Perceptions of a Changing Climate, Exposure, and Vulnerability in Himachal Pradesh

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Abstract

We aimed to characterize perceptions of exposure and vulnerability to climate change among lifelong residents of Mandi District, Himachal Pradesh. We examined local climate data and interviewed rural and urban residents to identify and map perceived exposures and vulnerabilities to climate change. Residents reported shorter winters and decreased precipitation and attributed these changes to human activity. Most residents expressed willingness to make personal lifestyle changes to address climate change. We also determined that the villages' vulnerability to climate change is primarily due to lack of income opportunities outside of subsistence agriculture. Additional studies should be conducted to more completely assess the exposure and vulnerability of the region to climate change.

Executive Summary

Addressing climate change is perhaps the most significant challenge of this century, given that it is a pressing social, political, economic, and environmental problem. Since 1880, the average global temperature has increased by 0.85°C (Sharma, 2016). This rise in temperature has had profound effects, including the increased prevalence of adverse weather events, such as hurricanes and tropical storms, sea level rise as a result of glacial melt, and prolonged periods of drought due to change in precipitation patterns (Loria, 2016). These in turn can have impacts on all aspects of life.

Consider, for example, the Hindu Kush Himalaya, which provides farm and rangelands to the roughly 700 million people who rely on agriculture and animal husbandry for their livelihoods (Pandey et al., 2016; Ning, 2018). These farm and rangelands are shifting to higher altitudes in response to the changing climate (Asian Development Bank, 2010). Additionally, the region delivers freshwater to the mountain communities by providing the source for many river systems through snow and glacial melt (Mukherji, 2018; ICIMOD, 2017). Delay in monsoon arrival and increased glacial melt has already been observed, simultaneously threatening water availability especially at high altitudes and increasing the risk of flooding (Asian Development Bank, 2010; Pandey et al., 2016). Therefore, climate change in the Hindu Kush Himalaya may have a profound effect on the livelihoods of members of the surrounding mountain communities, including the communities of Himachal Pradesh.

The goal of our project was to characterize perceptions of exposure and vulnerability to climate change among lifelong residents in Himachal Pradesh. While there is an abundance of scientific evidence that demonstrate recent changes in climate, public perception of and social responses to climate change are far less well researched. To meet our goal, we first compiled scientific data on current climate indicators and future projections of climate change in Himachal Pradesh. Second, we collected and assessed public attitudes and perceptions about climate change within the Mandi District of Himachal Pradesh. The figures below illustrate our team conducting interviews in Arnehar and Darlog, Mandi District, Himachal Pradesh.

Interview in Arnehar (Kiehn, 2018)

Group Interview in Darlog (Bergeron, 2018)

Finally, we identified and mapped exposures and vulnerabilities to climate change within Mandi District.

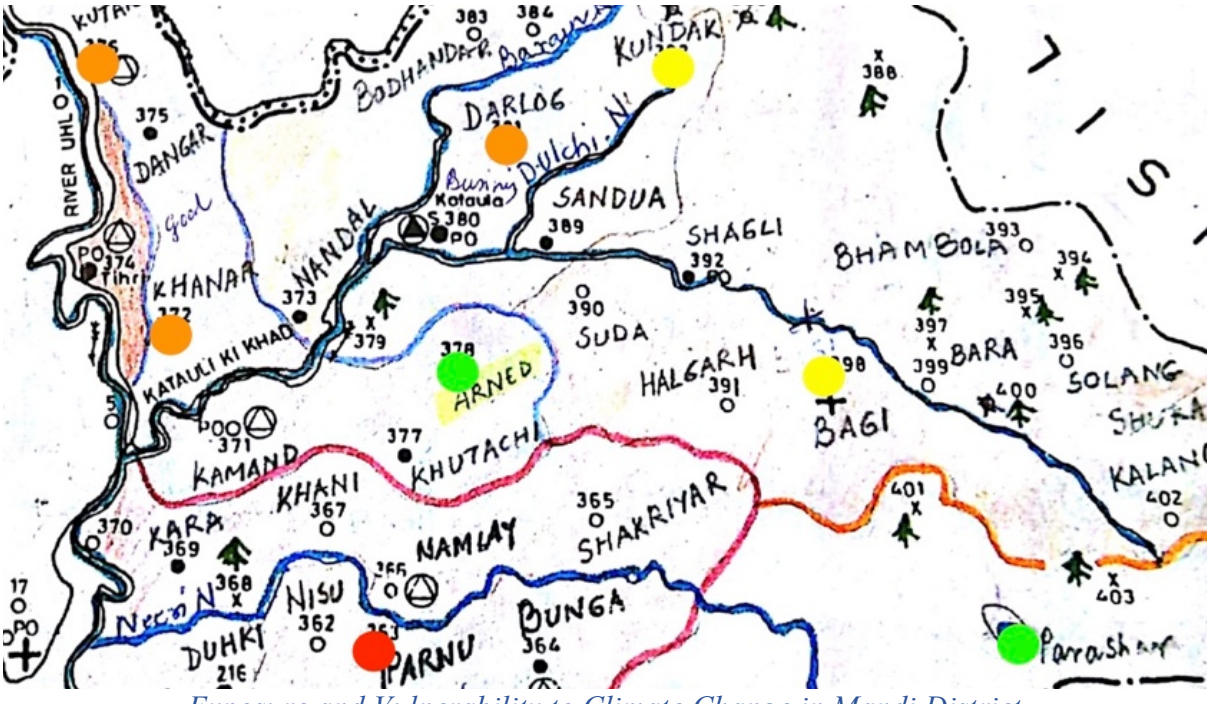
First, we compiled temperature and precipitation data from 1901 to 2013 for a 100 square-kilometer grid encompassing Mandi District. We constructed scatter plots of the data, then used linear regression analysis to produce trend lines (see Supplemental Materials). The trend lines reveal the most prominent temperature increase in the months of February (0.0185ºC per year for 113 years) and March (0.0162ºC per year for 113 years). For precipitation, while there is much more variation in the data, there has been a decrease in precipitation during the months of July (-0.75985 mm per year for 113 years) and August (-0.65973 mm per year for 113 years) and also a decrease in precipitation during December (-0.14033 mm per year for 113 years) and January (-0.16798 mm per year for 113 years). Analysis confirms increasing temperatures during winter months and decreasing precipitation during both the monsoon season and the winter months.

Second, we collected and assessed public attitudes and perceptions of climate change through a modified ethnographic approach in eight rural villages within Mandi District: Arnehar, Bagi, Darlog, Khanahar, Kundak, Kutahar, Parashar, and Parnu. In addition to interacting with residents of these villages in group settings, we also conducted interviews with 13 lifelong residents of more urban areas. Ethnography is a field a research that involves "understanding way of life from the native point of view" (Berg, 2007, p. 171). Our approach sought to understand how climate change affects local residents by interviewing them in a semi-structured manner that allowed them to tell their story while also addressing key points that were crucial for our study. Residents in all villages discussed a general increase in temperature and decrease in

rainfall in recent years. They also all noted shorter winters with less snowfall. Although not all of the villagers were aware of the concept of climate change, most were still able to identify human activity to be the cause of the changes they have seen in their climate. Similarly, 70 percent of the residents of Mandi Town that were surveyed believed people were responsible for the changes in the climate, and they were more slightly more likely than rural residents to be familiar with climate change as a concept.

The changing climate has impacted both the residents of villages within Mandi District and the residents of Mandi Town. The residents of the rural villages reported reduced crop yield due to the lack of water. As a result, there is increased pressure to find an alternative source of income to pay for food that they are usually able to grow on their own. Similarly, clothing shop owners reported excess stock of winter clothes because fewer than expected were sold during the winter. Electronics shop owners have recently had an increase in the number of sales of fans and air conditioners. Though some urban residents were aware of the negative implications of climate change, climate change appears to be of greater concern to the rural residents. While the changes in climate affect what the shops in Mandi sell and when, it does not appear to threaten their businesses as a whole. In contrast, the survival of the rural villages is closely tied to the climate and as farmers they are very aware of this reality. When asked what they would do if these climate trends continued many of the rural residents did not have an answer.

To complete our third objective, we defined two indices based on interview responses by which we could measure vulnerability: an adaptation index and a sensitivity index. (O'Brien, 2004). We used the sum of these indices to determine the current vulnerability of the community to future changes in climate. We also created a third index to measure exposure. The sum of exposure and vulnerability were used to create a color scale that was incorporated into a map of the villages with relation to their exposure and vulnerability, as shown below.



Exposure and Vulnerability to Climate Change in Mandi District

Our exposure and vulnerability indices reveal that some villages are at greater risk with respect to climate change than others, as marked in red or orange on our map. We found three factors to be most negatively impacting the vulnerability of the villages; availability of work outside of the villages, ability to sell excess crops, availability of consistent water resources.

Finally, we developed two platforms through which this data may be presented: an Instagram account highlighting the individuals that we interviewed and their stories, and a website documenting the risk climate change poses to each village visited with regard to exposure, sensitivity, and adaptive capacity (www.instagram.com/messagesfrommandi and www.studyclimatechange.tk, respectively). While they are still being developed, they demonstrate platforms through which this information could be presented to the public.

