WPI/IIT Mandi Project Center: 2019

Indian Institute of Technology Mandi

Annual Report

March 12-April 30

Worcester Polytechnic Institute 1865

WPI

Greetings from the Director

The WPI Project Centre at IIT Mandi has been running smoothly since 2013. Every year about 25 WPI students and 30-70 IIT students join hands in the ISTP-IQP teams. Over the years, these joint projects have explored assorted technological interventions in the villages and towns surrounding IIT Mandi, guided by 2 WPI faculty and a dozen IIT faculty every year. These projects have built up a valuable corpus of knowledge and experience.

The annual influx of ISTP teams into surrounding villages raises expectations of improvement in living standards in the villages of the region. To translate some of the ideas generated in ISTP and related courses such as Design Practicum and Major Technical Project into widely-used, sustainable technologies and products adopted by villagers of the Himalayas, IIT Mandi has several avenues. These include IIT Mandi Catalyst, the 1st technology-business incubator in Himachal Pradesh. EWOK, an incubator for businesses by rural women, was a direct outgrowth of 2 years of ISTP studies. Our Design and Innovation Centre and a number of sponsored R&D projects funded by the Himachal Govt and the Govt of India are also having a material impact on our vicinity.

With its growing maturity, the ISTP-IQP programme faces the challenge of how to retain its vitality. Some of the challenges to be addressed include:

- How to build on the corpus of previous ISTP studies, yet make a unique contribution?
- How to increase the benefits that flow back to the villages from ISTP and allied programmes?
- How to evaluate diverse projects fairly, giving due credit to the contributions of the team and of the individuals in the team?
- How to better mesh the disparate academic schedules of WPI and IIT?

Given the success of ISTP in attracting many WPI students every year, we are planning to expand ISTP to include institutions in other countries. To this end, ISTP may be run twice or even thrice a year.

Best wishes to all teams who will be participating in the Open House. I'm sure that your careers will benefit greatly from your unique experience in the ISTP-IQP. Thanks to the faculty from WPI and IIT Mandi, especially Dr. Ingrid Shockey and Dr. Devika Sethi, whose tireless dedication to this unusual concept is responsible for its success.

Timothy A. Gonsalves
Director, IIT Mandi
20th April 2019

WPI President Laurie Leshin with IIT Mandi Director Timothy Gonsalves

Welcome from the Project Coordinators

IQP/ISTP Coordinators (from left to right) Dr. Devika Sethi, Dr. Gbeton Somasse, Dr. Ingrid Shockey, Dr. Aditi Halder, and Dr. Dericks Shukla

This year, IIT MANDI hosted an International Workshop on Climate Change and Extreme Events in the Himalayan Region. It was a compelling reminder that we are situated here among the most beautiful and also some of the most fragile mountain environments in the world. At the same time, we have every resource of scholarship and outreach at our disposal to tackle the complexities of Himalayan ecologies and economies.

The ISTP was envisioned as an opportunity for science and engineering students to learn the value of culture and context in the pursuit and design of a better world. Beyond the project, this is a lifelong lesson in holistic thinking that will inform perspectives as they move forward in their careers. Whether the project engaged teachers, farmers, school children, ecosystems, economics, or climate, each investigation brought a chance to think about the interrelated manner in which we can join forces to solve problems. Some solutions come more easily than others, and some have attracted more media attention than others, but all of the work has generated a conversation on this campus and in the community to better the system or environment we live in. To that end, we thank the teams for taking the time to listen carefully to the stakeholders, and for undertaking the responsibility to express back what they have learned in these reports.

We are deeply grateful to Professor Timothy A. Gonsalves, who has championed this collaboration from the start, and to IIT Mandi for hosting the joint Project Center with WPI. We are honored to be part of a process that is building capacity between our partnering institutions, faculty, students, and local stakeholders. We hope you enjoy these reports!

April, 2019

IIT: Dr. Devika Sethi, Dr. Dericks Shukla, Dr. Aditi Halder

WPI: Dr. Ingrid Shockey, Dr. Gbeton Somasse

Table Of Contents

⇒ Evaluations of School Libraries in Himachal Pradesh
p. 75

⇒ Evaluating Sericulture Feasibility in Himachal Pradesh
p. 91

⇒ Smart Village Potential
p. 105

⇒ Feasibility of Improving Sanitation along trekking…
p. 119

⇒ Overview of needs and requirements of persons with disabilities….
p. 131

⇒ Evaluating Waste Management Practices of IIT-Mandi Campus
p. 145

⇒ Assessing technology as a tool in History Education
p.159

Supply for Fresh Fruits and Vegetables to the Campus from Surrounding Villages

Abstract

Farmers are the backbone of the country, yet they are one of the most underprivileged section of Indian society. In our project, we tried to understand the problems faced by the farmers and account for the economic disparity. In the process, we interviewed various farmers, vendors, wholesalers, and customers to understand their issues. The multiple interviews led us to recommend better agricultural practices to farmers, and also new types of storage facilities to store their produce for longer periods of time. We also developed an app.

Team Members

Param Kashyap (B16098)
Paresh Agrawal (B16042)
Amit Rajain (B16009)
Amirth Varshan (B16089)
Prashant Shekar Gupta (B16025)
Hardeep Malik (B16131)

Advisors

Dr. Satvasheel Powar
Dr. Surya Prakash Upadhyay

Helping Farmers gain profits

As we all know that farmers are the backbone of the agricultural industry yet, they are the most exploited and least paid individuals. Farmers contribute to about 15.37% of the India GDP, yet their monthly income is a meagre Rs.8,931 which is below the national average of Rs.9,416.66. Inadequate storage facilities, low bargaining power, and other factors have led the farmers at minimal profits or sometimes a loss.

Here at Himachal Pradesh, we identified the problem on both the farmer side and consumer side. Only the middle man makes the most profit. Farmers sell their produce at a low price, and consumers buy at high prices from vendors even though they are not fresh enough to consume.

The idea of this project was to understand the difficulties faced by the market participants in the agricultural industry and to account for the vast gap in cost. The goal of this project was to carefully look at the options available and feasible to increase the farmer's income and equally enhance the value for consumers. The project would require a logistics approach at digging out all the possible flaws in the chain and then rectifying it to benefit all the segment proportionately. Hence, we aim at helping farmers to get more profits from their produce and help consumers get a fresh supply of fruits and vegetables.

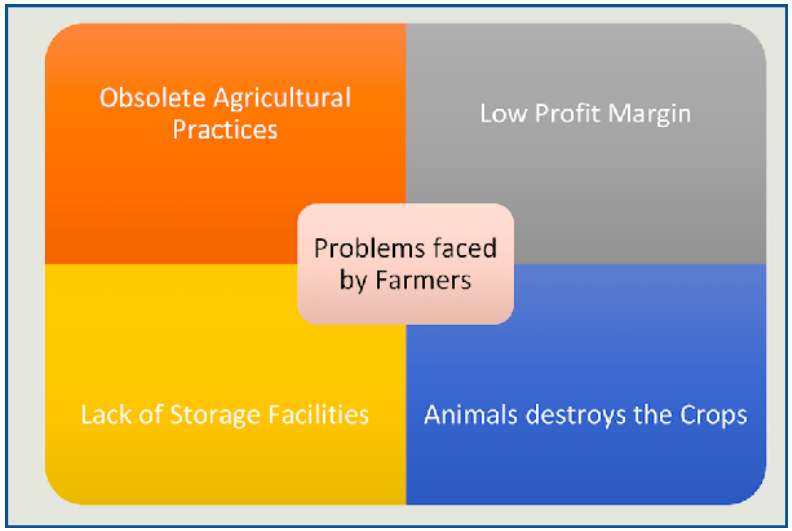


Fig : The prevalent problems of farmer in this region

Understanding the prevalent situation

Himachal Pradesh lies in the temperate region and in this region a variety of fruits and vegetables are grown (State Department of Horticulture, 2018). Despite this favourable climate, the farmers in Himachal are not well off. In this project, we looked into the various possible problems faced by them and also on how we can improve their situation. We also took an insight on the problems faced by the customers who buy vegetable and fruits from the market.

The climate and geography of this region is conducive to large harvests. The warm weather and rain make the area very suitable for growing fruits and vegetables. The monsoon season, from July until September, brings plentiful rain to needy crops, hastening growth (Arnfield, 2016). However, these conditions are very poor for storing crops in the open or in makeshift storage. This forces the farmers to sell their produce early into the market which in turn leads to lower returns for the farmers. Some of the farmers which we interviewed claimed that at times they have to sell 35kg of vegetables for a meagre Rs.100 and this return is lower than the investment.

Apart from this the other major problem that the farmers face is the monkey problem, over the various interviews that we conducted across Riyagadi and Navalay farmers expressed their concern that the monkeys ruin almost 25% of their produce even before they could actually harvest their produce.

The customers who buy fruits and vegetables from the market have their own concerns. They have complained that they don't get fresh fruits and vegetables. Also, they get farm products from the market at really high prices. The customers believed that if they are directly connected to the farmers then it would ensure that they get fresher supply of vegetables.

The Himachal Pradesh krishi Market Committee have decided upon a rate to be given to the agents to facilitate the sell of the vegetables and fruits. The agents sell vegetables and fruits by auctioning them. They charge a commission of 5% for this (see figure 3).

(Above) Figure 3.

(Right) Figure 4: The poor packaging of vegetables and fruits often lead to wastage

There is also a lot of wastage in transport of fruits and vegetables. These are perishable goods and often during travel due to poor packaging and poor handling the fruits and vegetables suffer damage (figure 4) Peels could be punctured in transit. The fresh opening in the fruit or vegetable will rot more quickly (Harvesting and Food Handling). Furthermore, the fruit /vegetable becomes a food safety issue, as consuming fruit which has been punctured and exposed can cause illness (Parasites, 2013). Also, this wastage is unaccounted for and no utilization is done of the waste produced.

Need for storage facility

Fischbacher and Marsden (1966) indicate that refrigerated or controlled atmosphere storage can increase the shelf life of fruits and vegetables by a long time. But the number of storage facilities in India is really low. As of May 2015, there are only 7 cold storage facilities in the region (Bodhi, 2015, Sharma, 2013, and Sally, 2011). Figure 5 demonstrates that Himachal Pradesh is in desperate need of cold chain infrastructure as compared to other Indian states. This less number of cold storage facility can be attributed to the fact that the cold storage facilities are expensive.

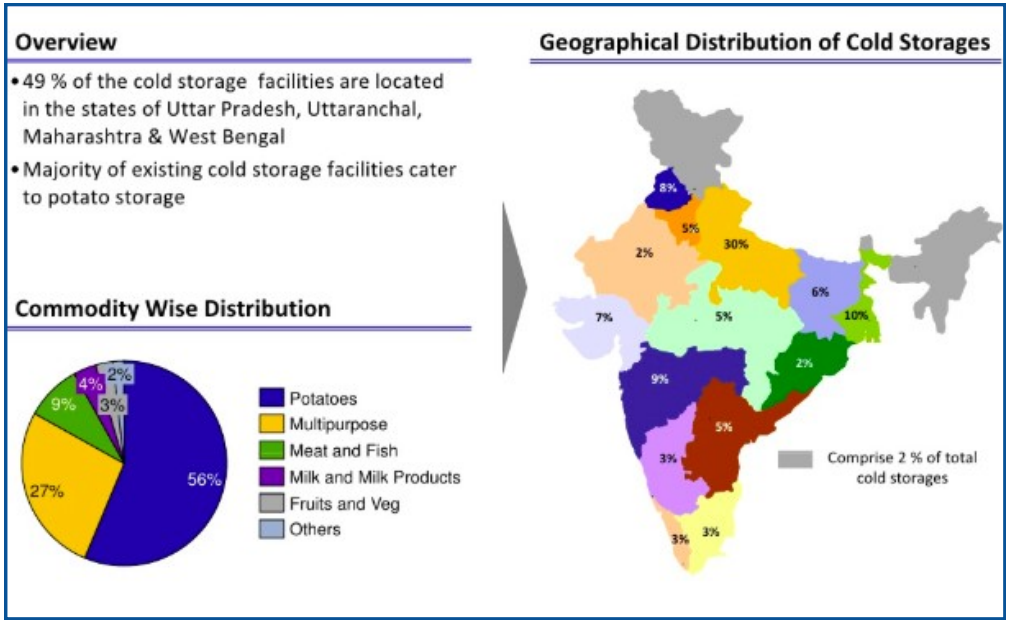


Figure 5 : Cold storage facilities in India

Need for Mobile App

The problems faced by the farmers align with the problems faced by the farmers. So, the best way to solve this would be to connect them. As part of the study conducted by the Boston Consulting group titled 'The rising Connected Consumer in Rural India.' Around 70% of the internet users in rural areas use social networking sites on their mobile phones, this indicates the high percentage of active mobile users in India. Figure 6 indicates the internet users in rural India. Thus an app would be a reliable source of connecting the farmers with the consumers.

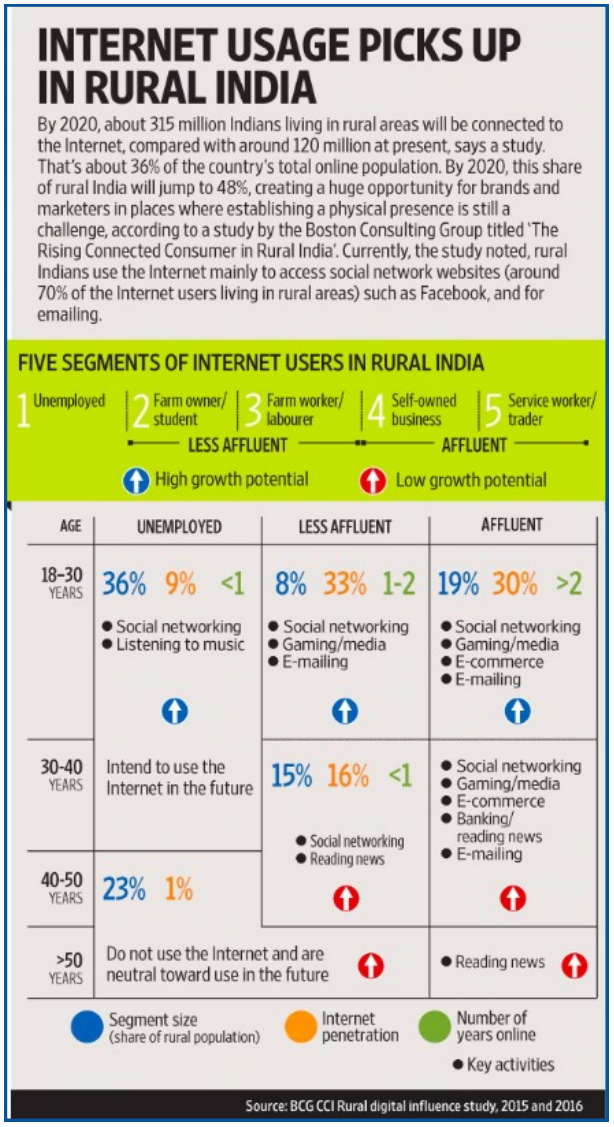


Figure 6 : Internet Users in Rural India

Methodology

There are two main stakeholders in this project the suppliers (farmers) and the consumers (mess, faculty members, staff members, and students). Looking at the more significant requirements, we targeted one of the messes (pine mess) to figure out a proper demand to get an idea of how much vegetables are required. The amount needed by faculty members and students might fluctuate by a lot. The mess has a suitable weekly schedule, and we got a clear picture of the demand.

Now we reached the suppliers (farmers) to find out how much they produce in a span of time, e.g., per week. And the availability of the demanded vegetables throughout the semester/season.

Conducting surveys and interviews

We focused on two villages Navalay and Riyagadi and interviewed few farmers about the issues they face while cultivating crops here. Next, we conducted surveys in both the villages and noted the variety and amount of crops they can produce.

There were crops which were available for a few months only and some were available throughout the year.

Surveying vendors in Mandi

We conducted interviews with the vendors in Mandi to know about their situation. We found that they buy vegetables from the wholesalers and they are allowed to sell the produce at prices 145% of the rate at which they buy the produce from wholesalers. This provision covers the losses made from wastage. Around 20-25% of the produce gets wasted on retailer side either due to spoilage or because they don't get buyers. See figure 7.

(Right) Figure 7 : Interviewing Vendor in Mandi

Connecting consumers and farmers

To make it comfortable for the consumers to select their products we created a user-friendly app which allows the farmers to directly or indirectly(with the help of BPOs) to input their produce, then consumers can place an order in the app.

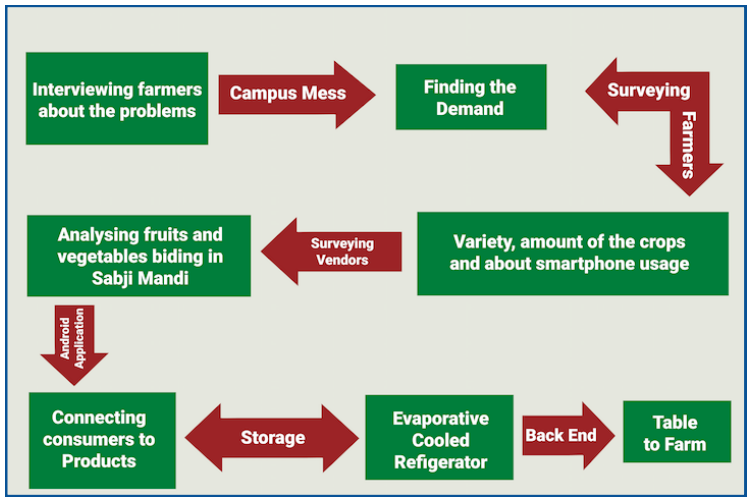


Figure 8 : Flowchart for project

Results

The interviews conducted by us gave us great insight into the present problems faced by the farmers and also we got to understand the loopholes in the existing system. This learning led us to understand what best can be done to overcome the current problems and help farmers earn higher profits. Also the findings helped us to understand what best can be done from the viewpoint of the consumers to help them get fresh fruits and vegetables at relatively lower rates.

