0	1	1	1	1	0	1	0	1	0	1	0	0	1	0	0
66	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	0	1	0	1
67	1	0	0	1	1	1	1	0	1	0	1	1	1	0	0	1	1	0	1	1	1	0	0
68	1	0	1	1	1	1	0	0	1	1	0	1	0	1	0	1	0	1	0	0	0	0	1
69	1	1	0	0	0	0	1	1	1	1	0	1	0	0	0	0	1	0	0	0	1	0	1
70	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	1	1	1	0	0	1	0	0
71	1	0	1	1	1	0	1	1	1	0	0	1	0	0	0	0	1	0	0	1	1	0	1
72	1	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1
73	1	0	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	0	0	0	0	1
74	1	0	1	1	1	0	1	0	1	0	0	1	0	0	1	1	0	0	1	0	1	0	0
75	1	0	1	1	1	1	0	1	1	1	0	1	1	0	0	0	1	1	0	1	1	0	1
76	1	0	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0
77	1	0	1	1	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1
78	1	1	1	1	1	0	1	1	1	1	0	1	0	1	0	1	0	1	1	0	1	0	0
79	1	1	1	1	1	0	1	0	1	1	1	1	0	0	0	1	1	0	0	0	1	1	1
80	1	1	1	1	1	0	1	0	1	1	1	1	0	0	1	1	0	1	1	0	1	1	1

81	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	1	0	0	1	1	0
82	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1	0	1	1
83	1	1	1	1	1	0	1	0	1	1	0	0	0	0	1	0	0	1	1	0	1	1	0
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123	1	1	1	1	0	1	1	1	1	0	0	0	1	0	1	0	0	1	0	0	1	0	0
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(*Contd*.)

Table S2:(*Contd*.)

R/Q	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*
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127	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1
128	1	1	1	1	1	0	1	1	1	1	0	1	0	0	1	1	1	1	1	1	1	0	1
129	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1	1	0	1	0	1	1	1
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(*Contd*.)

Table S2:(*Contd*.)

R/Q	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*
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