Further research is also required to more adequately map the vulnerability of the region. A continuation of this study or a similar study should be conducted to more completely assess the exposure and vulnerability of the region to climate change. Future studies may want to focus on more isolated communities. The villages in this study are all in relatively close proximity to IIT Mandi and most are reasonably close to roads. The study of communities with significantly less outside interaction would contribute greatly to the information on local perceptions of climate change and vulnerability. This information is best used to guide and focus adaptation efforts in order to address the concerns of the people.

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Authorship Page

Troy Bergeron contributed to the writing and editing of every section of the report; the analysis of the interviews; and the development of the exposure and vulnerability indices and design of the exposure and vulnerability map.

Aylin Padir contributed to the writing and editing of every section of the report; the analysis of the interviews; the development of the exposure and vulnerability indices and design of the exposure and vulnerability map; the design of the poster and brochure; and the development of the Messages from Mandi Instagram account.

Rahul Singh contributed to the organization and conduction of interviews and the translation of the interviews.

Shubham Kumar Singh contributed to the organization and conduction of interviews; the translation of the interviews; and the development of the Studying Climate Change webpage.

Udit Soni contributed to the organization and conduction of interviews and the translation of the interviews.

Team Photo: (L to R) Troy Bergeron, Rahul Singh, Aylin Padir, Mahak Mahajan, Udit Soni, Shubham Kumar Singh

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I. Measuring the Complexity of Climate Change

Addressing climate change is perhaps the most significant challenge of this century, given that it is a pressing social, political, economic, and environmental problem. Since 1880, the average global temperature has increased by 0.85°C (Sharma, 2016). This rise in temperature has had profound effects, including the increased prevalence of adverse weather events, such as hurricanes and tropical storms, sea level rise as a result of glacial melt, and prolonged periods of drought due to change in precipitation patterns (Loria, 2016). As a result, climate change may alter the quality of life for millions of people around the globe. Addressing this phenomenon requires an interpretation of projected and uncertain weather patterns, as well as an understanding of its implications on livelihoods and difficult choices to adapt or mitigate adverse consequences. Addressing climate change is perhaps the most significant challenge of this century.

Climate change will impact individuals, households, communities, and regions in varied ways because of different levels of exposure, sensitivity, and adaptive capacity to climate change. Sensitivity and adaptive capacity collectively reflect vulnerability (IPCC, 2014). Houses built beside a river are more exposed to flooding than ones that are not. Communities without large natural water sources are more sensitive to decreases in rainfall. Regions that grow a larger variety of crops are more adaptive to changes in climate. Little is known with regard to the exposure and vulnerability of communities in the Hindu Kush Himalaya to withstand current indicators and future projections of climate change. The Hindu Kush Himalaya provides farm and rangelands to the roughly 700 million people who rely on agriculture and animal husbandry for their livelihoods (Pandey et al., 2016; Ning, 2018). These farm and rangelands are shifting to higher altitudes in response to the changing climate (Asian Development Bank, 2010). Additionally, the region delivers freshwater to the mountain communities by providing the source for many river systems through snow and glacial melt (Mukherji, 2018; ICIMOD, 2017). Delay in monsoon arrival and increased glacial melt has already been observed, simultaneously threatening water availability especially at high altitudes (as shown in Figure 1) and increasing the risk of flooding (Asian Development Bank, 2010; Pandey et al., 2016). Therefore, climate change in the Hindu Kush Himalaya may have a profound effect on the livelihoods of members of the surrounding mountain communities, including the communities of Himachal Pradesh.

Figure 1: Dry Fields Reflecting Decreased Water Availability in Himachal Pradesh (Chakravorty, 2017)

While there is an abundance of scientific evidence that demonstrate recent changes in climate, public perception of and social responses to climate change are far less well researched. Some limited studies have been conducted, including in the United States, Uzbekistan, Georgia and others (Broday et al, 2007; Sutton et al, 2013; Ahouissoussi et al, 2014). However, it is difficult to extrapolate these findings to other locations and communities because exposures, vulnerabilities, capacities, education, and culture are not the same across locations. Efforts to implement changes to mitigate the effect of climate change are more successful, however, when the perspectives of those at risk are taken into account. The cultural and social contexts through which people view the issue of climate change impacts how they will respond to mitigation and adaptation efforts (Besel et al., 2017).

One region for which there is limited data is Himachal Pradesh, India. Therefore, the goal of our project was to characterize perceptions of exposure and vulnerability to climate change among lifelong residents in Himachal Pradesh. To meet our goal, we first compiled scientific data on current climate indicators and future projections of climate change in Himachal Pradesh. Second, we collected and assessed public attitudes and perceptions about climate change within the Mandi District of Himachal Pradesh. Finally, we identified and mapped exposures and vulnerabilities to climate change within Mandi District. By accomplishing these objectives, we obtained a better understanding of public perception of climate change in Himachal Pradesh, and thereby contributed to the body of knowledge used in the development of effective strategies to combat the effects of climate change in this region.

II. Climate Change in Himachal Pradesh: Risk, Vulnerability, and Adaptation

Characterizing climate vulnerability in Himachal Pradesh requires a sense for the range of experiences and livelihoods that stem from the land and how residents in the area may be impacted by climate change. It is also important to understand existing climate change adaptation policies in order to determine how these initiatives could better respond to public perception. In the following sections, we outline the social implications of climate change in Himachal Pradesh that have already been reported. Next, we discuss evidence of other negative implications of climate change and illustrate how these implications may relate to Himachal Pradesh. Then, we discuss the concepts of exposure and vulnerability in relation to various stressors, including climate change. Finally, we highlight how public perception can shed light on the vulnerability of an area to climate change, thereby informing government agencies and policy makers.

The implications of climate change in Himachal Pradesh

Changes in weather patterns can threaten communities. Himachal Pradesh historically obtains roughly 80 percent of its annual rainfall from the summer, southwest monsoon (Saha et al., 1979; Jena et al., 2016). Decreased precipitation and late onset of the monsoon have already been observed, and various models that aim to predict the impact of climate change also support these observations (Jena et al., 2016). For example, Shimla, the capital of Himachal Pradesh, has seen an annual decrease in monsoon precipitation of 3.71 millimeters per year between 1951 and 2005 (Jaswal et al. 2015). Winter precipitation, on the other hand, is generally the result of western disturbances (WDs). WDs are weather systems that develop as air moves from west to east across the Himalayas, bringing heavy snowfall to the region (Kumar et al., 2015). Between 1977 and 2007, there were between two and five fewer WDs per month in December, January, February, and March. As a result, a decrease in overall winter precipitation in Himachal Pradesh was also exhibited. During the same time period, there was a 13 percent decrease in precipitation from the mean (Kumar et al., 2015). Although there has been an overall decrease in precipitation, in the past five decades, there has been an increase in the frequency of heavy rainfall episodes, likely due to surface warming (Kumar et al., 2015; Jena et al., 2016). Melting glaciers and mountain snowpack serve as a water source by providing water to nine river systems in the region (Asian Development Bank, 2010). However, rising temperatures due to anthropogenic activity have caused an increase in the annual glacial melt. This in turn is causing a year after year decrease in glacier size, thereby depleting freshwater resources in the province in the long-term (Asian Development Bank, 2010). While the Hindu Kush Himalaya hosts a wide range of temperatures due to highly variable elevations throughout the area, maximum temperatures throughout the region are rising as a result of anthropogenic activity (Asian Development Bank, 2010). Higher temperatures facilitate evaporation and thereby reduce soil moisture.

These bio-physical changes have already had implications on communities within Himachal Pradesh. Reported implications include:

- Declining water availability for irrigation: Reduced soil moisture has led to an increasing demand for irrigation water. Residents obtain water for domestic and agricultural use from natural sources and from the government supply: The Department of Irrigation and

Public Health. The government supply also relies on local rivers and springs for freshwater. The decrease in precipitation associated with the summer monsoon is causing the surface water resources to dry up, threatening the source of the government water supply (Asian Development Bank, 2010).

- Shifting agricultural land use: Rising temperatures have caused apple farmers to move to higher altitudes in order to achieve an appropriate chilling period required for high quality apples. Consequently, lower altitude lands are growing alternative crops in order to accommodate the rising temperatures (Rana et al., 2013; Basannagari and Kala, 2013; Kumari et al., 2012).
- Shifting agricultural productivity: Rising temperatures have caused a delay in sowing and harvesting times. Some fruits are ripening prematurely. There has also been an increase in the prevalence of disease among crops (Kumari et al., 2012).

Given that 90% of the nearly seven million inhabitants of Himachal Pradesh are dependent on agriculture, these negative implications have profound, detrimental effects on the state as a whole (Changing Trends of Monsoon, 2013). Additionally, while they are negative implications in and of themselves, declining water availability and shifting agricultural land use and productivity simultaneously threaten food security. It is likely that there are additional implications that are not as well recorded.

The impact of climate on mountain communities extends beyond that which has been documented for Himachal Pradesh. One example is a case study of rural villages in the Lo-pa region of north western Nepal, which relies primarily on agriculture and animal husbandry for livelihood. Recently, the region has supported fewer animals, yet there is still not enough grass for them to graze (Devkota, 2013). In the village Dhe, there is a special festival called Dhimpuche. This festival involves one particular pine tree and is only celebrated in Dhe. If residents relocated they would be unable to observe this important holiday. As a result, many are hesitant or unwilling to relocate even if it is in their best interest. Migration is an example of a climate change adaptation policy, yet as demonstrated through the case study of Lo-pa, cultural factors and perceptions must be considered if they are to be successful.