The significant problems that the farmers faced were poor irrigational facility and lack of storage facility, and also that half of their crops were destroyed by monkeys even before they could be harvested. Also, the lack of storage facility forces the farmers to sell their produce at a meagre cost, causing considerable losses to the farmers. Also, about 5% of the produce is wasted in transport and the fact that sometimes there are fewer buyers for certain vegetables and fruits.

Apart from interviewing the farmers we also extensively interviewed the other members of the value chain, retailers and wholesalers in Mandi, to know about the existing system. Also, we found that more than 25% of the produce goes as waste which has no use. The survey which we conducted among the mess in both the campuses we found that the mess vendors had to dole out a lot of extra money to purchase vegetables and also there was a measurable wastage (about 5 %) while bringing the vegetables from Mandi to campus.

Due to lack of storage facility, farmers have to sell their crops at a cheap rate to avoid wastage. Therefore, low-cost storage facilities are the need of the hour. Not only storage facility would increase the shelf life of the vegetables, but also increase the profitability of the farmers. Since a proper and cheap storage facility would enable the farmers to delay their point of sale and help farmers reap profits.

We were able to get data on the prices at which the farmers sell their produce to the vendors and the rate at which the vendors sell their produce to the consumers. We were startled to see the difference in prices. The vendors sell at almost double the rate at which they it. This is not in accordance with the law set by the Mandi administration which re-

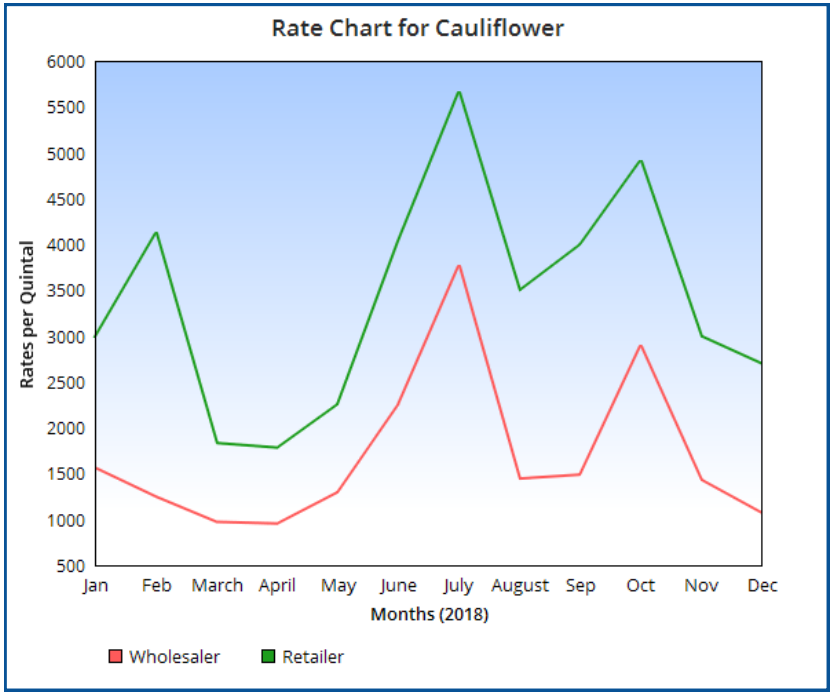


Figure 9 : Graph for difference in price of cauliflower sold by Retailer to the price sold by Farmer

The survey done on the campus fetched positive results for us. We contacted the mess vendors and the mess vendors in their interviews showed their eagerness to buy from the farmers in the nearby farms. This would help save them the cost of transportation and also provide them with fresh fruits and vegetables. Their demand was in tandem to the supply by the farmers. Figure 10, shows the demand for d1 mess for a week.

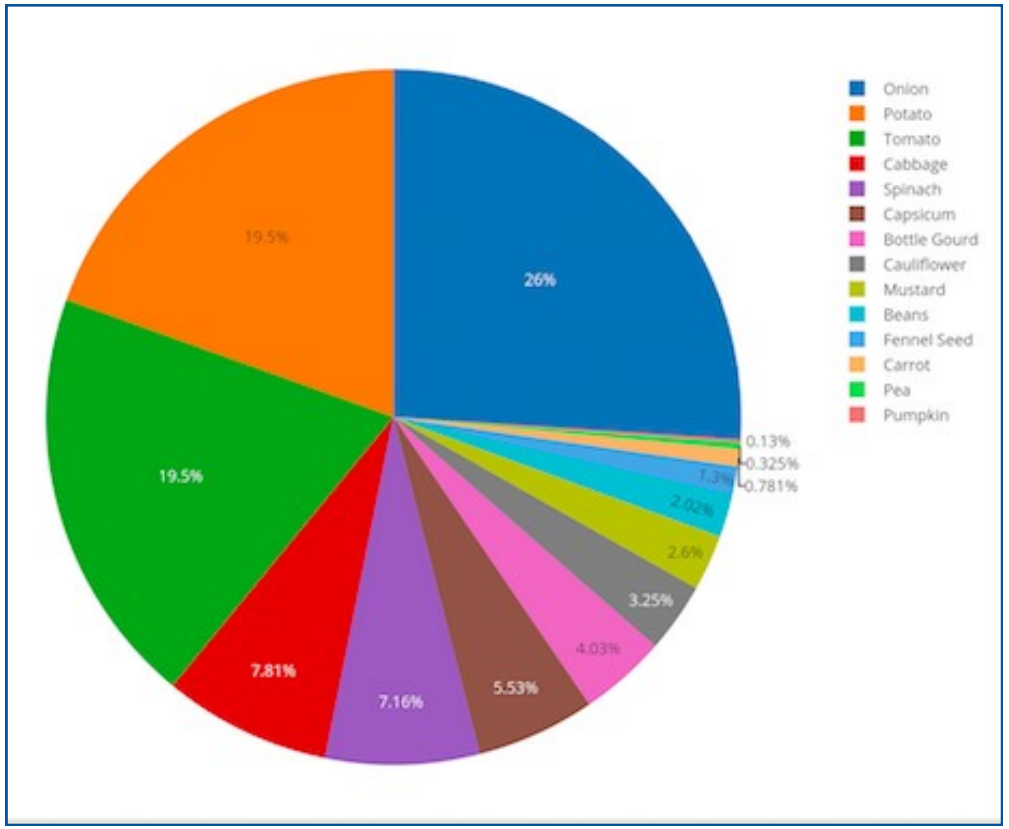


Figure 10 : Demand of vegetables for d1 mess.

The surveys gave us some other insights on the existing situation. There is a lot of waste that is unaccounted for. The wastage from the farm directly go to the dustbins and from there they go to the dump yards. These farm wastes are bio-degredable and if treated properly these are excellent source of manure. Figure 11 shows the wastage in terms of produce.

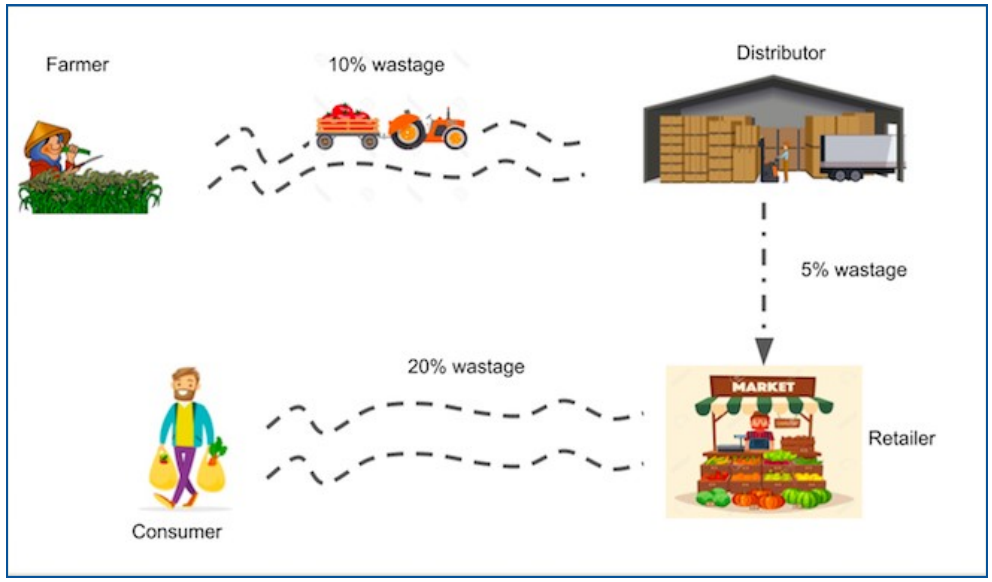


Figure 11 : Farm wastage

Also to quote Mr. Yogesh Thakur, one of the vegetables vendor in Mandi :

> "We bring about 100 kg of vegetables from the main mandi. Out of these around 20-30 kg of vegetable go waste because no one buys it and we have no place to store these vegetables. We are willing to sell the waste for free to anyone who is willing to buy it"

Discussion

Figure 9 clearly indicates that the rates of vegetables and fruits vary over season. During off season the prices of vegetables shoot up and during season the rates of vegetable are relatively lower.

If you take the case of cauliflower as in figure 9, during the start of the season(October-Nov) the prices go up but as the season proceeds, the prices fall down. This is due to the fact that the market has surplus. If the farmers don't sell their produce during this time but keep it in some kind of storage facility they would be able to sell the cauliflower in future when the rates are bound to increase as shown by the graph in figure 9.

The data showed that both the consumers and the farmers will be willing to use the app to buy and sell the vegetables. This not only ensures higher return for the farmers but also prevents a lot of wastage. The consumer on the other hand is ensured of high quality fresh vegetable and fruit.

Project Outcomes

We felt that most of the problems of the farmer can be resolved if they are directly connected with the consumer. To solve this problem of the gap between the farmers and the consumer, we have developed an app. This app would help the consumer know what all vegetables are available fresh and they can order it through the app. This would ensure that the consumer gets fresh fruits and vegetables, and also the farmers get a higher share of the profit.

Also, we informed farmers of the better agricultural practices, and we also showed them the rate variation graph over a different season. This ensured that the farmers are aware of the advantages of having storage facilities.

Figure 12 shows the chart in which we clarify the goals we had in our hand before the start of the project and the deliverables from our side.

Goals	Deliverables	Recommendations For Future
More profit for the farmers	Android App	Cheaper storage facilities
Help Consumers	Android App	Fresh vegetables at Cheaper rate
Inform farmers about Their shortcomings	Android App	Managing wastage

Figure 12 : Goals and Deliverables

Long Term Recommendations

After going through all the supplying processes, one crucial challenge was to manage the waste created by this, which includes the surplus amount of the supplied waste generated plus the vegetable waste produced by the mess and the rest of the consumers.

We had a few options to deal with this kind of waste

1. We could find a way to get back all the biodegradable waste in the campus and feed the livestock with it.
2. We could provide this waste as an input to the biogas plant on the campus. But the plant's capacity is minimal compared to the generated waste.
3. We could use a process called “table to farm” (figure 13)

The idea is to collect the waste (vegetable) by using bins and convert the waste into manure and resend this manure back to the farms, which is the origin of these vegetables, making this cycle truly complete and waste-free.

Possible storage idea

These farmers always had problems with storing the perishable crops produced, which is one of the reasons why they sell their output for such a low cost to the vendors. There are low cost evaporative cooling technology based cooling solutions available in the market. We intend to apply a similar concept in the local market. This works basically on the principle of mud pots except that one can store vegetables and edibles in them.

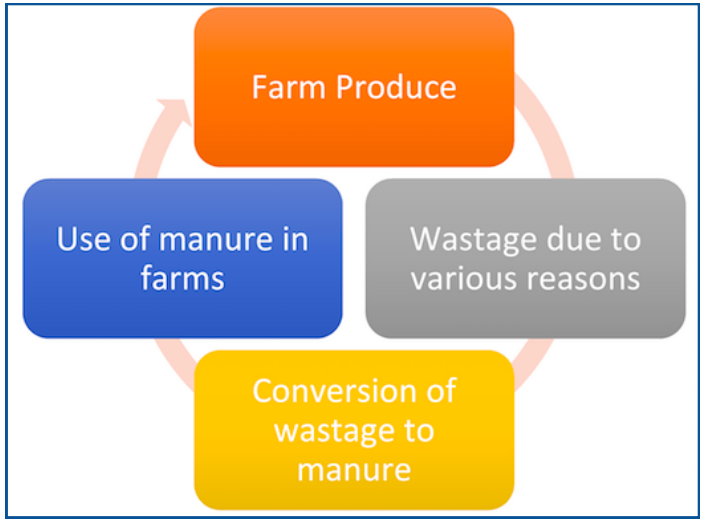


Figure 13 : Table to Farm concept

Conclusion

The project gave us a great insight on the current situation of the farmers and the plight they are in. The farmers that we talked to gave us some vital information. They said that their younger generation is no longer into farming and the number of farmers is constantly dwindling. This is not at all a good sign for anyone. We as responsible citizen of this country should take the onus upon us to make sure that farmers live a respectful life.

The app made as a conclusion of the project will eventually help farmers grow and in turn earn larger profits. This would also help the customers get fresh supply. The conversion of the waste from farms into manure can prove to be a big opportunity for farmers to gain extra bucks. A future project on how to effectively convert farm waste into manure should be taken up by teams.

Acknowledgements

We would to thank our advisors, Professors Satvasheel Powar and Suryapraksh Uphadhaya for all of their support and feedback, especially with all the twists and turns this project has taken. We would also like to Devika Sethi for all of her help and information and our TA, Varun Kumar, for the assistance with finding and getting in contact with farmers.

Works Cited

Fischbacher, C. A., and K. J. Marsden. "Progress in Refrigeration Science and Technology." Physics Bulletin 17.6 (1966): 205.

Choudhary, A. K. (2016). Scaling-up of protected cultivation in himachal pradesh, india. Current Science, 111(2), 272-277. Retrieved from http://www.currentscience.ac.in/Volumes/111/02/0272.pdf

http://www.nhb.gov.in/OnlineClient/MonthwiseAnnualPriceandArrivalReport.aspx

https://www.livemint.com/Consumer/QgM23BLpCo4ovHxA0jpOGM/Rural-India-getting-online-faster-BCG-report.html

Kalyanasundaram, J. J. (2015, June 27). Managing fruit fly in mango. Retrieved April 18, 2017, from http://www.thehindu.com/sci-tech/science/managingfruit-fly-in-mango/article7130611.ece

Mishra, S. (2002). Calcium Chloride Treatment of Fruits and Vegetables. Retrieved April 18, 2017.

mKisan http://mkisan.gov.in/

The full report can be found at the IIT Mandi, ISTP website.

Farm near IIT Mandi campus
Picture credits: Dr. Ingrid Shockey

The Story of Climate Change in Himachal Pradesh

Abstract

Climate change research has focused on scientific data as the driving force in building awareness of climate change. Less has been done to collect climate data from the perspectives of ordinary people. Ethnographic approaches enable citizen science participation in climate change research. We conducted and recorded semi-structured interviews and collected stories of lifelong residents in Himachal Pradesh to assess the perspectives of climate change. These findings communicate subtle perspectives on the experience and indicators of climate change through the stories.

Team Members

Rohan Agrawal (B16075)
Kevin Baptista
Emma Edwardson
Rachit Maheshwari (B16071)
Brant Reymann
David Santamaria

Advisors

Dr. Ingrid Shockey
Dr. Gbeton Somasse

Documenting Climate Change Perspectives

While climate change trends and projections are on a global agenda, less data has been recorded that reflects the climate change experience for individuals and families. The science behind climate change can be given a voice by documenting first-hand accounts of changes that local residents have observed in their communities. In fact, it is the first step towards gathering strength for policy interventions and for the world to acknowledge the implications of climate change on families and individuals in communities.

With objectives such as the United Nations Sustainable Development Goal for climate action at the forefront of global assessments, understanding what communities are experiencing on a daily basis is crucial to ensure that strong policies are put in place. The climate action goal aims to "promote mechanisms for… effective climate change-related planning and management in least developed countries… including focusing on women, youth and local and marginalized communities" (Goal 13: Climate Action, n.d.). Furthering this directive for research in Himachal Pradesh is critical as rural communities of this region have begun to feel the effects of climate change, and these effects will only worsen in the future.

Figure 1: Remnants of a bridge destroyed in a flash flood in Bagi village (Photo by Brant Reymann).

While there is an abundance of scientific data, there is less ethnographic data related to climate change. This project joins an expanding effort to document perceptions and experiences of climate change around the world. In 2014, a group of Worcester Polytechnic Institute (WPI) students working in New Zealand collected and analyzed responses from public interviews in order to understand perceptions of climate change (Kodzis et al., 2014). To advance this work, a joint team of students from WPI and IIT launched an initiative in the spring of 2018 to record the voices and stories of climate change in Himachal Pradesh, India (Bergeron et al., 2018). The team recorded risk and resilience in villages around Mandi and used Instagram to promote profiles of the villages. The project continued in Iceland in 2018, where students produced a short film to profile the climate change stories impacting northern latitudes, and Japan (2019).

Media serves as a worldwide platform that can express climate change experiences in vulnerable communities. A majority of Himachal Pradesh relies on agriculture for their livelihood, an industry that has been increasingly affected by climate change. Climate change storytelling can voice the struggles felt in communities. Narrative research can play a crucial role in understanding how climate change affects individuals and families. The stories that result put science on a scale that is humanized. A deeper understanding of the effects of climate change can better government policies and help prevent further environmental effects.

This project has expanded our reach in rural villages of Himachal Pradesh. It is a challenge to understand how a community has become different due to climate change, even for residents. Responses and perceptions of climate change cannot be predicted, so there is no set narrative for how different communities experience climate change. The goal of our project is to expand the work of the 2018 study in Himachal Pradesh to understand the experience of climate change in rural communities. Toward this goal we recorded ethnographic stories of lifelong residents in Himachal Pradesh. We documented audio and visual indicators attributed to climate change by residents. Lastly, we assessed the perspectives of local experts. By accomplishing these objectives, we gained a better understanding of personal and community experiences of climate change and gave a voice to the impacts felt throughout Himachal Pradesh.

State-Led research and initiatives in Himachal Pradesh

In response to widespread indicators and projections for climate change and the implications for Himachal Pradesh, the state has taken research and policy initiatives to promote awareness and response. In 2007, the National Action Plan on Climate Change was prepared in order to create a national plan "for addressing the challenge of Climate Change, and the action it proposes to take" (NAPCC, 2008). The plan includes sustainable development strategies to combat climate change and enhance ecological sustainability. This action aligns with the UN's sustainable development goal on climate action. One of the targets of the climate action goal is to incorporate climate change measures into national policy. India is also working to reform their infrastructure and decrease their carbon footprint while also working to protect vital ecosystems that support life throughout the country. The NAPCC has put forth eight national missions aimed to "promote understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation" (NAPCC, 2008).

One of these eight missions is the National Mission on Strategic Knowledge for Climate Change. This mission focuses on correcting the lack of climate change data available in Himachal Pradesh. The International Panel on Climate Change, or IPCC, has released reports detailing climate data in the Himalaya, but there are little to no reports based in Himachal Pradesh (NAPCC, 2008). In the years directly following the NAPCC's inception there were numerous government-sponsored studies conducted in Himachal Pradesh about agriculture, biodiversity, glaciology, forests and rainfall. The most recent study published, however, was in 2015. In addition, about a quarter of the web-based links are no longer activate. A ten-year assessment on the NAPCC's eight core missions done in 2018 concluded that all eight missions are behind schedule and lack funding. This calls into question the ability of the government to enact change on a governmental and community level. According to the Global Climate Change Risk Index, published in 2018 by German Watch, India is the twelfth most vulnerable country to climate change impacts (Eckstein, 2018).

Implications for Himalayan region

The state of Himachal Pradesh, India lies at the foothills of the western Himalayas, and nearly 90 percent of people live in rural environments (Asian Development Bank, 2010). The communities predominantly rely on agriculture, leaving approximately 80 percent of the residents to depend on rainfall for their livelihoods (Loria, 2016). The area is one of the most sensitive regions in the world for climate change. The cumulative effects of these impacts have created an uncertain future for those living in affected areas and leave open the question of strategies for community survival in fragile ecosystems.

Figure 2: Snowline looking out from Chansari Village (Photo by Brant Reymann)

Among the most reported indicators for climate change in Himachal Pradesh are troubling accounts of increasing water scarcity. In fact, there is strong evidence "anthropogenic climate change is one of many stressors of water resources" (IPCC A 2014). Many farms are partly dependent on rainfall to provide crops with water. In Kullu, a district in

central Himachal Pradesh, 95% of farmers interviewed reported that the rain from monsoons are insufficient for irrigating crops. Many of the farmers were able to use the regularity of rainfall to their advantage, however, many have reported that in recent years the rain has become completely unpredictable (IHCAP, 2016).

In addition to the previously mentioned long term effects, Himachal Pradesh is vulnerable to climate-related disasters such as landslides, cloudbursts and glacial lake outburst floods, or GLOFs (IHCAP, 2017). Landslides can cause direct damage to villages and vehicles on the road, but they can also cause floods by blocking river flow, or damaging dams (IHCAP, 2017). Floods and landslides can be extremely destructive, making it more difficult to adapt to the long term effects of climate change.

Early reports on climate change conclude that environmental effects bring social implications that can be devastating to communities. These effects can disrupt transportation networks, reduce farmers' crop yield, and cause destructive disasters (IHCAP, 2017). Apples are an important part of Kullu's economy, and climate change has had a negative impact on the production of apples. There has been a decreased crop yield and a shift in the location of apple orchards to higher altitudes. Communities are moving away from traditional agriculture, instead cultivating cash crops and joining the tourism industry (IHCAP, 2016). Tourism, however is also at risk due to threats such as floods and landslides; a 2013 flooding in Uttarakhand caused an 85% decrease in tourism, resulting in a US$ 1.85 billion loss to the state's tourism sector (IHCAP, 2017). These measurements and statistics are important, but they lack neglect critical perspectives from the residents themselves. Linking scientific data with stories can create a connection that enriches understanding and empathy.

Ethnographic Climate Change Research

The climate stories recorded in Himachal Pradesh in 2018 indicated that while some residents do not fully understand the scientific basis for climate change, they do have an awareness of deep changes that have occurred at the community level (Bergeron et al, 2018). Ethnographic recordings can be used to update climate change research and bridge the gap between government literature and observed indicators of social and environmental stress in Himachal Pradesh. By creating synergy between government agencies and villages, residents can better understand the tools and policies that can help them combat environmental, social, and cultural effects of the change and vice versa.

In recent years, an interest has grown in studies on climate change that include a narrative or citizen science approach. A study by Dahlstrom (2014) furthermore found that using narratives to inform is more appealing for non-expert audiences. Moezzi et al. claims that stories, "provide insight, and reframe evidence in ways that more science-ordered formats miss" (2017, p.1). Both sources agree that the use of narratives in research can put science on a scale that is humanized. The stories are relatable, and communicate challenges that are not always seen, catalyzing increased empathy for climate change in vulnerable communities.

Paschen and Ison (2014) found that narrative research in climate change adaptation can construct stories about problems through local knowledge and past experience. The values of the community are then more easily integrated into local policy and management, because how a community understands "past experiences...determines how it understands and practices future adaptation" (p. 1084). In order to record narratives, open ended research questions are best, and images can be a powerful tool for communicating the effects of climate change. Wozniak et al. suggests that images provide a dramatic visualization of climate change while still being easy to understand and ethically compelling

Figure 3: Interviewing a subject at Prashar Lake (Photo by Brant Reymann).

While there is plenty of consensus that narrative and ethnographic research is a useful tool for studying climate change, there is comparatively less data on how audiences perceive and adapt to the effects climate change. Across the Himalaya, no two communities are affected by climate change in exactly the same way, nor will they adapt in the same ways. Some experience vary within a community, even between residents. Their responses and perceptions of climate change often cannot be predicted, so there is no set template for how different individuals experience climate change. Ethnographic study encourages the sharing of these points of view and allows for expression of indicators and stories of those affected in Himachal Pradesh.

Project Approach

Here we give an overview of the data and methods we used to complete our project. The goal was to document the experience of climate change in communities in Himachal Pradesh. To accomplish this goal, we outlined three objectives:

A. Record ethnographic stories of residents.
B. Document audio and visual indicators of climate change.
C. Assess the climate change perspectives of local experts.

The objectives and methods are summarized in the flowchart below, and then described in greater detail.

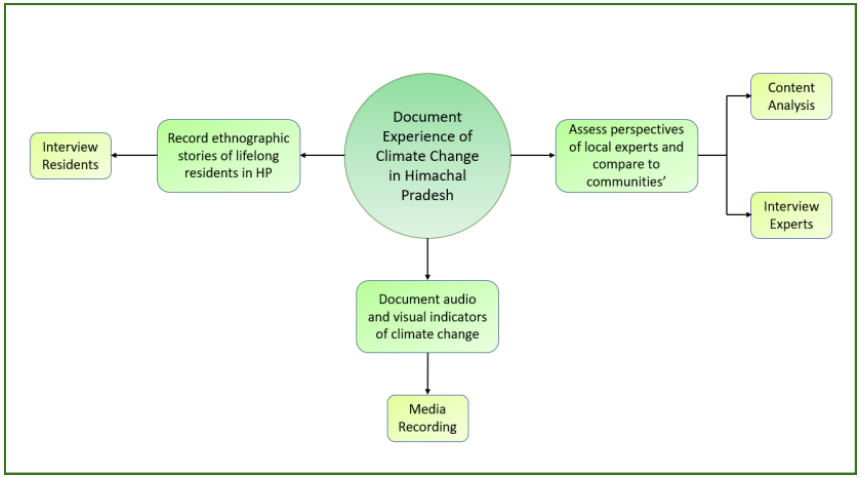


Figure 4: Overview of goal and objectives

Climate Change Storytelling

Our first objective was to conduct ethnographic interviews in Himachal Pradesh. To record these stories we visited rural communities in Himachal Pradesh, with a few chosen because of known climate change vulnerabilities. Figure 5 provides a map of the villages visited in 2018 (in green), along with 2019 (in orange). The map was created using google maps.

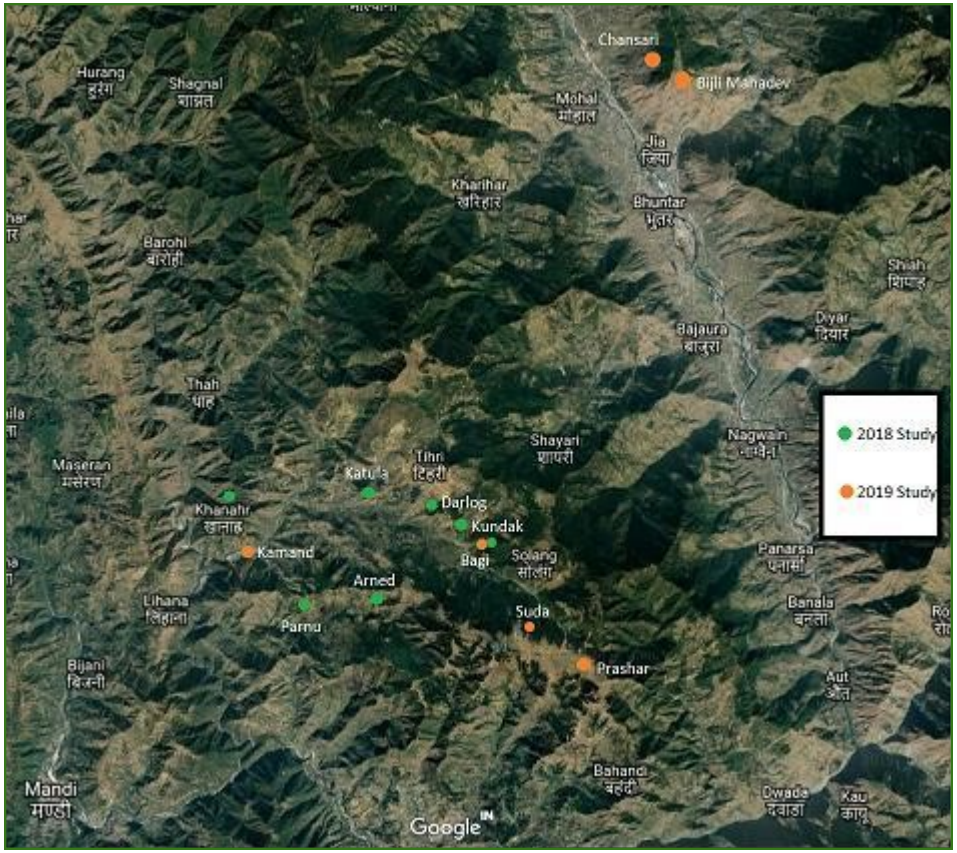


Figure 5: Map of villages visited in 2018 and 2019 (Google Maps, 2019).

Ethnography can "create richly written narratives" using the voice of individuals, something that quantitative research cannot fully achieve (Ward, 2014, p.65). Therefore, because the primary goal of our project was to collect experiences of climate change, we used face to face interviews, film, and photography to record the narratives. A filmed interview

set at Prashar Lake is shown below in Figure 6.

Figure 6: Interviewing a subject at Prashar Lake (Photo by David Santamaria).

We designed semi-structured interviews to initiate our conversations with residents. In order to encourage stories, Paschen et. al (2014) states that a "conversational interview technique with open-ended questions" works best (p. 1084). A conversational interview leads to the understanding of "seemingly unrelated socio-cultural or institutional aspects" that influence local perceptions of climate change (Paschen et al., 2014, p. 1084). Therefore, we began interviews by asking residents about where they are from and what they do for a living. We also asked more personal questions about their childhoods and how their lives have changed since then, and if they have any concerns for the future. We asked about changes in livelihood or agriculture patterns in the village. When relevant or interesting stories were told, we asked questions related to the stories. Every interview was different, and did not always follow the questions listed on the interview guide. Less personal prompts included questions about government subsidies and crop yield in the village. Our questions allowed residents to reflect upon social, economic, and environmental change in the community. In order to interview as many residents as possible, we used a sample of convenience or a snowball method of sampling. The stories recorded from the interviews were transcribed and translated. Next, the stories were combined with media such as photography and video to produce profiles for our media platforms: our Instagram account @messagesfrommandi and short videos for climatestoriesproject.org.

Audio and visual indicators of climate change

Our second objective documented audio and visual indicators of climate change to enhance the ethnographic stories recorded from residents. As Berg states that "the array of possible uses for... video and digital film data have simply grown too large to be overlooked or ignored by researchers" (Berg, 2014, p. 250). We prompted residents to point out or reflect on visual indicators of climate change in their community, and then used film and photography to document the responses. The responses could be prompted with discussions around planting dates or other environmental benchmarks. We then used digital and social media as our platform for presentation, bringing greater depth and clarity to the findings about how climate change has impacted lives in Himachal Pradesh.

Climate change perspectives of local experts

Our third objective was to interview climate change experts in order to understand whether scientists and policymakers are in sync with community members. We assessed alliances and discrepancies between observed indicators from local residents and actual perspectives from experts in Himachal Pradesh. To assess interview responses, we dissected transcripts to identify themes that showed shared or disparate responses between experts and residents.

Stories from Residents

Our team visited villages and recorded stories from residents primarily through filmed interviews. We found that climate change, global warming, and related terminology are still not well known among villagers, but many had stories about experiences and the impacts of climate change. We combined audio and visual to produce profiles that could be added to one of the platforms for the stories. One quick outlet for our profiles was the Instagram account @messagesfrommandi, where we have posted portraits of residents with a short story they have shared (see Figure 7). In this story about climate change, a school principal in Bagi village spoke about the "drastic change" she has seen at her summer home. At one time, they could fill baskets of mangoes, but now "there are no mango trees left" (Bagi village, March 23, 2019). She was concerned about the changes in flora and fauna, and what it will mean for future generations.

Figure 7: @messagesfrommandi Instagram post.

Many local residents told about their experiences of changes in livelihoods. The shifts in climate, combined with shifts in economy have pushed farmers away from traditional crops and toward cash crops, such as apples, barley, and wheat. Villagers in Chansari and Suda reported that they no longer grow traditional crops such as korda, saraya, and rajma because they are not productive enough to generate sufficient income. Residents of Suda reported that snow melt would "increase the productivity by three times" (Suda village, March 16, 2019). Now the village gets very little snow, if any, and agricultural productivity has subsequently suffered. Farmers have also started to use pesticides in order to increase the productivity of their crops. In Chansari, a farmer stated that his "crops are not growing as much" as his neighbors because they use pesticides and he does not. He also uses artificial sprays in order to fertilize his soil, something that was never needed in the past (Chansari village, March 30, 2019). Another cause of decreased agricultural production reported by villagers has been the increase in temperature of the region. In Chansari, a villager stated that he thinks the days are getting warmer because of "deforestation and factories… in the nearby region and because of pollution" (Chansari village, March 30, 2019). The village resident believed that the government should plant more trees to fight the pollution.

Moreover, some villages reported that young people have started to leave home because agriculture is no longer a sustainable livelihood. In Suda, many are leaving the village to find outside work because of the declining productivity of agriculture in the area. Younger generations have left to get better educations as well. While villagers support younger generations pursuing a higher education, they also expressed concern for the future population. Similarly, in Bagi, a school principal reported that children have a greater desire to study in the urban areas such as Mandi, which contributes to a decline in the interest of the agricultural lifestyle. The stories told by villagers were posted on our Instagram account, which is shown in Figure 8.

Figure 8: Gallery of @messagesfrommandi Instagram account.

Indicators of Climate Change

Perhaps because we were visiting in early spring, one of the most reported changes was a receding snow line. The village of Suda sits at 1560 meters with a nearly panoramic view of the Dhauladhar range. Here, a villager stated that 50 years ago, Suda would see one and a half to two feet of snow in the winters, but "now there is no snow, and much less on the mountains" (Suda village, March 16, 2019). The villager also pointed to another indicator of climate change. In previous times, snow cover on seedlings would result in natural branching of plants, but that has changed. Now, with no snowfall, young plants grow straight instead of the natural branching pattern as before (Suda village, March 16, 2019). The agricultural productivity of the village has subsequently suffered from the associated lack of snowmelt in recent years. Villagers in Chansari, a village high in the hills around Kullu, also reported decreased snow and a receding of the snow line, despite noting that 2019 received a normal amount of snow for the village after many years.

"Back when I was young the flowering season started March 31, but now there is a fifteen to twenty day gap in flowering. It has been pushed back along with the end of the season, it now goes into mid August. I think it's getting warmer because of the deforestation and factories in nearby regions. There has been great decline in quality of the apples, and there used to be big trees in the Kullu Valley, but now they have all shifted upwards.

Chansari Village

Many interviews told of shifts in agricultural crops and seasons. For example, in Chansari, where many apple farmers live, villagers told of a shift in the growing season for apples. A shop owner in Chansari stated that the growing season has been pushed back by fifteen to twenty days because, "the winter season used to last until April but now it is only until February" (Chansari village, March 30, 2019). In the past, apples had been grown in the valley of Kullu, but in recent years apple farms have all left for higher elevations due to the warming temperatures.

Villagers in Suda, Bagi, and Chansari also agreed that summers have been longer and more severe in recent years. Residents in Chansari have been attributing the length in the season to human activities such as deforestation and an increase in the number of factories throughout the region (Chansari village, March 30, 2019). Similarly, as the length of summers have increased, villagers in Suda have reported that they have now begun to face problems with water scarcity, which they attribute to the changes in the climate of the region (Suda village, March 16, 2019).

Perspectives of local experts

Our experts confirmed many of the same observations made in the villages, including worrisome trends such as the migration of apple orchards to higher altitudes. At the G.B. Pant National Institute of Himalayan Environment and Sustainable Development, we learned some prime examples of climate change seen from the government perspectives. The head of the institute explained that Kullu valley, where the institute is based, used to have the most productive apple orchards, but now "production has moved along the Beas river 3500 km" away (GBPNIHESD, April 3, 2019). Now, fruits such as pomegranates, peaches, mangoes, and citrus fruits are grown in the valley. The shift in crops is a glaring indication of how climate change is affecting livelihoods in Himachal Pradesh.