Incorporating risk assessments and perceptions studies into adaptation efforts

The Intergovernmental Panel on Climate Change (IPCC) defines risk as a function of three factors: hazard, exposure, and vulnerability (IPCC, 2014). Hazard indicates of the potential for a specific event to occur in a given area that may have devastating consequences. Vulnerability is representative of the area's ability to respond to such an event. Exposure is the potential a hazardous event has of occurring. The relationship between risk and its three components is shown below in Figure 2.

Figure 2: Schematic Interaction Between Risk, Hazard, Exposure, and Vulnerability

Our study focuses on the exposure and vulnerability components of risk. Exposure is the amount of stress likely to be experienced by a community due to climate change and can be measured by considering either long-term changes to weather patterns or by considering the changes in the number and severity of extreme weather events (O'Brien et al., 2004). Vulnerability measures both sensitivity and adaptive capacity. Sensitivity is the likelihood an entity has of experiencing negative impacts from exposure. Adaptive capacity is an entity's ability to counteract changes in climate based on various factors including wealth, technology, education, and skills (O'Brien et al., 2004). Indices can be developed to measure exposure, sensitivity, and adaptive capacity (IPCC, 2014, O'Brien et al., 2004, Sharma, J. et al., 2017), allowing differences in exposures and vulnerabilities to climate change throughout a region to be mapped, as shown in Figure 3.

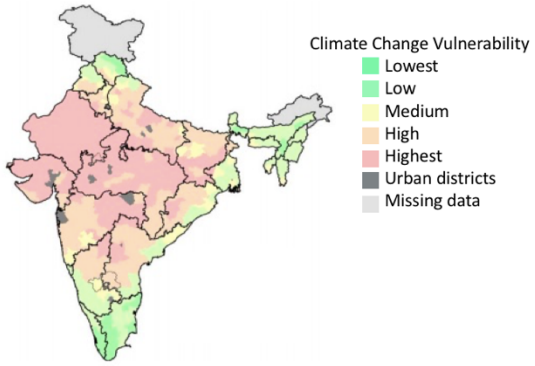

Figure 3: Vulnerability to Climate Change Across India (O'Brien et al., 2004)

Understanding the exposure and vulnerability of an area to climate change is important information to have when taking action to mitigate or adapt to climate change. Government agencies such as the Department of Environment, Science, and Technology of the Government of Himachal Pradesh, are tasked with efforts to "plan, coordinate, promote and oversee the environment conservation and enhancement programs through environmentally compatible management practices and technologies" (Government of Himachal Pradesh, n.d.). One such directive is the Department's State Strategy and Action Plan of Climate Change, published in 2012 (Department of Environmental Science and Technology, 2012). The plan outlines specific

goals for Himachal Pradesh and makes connections to the national action plan. These goals include, but are not limited to, a significant increase in solar energy production, improved habitat sustainability through improved energy efficiency in buildings, conservation of water resources, and renewed focus on sustainable agriculture (Department of Environmental Science and Technology, 2012). Given that the missions of the National Action Plan on Climate Change and the Department's State Strategy and Action Plan of Climate Change are dependent on the behaviors and livelihoods of the public, it is crucial that the missions align with public attitudes and perceptions. Public perception is just as important to the formation of effective policies as the scientific evidence that support the need for said policies (Besel et al., 2017). In fact, according to environmental scientist Anthony A. Leiserowitz, "public support or opposition to climate policies ... will be greatly influenced by public perceptions of the risk and dangers inherent in climate change" (Leiserowitz, 2005; Besel et al. 2017). This is because perceptions influence how people act and respond to climate change initiatives.

There is some information about perceptions in India and in the Hindu Kush Himalaya, but it is limited and there is a need for more research in Himachal Pradesh. A study regarding climate change perceptions was recently conducted in Meghalaya, a state in northeastern India (Department of Science and Technology Centre for Excellence, 2017). It is one of the few states to receive national funding to combat climate change through the National Adaptation Fund for Climate Change. Through their study of Meghalaya, researchers highlighted the need to strengthen the adaptive capacity of communities in order to reduce their vulnerability to climate change. This can be accomplished by taking into consideration traditional knowledge in relation to climate (for example, how residents believe nesting behaviors of insects can predict flooding), impact studies, and vulnerability assessments. The vulnerability assessment itself is dependent on public perception regarding temperature and precipitation, extreme weather events, water availability, and forest cover. Researchers also evaluated how residents believed agriculture has been impacted by the climate (Department of Science and Technology Centre for Excellence, 2017).

One way to understand vulnerabilities and risk is to listen to the stories of residents to reveal how climate has affected their lives in the past and how its impact has changed over time. In 2017, researchers conducted a study on perceptions of risks related to global climate change. The team the of participants by obtaining what they referred to as "limited life histories" (Besel et al., 2017). The researchers prompted participants on the topic of climate change, after which the participants were able to freely reflect in writing. Examples of prompts include "What is your earliest memory about global warming/climate change?" and "Do you remember when you decided climate change/global warming was or was not a real phenomenon, or are you still uncertain about the issue?" (Besel et al., 2017). The research team determined that this method involving limited life histories provided useful insight on public perception and that this method overcomes limitations of the more traditional methods of analyzing the change in media content over time or conducting typical surveys and interviews (Besel et al., 2017). Similar studies may be useful in Himachal Pradesh in order to evaluate the vulnerability of the region and determine appropriate adaptive measures.

III. Methodology: Recording Experience and Perceptions

Here we provide an overview of the methods used to conduct our study. The goal of our project was to characterize perceptions of exposure and vulnerability to climate change among lifelong residents in Himachal Pradesh. Our goal, objectives, and associated tasks are summarized in Figure 4.

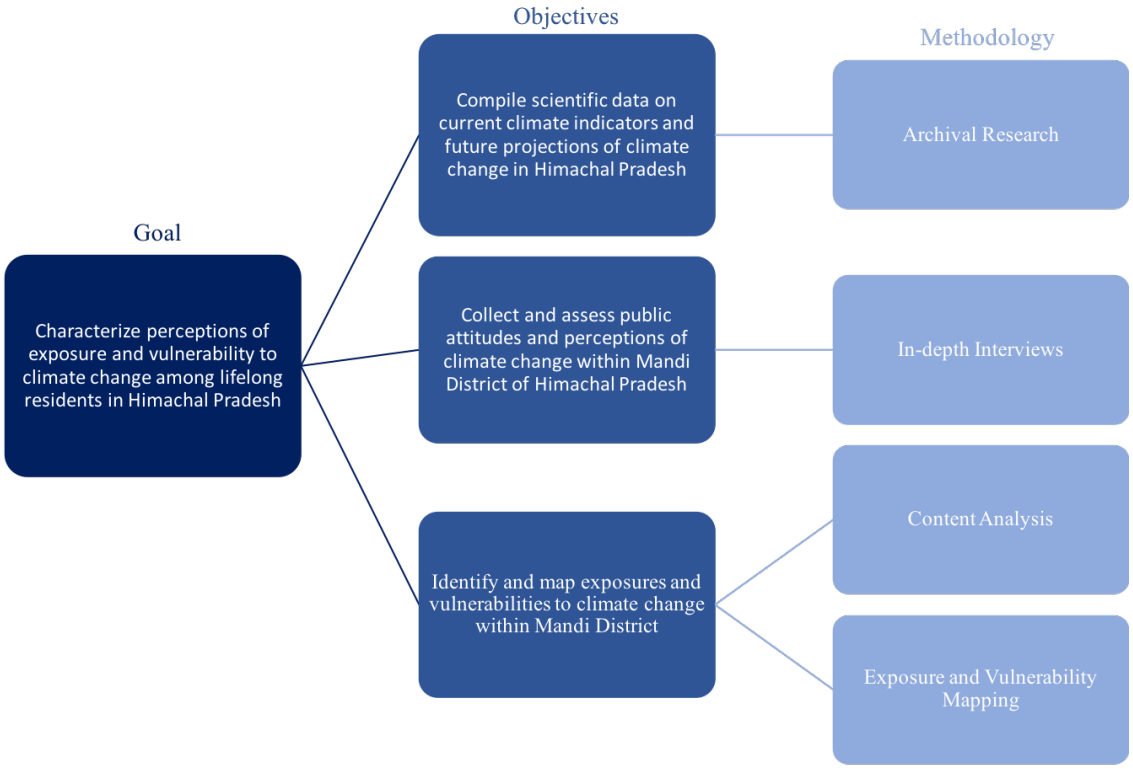

Figure 4: Goal, Objectives, and Associated Tasks

We describe each of the objectives, as well as the associated tasks for each, in more detail in the sections below.

Objective 1: Compile scientific data on current climate indicators and future projections of climate change in Himachal Pradesh

We compiled scientific data on current climate indicators and future projections of climate change in Himachal Pradesh. To do this, we analyzed rainfall data broken down by month over the past five years from the Shimla Meteorological Center (Shimla Meteorological Center, 2017). These data were used to identify whether a particular district seemed to have experienced any significant changes in rainfall.

Next, we compiled temperature and precipitation data from 1901 to 2013 for a 100 square-kilometer grid encompassing Mandi District (shown in Figure 5 below).

Figure 5: 100 Square-Kilometer Grid Encompassing Mandi District (Google Maps, 2018)

These data were provided by Dr. Kaustav Sarkar of the Indian Institute of Technology, Mandi, and shed light on climate change with relation to temperature, precipitation, and weather pattern changes in Mandi District (Sarkar, K., 2018). These temperature and precipitation data can be found in Appendix A.