Our expert at GBPNIHESD also discussed the changes in climate patterns in recent years. The snowfall pattern has been changing, with less and less snow in recent years. The average

"The snowfall pattern has been changed… you can see that 1 week before it was to cold that you could not wear t-shirts, but within 4 or 5 days you can see how the temperature has gone up. We can say this is due to a consequence of climate change. Various anthropogenic activities are going on so these are contributing to the deterioration of the environment. Climate change is the major concern of today, because it is changing environmental conditions.

GBPNIHESD

temperature has been increasing, shortening the length of the winter season overall. At the tea board in Palampur, an official also stated that temperatures have increased, leading to a "decline in the production of crops" (Palampur, April 18, 2019). The rising temperature has lead to the resurgence of the red spider mite, an insect that can be devastating to tea crops. The changing temperatures have also pushed back the flowering season for tea crops, which has affected farming patterns in the region.

The decline in snowfall and rainfall has also lead to water scarcity in Himachal Pradesh. The snow and rain helps to "recharge the water table, but apart from this year...the rainfall was relatively less" (GBPNIHESD, April 3, 2019). An officer at the tea board in Palampur reported a similar trend in water scarcity. In the Palampur region, there has been a decrease in rainfall and snowfall, which has lowered the water table (Palampur, April 18, 2019).

Discussion

Our findings suggest that villages we visited are seeing many of the same indicators around Himachal Pradesh. There is an increased sense of urgency in communities that rely on farming for livelihoods. Agricultural patterns are changing, and farmers are concerned about how their future will be affected. The 2018 project had similar findings. In both years, villages reporting decreased snowfall and increasing temperatures, affecting agriculture in the region. Furthermore, there were alliances between reported indicators of climate change from local residents and experts. Respondents at GBPNIHESD and the Tea Board at Palampur reported less snow and rain, a trend reported in numerous villages. Both agencies reported that the growing season of numerous crops has been changed due to differences in temperature and precipitation. The agreement between respondents shows that climate change has become a pressing problem in Himachal Pradesh, and it gives greater significance to the stories taken from communities.

Social changes were apparent in both studies as well. Villagers report seeing the younger generations moving into urban areas to pursue their education as they witness a decline in agriculture throughout the region. Even with the troubling indicators, the responses were not always negative. Although people are leaving, some villagers remain positive about their future. In Suda Village, a resident stated that she does not "want the kids to stay" and she remained hopeful for the future of the children.

Figure 9: Suda resident hopeful for the future of her village (Brant Reymann).

Our study took a different approach from the 2018 study by looking at government policy and expert opinions on climate change in the region. Interviews revealed that many residents think there is a lack of government action pertaining to climate change and helping struggling farmers. In Chansari, an apple farmer stated that he gets no subsidy from the government, even though his crop has struggled in recent years. His neighbors have started to use pesticides, but he refuses to. He told us that "the government is not taking any action on these fertilizers," which pollute the environment (Chansari Village, March 30, 2019). An interview at G.B. Pant National Institute of Himalayan Environment and Sustainable Development, we heard a similar story. A respondent told us about the growing use of pesticides in Himachal and how they are harmful to health, but he did not tell us of any plan to mitigate pesticide use. He also stated that the government does have an environmental management plan, but he worried that "it is not being followed" (GBPNIHESD, April 3, 2019). We talked about numerous programs, but less about

about government climate action plans or other environmental management plans. In another interview, a worker on the campus of IIT Mandi, who has lived in Himachal Pradesh all his life, stated that while there may be government policies about climate change, it's "not going to the ground level" (Kamand, March 29, 2019). He did not believe that enough villages know about climate change and what the government is doing to fight it. These findings confirmed that there is a gap between government policy and awareness in villages. In many of our interviews, respondents did not understand climate change terminology, much less the legislation in place to mitigate it. The reported indicators of climate change are troubling, but so is the gap in understanding between the government and rural villages.

Project Outcomes

Climate change is a global problem, and while it is being studied at a scientific level, there is not enough research into how climate change affects individuals at the ground level. Rural and remote communities in the arc of the Himalaya are particularly vulnerable. Based on our research and interviews, we found that rural areas do not seem to have the resources or knowledge to confront climate change and its effects.

"My biggest concern is the lack of knowledge about climate change among the people in the villages. There may be policies in place but that's not going to the ground level. People on the ground level need to be educated about these changes we are seeing."

IIT Mandi Campus

Himachal Pradesh is a state full of unique culture and vibrant residents, whose lives are tied to the landscape for livelihoods and sustainability. We recommend that more effort be made to give residents a voice to communicate what they have felt from climate change. Partnerships between rural communities can link residents to share their experiences. Understanding the past can help plan for the future, and it can further develop climate change action plans currently in place.

Furthermore, we encourage the state and local government make a stronger commitment to extend their reach further into rural communities, as these are the ones impacted most from climate change. Furthermore, these communities seem to have less awareness on the subject, including programs and policy in that are in place to help the environment and fight the ramifications of climate change. The promotion of strong policies to protect the environment would also assist in educating and supporting communities around Himachal Pradesh.

Lastly, we recommend this project continue to give voice to fragile Himalayan communities. The villages of Himachal Pradesh are diverse and changing rapidly, and so the project should not stop here. Instagram and the Climate Stories Project are global platforms, and they have the potential to highlight lives affected by climate change around the world. Climate Stories Project is only one of many forums that can be used to empower rural communities. Social media can build connections, enable shared futures, and play a crucial role in giving people a chance to participate and be heard.

Conclusion

Finally, the environment is changing and affecting people all over the world, especially those in the Himalayan region. Recording stories from vulnerable places is essential to bridge the gap between communities and government agencies. The realities expressed by ordinary citizens will inform more effective climate change related planning and management in marginalized communities. The stories from vulnerable communities enables shared experiences, and allows for a deeper understanding of climate change in the Himalaya.

Humanity is at a crucial point in climate change planning, because the decisions made now will forever affect future generations. Without immediate action and increased awareness these regions will face irreversible consequences. Himalayan communities are vibrant and unique places that need to be protected from the effects of climate change. By combining citizen science participation and climate change planning,

more informed decisions can be made in relation to environmental management. Climate change is not a problem for the future, it is a problem now, and it must be addressed in the coming years if humanity has any hope for confronting its worsening effects.

Acknowledgments

Our team would like to thank the following individuals for their assistance and guidance during the completion of this project:

Dr. Ingrid Shockey and Dr. Gbetonmasse B. Somasse for their insights and contributions on this project and report.
Arpit Dwivedi for his assistance in interviews, translation of media content, and insight on this project.
Dr. Rinki Sarkar for providing our team with a basis of how to conduct interviews.
The editorial team for all their hard work in getting putting together this booklet.
All interview participants for sharing their experiences on how they have been affected by climate change.
Indian Institute of Technology Mandi and Worcester Polytechnic Institute for the opportunity to take part in this experience.

The reports in this book represent the work of WPI and IIT Mandi undergraduate students. For more information and to see the complete report, you may search using keywords or author at https://digitalcommons.wpi.edu/iqp/ or http://www.iitmandi.ac.in/istp/.

Works Cited

ABD (2010). *Climate change adaptation in Himachal Pradesh: Sustainable strategies for water resources. https://www.adb.org/sites/default/files/publication/27999/cca-himachal-pradesh.pdf*

Berg, B. (2007). *Qualitative research methods for the social sciences (6th ed.). Boston, MA:* Pearson.

Bergeron, P. T, Padir, L. A. *Perceptions of a Changing Climate, Exposure, and Vulnerability in Himachal Pradesh. (Undergraduate Interactive Qualifying Project* No. E-project-043018-001720). Retrieved from Worcester Polytechnic Institute Electronic Projects Collection: https://digitalcommons.wpi.edu/iqp-all/3263/

Dahlstrom, M. (2014). Using narratives and storytelling to communicate science with nonexpert audiences. *National Academy of Sciences, 111, 4, 13614-13620. https://doi.org/10.1073/pnas.1320645111*

Eckstein, D., Kunzel, V. and Schafer, L.. Global Climate Risk Index 2018. *German Watch.https://www.germanwatch.org/sites/germanwatch.org/files/publication/20432.pdf*

Goal 13: Climate Change Action. (n.d.) United Nations Development Programme. Retrieved
From https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-13-climate-action.html

IHCAP (2017) *Mountain and lowland linkages: A Climate Change perspective in the Himalayas.(n.d.).* Retrieved from https://www.weadapt.org/placemarks/maps/view/40871

IHCAP (2016) *Synthesis report: climate vulnerability, hazards and risk: an integrated pilot study in Kullu District, Himachal Pradesh.*

IPCC A: Field, Christopher B (2014).*Climate change 2014–Impacts, adaptation and vulnerability: Regional aspects. Cambridge University Press.*
https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-PartA_FINAL.pdf

Retrieved from: http://ihcap.in/?media_dl=584

Loria, N. & Bhardwaj, S. K. (2016). Farmers' response and adaptation strategies to climate change in low-hills of Himachal Pradesh in India. *Nature Environment and Pollution Technology, 15(3), 895. Retrieved from https://search.proquest.com/docview/1818060605*

Kodzis, S. R, Malcolm, R. R, Nagelin, A. M, Peng, Q. *Climate Change Identities 2014.* (Undergraduate Interactive Qualifying Project No. E-project-030514-234328). Retrieved from Worcester Polytechnic Institute Electronic Projects Collection: https://digitalcommons.wpi.edu/iqp-all/239/Moezzi, M., Janda, K.B., & Rotmann, S., (2017). Using stories, narratives, and storytelling in energy and climate change research. *Energy Research and Social Science, volume 31, 1-10. https://doi.org/10.1016/j.erss.2017.06.034*

National Action Plan on Climate Change (NACPP). Prime Minister's Council on Climate Change. (2008) Government of India. http://www.hpccc.gov.in/PDF/NAPCC.pdf

Paschen, J.A, Ison, R. (2014). Narrative research in climate change adaptation-Exploring a complementary paradigm for research and governance. *Research Policy, volume 43, 1083-1092. https://doi.org/10.1016/j.respol.2013.12.006*

Seibert, M. B, McClung, P. J, Jalbert, R. M, Yeung, P. *Perceptions of Climate Change in Iceland.* (Undergraduate Interactive Qualifying Project No. E-project-101118-090259). Retrieved from Worcester Polytechnic Institute Electronic Projects Collection: https://digitalcommons.wpi.edu/iqp-all/5142/

Ward, K. (2014). *Researching the city. London: Sage Publications.*

Wozniak, A., Luck, J., & Wessler, H. (2014). Frames, Stories, and Images: The Advantages of a Multimodal Approach in Comparative Media Content Research on Climate Change. *Environmental Communication, 9, 4, 469-490. https://doi.org/10.1080/17524032.2014.981559*

Integrating Earthquake Preparedness at IIT-Mandi

Abstract

The goal of our project was to create a Resource for Emergency Planning (REP) for the Indian Institute of Technology, Mandi. An online survey gauged the level of awareness concerning seismic risk on campus and in-person interviews were conducted with family members, staff and security guards. We evaluated the campus terrain with regard to earthquake vulnerability. Lastly, we met with officials in Mandi District to understand the government's policies toward preparing communities for a quake. In completing these tasks, we identified gaps in preparedness on campus and were able to provide recommendations in the REP manual for the institute, including evacuation maps for resi-

Team Members

Christopher Brainard
Davis Ladd
Jake Tappen
Abhay Kumar (B16121)
Chirag Vashist (B16094)
Prabhakar Prasad (B16069)

Advisors

Dr. Kala V. Uday
Dr. Maheshreddy Gade
Dr. Gbeton Somasse
Dr. Ingrid Shockey

Preparing for Seismic Risk in India

Earthquake preparedness protocols are a crucial safety practice in areas of high seismic activity. They serve multiple purposes that can protect communities where earthquakes are most prominent. First, they can limit injury by encouraging residents to adhere to immediate guidelines in the event of an earthquake. Secondly, they standardize actions and expectations in an emergency situation, ensuring the entire community can manage disaster relief following the event. Finally, they encourage regular assessments and coordinated drills. This project is in accordance with the eleventh goal of the United Nations Development Programme (UNDP) on promoting sustainable development in cities and communities. One of the goal's main targets is to "increase the number of cities and human settlements implementing integrated plans and policies towards resilience to disasters and holistic disaster risk management" (United Nations Development Programme, 2019). Providing a state, province, or community with an earthquake preparedness guide is an extremely important security step to conserve human life as well as mitigate the long-term effects of a disaster.

Each year, millions of people are at risk around the world and are vulnerable to loss and destabilization in the aftermath of seismic activity. On April 25th, 2015, a 7.8 earthquake was recorded on the Richter scale in Kathmandu, Nepal. The sheer force of the earthquake reportedly caused "8,700 deaths and destroy[ed] 299,600 buildings and 90% of medical facilities in the region", resulting in increased difficulties to aid those in need of medical attention (Zhao, 2016). Following the disaster, it was learned that earthquake preparedness training had likely reduced the casualty rate and destruction, as compared with other major disasters, such as the 2010 Haiti earthquake. The destructive aftermath recorded in each country, show that "preparedness is essential" (Auberach, 2015, p. 1).

Northwest India, and more specifically the state of Himachal Pradesh, is due for a major earthquake. The Minister of State for Science, Technology and Earth Sciences, Yalamanchili Satyanarayana Chowdary, developed seismic zones for the country of India, keeping in mind the countries elevated risk for seismic activity (Bhawan & Road, 2017). As depicted in Figure 1 below, the northern border of India falls within severe earthquake zones due to its close proximity to the Indian and Eurasian tectonic plates.

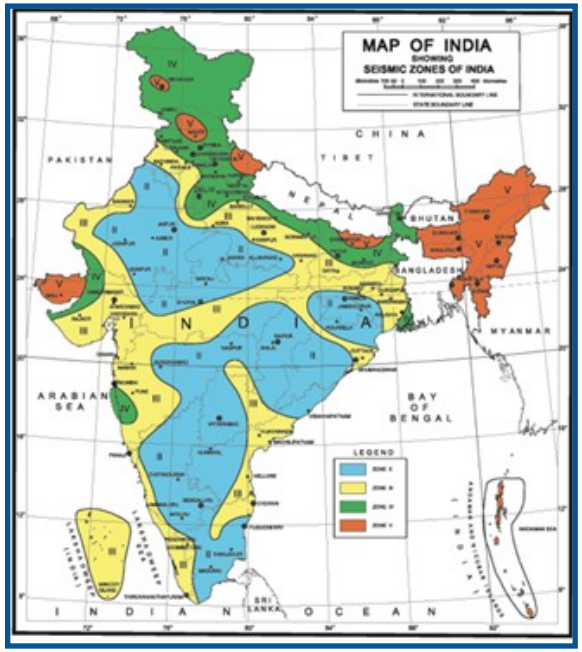


Figure 1: Seismic zones of India (Government of India, 2016)

More specifically, the area surrounding Mandi and its Kamand Valley is located in a Zone V Seismic Zone, the highest earthquake risk level possible. Though there has not been significant earthquake activity in Himachal Pradesh recently, a "seismic swarm of activity" recently shook the city of Rampur, located in neighboring Uttar Pradesh (Singh, 2016, p. 44). In late August of 2016, 58 earthquakes struck in one day, demonstrating the high frequency of tectonic plate movement in the region. India's northern regions need protocols in place to prepare for natural hazards such as these.

The State Disaster Management Authority of Himachal Pradesh designed a template for disaster management. The plan, entitled, *Preparation of Disaster Management Plans by Various Departments of Government of Himachal Pradesh,* outlines the state's vision on disaster management. The plan specifically aims to "build a safe and disaster resilient Himachal Pradesh...through a culture of prevention, mitigation, preparedness and response" (Government of Himachal Pradesh, 2016, p. 1). Yet, despite this initiative from government agencies, less has been done to prepare specific protocols in communities vulnerable to a natural disaster.

The goal of our project was to create a Resource for Emergency Planning (REP) manual for the Indian Institute of Technology-Mandi (IIT -Mandi), located in the Kamand Valley of Himachal Pradesh. To meet this goal, we identified three objectives. First, we measured the awareness of the IIT-Mandi community on seismic risk to their person. By doing this, we were able to better understand the current knowledge, awareness, and training the community has in the event of an earthquake. Second, we evaluated natural and structural hazards of the IIT-Mandi campus in terms of seismic activity. This objective was implemented into an evacuation map to highlight areas to avoid during the disaster. Finally, we appraised current earthquake risk and safety practices of Mandi district and IIT-Mandi. This ensured that our REP manual complied with these resources. Achieving these objectives allowed our team to develop an effective REP manual for the community of IIT-Mandi to keep the residents safe, provide clear protocols, and establish safe zones on campus. We begin this report by providing an in-depth overview of seismic activity in the state of Himachal Pradesh, as well as highlighting key terms and best practices used in the event of a natural disaster.

Understanding the context for Vulnerability

The development of an effective risk mitigation plan for IIT-Mandi requires understanding of the seismic hazard potential of the area, and needs to build from existing local and government protocols. In this section, we explore the vulnerabilities of earthquake activity, how to predict risk, and how to think about readiness to confront the hazards presented by natural disasters. In preparation towards further risk mitigation and hazard preparedness, our overview includes geographical and seismic frequency summaries of the area, profiles of our stakeholders, and consideration of current government policies.

Seismic activity in Himachal Pradesh

Himachal Pradesh has experienced over 300 earthquakes in the past 90 years that were identified as 4.0 or greater on the Richter Scale. Sixty of these have been identified as 5.0 or greater resulting in lasting damage on communities (Himachal Pradesh State Government, n.d.). The state is one of the most dangerous with respect to seismic activity in the country, due to its proximity to fault lines in the western Himalayas. The institute's location in Himachal Pradesh is an active seismic zone, indicating a very high risk for damage, as illustrated in Figure 2 (*Earthquake hazard map,* 2002).

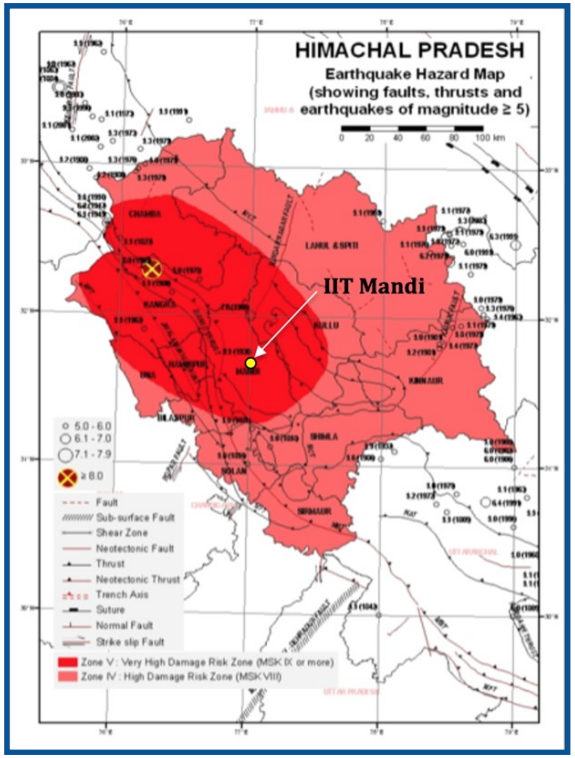


Figure 2: Hazard Map of Himachal Pradesh (Earthquake hazard map, 2002).

The area around the campus is labeled as a level V danger zone with respect to seismic activity (Charak, 1978). This rating is established by the government as a way of acknowledging potential hazards. What has been observed is that the hazards that typically cause loss of life during earthquakes are not the seismic disturbance itself, but rather the secondary damage from the terrain. This includes danger from landslides, liquefaction, and building collapse (Ammon, 2011). With the IIT-Mandi campus 14 miles northeast of Mandi Town, through winding narrow mountainous roads, the institute may be required to operate in isolation with help from outside resources in the days following a significant quake.

Risk assessment and community emergency guide planning

Terms such as risk assessment, vulnerability, hazard management, and risk mitigation are all used to describe the concepts behind the response to disasters (human or natural). The Government of India (GoI) has defined in their *National Disaster Management Guidelines* the definitions of these terms, carefully stating their purpose and specific meaning when it comes to natural disasters. The terms risk assessment and risk mitigation are significant in the context of earthquake preparedness and disaster control (for definitions specified by the federal government, see the Supplemental Information section of our full report). However, due to the wide variety of opinions and variables, risk assessment is an imperfect science. The Federal Emergency Management Authority (FEMA) provides one framework for risk as measuring the "expected casualties, direct economic losses and displaced households" (Your earthquake risk, 2019). In order to create a sufficient REP manual for the community of IIT-Mandi, these risks must be identified and evaluated.

When assessing risk and disaster control, it is vital to analyze how efficiently preparedness plans translate into community action. Though there may be current preparedness and risk mitigation plans in place, there are still factors that affect the actual implementation of these procedures. The government may set the "standard" for preparedness from certain disasters, but how well are these protocols followed at the micro level in a community is a question to keep in mind. For instance, the Community for Accredited Online Schools outlines the important aspects of earthquake preparedness for schools across the United States. Highlighting the national earthquake preparedness guidelines from the American Red Cross and other organizations, schools get prepared by "considering the buildings, securing furniture, gathering emergency supplies, and holding earthquake drills and evacuation practices" (Russell, n.d.). Below, Figure 3 provides an example of those guidelines and their descriptions.

Evidently, though organizations such as the American Red Cross and FEMA have disaster protocols on the national and community level, guidelines can be established in schools, homes, businesses, and other organizations. Local communities, schools, and households need to coordinate their own disaster management activities to ensure that their

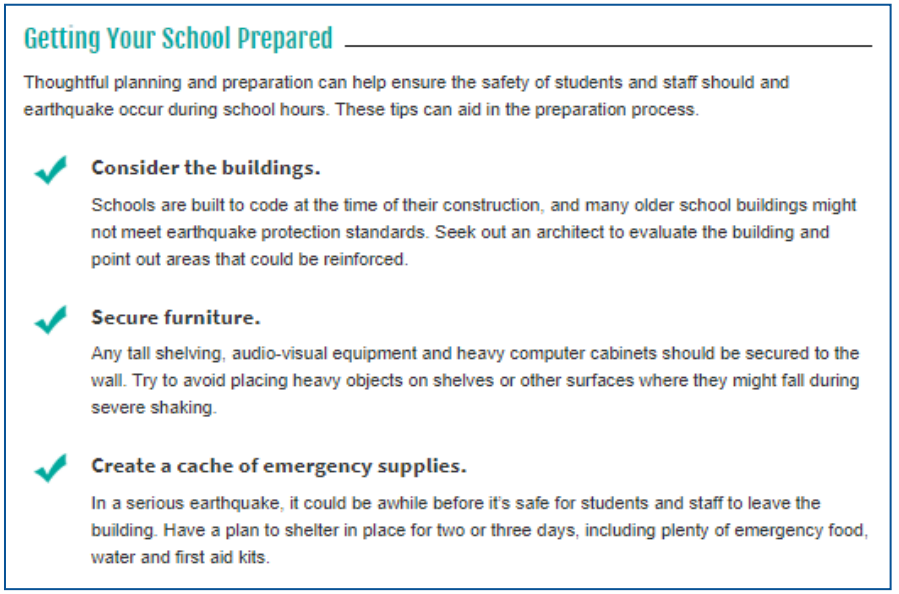


Figure 3: Getting your school prepared (Russell, n.d.).

communities are responding correctly to reduce and mitigate risks. IIT-Mandi is located within an extremely high-risk zone for seismic activity, leaving the university community subject to a catastrophic event with little to no warning. Furthermore, developing a safety guide for a community encompasses more than just earthquake preparedness. Past case studies have been analyzed to gauge seismic activities effects on similar areas and one is analyzed in the next section. A serious focus has to include the local perceptions of risk and vulnerability, as well as streamlining response for initiating coordinated protocols. At this time the national, state, and district plans for disaster management are quite comprehensive in writing, however, in terms of the campus and surrounding villages there is little information known about how well these plans transition to a citizen accountability level.

Best Preparedness Practices

In 1905, Himachal Pradesh was hit by a magnitude 8.4 earthquake close to Kangra, in northern India. Occurring over a century ago, it remains one of the most devastating earthquakes to affect the country of India and caused critical damage to the region and more than 15,000 casualties. IIT-Mandi is located in a very similar terrain compared to Kangra, and the effects of an earthquake at this magnitude could reap the same results even with building adaptations over the past century.

In order to better understand risk assessment and hazards in a natural disaster such as an earthquake, we evaluate a case study that serves as important lessons for future disasters. Our case study is a risk assessment on seismic activity in Nepal, which demonstrates the benefits of earthquake preparedness (Chaulagain, 2014).

Seismic Risk Assessment in Nepal

Research in a study entitled *Seismic Risk Assessment and Hazard Mapping in Nepal* has a similar goal to our own in assessing hazards related to seismic activity. Nepal's history of severe earthquakes dates back to the early 13th century (Chaulagain, 2014). Due to the number of seismic events in Nepal, multiple studies have been conducted to estimate the damage, death toll, and injuries expected if a large magnitude earthquake were to occur. This team successfully used "combining probabilistic seismic hazard, structure vulnerability, and exposure data" to create hazard maps and building models across Nepal (Chaulagain, 2014).

To get a better understanding of the severity of earthquakes in Nepal, the researchers examined ground motion in the region by using prediction equations to classify the tectonic makeup of the country. In doing so, the researchers were able to accurately represent the levels of building collapse, destruction, and damage in each region. This was significant in their study because the "level of building damage depends on the intensity of ground shaking" (Chaulagain, 2014). By gathering data and making methodical predictions using ground motion equations and previous data from other experts, this study was effective in mapping probabilistic seismic hazards in Nepal. The creation of these geographical hazard maps proved its significance to the reconstruction of the country of Nepal. Prior to the earthquake of 2015, "the lack of information of the physical geography of the affected areas" suggested that it was not possible to know which places would be safe for development (Hall, 2017, p. 41). Moreover, those agencies that did provide geographical hazard maps of particular regions in Nepal stated that "reconstruction had run more smoothly as a result" (Hall, 2017, p. 41). This shows evidence that geographical hazard maps provide regions of seismic activity with safety not only prior to an earthquake, but also afterwards. Evaluating the ground motion in a particular region is an essential part of hazard map design, however, this could prove a difficult or impossible task to achieve when creating a hazard map of the Kamand Valley for IIT-Mandi since these technologies may not be available.

Our Approach

Here we provide an overview of the data and methods used to create a Resource for Emergency Planning for IIT-Mandi. The guide includes hazard maps and community safety procedures with the intent of mitigating risk during the event. Toward that goal, we developed three objectives:

1.Measure the awareness of the IIT-Mandi community on seismic risk to their person.

2. Evaluate natural and structural hazards of the IIT-Mandi campus in terms of seismic activity.

3. Appraise current earthquake risk and safety practices of Mandi and IIT-Mandi.

These objectives were accomplished from a combination of interviews, rapid vulnerability assessments, and hazard mapping as summarized in the chart on the next page (see Figure 4).

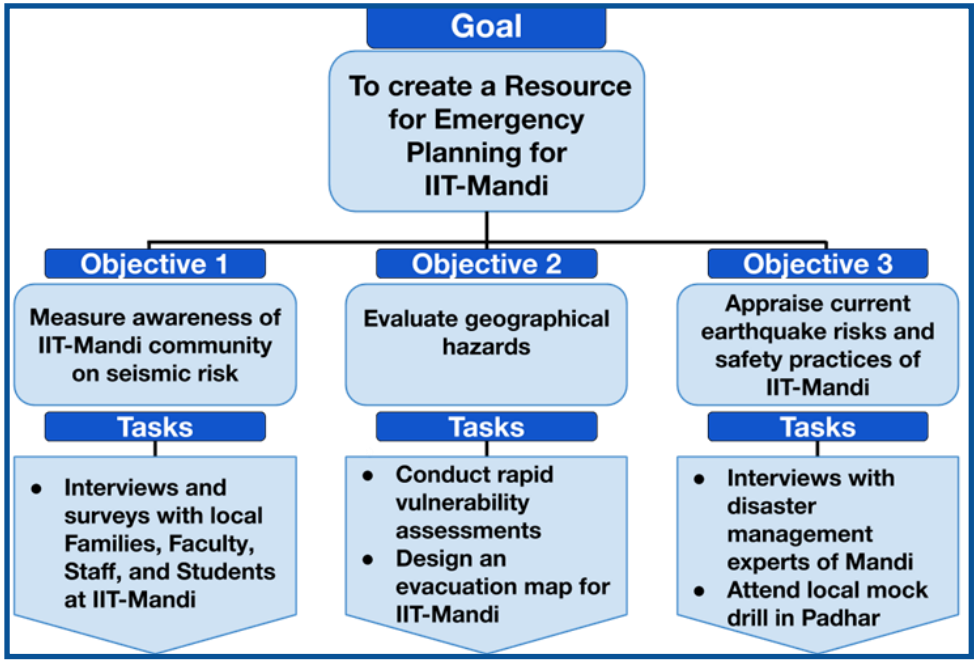


Figure 4: Methodology and objectives flow chart.

Measuring awareness of IIT-Mandi community on seismic risk

Our first objective assessed the awareness of the IIT-Mandi campus and extended campus communities on the risks associated with seismic activity. We measured the level of preparedness of the campus in case of earthquakes. This data was used as a starting point towards understanding the baseline of knowledge and practices.

A combination of surveys and interviews with faculty, staff, students and families living on campus helped to assess the current level of preparedness against hazards based on a sample of convenience. Interviews were conducted in a semi-standardized format (Berg, 2007). These information gathering techniques also served as a way to estimate the current safety standards known by the IIT-Mandi community. The surveys were presented in English and distributed online using the school's email to students and faculty. The student population's sample size was larger in proportion to any other body. Therefore, their answers' were most representative out of all other responses. Staff and construction workers hired by the school were interviewed in-person using a semi-standardized format in Hindi or English using a convenience sample. We also interviewed family members living on campus using a snowball sample derived from faculty contacts or by convenience (Berg, 2007).

Evaluating geographic hazards

The second objective was to evaluate the potential hazards of the terrain surrounding IIT-Mandi in the event of seismic activity. The geographical composition of the land surrounding IIT-Mandi, while being a risk itself, played a direct role in planning the best safety strategies. Understanding the terrain of IIT-Mandi, where construction was most prominent, and what areas were most traffic prone allowed us to identify regions where there was greater risk of damage or compromises to evacuation zones. By conducting Rapid Vulnerability Assessments (RVA) and creating evacuation maps, we worked to identify key areas of geographical risk if an earthquake were to occur in the IIT-Mandi region. We also looked at non-geographical hazards in the urban environment of the campus such as the collapse of nonstructural building components and power lines that could fall in the roads.

Using RVA's and hazard maps was the best approach to evaluate the land surrounding IIT-Mandi because it presented immediate assessments of which areas should be avoided and how they will affect accessibility if seismic activity were to occur. Some questions that this assessment addressed:

1. Which areas are the most susceptible to destruction due to an earthquake?
2. How will the location of the campus affect accessibility and emergency response?
3. Which areas will prove to be the best safe zones during and in the aftermath of an earthquake?

We walked the entire campus taking over 300 pictures to assess which of the three zones each area depicted: safe zone, cautionary zone or evacuation route. Green zones represent safe gathering points that could serve

as a basis for operation during and after the disaster, such as managing the wounded. Yellow zones are approved evacuation routes that serve as the safest way to reach the green zones. While orange zones represent areas of caution were people should avoid if possible and largely encompass the locations that are being evacuated from. Through discussion at each site and referencing pictures after the fact we were able to justify areas that could be considered safe and those that had the potential for causing hazards.

The assessment included the collection of data for an evacuation map, with areas marked to serve as muster points for the people on campus (i.e. places they will evacuate to for safety). Similarly, we evaluated the vulnerability of residents with regard to structural material of buildings as well as potential danger from landslides and flooding. Finally, we assessed road and civil access routes in and out of campus in order to locate areas where evacuation can affect emergency response. The results from the RVA's were collected to note vulnerable locations and create a map that highlighted key areas of risk. This map used a color-coded system as defined above to illustrate the levels of risk on the campus.

Appraisal of the current earthquake risk and safety practices of Mandi and IIT-Mandi

The final objective was to appraise the current risk mitigation practices by the local management of IIT-Mandi and surrounding villages. We visited a community emergency planning drill in the village of Padhar, to observe the strengths and weaknesses of how the local school conducted a mock drill. We took note of the seriousness with which the children took the drill and the length of the drill. Further, we watched how and by whom the majority of the drill was managed, as well as comparisons between how well the information presented in the drill held up against other sources we had investigated.

We conducted interviews with Mandi district planning officials at the Padhar village office to assess current hazard mitigation practices in and around the IIT-Mandi community. Our method of sampling for interviews was a snowball sample to gather expert opinions. These interviews were designed to aid in furthering our research on how the experts of Mandi district structure their disaster management plans as well as how we applied these policies into the recommended evacuation map and REP manual for IIT-Mandi. Therefore, we used semi standardized interview formats (Berg, 2007). After completing these interviews, the data collected was analyzed for similarities and differences in response. Furthermore, the results were also used to investigate correlations to the surveys conducted in Objective 1.

Risks and capacities at IIT-Mandi

Results

The results of our study confirmed considerable risk on campus and also provided some interesting findings in terms of local capacity. Key responses to our survey are highlighted below.

Limited awareness of seismic risk in the community

Our survey of the Mandi community generated 117 responses that helped us gauge the perceptions of earthquake preparedness across the campus. The majority of these surveys were answered online, with twenty-eight conducted as in-person interviews.

As depicted below in Chart 1, only 39% of participants knew the correct answer to which earthquake zone Mandi falls in as defined by India's Ministry of Science, while 38% admitted they did not know.

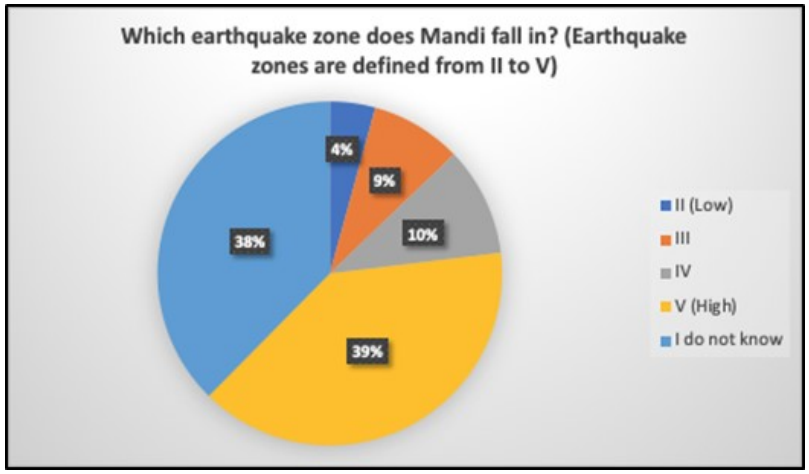


Chart 1: Responses to Mandi's Earthquake Zone.

Chart 2 summarizes the current state of earthquake preparedness knowledge gap. This chart depicts that on average roughly 25% of respondents learned of an earthquake preparedness guide from an academic textbook, and 21% read of one in a newspaper or magazine. Surprisingly, 24% have never received any form of education on earthquakes.

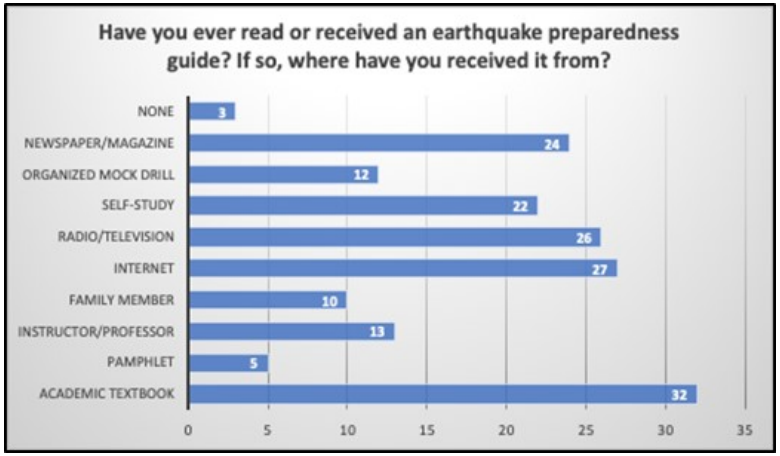


Chart 2: Response to Previous Earthquake Preparedness Guides.