Objective 2: Collect and assess public attitudes and perceptions of climate change within Mandi District of Himachal Pradesh

We accomplished our second objective through a modified ethnographic approach in eight rural villages within Mandi District: Arnehar, Bagi, Darlog, Khanahar, Kundak, Kutahar, Parashar, and Parnu. The location of these villages is shown below in Figure 6 (Sarkar, 2018).

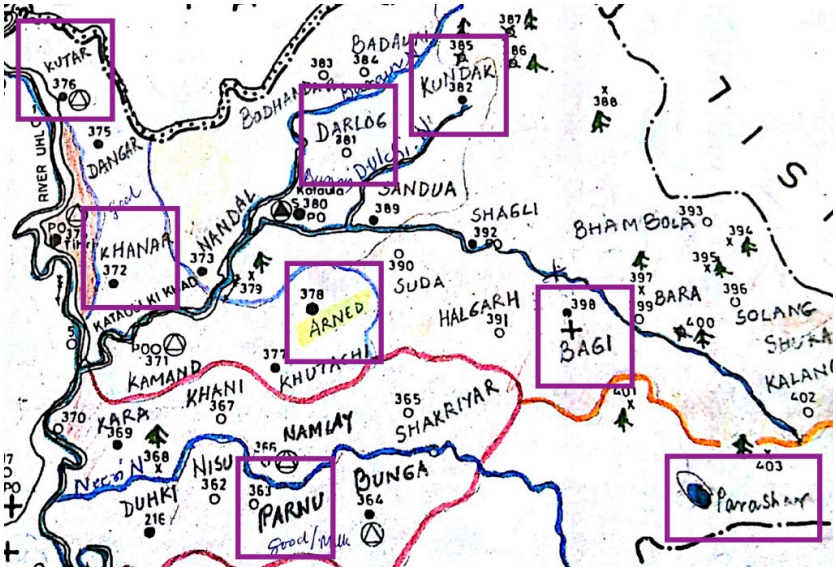

Figure 6: Villages for Interviews (Sarkar, R., 2018)

Ethnography is a field a research that involves "understanding way of life from the native point of view" (Berg, 2007, p. 171). Our approach sought to understand how climate change affects local residents by interviewing them in a semi-structured manner that allowed them to tell their story while also addressing key points that were crucial for our study. We prompted residents when necessary to obtain consistent information from each village in order to measure perception, adaptive capacity, sensitivity, and exposure, as highlighted below in Table 1.

Table 1: Interview Topics

Perception	Adaptive Capacity	Sensitivity	Exposure
Awareness of climate change	Ability to sell excess crops	Water availability	Threat of landslides
Relationship to human activity	Availability of work outside of the village	Number of crops	Threat of floods
	Education level	North/South facing	Changes in precipitation
			Changes in temperature
			Changes in length of seasons

These interview topics were determined based on our review of literature regarding exposure and vulnerability to climate stressors (e.g., O'Brien et al., 2004; IPCC, 2014). They also relate to climate change awareness, beliefs, understanding, and misconceptions. Figures 7 and 8, below, illustrate our team conducting interviews in Arnehar and Darlog, Mandi District, Himachal Pradesh.

Figure 7: Interview in Arnehar (Kiehn, 2018)

Figure 8: Group Interview in Darlog (Bergeron, 2018)

In addition to interacting with residents of eight villages in group settings, we also conducted interviews with 13 lifelong residents of more urban areas. We reviewed the content of each in order to determine overarching similarities or contrasting themes between the qualitative and anecdotal reports for the local perceptions of climate change. The data were also used to identify vulnerabilities to climate change from the perspective of the residents. Our interview guide can be seen in Appendix B.

Objective 3: Map exposures and vulnerabilities to climate change within Mandi District

Our fieldwork from Objective 2, as well as our previous research, defined how we measured exposure, and two indices by which we could measure vulnerability: an adaptation index and a sensitivity index (O'Brien, 2014). We used the sum of these indices to determine the current risk (without regarding hazard) of the community to future changes in climate. The components of exposure and the two indices of vulnerability are illustrated in Table 1. The sum of exposure and vulnerability were used to create a color scale that was incorporated into a map of the villages with relation to their exposure and vulnerability.

IV. Results and Discussion

To meet our first objective, we analyzed rainfall data over the past five years for the twelve districts of Himachal Pradesh obtained from the Shimla Meteorological Center (see Appendix A). The data analysis was inconclusive. As a result, and as well as for convenience, we focused on Mandi District as the area for our study.

We analyzed the average temperature and precipitation each month from 1901 through 2013 at the four corners of a 100 kilometer-square grid encompassing Mandi District. We constructed scatter plots of the data, then used linear regression analysis to produce trend lines (see Appendix A). The trend lines reveal the most prominent temperature increase in the months of February (0.0185ºC per year for 113 years) and March (0.0162ºC per year for 113 years). For precipitation, while there is much more variation in the data, there has been a decrease in precipitation during the months of July (-0.75985 mm per year for 113 years) and August (-0.65973 mm per year for 113 years) and also a decrease in precipitation during December (-0.14033 mm per year for 113 years) and January (-0.16798 mm per year for 113 years). Analysis confirms increasing temperatures during winter months and decreasing precipitation during both the monsoon season and the winter months, as suggested in our background research.

Perceptions about changes in climate

Following our analysis of local climate data, we conducted group interviews in eight villages within Mandi District (refer to Figure 6). In these interviews, villagers shared stories that gave a more complete picture of climate change in Mandi District and how they view these changes (see Appendix B). We also conducted individual interviews with 13 shop owners who are residents in Mandi Town in order to compare the perceptions of rural and urban residents (see Figure 9). Images of village and Mandi Town visits can be found in Appendix C.

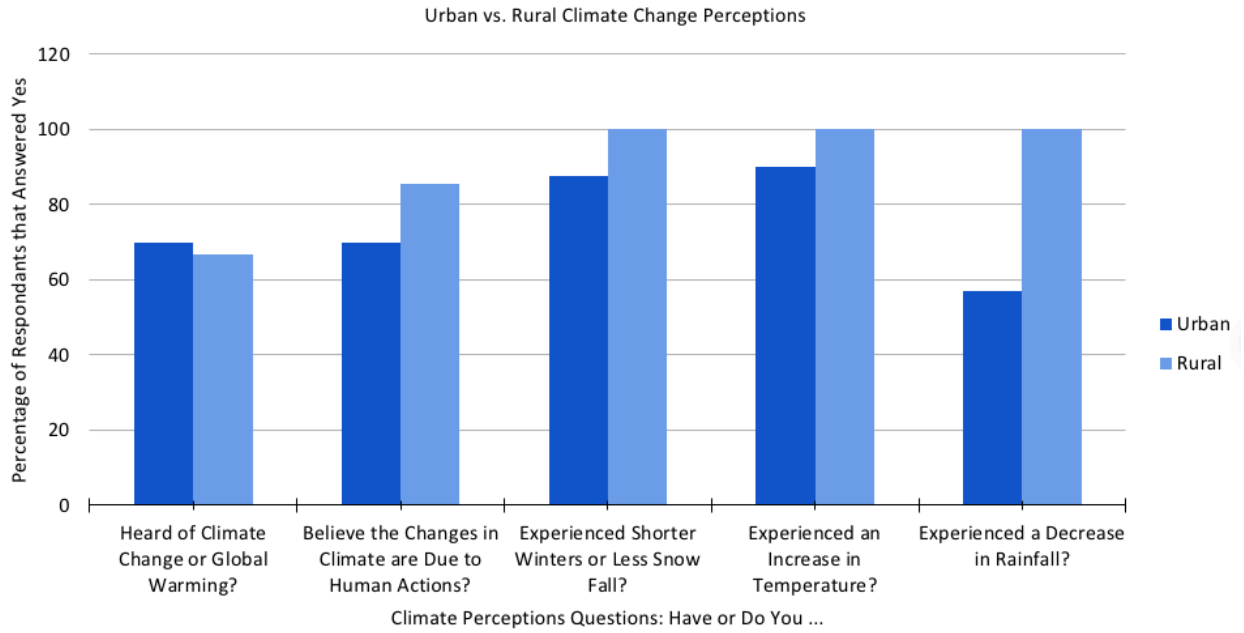

Figure 9: Contrasting Urban and Rural Climate Change Perceptions

Residents in all villages discussed a general increase in temperature and decrease in rainfall in recent years. This was reported in 100% of the villages we visited. They also all noted shorter winters with less snowfall. All villages except for Bagi and Kundak face issues of water scarcity. Bagi and Kundak both have larger natural streams close to their villages that provide water for drinking and irrigation. Most, though not all, of the residents of the more urban Mandi also noticed these same changes in the climate. They most often referenced the shorter winters and lack of snowfall as well as delays in the arrival of the monsoon.