The remaining survey questions asked respondents what they would pack in a disaster bag, and about awareness regarding the immediate physical consequences in the aftermath of an earthquake. These results also indicated a wide spectrum of answers, some of which could be classified as highly inadvisable and suggesting a lack of uniform education on disasters, as shown in Chart 2. This difference in understanding of priorities during an earthquake could lead to miscommunications and poor decisions that result in loss of life.

Finally, we asked the community how often a mock drill should be held at IIT-Mandi to help gauge whether or not the residents thought participation was needed. The responses indicated that 49% of the community believed that there should be a mock drill held twice a year to simulate earthquake evacuation and safety protocols.

Rapid vulnerability assessment concerns

Below are highlights from our rapid vulnerability assessment, to identify safe and cautionary zones as well as evacuation routes. Through this assessment we found that there are ten evacuation sites on South campus and three safe zones on North campus. The evacuation routes were identified as the main walkways that connect the campus and we determined that all small paths or walkways could be blocked easily by structural decay of buildings or the surrounding terrain. A series of images from our RVA's can be seen below.

Figure 5: Safe Zone on North Campus (Photo Courtesy: Tappen, 2019).

Safe Zone - This is the bus stop on North Campus, which is designated as an open space that has no or a low risk of hazards resulting from earthquakes. This location will serve as an evacuation point on the hazard map where students, faculty, staff and families will evacuate to in the event of an earthquake.

Figure 6: Cautionary Zone on North Campus (Photo Courtesy: Brainard, 2019).

Cautionary Zone - This shot of the construction underway depicts an area where residents on campus are in immediate danger if an earthquake were to strike. The hillside, where this picture was captured has seen landslides on a frequent basis and therefore it is advised those in this area evacuate as swiftly as possible towards a safe zone.

Evacuation Routes - This location shows a pathway, which serves as one of many evacuation routes towards the designated safe zone. The walkway is safe with respect to falling objects and potential landslides. Therefore, it is advised faculty, families, students, and staff proceed along these paths in order to reach safety after an earthquake strikes.

Appraisal of standard earthquake risk and safety practices

We attended an earthquake drill at a local government secondary school named, Netaji Subhash Chandra Bose Memorial Government Senior Secondary School in the Padhar region of Himachal Pradesh. The earthquake drill at the secondary school was held by the local government officials of Padhar, including police officers, fire safety personnel, and the Sub-Divisional Magistrate (SDM).

The school was preparing for an earthquake using evacuation drills from buildings in various scenarios. Figure 8 depicts a student repelling from the roof with a rope, which shows one way that safety personnel can evacuate individuals in the event of building collapse or structural failure. Figure 9 shows the appropriate emergency response vehicles recommended during a disaster. In this drill, the ambulance is tasked with transporting students who were injured to the nearby Civil Hospital. This could be similarly carried out to familiarize students with the IIT -Mandi hospital and their protocols.

A second aspect of our third objective was to interview local government officials in the Mandi district on disaster management. We interviewed the SDM of Mandi, Avneesh Sharma, who coordinates the emergency guide planning to natural disasters in the Mandi district. Our discussion focused on local villages "disaster management plans with resources specific to their community" that aim to ensure the safety of each villager (Sharma, 2019). As Sharma explained, nearly all villagers have experienced at least one consequential disaster in their lifetime. For this reason, community members are open to helping and listening to experts who want to teach the community the best practices for disaster preparedness. However, for these guidelines to work, Sharma notes that it is essential to identify those individuals at the community level who are most experienced in disasters specific to their region to gain a sense of the community's perceptions and readiness. These steps followed by the district level will be important in implementing our REP manual for IIT-Mandi. Essentially, by raising each individual's awareness we increase the safety of the school.

Figure 8: Rope Procedure from Mock Drill (Photo Courtesy: Brainard, 2019).

Figure 9: Ambulance Procedure from Mock Drill (Photo Courtesy: Brainard, 2019).

Discussion

Our results throughout all three objectives show that preparedness for earthquake readiness has yet to take shape at IIT-Mandi. When we analyze our RVA's and compare them with the public perceptions we obtained through our surveys, there are clear gaps in how the community identifies risks during seismic activity. Our own background research, speaking with university experts, and government regulations assured us that the campuses buildings are built to withstand some seismic activity. However, we identified other concerns likely to cause damage during the disaster throughout the campus grounds. Unfortunately, the community's response towards what to do in the event of seismic activity revealed a sizable portion of people exposing themselves to possible hazards. The variation in answer shows a general lack of the technical knowledge of the area that they live, which too indicates a shortcoming of the subject matter in the classroom. For example, 10% of respondents answered incorrectly for proper reactions inside buildings and 38% responded incorrectly for reactions in an automobile. These discrepancies for such notable sizes of the population show that the current preparedness at IIT-Mandi is extremely lacking. The misconceptions of the subjects from this survey allowed us to develop a cohesive plan that will be IIT-Mandi's REP. We justify our plans in the REP by using the answers of this survey to demonstrate that the community, while having some earthquake awareness, is ill prepared in some scenarios.

Our most notable finding was that IIT perceptions are not in sync with capacity shown by the emergency planning drill at the school in the Padhar region of Himachal Pradesh. This was especially valuable because of the interview with the SDM, which helped explain how education around these programs begins. He explained how to start when building a plan from an individual to a village which can be adjusted to fit the mold of the institute's community. This information can form the basis for what IIT Mandi will need in the future.

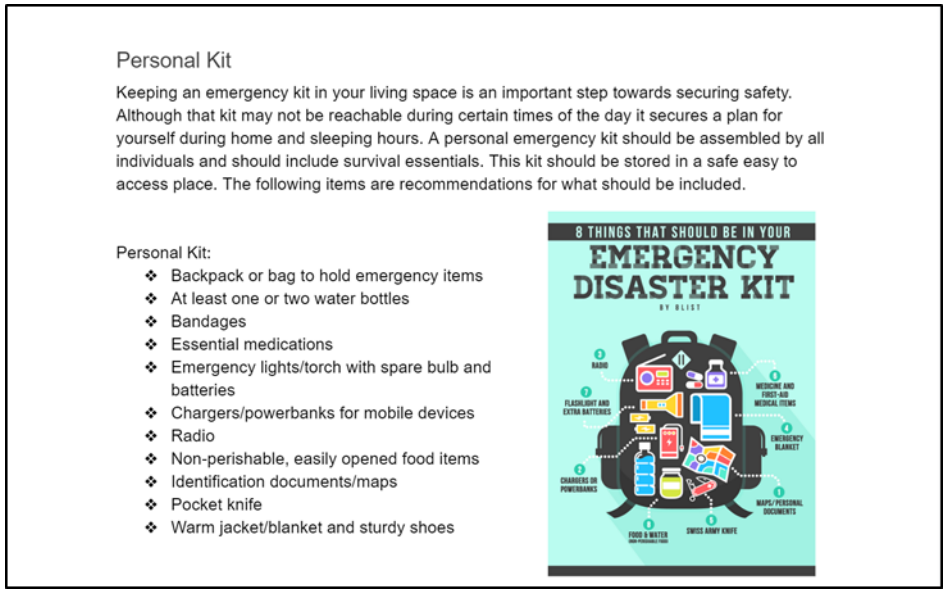
From watching the roles of students, teachers and police trainers carried out in the emergency planning drill, we can extrapolate responsibilities to IIT-Mandi individuals with confidence that the parties are capable of their assigned role in disaster preparedness. Through this method we would not start fresh, but rather update the campus to the highest standards by implementing strategies that communities with similar earthquake hazards face and have already developed plans to uphold. Toward that end, we combined the results to obtain best practices for a guide that can be adjusted in the future based on terrain and personnel changes to campus.

Project outcomes

To provide the campus of IIT-Mandi with an earthquake preparedness guide, our team designed a Resource for Emergency Planning (REP) to ensure that the campus is safe in the event of an earthquake. This REP has four recommended steps to guide the campus on how to create an earthquake preparedness guide. These steps are listed below.

- **Step 1: Preemptive Planning**
- **Step 2: "Drop, Cover & Hold On"**
- **Step 3: Evacuation Protocol**
- **Step 4: Campus Recovery**

Within these steps, there are a series of recommendations that include procedures for the community in earthquake preparedness. Step 1 lays out the actions that should be taken before the seismic event. For instance, suggestions on securing objects within a building, implementing a chain of command as well as response team, coordinating personnel to teach the campus about earthquake awareness and safety, establishing an auditory alarm and SMS communication systems, setting in place preparedness kits for personal and school use, and lastly performing routine mock drills. With respect to a mock drill on campus, the manual provides clear instructions and steps on the key points of a mock drill, breaking them into procedures that should be followed as an earthquake strikes. Moreover, our findings indicate the IIT community currently has no administration for handling seismic events, therefore we strongly recommend the immediate integration of one. The picture below illustrates a section of the REP in Step 1.



Personal Kit

Keeping an emergency kit in your living space is an important step towards securing safety. Although that kit may not be reachable during certain times of the day it secures a plan for yourself during home and sleeping hours. A personal emergency kit should be assembled by all individuals and should include survival essentials. This kit should be stored in a safe easy to access place. The following items are recommendations for what should be included.

Personal Kit:

- Backpack or bag to hold emergency items
- At least one or two water bottles
- Bandages
- Essential medications
- Emergency lights/torch with spare bulb and batteries
- Chargers/powerbanks for mobile devices
- Radio
- Non-perishable, easily opened food items
- Identification documents/maps
- Pocket knife
- Warm jacket/blanket and sturdy shoes

Figure 10: Snapshot of REP.

Step 2 of the manual, describes the "Drop, Cover, & Hold On" procedure that should be the immediate response of the IIT community at the first feeling of tremors. This includes how to react both inside, outside, and in a vehicle.

Step 3 covers the evacuation protocols following an earthquake for all persons, including injured and those with disabilities. Evacuation maps for both North and South campus are also presented in step 3 of the REP, and the map of North campus is displayed in Figure 11 below. The evacuation maps illustrate areas that are safe zones, areas that can be used as an evacuation route, and locations that are in the cautionary zones from an earthquake. We recommend that this map be posted in classrooms, sent out to faculty and students, and be implemented into the IIT student handbook. Furthermore, we suggest that this map be updated every two years to better reflect the development of the campus following construction periods.

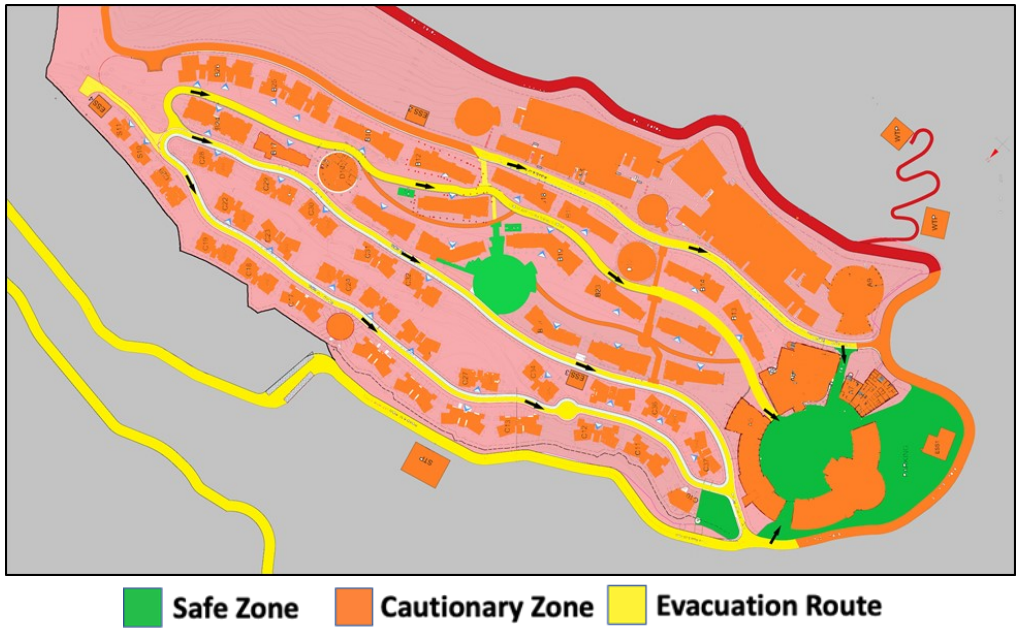


Figure 11: North Campus Evacuation Map.

Finally, step 4 highlights how the campus should act once people have evacuated to the specified safe zones on the maps. We recommend the disaster management administration on campus coordinate some form of attendance system to account for any missing persons, therefore, allowing proper authorities to be notified and then handled in a timely fashion. This will in the end, help the administration to maintain control during a very chaotic event.

Conclusion

In sum, the importance of this project cannot be overstated after learning the status of the IIT-Mandi community's risk and vulnerability with regard to earthquakes. It is clear that while there is some basis of understanding about the potential hazards caused by an earthquake, the uniformity and organization that can prevent unnecessary injury does not exist. The greatest preventive measure that can be made is education of the community so that actions taken during the disaster mitigate damages that can ultimately be avoided. We were able to identify best practices that prepare an individual for a disaster, however sustainability of an education system will be a crucial step in the future. Vulnerability assessments will need to be conducted again as incoming students arrive and as the campus expands. New residents will need to be educated on what they can do to protect themselves from hazards. In addition, the policies and protocols will need to be practiced by all administrative personnel so that the precious moments during and after a seismic event are not wasted in regaining control of the campus. Earthquakes are inevitable in the area, and as we have seen, the IIT community is receptive to preparedness and open to incorporating a guideline that seeks to create a more resilient campus.

Acknowledgements

We would like to thank the following individuals who assisted us and guided us throughout our project:

- Our mentors, Dr. Kala V. Uday, Dr. Maheshreddy Gade, Dr. Ingrid K. Shockey, and Professor Gbetonmasse B. Somasse for their contributions and thoughtful critiques towards the development of our project.
- Dr. Devika Sethi for accommodating our team with the necessary resources for the successful conclusion of the ISTP/IQP.
- We would like to extend gratitude towards everyone who took the time to participate in our study.
- Sub-Divisional Magistrate of Padhar, Avneesh Sharma, for his guidance in breaking down the government strategies for community -based disaster management.
- The Indian Institute of Technology Mandi and Worcester Polytechnic Institute for providing us with the opportunity to complete this study.

The reports in this book represent the work of WPI and IIT Mandi undergraduate students. For more information and to see the complete report, you may search using keywords or author at https://digitalcommons.wpi.edu/iqp/ or http://www.iitmandi.ac.in/istp/.

Works Cited

Ammon, C. (2011). Earthquake effects. Retrieved from http://eqseis.geosc.psu.edu/~cammon/HTML/Classes/IntroQuakes/Notes/earthquake_effects.html

Auerbach, P. (2015). Preparedness explains some differences between Haiti and Nepal's response to earthquake on JSTOR. *British Medical Journal, 350*, 2. Retrieved from https://www-jstor-org.ezproxy.wpi.edu/stable/26520874

Berg, B. L. (2007). In Lasser J. (Ed.), *Qualitative research: Methods for the social sciences* (6th ed.). New York City, New York: Pearson Education, Inc.

Bhawan, S., & Road, R. P. (2017). Seismic zones. Retrieved from http://pib.nic.in/newsite/mbErel.aspx?relid=168661

Charak, S. S. (1978). *History and culture of Himalayan states*. Atlantic Highlands, N.J.: Humanities Press. doi:10.1086/ahr/85.1.195

Chaulagain, H., Rodrigues, H., Silva, V., Spacone, E., & Varum, H. (2015). Seismic risk assessment and hazard mapping in Nepal. *Natural Hazards, 78*(1), 583-602. doi:10.1007/s11069-015-1734-6

Earthquake hazard map (2002). Himachal Pradesh state disaster management authority.

Government of Himachal Pradesh. (2016). *Preparation of disaster management plans by various department of government of Himachal Pradesh*. Government of Himachal Pradesh-UNDP. Retrieved from https://hpsdma.nic.in//admnis/admin/showimg.aspx?ID=71

Government of India. (2016). *Seismic zones of India* (IS 1893 (Part 1) ed.)

Hall, M. L., Lee, A. C. K., Cartwright, C., Marahatta, S., Karki, J., & Simkhada, P. (2017). The 2015 Nepal earthquake disaster: Lessons learned one year on. *Public Health, 145*, 39-44. doi:10.1016/j.puhe.2016.12.031 23

Russell, J. (n.d.). Emergency preparedness in school. Retrieved from https://www.accredit edschoolsonline.org/resources/emergency-preparedness-in-school/

Sharma, A. (2019). *SDM interview*

Singh, R. (2018). Earthquake swarm of Himachal Pradesh in northwest Himalaya and its seismotectonic implications. *Physics of the Earth and Planetary Interiors, 275*, 44-55. doi:10.1016/j.pepi.2018.01.002

United Nations Development Programme. (2019). Goal 11: Sustainable cities and communities; Retrieved from https://www.undp.org/content/undp/en/home/
sustainable -development-goals/goal-11-sustainable-cities-and-communities.html

Your earthquake risk. (2019). Retrieved from https://www.fema.gov/your-earthquake-risk

Zhao, B. (2016). April 2015 Nepal earthquake: Observations and reflections. *Natural Hazards, 80*(2), 1405-1410. doi:10.1007/s11069-015-2001-6

Valuing Forests: From Visible to Invisible

Abstract

'Valuation' of the various services and products provided by forests remains an important task for ecological economists, besides having grave social, cultural and environmental implications. Starting off building an introduction to the concepts of 'value', we dwell into the background and purpose of our report. A methodological framework has been presented as implemented. The choice of study locations has been thoroughly justified and substantiated. Thereafter, descriptive findings and inferences of the report are concluded with understandings and recommendations for the system.