Perceptions about causes of climate change

> "There used to be small shops on the roadsides in circular way. But now they have moved all the shops from there to here. This is because of population growth and traffic issue ... Population is increasing so the number of vehicles is also increasing. Every family has 2-3 vehicles. They use vehicles wherever they go ... Even for a small task, we don't want to walk. Vehicles release carbon dioxide. We should plant the Peepal tree which is found only in India -- it absorbs most of the CO2 and gives lots of oxygen. ... Environment was very good in the past. People are adapting individualism culture now. They don't care about others' problem. But in the past people used to solve the problems together."
>
> Resident of Mandi Town

Although not all of the villagers were aware of the concept of climate change, most were still able to identify human activity to be the cause of the changes they have seen in their climate. They referenced projects such as the construction of IIT Mandi as contributing to the change. In other circumstances, villagers reported that they believed the gods were responsible for climate changes. Still, they could identify human activity as the primary cause due to the belief that people upsetting the gods brought about these detrimental changes. Though they were not generally aware of the scientific reasons for their observations, many correctly identified the causal link between people and climate change. Similarly, 70 percent of the residents of Mandi Town that were surveyed believed people were responsible for the changes in the climate, and they were more slightly more likely than rural residents to be familiar with climate change as a concept. Urban residents tended to associate the changes in the climate with increased population in the area and the increased prevalence of motor vehicles.

Perceptions about the impacts of climate change

The changing climate has impacted both the residents of villages within Mandi District and the residents of Mandi Town. The residents of the rural villages reported reduced crop yield due to the lack of water. As a result, there is increased pressure to find an alternative source of income to pay for food that they are usually able to grow on their own. Some are also having to adjust their planting and harvesting cycles due to delay in the arrival of the monsoon (which is supported by climate data from the area). Similarly, clothing shop owners reported excess stock of winter clothes because fewer than expected were sold during the winter. Electronics shop owners have recently had an increase in the number of sales of fans and air conditioners. They also reported a shift in the timing of sales to earlier in the year. Overall, store owners within

"[Our work is] mostly agriculture, it's all that we do. Our whole households are dependent on that. If by God's grace there is good rain then we grow enough with our hard work to keep our family going and if not then we do some manual jobs as workers and earn 20-30 Rs so that we can get our family rations. We somehow make our ends meet, some of our people go to Manali, to Lahaul, to Leh, to Kullu for seasonal works and we somehow survive, what's to be done – we've got to feed ourselves right?"

Villagers of Kutahar

Mandi Town stated that their "summer" season is beginning up to a month earlier than in the past, thereby affecting their businesses.

Perceptions about vulnerability to climate change

Though some urban residents were aware of the negative implications of climate change, climate change appears to be of greater concern to the rural residents. Urban residents did not mention concern for their livelihood in relation to climate change. while in contrast, climate change may threaten sources of food, water, and income for residents of rural areas. while the changes in climate affect what the shops in Mandi sell and when, it does not appear to threaten their businesses as a whole. In contrast, the survival of the rural villages is closely tied to the climate and as farmers they are very aware of this reality. When asked what they would do if these climate trends continued many of the rural residents did not have an answer. Our interviews with the residents of eight villages in Mandi District shed light on the exposures and vulnerabilities to climate change for each village. In order to measure the exposure of each village, we considered five factors: landslide threat, flood threat, shortened winter (or less snow), increased temperatures, and decreased rainfall. Each of these factors with respect to each village is shown below in Table 2.

Table 2: Exposure to Climate Change by Village

	Arnehar	Bagi	Darlog	Khanahar	Kundak	Kutahar	Parashar	Parnu
Landslide Threat	1	0	1	1	0	0	1	0
Flood Threat	1	0	1	0	1	1	1	1
Shorter or Drier Winter	0	0	0	0	0	0	0	0
Increased Temp.	0	0	0	0	0	0	0	0
Decreased Precip.	0	0	0	0	0	0	0	0
Exposure	**2**	**0**	**2**	**1**	**1**	**1**	**2**	**1**

We gave the villages a score of 1 for each of the threats that was present and a score of 0 for each threat that was not present. Therefore, Bagi is most exposed to climate change, while Arnehar, Darlog, and Parashar are least exposed.

In order to measure vulnerability, both sensitivity and adaptive capacity need to be considered. Sensitivity for each village was measured by considering the availability of water and the number of different crops grown. A score of 1 for water availability signifies the presence of a significant source of water near the village. To ensure that the "number of crops" index was not disproportionately weighted the index had to be normalized. Normalization is a standard method of comparing indicators with different units. The normalized value of an indicator is found using the following equation: x-min/(max-min). The max and min are the maximum and minimum non-normalized values of the indicator. In our case, the maximum was four crops and the minimum was two crops. For the north or south facing index, 1 indicated that the village was north facing, 0 indicated that the village was south facing, and 0.5 indicated that the village was either east or west facing. According to our research, Arnehar and Bagi are least sensitive to climate change while Kutahar and Parnu are most sensitive. This information is displayed in Table 3.

Table 3: Sensitivity to Climate Change by Village

	Arnehar	Bagi	Darlog	Khanahar	Kundak	Kutahar	Parashar	Parnu
Water availability	0	1	0	0	1	0	1	0
Number of crops	1	0.5	0	0.5	0.5	0	0	0
North or South facing	1	0.5	0.5	0	0	0	0.5	0
Sensitivity	**2**	**2**	**0.5**	**0.5**	**1.5**	**0**	**1.5**	**0**

Finally, Table 4 illustrates the breakdown of the adaptive capacity index. This index is based on three factors: ability to sell extra crops, availability of external work, and education. For ability to sell extra crops, a score of 1 signifies that the village sells any excess crops at a market. A score of 0 indicates that the crops are for subsistence only. The same measurement system is used for availability of external work. For education, a score of 1 means there is a primary school in the village. Consequently, Bagi, Khanahar, Kundak, Kutahar, and Parashar are more adaptive to climate change than Arnehar, Darlog, and Parnu. A picture of the primary school from Kutahar is shown below in Figure 10.

Figure 10: Education Opportunities in Kutahar (Bergeron, 2018)

It should also be noted that because Parashar does not have permanent residents, therefore the ability to sell extra crops was not applicable. Therefore, Parashar's sensitivity score theoretically could have been one point higher.

Table 4: Adaptive Capacity to Climate Change by Village

	Arnehar	Bagi	Darlog	Khanahar	Kundak	Kutahar	Parashar	Parnu
Able to sell extra crops	0	1	0	0	0	0	N/A	0
External work present	0	0	0	1	1	1	1	0
Education	1	1	1	1	1	1	1	1
Adaptive Capacity	**1**	**2**	**1**	**2**	**2**	**2**	**2**	**1**

The sum of the adaptive capacity index and the sensitivity index reveals the vulnerability for each village to climate change (see Table 5). A lower score represents a more vulnerable village.

Table 5: Vulnerability to Climate Change by Village

	Arnehar	Bagi	Darlog	Khanahar	Kundak	Kutahar	Parashar	Parnu
Sensitivity (Max: 3)	2	2	0.5	0.5	1.5	0	1.5	0
Adaptive Capacity (Max: 3)	1	2	1	2	2	2	2	1
Vulnerability (Max: 6)	**3**	**4**	**1.5**	**2.5**	**3.5**	**2**	**3.5**	**1**

We identified Parnu as the most vulnerable of the villages, though all the villages scored within two thirds of the highest possible (least vulnerable) score. We identified Bagi as the least vulnerable village.

Discussion

Our research, seeking to understand how people view climate change in the area, revealed three key points about climate change perceptions in Mandi District.
First, despite relative lack of education, residents of the rural villages generally believe that humans and human actions are the reason for the changes in the climate. This is a major component of their perception of climate change. They understand that people are the cause of the changes to their climate even if they do not understand the mechanisms by which these changes occur.

Second, people we interviewed reported that they were impacted by a changing climate. This includes farmers in remote, rural villages and shopkeepers in Mandi Town. However, those whose livelihoods depended on the climate seemed to be more aware of the types of changes that have already occurred. Still, it is clear climate change is affecting and will continue to affect all residents of Mandi District.

Finally, the majority of residents (both rural and urban) that we interviewed believed people should be taking action to mitigate or adapt to climate change impacts and help prevent future change. When asked whether they would be willing to make personal changes to their lifestyle to help address the issue of climate change the majority said that they were. Similarly, these same people also expressed the belief that the government should implement policies to help mitigate the impacts of climate change. This indicates that people of Mandi District are potentially open to climate change mitigation policies.

"With rise in summers and if [water and waste water] areas are not properly cleaned, there would be rise in disease like malaria, dengue, typhoid etc. We rarely used to see these insects earlier but now there are a large amount of insects like mosquitoes even in winters ··· God knows what will happen and with hospitals very far from us, the situation will be very grave. People generally hesitate to go to doctors even if they have a slight fever. People would just not go to hospitals until the situation is very serious and sometimes things go out of hand. Sometimes blood test have to be done for such diseases and people ··· have to shell out 5000-10000 Rs of cash on this. This puts extra pressure on the lives of individuals who are already poor, who are already dependent on a source of income which is not regular and dependent on monsoon. A person with regular job can afford to be sick but a poor person can't be sick if he has to survive in these regions. Cleanliness drives need to be down to remove the dirt ridden areas. "

Villagers of Khanahar

Our exposure and vulnerability indices reveal that some villages are at greater risk with respect to climate change than others. We found three factors to be most negatively impacting the vulnerability of the villages:

1. Availability of work outside of the villages
2. Ability to sell excess crops
3. Availability of consistent water resources

Only half of the villages reported that their residents were able to find work outside of their villages. This means that half of the villages visited are entirely dependent on their crops for food and income. Further, only one of the villages reported being able to sell excess crops at market. Therefore, the villages of Mandi District are primarily vulnerable due to lack of

livelihood beyond subsistence farming and water scarcity. The exposure of the villages was more similar as all of the villages face the same long-term climate projections. The larger climate trends of the area (higher temperatures, less rain, shorter winters) are the same for all of the villages. The differences in exposure, therefore, come from exposure or lack of exposure to localized climate change related incidents like flooding or landslides.

There are several limitations to this study. First, the sampling for the interviews was a sample of convenience, and the sample size as a whole was very small. As a result, the subjects interviewed may not accurately represent the perceptions of all of Mandi District and cannot be generalized to the larger state of Himachal Pradesh. Another issue with the sampling is that very few women were participants. All of the interviews conducted in Mandi were conducted with men. Though both men and women were present during the group interviews in the villages, the questions were primarily answered by men.

Concern for the future was a common theme in the responses from villagers. The interviewed residents can see their water resources decreasing and their crop yields suffering. Their source of food and income is at risk. As the climate trends are expected to continue into the future some of these villages may find themselves unable to sustain themselves or maintain their quality of life. As farming becomes more unreliable they will be forced to find other means of supporting themselves. This exposes villagers to some of the issues of modern living from which they were previously protected and threatens their culture and way of life. This region could benefit greatly from outside intervention to help them cope with climate change which is explicitly informed by the specific vulnerabilities and perceptions of the people that it seeks to help.

"People of our land are hard to anger and very calm and peace loving, and according to me one reason is that mostly we don't consume refined oils or artificial Dalda … Our elders used to tell us that if you eat pure, you will get not get angry very soon. They were calm and muscular and strong. They were resilient and used to lift 100-200 Kgs of weight but now this trend is disappearing. The curse of cigarettes, drugs and other such habits are slowly starting to be seen. [Youngsters] see people do it and the start doing it. These things give vigor on outside only make you hollow from inside."

Villagers of Kutahar

V. Project Outcomes

We coded villages based on their combined exposure and vulnerability indices create a map that shows exposure and vulnerability rankings within the District (see Figure 11).

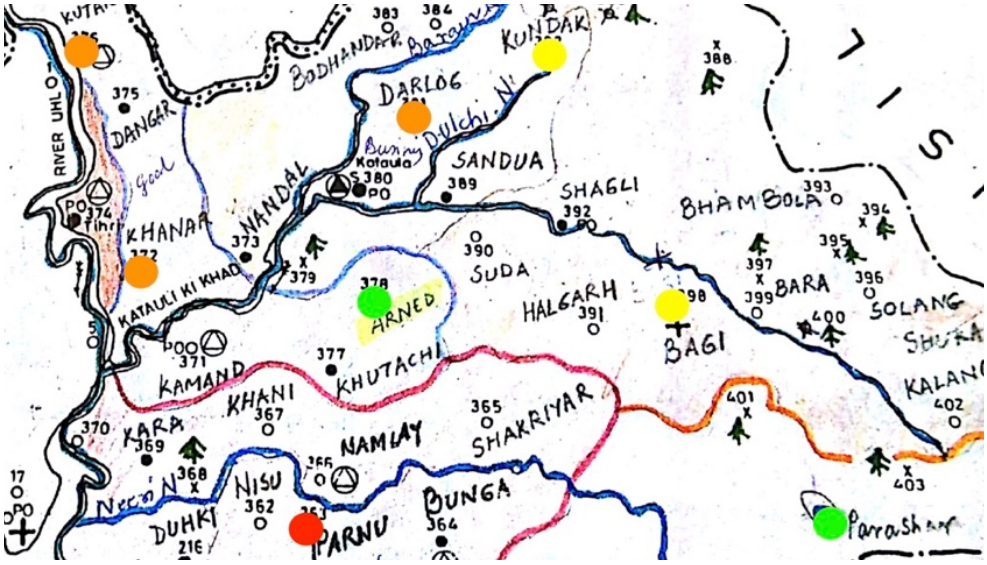

Figure 11: Exposure and Vulnerability to Climate Change in Mandi District

Green represents the villages with the highest combined exposure and vulnerability score, with yellow as the next highest. In contrast, red indicates villages with the lowest score, with orange as the second lowest. This combined exposure and vulnerability score identifies communities at, potentially, the greatest risk due to climate change. This map may be used as a baseline by researchers for risk analyses studies in Mandi District in the future, as it identifies two of the components of risk (vulnerability and exposure). Additionally, it may be used, in conjunction with the rest of the results of our exposure and vulnerability study, by policymakers to identify communities in the most need of assistance as well as the ways in which they are vulnerable. This information can better inform adaptation and mitigation policies. We are currently developing a template for an interactive web page which will display village profiles and relevant information in conjunction with the map presented above. This would serve as the beginnings of a local climate perceptions and vulnerability database.

Additionally, we developed two platforms through which this data may be presented: an Instagram account highlighting the individuals that we interviewed and their stories, and a website documenting the risk climate change poses to each village visited with regard to exposure, sensitivity, and adaptive capacity (www.instagram.com/messagesfrommandi and www.studyclimatechange.tk, respectively).

As previously discussed, we accomplished our goal by using a life-history approach, which captures perceptions by listening to stories of residents regarding how climate has affected their lives in the past and how it's changed over time. Our "Messages from Mandi" Instagram account is an outlet for us to share some of the stories of the people we interviewed (Figure 12).

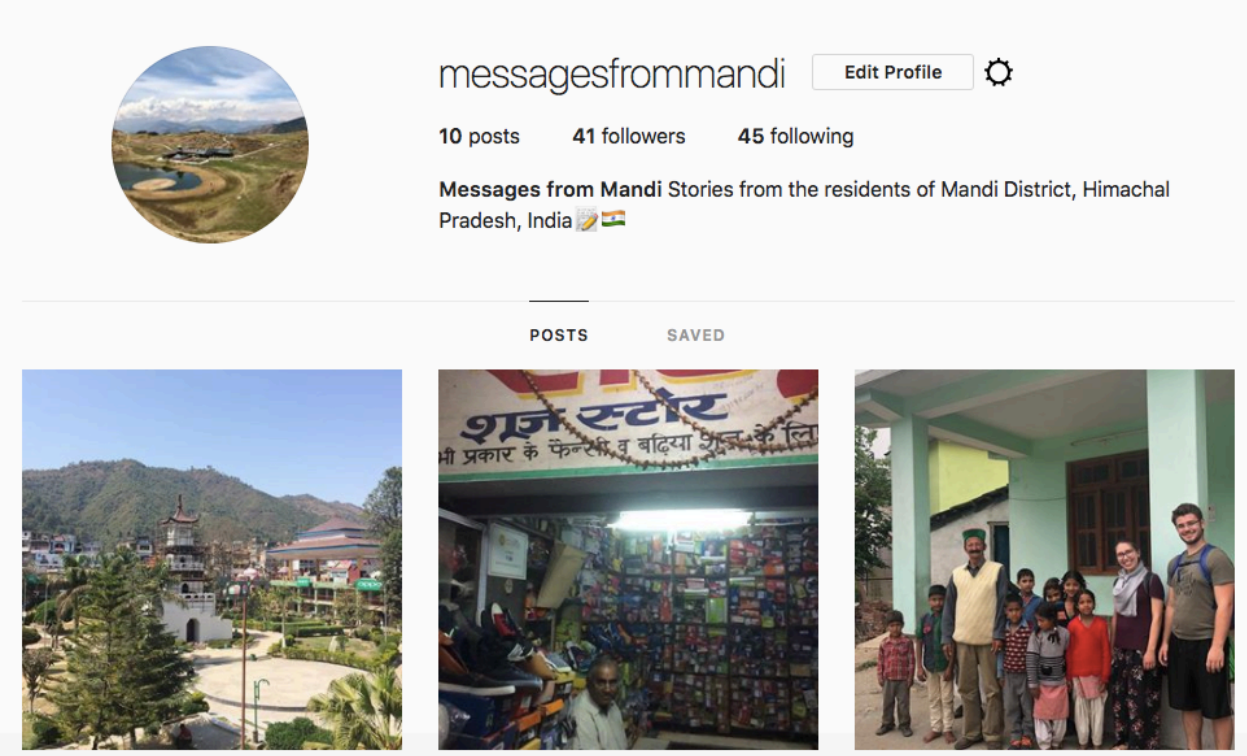

Figure 12: Messages from Mandi Instagram

In addition to sharing the stories reviewed through our life-history approach, we sought to find the means by which we could present our exposure and vulnerability analyses. We developed an interactive webpage that demonstrates the exposures and vulnerabilities of the villages by location (Figure 13). While both of these platforms are still being developed, they demonstrate platforms through which this information could be presented to the public.