Team Members

Abhinav Dixit B16003
Rohit Kaushal B16028
Vinayak Kuthiala B16039
Chahak Godara B16051
Devashish Singh B16055

Advisors

Dr. Shyamasree Das Gupta

Teaching Assistant
Vishal Sharma

Introduction

"Forests are valuable!" - That's something that although each of us have come across quite many times, but failed to realize. Humans have been relying on forests and their produce for essential goods since times immemorial. However, in the present age of rampant urbanization and incessant modernization, they have now receded into an aspect whose value consideration is marred by mere quantitative analysis (and that too, not in the best way it could have been done). The 21st century human thus needs to endeavour to find a better, superior and an efficient valuation system that encompasses a wider thought process in its approach.

In our pursuit of understanding and presenting a perceptive valuation that encapsulates varied approaches, we found ourselves amidst the worthwhile effort of dwelling into the literature, research and efforts directed towards this genre. As we dwelled deeper, we identified a few milestones that need to be set forth explicitly for a clear understanding of the nature and goal of our project.

Addressing the 'Why' to Forest Valuation

Like with any problem, the need for its redressal needs to be highlighted upfront -

- Forests, by their mere existence exert a positive influence on the environment (carbon cycles, regulating climatic cycles, etc.).
- In the (very likely) events that the forest resources are undervalued, or valued using an inappropriate, incomplete or an improper methodology, there is an increased likelihood of forest lands being diverted for non-forest purposes.
- Forests enrich the aesthetics, society, culture, and the ecosystem of the region; besides rendering economic benefits to the locality that can be deemed nothing short of 'considerable' when compared with the scales of the locality's economic standing. Under the current SNA -SEEA framework, natural resources play an important role for National Income Accounting.

Therefore forest valuation is important.

'Values' - What and How?

Now that the need and motivation for valuation of forests stands addressed, next we need to dwell upon 'what' is it that needs to be valued.

The Millennium Ecosystem Assessment (MEA) in the early 2000s, categorized all ecosystem services in four broad categories. In the context of forests, these ecosystem services can be explained as -

1. **Provisioning:** Forests provide means of producing or collecting different goods, e.g. honey, fuelwood, fodder etc.
2. **Regulating:** Forests regulate the natural systems, e.g. forest contributes in carbon sequestration, controls microclimate.
3. **Supporting:** Forests support living organisms, e.g. forests contribute to pollination in neighboring areas.

Cultural: Forests have spiritual and recreational benefits. Many forest areas are considered sacred, and hence have deep associations with the local communities, while others possessing aesthetic virtues, are visited for recreation.

Project—Background and Purpose

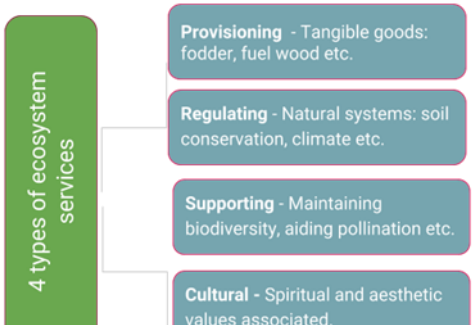


Figure 1.1 : 4 Types of ecosystem

Himachal, being a mountainous region hosting a plethora of ill-connected regions features a considerable population that, although not 'lives off' forests in the 21st century world, but has major dependencies as far as lifestyles are concerned, and hence every concept of value finds good grounds in the perspective of the state.

Therefore, our project, aimed at an extensive and thoughtful analysis of forests finds a perfect context in exemplifying the forests of the Mandi District Of Himachal Pradesh.

It now stands established that there is a range of crucial ecosystem services that a forest provides and these ecosystem services are 'valuable' to human being. Now the question is: if forests provide services that are 'valuable', then why is it the case that the beneficiaries themselves allow its degradation? What is central to the answer is the inadequacy in capturing the 'values' of these services. This inadequacy arises from two sources: first, in terms of developing a comprehensive list of ecosystem services that a forest provides, and second, in terms of understanding the value attached to these services by different stakeholders. In this context, let us first appreciate the fact that while some of the forest products (e.g. timber) are visible, marketed and hence easy to value, some of them, especially services are not even visible (e.g. cultural values).

Thus, our project aims to combine data, knowledge and understanding compiled into an extensive report for the purpose of creating a solid and objective base for determining the future course of action based on inferences and interpretations drawn from our study.

Also, there's a serious disparity in the actual values that forests deliver and their consideration when put forth for exploitation. Besides, the means as well as the ends in the context of the said exploitation, might be different for different stakeholders.

Hence the main problem at hand is assessing a forest region as an example, and an effort to neutralize these disproportionate differences, not with merely thoughts and plans, but with the solid backing of a thorough, well documented analysis.

The purpose is of paramount importance; for the values as seen at their immediate level of exploitation, can be deemed far different than those at the helm of supervision and policy making. Thus, this study, apart from the value assessment, data and stats it generates (alongside the understanding and thought process involved), can also be helpful for bridging this gap. The challenge nevertheless remains picking vital threads (of ideas and data) amidst the vastly marred content available in the context.

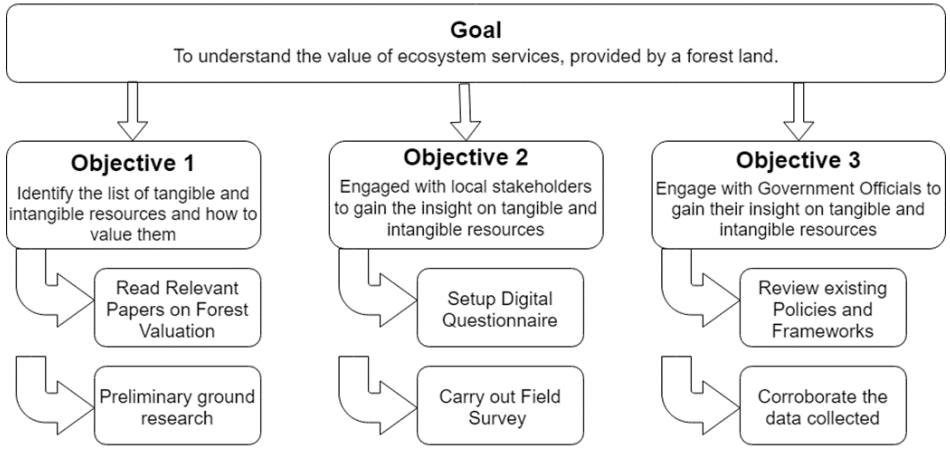
Methodology

The goal of this study is to evaluate the economic value associated with the Forests in Himachal, mainly in Mandi District of Himachal Pradesh.

To accomplish this goal, we fixed three objectives:

1. Identify the list of tangible and intangible resources and how to value them.
2. Engaged with local stakeholders to gain the insight on tangible and intangible resources.
3. Engaged with Government Officials to gain their insight on tangible and intangible resources.

The study covers various stakeholders at different levels, from the consumer at the grassroot level to the Government officials. These objectives and our work flow is shown in Figure 3.1 below.



Objective 1: Research

We first sat down and listed all the good and services that can be extracted from a forest, along with going through the forest policies and previous forest valuations of the forests in India.

After going through various valuation techniques, focusing on all three aspects, we designed our questionnaire.

Objective 2: Questionnaire and Survey

We decided to record the data on a digital questionnaire prepared on a software known as Open Data Kit to go for a paperless survey.
ODK is a data collection software where data is stored on a central server, which makes very easy to do post processing of the data and to carry out quantitative and qualitative analysis very easily. Data on the server is exported on the excel format so analysis of the data be done very easily.
ODK Software package includes three parts:

- ODK Collect: An android based application where the questionnaire is filled by the user,
- ODK Build: An interactive interface to build the questionnaire in xml format.
- ODK Aggregate: A central server on which the data is finally stored.

Steps in setting up ODK:

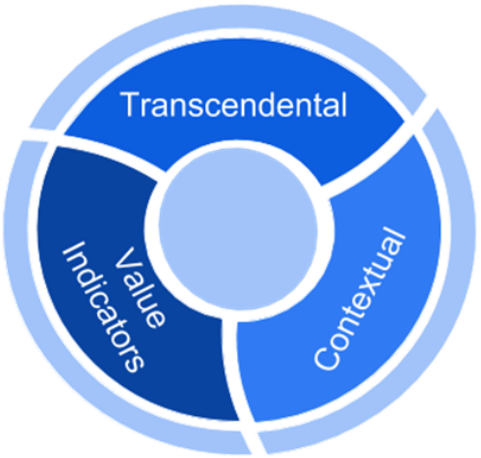
- We build our questionnaire on the ODK build in xml format.
- We hosted an ODK Aggregate Server on Amazon Web Services (AWS) to act as central server.
- We had installed ODK Collect on our phones and tablets and loaded our questionnaire in it

Next, we picked two survey locations out of shortlisted few, based on a few parameters

- Prepared questionnaire for structured and semi structured interviews.
- Pilot study and reworked on the changes.
- Collected and analyzed both qualitative and quantitative responses.

Objective 3: District Forest Office

For the last objective, we visited the District Forest Office and gathered their insight and corroborated the data we gathered. This was an important part as this is the regulating body which decides the laws and policies which people adhere to, and seeing whether their priorities are in line with the common people is of utmost importance.



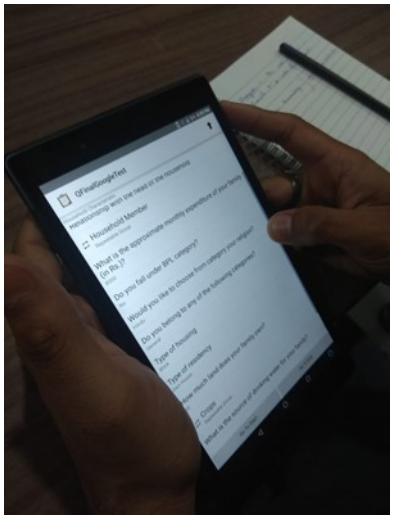


Fig 3.2: ODK being Setup

IV. Study Locations

To accomplish the goals of the project and to gather information, various sample surveys of the households in selected villages was done based on a structured questionnaire.

For our project we specifically chose two major locations Parashar Forest Land and Kamru Nag Forest Land. The surveys were done in specific villages depending upon various parameters as mentioned -

1. **Closeness to Forest Land and Resources** Households in the vicinity of forestlands are more prone to consuming forest resources due to the rich availability of forest resources and easier collection process to arrange resources such as Grass, Fuelwood, Fodder. The closeness to forest also affects the lifestyle and livelihood of the dwellers in cultural and spiritual aspects as well. Thus, we chose villages that were closer to the forestlands that gave us more insights into the resource valuation process.
2. **Distance of Village from Roads** Villages nearby forest areas that are connected by roads have a better connectivity to the outside forest area and thus have a better chance of existing markets for forest resources such as Plants, Flowers, Fruits and medicines. As the major occupation in rural areas of Himachal is agriculture, the roadside villages seem to have a better market for the agro-produce as well. We

1. chose villages that were lying completely or partially inside the forest areas or about a kilometer away from the forest. This not only allowed us to easily access the people of the village but also helped us in understanding the role of connectivity in their lives. As the connectivity progresses, the market and sale of resources flourishes.
2. **Distance from Mandi** Since our project is constrained to Mandi district only, we chose villages that were not so far away from the Mandi town. Villages were identified and then geographical data was obtained to get the potential households that would be surveyed in a particular forestland.
3. **Population, Caste Distribution and Literacy Rate** The information about number of households and total population of a village and its *panchayat* helped us in identifying potential villages that could be surveyed. We chose both kind of villages, one with lesser population around 180 and the latter having a population of about nearly double the former. We also considered the caste distribution of the villages so that the survey can portray diversity in opinions of people. Also the Literacy rate of a village was identified before the field trips for a better communicational preparation for all the project staff.

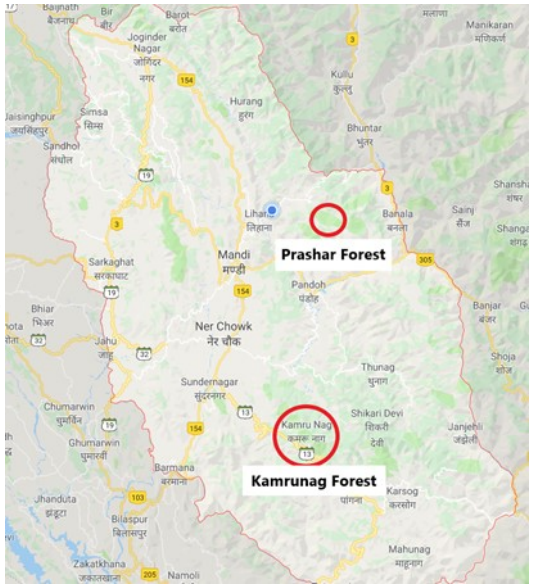


Fig 4.1 : Mandi District Map showing

4. **Major Occupation** Almost all the villages of Himachal Pradesh practice cultivation of crops either for economic benefits or for subsistence. We selected particular villages in which people practice crop cultivation along with livestock and animal husbandry as these practices need forest resources as supporting materials and hence a good quantitative estimate can be obtained from such areas.

Fig 4.2 : Chowki village under the Rohanda panchayat, Kamrunag Area

Fig 4.3: Aukal village under the Rohanda panchayat, Kamrunag

Fig 4.4 : Parashar Forest Area and

Forest Area	Village Panchayat	Households Surveyed	Major Occupation	Major Collection (Resources)
Prashar	Halgarh (Teel, Nandani)	10	Farming & Tourism	Fuelwood, Fodder
Kamru Nag	Rohanda (Aukal, Chakrat, Chauki)	23	Farming	Fodder, Fuelwood, Timber

Table 4.1 : Showing Factors and Parameters of Locations to be surveyed

Forest Area	Village Panchayat	Households Surveyed	Major Occupation	Major Collection (Resources)
Prashar	Halgarh (Teel, Nandani)	10	Farming & Tourism	Fuelwood, Fodder
Kamru Nag	Rohanda (Aukal, Chakrat, Chauki)	23	Farming	Fodder, Fuelwood, Timber

Table 4.2 : Outcomes from the field trip about the households surveyed and major occupations along with items from the forest that are collected majorly.

Results and Discussion

For our project we specifically chose two major locations Prashar Forest Land and Kamru Nag Forest Land. The surveys were done in specific villages depending upon various parameters as mentioned in our methodology.

The demographics of the respondents are presented-

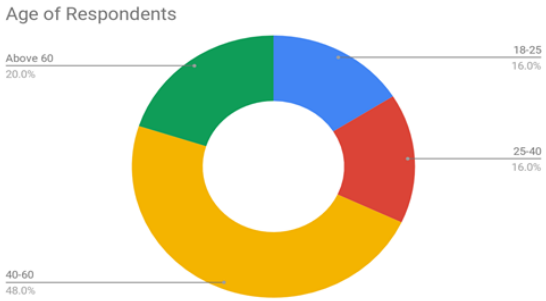


Table 5.1 : Gender of Respondents

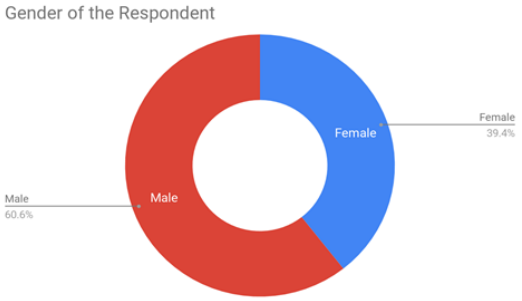


Table 5.2 : Age of Respondents

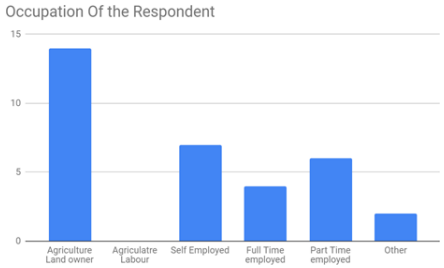


Table 5.3 : Occupation of the Respondents

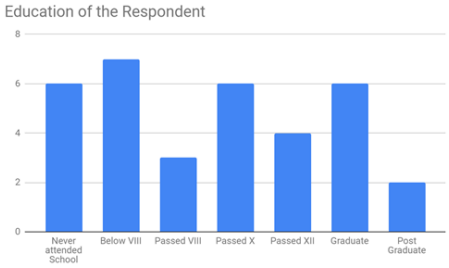


Table 5.4 : Education of Respondents

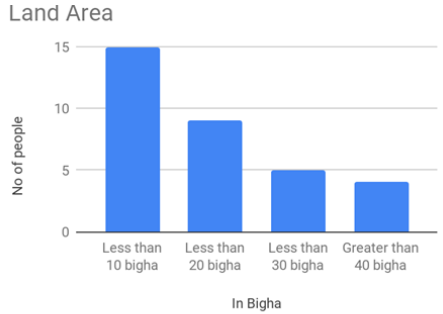


Table 5.5 : Respondents' land ownership stats

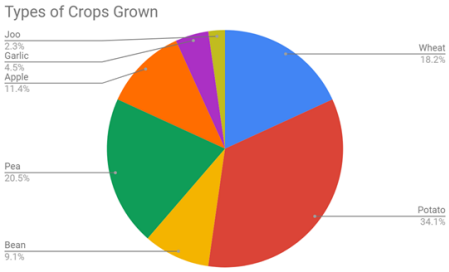


Table 5.6: Type of crop grown

Staying open for all varieties of responses with a ready , thorough questionnaire - we draw the understated inferences, implications and conclusions with a cumulative understanding of recorded data (alongside an inevitable tinge of various aspects and contexts that sprung up in between conversations).

Through the basic survey executed at the level of an extensive questionnaire with 2 different forest surrounding populations, we found out that in the 21st world, the variety in extraction and consumption of forest goods at the level of an individual stands limited to chiefly wood and fodder.