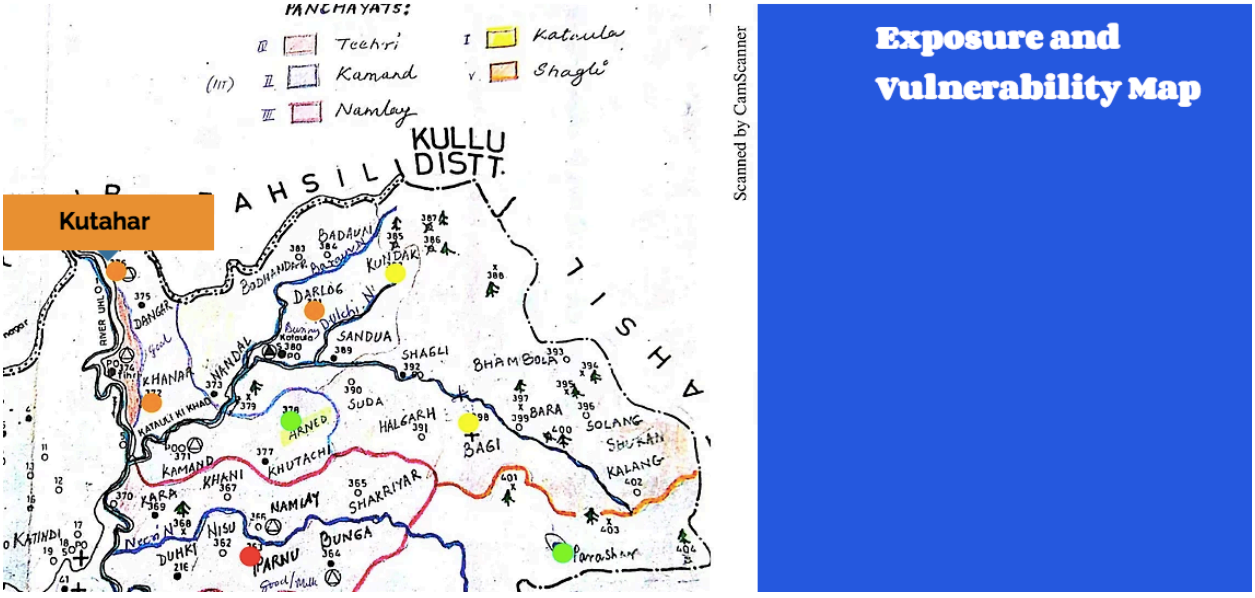

Figure 13: Exposure and Vulnerability Interactive Webpage

Recommendations

Our analysis of the Mandi District's exposure and vulnerability to climate change has revealed that there are two significant factors contributing specifically to the rural communities' vulnerability to climate change.

1. There is the little work available to residents outside of their village.
2. There is little (if any) income due to the fact that residents are unable to sell their excess crops.

Of these two factors, addressing the first has the greatest potential to reduce the vulnerability of the villages. As the climate continues to change, agriculture will become increasingly unreliable source of income. Even if the second factor above was addressed, the residents would still be very reliant on the climate. As a result, adaptation policies in the area should instead focus on increasing the availability of occupations outside of subsistence agriculture. In some cases, policies may call for improved infrastructure (for example, improving the quality of roads) in order to facilitate access to jobs due to the remote locations of the villages. Another approach is to provide job training for residents. In either case, government interventions should be centered around creating work for the villagers that is not reliant on the increasingly unreliable climate. This approach, if successful would likely decrease the vulnerability of the villages.

The above approach would require significant changes to the way of life of the rural residents of Mandi District. Remote villagers would likely have to travel for work outside of agriculture. This would dramatically change the day to day life of these villages. Facilitating work outside of the villages would result in fewer villagers that are available during the day to do any necessary tasks. Finally, although increased employment outside of the village may reduce vulnerability to climate change, it would increase vulnerability to economic fluctuations. Villagers that are largely farmers now would become susceptible to unemployment and other issues related to the larger economy of the region.

Another approach the government could take is addressing vulnerability through sensitivity. Only three of the villages had access to large and consistent natural water sources. The government supplied water is only enough for drinking not for irrigation. This water scarcity is a primary contributor to the vulnerability of the region. However, although one might consider the government providing additional water to support irrigation, this may not be a long-term solution as this water also comes from natural sources in Himachal Pradesh. These water sources are subject to the same strains from climate change. Instead of being susceptible to drought in their local area, villages would become susceptible to drought in other areas of Himachal Pradesh. Providing enough water for irrigation would also be a very large project for some of these remote villages. The population of the area may not be large enough for the government to consider implementing such a costly intervention. Increasing government water supply to rural villages does not solve a problem, at best it delays the impacts of climate change and masks the issue until it becomes dire.

Finally, we recommend a combined approach. These villages need access to drinking water and water for irrigation. They cannot transition away from farming in a single season and probably will never do this entirely. This water would be provided by the government as an expansion of the current system. It is understood that this is not a permanent, long term solution to address the vulnerability of these villages, rather it is a short-term solution that will reduce their sensitivity to the reduction in rainfall. Providing access to work outside of the villages will address vulnerability in the long term by creating a source of income that is not dependent on the climate.

VI. Conclusions

As demonstrated throughout the course of this report, Mandi District, and likely similar regions in this part of the world are particularly exposed and vulnerable to climate change. This is due to its dependence on the southwestern monsoon, winter precipitation, and snow and glacial melt for freshwater, as well as the general climate conditions for sustaining local agriculture (Asian Development Bank, 2010; Pandey et al., 2016). Rising temperatures and decreasing amounts of precipitation have already begun to have negative social implications in the area, particularly with regard to freshwater resources (Jena et al., 2016). In order to implement policies to counteract these negative implications, it is important to take public perception, exposure, and vulnerability into consideration. Listening to the stories of these villagers revealed the ways in which these people understand their environment and the changes therein. Our research identified that the residents of Mandi District are aware of the changes in their climate and that these changes are already impacting their lives. These residents are concerned about climate change and believe human action is necessary to address the issue. Further research is also required to more adequately map the vulnerability of the region. A continuation of this study or additional studies should be conducted to more completely assess the exposure and vulnerability of the region to climate change. Future studies may want to focus on more isolated communities. The villages in this study are all in relatively close proximity to IIT Mandi and most are reasonably close to roads. The study of communities with significantly less outside interaction would contribute greatly to the information on local perceptions of climate change and vulnerability. This information is best used to guide and focus adaptation efforts in order to address the concerns of the people. Our study provides a better understanding of climate change in Himachal Pradesh and its effect on the local community.

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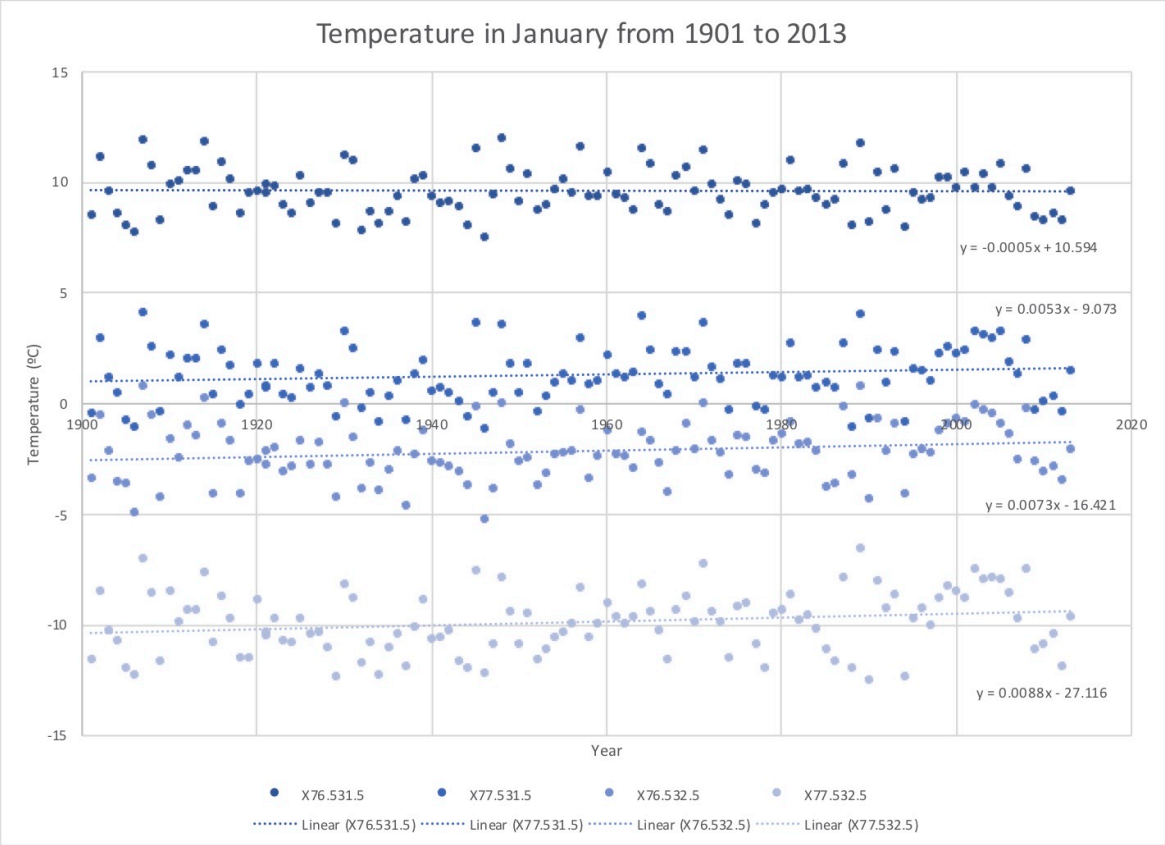
VIII. Appendices

Appendix A: Temperature and precipitation data



Source: (Sarkar, K., 2018)

Additional temperature and precipitation data for each month can be found at: https://drive.google.com/drive/folders/11BhJ0R4auH82DzKgBeSV8Zg_26Alky_N?usp=sharing

Appendix B: Interview guide

The order and wording of the questions varied as the interviews were designed to be open discussions.

(We begin with an introduction of ourselves and the sort of research we are doing)

1. How long have you lived here?
2. What sort of rituals/ religious ceremonies do you have?
3. What do you do for a living?
4. What sort of crops do you grow here?
5. Do you have cattle?
6. Is there a primary school in the village? Secondary school?

7. What sort of changes in the climate have you noticed over the course of your life?
8. How have these changes impacted your life/livelihood? Have you experienced problems with crop yield?
9. Is there risk of landslides here? Flash floods? Has the frequency of these events changed in recent years?
10. Is there any work besides farming? Does anyone work outside of your village?
11. Do you have access to government supplied water?

(Villagers typically have talked about an increase of temperature and decrease in precipitation, shorter winters with little snow, many mention a delay in monsoon arrival)

12. Have you tried growing different crops to handle the changes?
13. Have you had to alter planting and growing seasons?
14. What do you do with excess crops, are you able to sell them?
15. Have you ever heard of "climate change" or "global warming"?
16. What do you think the climate is changing?
17. Do you think changes in the climate are due to human activities?
18. Do you think people should take steps to address climate change? If so, do you have any ideas?

Interview recordings and transcripts can be found at:
https://drive.google.com/drive/folders/1F_vxZvX4bu4jmAOjVpAwkL9Tq64oGAE4?usp=sharing

Appendix C: Village Profiles

Village	**Altitude (m)**	**Population**
Arnehar	1340	745
Bagi	1600	342
Darlog	1600	220
Khanahar	1400	444
Kundak	1800	485
Kutahar	1300	359
Mandi Town	850	26,873
Parashar	2730	N/A
Parnu	1420	144

Source: (Sarkar, R., 2018)

Photos from each village can be found at:
https://drive.google.com/drive/folders/1htcZy6spYVDqCdIW7ufhDGkB-s0KXOQk?usp=sharing

Appendix D: Poster

Perceptions of a Changing Climate, Exposure, and Vulnerability in Himachal Pradesh

Troy Bergeron (WPI), Aylin Padir (WPI), Rahul Singh (IIT), Shubham Kumar Singh (IIT), Udit Soni (IIT)
Advised by: Dr. Astrid Kiehn (IIT), Dr. Kaustav Sarkar (IIT), Dr. Ingrid Shockey (WPI), Dr. Seth Tuler (WPI)

Implications of a Changing Climate

A Changing Climate

- Decreased precipitation in monsoon season and in winter months
- Increased temperature, especially in winter months

Associated Implications

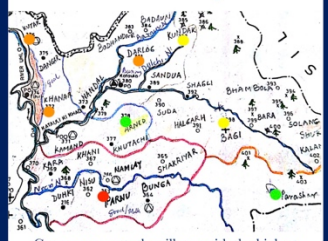
- Declining water availability for irrigation and personal use
- Shifting agricultural land use
- Shifting agricultural productivity

Understanding Risk with Regard to Climate Change

Associated Indices

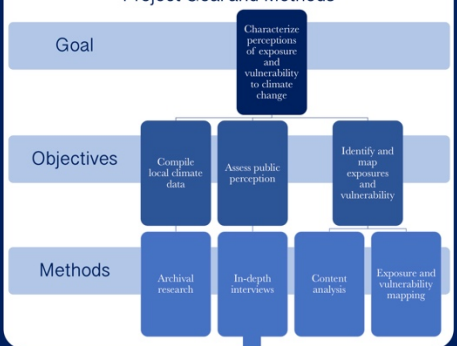
Perception	Exposure	Sensitivity	Adaptive Capacity
Awareness of climate change	Threat of landslides	Water availability	Ability to sell excess crops
Relationship to human activity	Threat of floods	Number of crops	Availability of work outside of the village
	Changes in precipitation	North/South facing	Education level
	Changes in temperature		
	Changes in length of seasons		

Measuring Exposure and Vulnerability to Climate Change



Green represents the villages with the highest combined exposure and vulnerability score, with yellow as the next highest. In contrast, red indicates villages with the lowest score, with orange as the second lowest. The combined exposure and vulnerability score was determined using the indices above.

Project Goal and Methods



Findings

1. There is little work available to residents outside of their village (i.e. agriculture).
2. There is little (if any) income due to the fact that residents are unable to sell their excess crops.

Recommendations

1. An expansion of the government water distribution as a temporary solution
2. The implementation of a work program for villagers outside of the agricultural sector

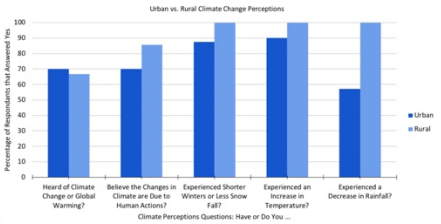
A Life-History Approach

The life-history approach captures perceptions by listening to stories of residents regarding how climate has affected their lives in the past and how its impact has changed over time. Here, we present some of their stories.

From the Villagers of Kutahar (left): *"[Our work is] mostly agriculture, it's all that we do. Our whole households are dependent on that. If by God's grace there is good rain then we grow enough with our hard work to keep our family going and if not then we do some manual jobs as workers and earn 20-30 Rs so that we can get our family rations. We somehow make our ends meet, some of our people go to Manali, to Lahaul, to Leh, to Kullu for seasonal works and we somehow survive, what's to be done – we've got to feed ourselves right?"*

From a shop-owner in Mandi Town (right): *"There used to be small shops on the roadsides in circular way. But now they have moved all the shops from there to here. This is because of population growth and traffic issue ... Population is increasing so the number of vehicles is also increasing. Every family has 2-3 vehicles. They use vehicles wherever they go ... Even for a small task, we don't want to walk. Vehicles release carbon dioxide. We should plant the Peepal tree which is found only in India -- it absorbs most of the CO2 and gives lots of oxygen. ... Environment was very good in the past. People are adapting individualism culture now. They don't care about others' problem. But in the past people used to solve the problems together."*

Quantifying Urban v. Rural Perceptions



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Hazard Image: http://clipart-library.com/hazard-sign-images.html
Exposure Image: https://www.gograph.com/vector-clip-art/flood.html
Vulnerability Image: https://www.ihacres.co.uk/courses/detail/safeguarding-vulnerable-adults
Exposure and Vulnerability Map: Dr. Rinki Sarkar, 2018
Water Feaure Image: https://www.pinterest.com/pin/415738695928638359/
Work Image 1: http://www.flickr.com/clipart-11664.html
Work Image 2: http://www.clipartpanda.com/clipart_images/two-laptop-working-clipart-58059004
Kutahar Photo: Troy Bergeron, 2018
Mandi Photo: https://i1.trekearth.com/photos/41312/imw.jpg
Team Photo: Dr. Astrid Kiehn, 2018

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Appendix E: Brochure

Our goal was to characterize perceptions of exposure and vulnerability to climate change among lifelong residents of Mandi District, Himachal Pradesh.

We accomplished our goal using a life-history approach, which captures perceptions by listening to stories of residents regarding how climate has affected their lives in the past and how its impact has changed over time. Here, we present some of their stories.

Mandi Town

On air pollution:

"[People] use vehicles wherever they go … Even for a small task, we don't want to walk. Vehicles release carbon dioxide. We should plant the Peepal tree which is found only in India -- it absorbs most of the CO2 and gives lots of oxygen. … Environment was very good in the past. People are adapting individualism culture now. They don't care about others' problem. But in the past people used to solve the problems together."

Fieldwork Photos

Climate Change Perceptions

Stories from urban and rural residents of Himachal Pradesh

Research conducted by Troy Bergeron (WPI), Aylin Padir (WPI), Rahul Singh (IIT), Shubham Kumar Singh (IIT), and Udit Soni (IIT)

March & April 2018

Kutahar

On climate change:

"[Our work is] mostly agriculture, it's all that we do. Our whole households are dependent on that. If by God's grace there is good rain then we grow enough with our hard work to keep our family going and if not then we do some manual jobs as workers and earn 20-30 Rs so that we can get our family rations. We somehow make our ends meet, some of our people go to Manali, to Lahaul, to Leh, to Kullu for seasonal works and we somehow survive, what's to be done – we've got to feed ourselves, right?"

Kutahar

On modernization:

"People of our land are hard to anger and very calm and peace loving, and according to me one reason is that mostly we don't consume refined oils or artificial Dalda … Our elders used to tell us that if you eat pure, you will get not get angry very soon. They were calm and muscular and strong. They were resilient and used to lift 100-200 Kgs of weight but now this trend is disappearing. The curse of cigarettes, drugs and other such habits are slowly starting to be seen. [Youngsters] see people do it and the start doing it. These things give vigor on outside only make you hollow from inside."

Khanahar

On health care:

"With rise in summers and if [water and waste water] areas are not properly cleaned, there would be rise in disease like malaria, dengue, typhoid etc. We rarely used to see these insects earlier but now there are a large number of insects like mosquitoes even in winters … God knows what will happen and with hospitals very far from us, the situation will be very grave … Sometimes blood tests have to be done for such diseases and people … have to shell out 5000-10000 Rs of cash on this. This puts extra pressure on the lives of individuals who are already poor, who are already dependent on a source of income which is not regular and dependent on monsoon. A person with regular job can afford to be sick but a poor person can't be sick if he has to survive in these regions."