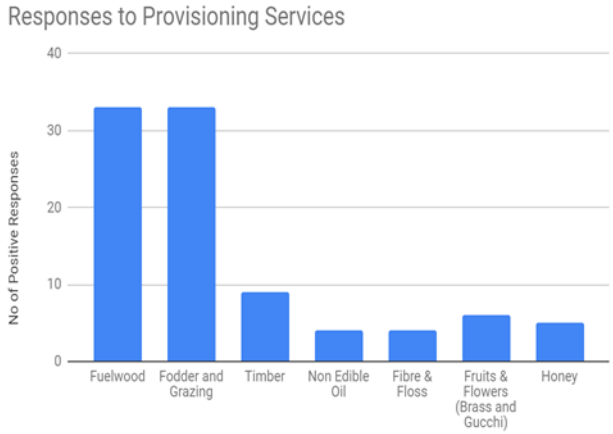


Table 5.7 : Consumption of the forest products by the respondent

On an average one household collects more than 2 tonnes of fuelwood per year alongside 11 tonnes of fodder.

A crude estimation of the value of resources collected per family is averaged at Rs. 10,000/- per month at peak consumption levels.* (A considerable amount, given the fact that the average per capita expenditure in the region is approximated to Rs. 2500/- per month

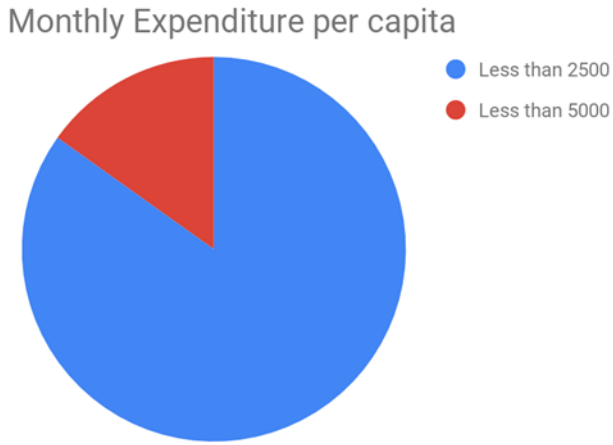


Table 5.8 : Monthly expenditure per capita among the respondents

Some points worth noting need to be highlighted here:

- There's considerable variation in consumption across seasons. Most families approximated their consumption ratio to 2:1 comparing winters against summers. The consumption rocketed in winters owing to their dependency on forest wood as the only source of fuel for heating and partial source of cooking (*chulhas).*
- A noteworthy, yet underlying factor came to light. The consumption of wood (in winters) was consistent against variations in number of family members - as a respondent put it *"ek hi chulhe ki aag sekte hain* (All members share the heat of the same fire) *".* The concept being, the entire family shares a common room for major part of their days during the harsh winters (and hence the same amount of fuel is consumed for heating up the room, irrespective of the number of family members).

-Probably one of the contributing reasons as to why 'family' remains a closely knit unit in the villages. Sharing and bonding thrives amidst the nature's unpleasant seasons - a sweet thought worthy social takeaway from our experience in making this report.

Points of Significance -

⇒ A persistent feeling amongst our surveys was that people are hesitant to open up to questions concerning their consumption of goods. Respondents were hesitant to reveal their expenditure and were skeptic to give a full account of resources that they collect from the forest, and this opened up a huge possibility for **under reporting of data**.

Data once under-reported, transcends across records for several years and mars the ability of policy makers to make informed decisions.

⇒ **How a measure to control timber extraction ended up promoting backdoor ways of doing the same! - A narrative -**

An old prevailing system of 'T.D' (**Timber Distribution**) ensured that folks from communities dwelling near forests had access to timber at regular intervals as per their requirements at regular intervals. However, later the rules were modified to limit their extraction to 10 cubic metre per decade.

Unable to meet their requirements within the framework and limits set by the government, the people started resorting to backdoor methods to illegitimately acquire timber.

Hence, while earlier the access was excessive yet recorded, now the same goes on incessantly through control channels.

⇒ Also, another realization was common folk are fairly aware of the environmental impacts and benefits of forests. An irregularity in climatic cycles over the years was reported. They were also aware that forests contribute to soil conservation. **A common notion of an increment in the nearby forest regions prevailed. This stands true** to the Forest Cover Report's findings.

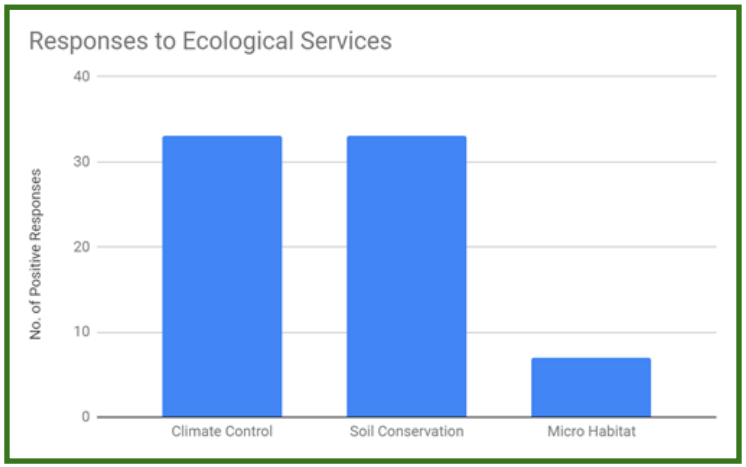


Table 5.9 : Response to Ecological Services

This is a transcendental value of forests, and it being common knowledge adds to their contextual value.

⇒ People, when asked about any sacrilegious aspects connected to the forest in their region, each had their unique version to narrate. The spiritual and cultural bonds that the locals share with the forest are quite deep, and although the valuation of forest products against the per capita expenditure is the highlight outcome, we cannot not value something that remains 'invaluable'.

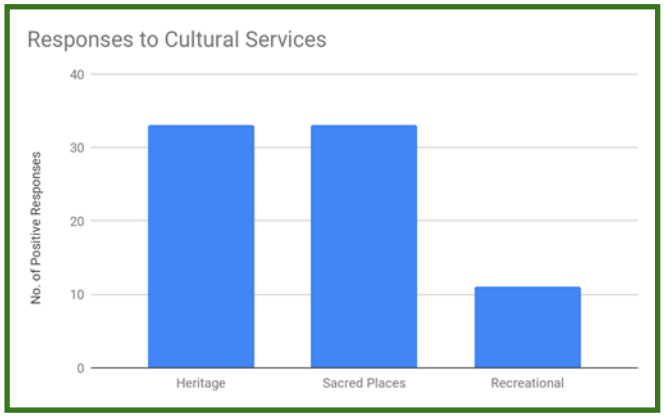


Table 5.10 : Response to Cultural Services

A brief interview with the District Forest Officer, Mandi

SS Kashyap

HPFS

Question: How are the forest policies made and who has a say in that? What about Mandi District?

Presently, the Forest Department, all over India, is following the Indian Forest Act,1927 that was made during the British Rule in India. Earlier, as per the National Forest Policy, the role of forest department was to get maximum commercial benefit (during the British Rule) but later as people found out that given the rate of consumption, the forests will not sustain efficiently. Hence, there were amendments that lead to a better sustainable growth procedure. The authority of making decisions or changes in Policies lies with the concurrent power of both the State Department and the Central Department of Forests. The needs and requirements of local people are identified way earlier through surveys as they form the fundamental base of the policy.

Regarding Mandi district, in 1917, 'Mandi Settlement' was written that listed out the villages that have access to a particular forest and the resources that could be extracted from it. It was written almost 100 years back and is still enforced.

Question: How are forests managed? Does local people give hands too?

In Himachal, we follow a concept of 'Joint Forest Management'. It came through the idea of 'Social Forestry'. In this venture, staff from the Forest Department mix along with the Local People of the neighbouring forest and start off a plantation drive, awareness drive etc. The purpose of JFMC is to make people aware of the importance of forests. Moreover, forest department also incorporates 'Eco -Tourism' where local people are given a livelihood such as Camping, Trekking guides. It is a way to make people believe that forests and the natural beauty of forests can be a source of income too.

Question: What about the security of forests? Any cases of illegal or backdoor trading of forest resources?

For the security, there are check posts at everyDPF. There are forest guards who patrol in shifts to verify that everything is alright. Moreover, with the help of technology, we were able to set up a few CCTV cameras at specific places in the forest periphery.
It is very often that forests catch fire. Most of the forest fire cases are man made. It is a myth among the people that forest fire lead to better growth of new plants and that also leads to a better rain fall but there are no scientific explanation to the process and hence it has no practical value rather than causing loss to the state.
There are cases of backdoor trading as forest is an open property, it is very difficult to keep an eye at all places 24*7. Nevertheless, illegal traders are often caught by the forest guards and have to undergo trials in the court.

Recommendations

Another interesting revelation, though not quantitative - Although, there is a marginal increase in forest cover, the same has a lot of grounds for expansion.

Local folks revealed that a hefty portion of newly planted tree saplings do not foster into trees and are marred by conditions beforehand. A better follow-up policy post plantation drives on the officials' part can help greatly influence the statistics. Collaborative efforts from the local people and the Forest Department staff can lead to better plantation drives and ultimately a sustainable style of development.

The productivity of Forests greatly depend on sustainable cutting and afforestation policies. Different regions have different vegetation, each of them having unique resource quality. Thus, regions where the forest growth is happening becomes the region where maximum resource can be exported for royalty. This strategy will not only help sustain forest cover but also improve the economic value associated with a particular forest.

There is a rich cultural and spiritual attachment of local people towards forest which is hard to be tabulated in a particular format. Howsoever, it has a great impact on the forest preservation and consumption that cannot be neglected. It falls under their livelihood as a lifestyle.

Acknowledgements

Our team would like to the following individuals for their assistance in helping us present a successful project:

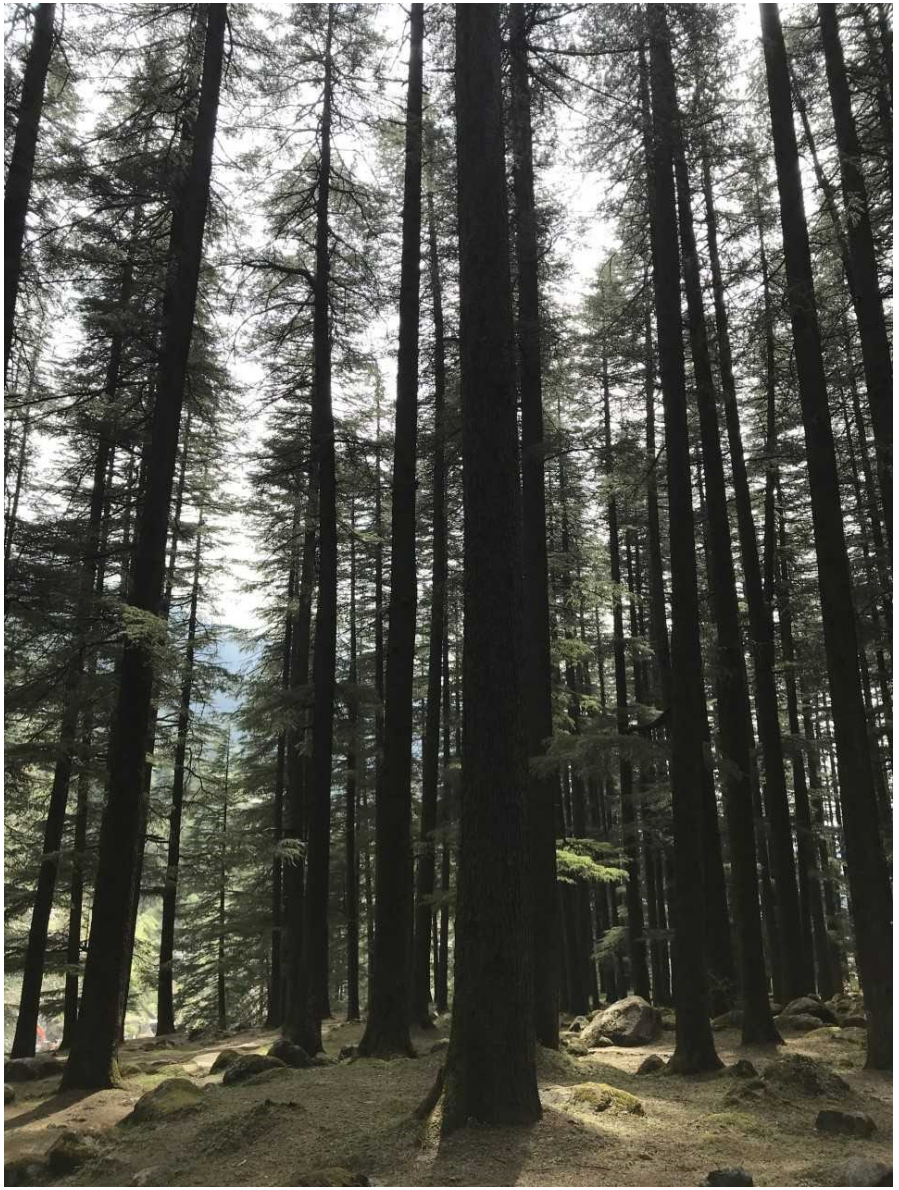
- **Dr. Shyamasree Das Gupta** for her significant contributions and insight on the project and report.
- **Mr. Vishal Sharma and Mr. Kritishnu** for his assisting us in inteviews and setting up rides for field work.
- **Dr. Rinki Sarkar** for showing us the basics of surveying.
- **The editorial team** for all of their hard work in order to get our booklet done.
- **All survey and interview participants** for sharing their experiences and opinions related to Forest and its importance in their lives.
- **Indian Institute of Technology Mandi** giving us the opportunity to take part in this experience.

The full report and Supplemental Materials for this project can be found at:

http://www.wpi.edu/E-project-db/E-projectsearch/search

using key words from the project title. Outcomes delivered after May 1 will appear on the IITs ISTP page at:

http://www.iitmandi.ac.in/istp/projects.html



Works Cited

Assessment, M. E. (2001). Millennium ecosystem assessment. Millennium Ecosystem Assessment.

Kenter, J. O., O'Brien, L., Hockley, N., Ravenscroft, N., Fazey, I., Irvine, K. N., ... & Church, A. (2015).

What are shared and social values of ecosystems?. Ecological Economics, 111, 86-99.

Semwal, R., Tewari, A., Negi, G. C., Thadani, R., & Phartiyal, P. (2007). Valuation of ecosystem services and forest governance: a scoping study from Uttarakhand. LEAD India, New Delhi.

Verma, M. (2000). Economic valuation of forests of Himachal Pradesh. Report on economic component of Himachal Pradesh forestry sector review, 7.

Forest image taken near Prashar Lake, India

Pic: Lynne Moore

Technological Interventions to Support Local Healthcare Infrastructure around IIT Mandi

Abstract

The goal of our project was to analyze the existing healthcare infrastructure available in villages around IIT Mandi. Surveys were conducted in local health centers and interviews with village residents, doctors, Asha workers, and lab technicians. Detailed analysis was done on the collected data and some bottlenecks were identified that were hindering the development of healthcare infrastructure in the region. Sparsely distributed population, difficult terrain, shortage of medical staff and equipment: these were the key challenges. Based on this analysis, we recommended the possible technical intervention in the present healthcare infrastructure of Mandi. Our recommendations include a telemedicine based system, medicine vending machine, training program of Asha workers and an improvised stretcher design.

Team Members

Bharat Lodhi [B16015]
Naveen Kumar Chouhan [B16022]
Nishant Rana [B16107]
Priyanshu Khandelwal [B16027]
Sajal Boris Negi [B16030]
Suryavanshi Virendrasingh [B16037]
Sylvia Mittal [B16038]

Advisors

Dr. Arnav Bhavsar

Introduction

Himachal Pradesh has a hilly terrain and has sparsely spread population. Medical needs differ in these areas due to distance, infrastructure, and disease patterns. The government has propelled healthcare initiatives aiming to improve healthcare delivery at the state and district level (Ministry of Health & Family Welfare Government of India, 2005). While these initiatives have been somewhat successful, a lack of resources and other constraints often prevent these initiatives from having the desired impact, due to inaccessibility.

The District of Mandi, where our research is focused, is located in the Shivalik region of the lower Himalayas in the state of Himachal Pradesh. The majority of the region is mountainous and contains several major rivers, including the Beas. In the hilly region of Himachal Pradesh, transportation can be difficult. Since the introduction of the IIT Mandi in 2009, some improvements to infrastructure brought benefits to neighbouring communities. But still, an important aspect to keep in mind when assessing regional healthcare around Mandi is a consideration for local needs and the constraints of the community. According to a census done in 2011, there were nearly one million people living in Mandi District, with 94% of the population living in rural areas (Mandi District: 2011 Census Data). Getting proper care in these rural areas can be difficult. Women and children need access to specific medical services, including maternal services and pediatric care.

Getting proper medical healthcare facilities is very important for every individual, but also their communities as a whole to make the country progress. The World Health Organisation's theme for World Health Day 2018 is "Universal **health** coverage: everyone, everywhere" and the slogan is "Health for All" (World Health Day, 2018). In the words of the World Health Organization, "Health is an intrinsic human right as well as a central input to poverty reduction and socio-economic development" (2014). Health enables resilience in communities, and thereby secondarily promotes welfare, including poverty reduction and sustained economic growth (Commission on Macroeconomics and Health, 2001).

Hence, to support the current health infrastructure in the villages around IIT Mandi, this project assesses the current state of the Infrastructure and suggests well thought out recommendations for technical interventions, ultimately targeting the improvement of access to quality care for the people in rural Mandi.

Background

In this section, we provide the background and analysis on determining healthcare quality in rural Mandi focusing on the site of our project, focusing on the economy, stakeholders, accessibility, culture, and geography.

Mandi is one of the twelve districts of the Indian state of Himachal Pradesh. Located in foothills of Himalaya and spanning an area of 4,000 square kilometres, it is known for its lush green hills and scenic views. It has a population of 999,567(census 2011) out of which 94% population is rural (Mandi District: 2011 Census Data). The Mandi District contains 3,338 villages, and many of them are not completely accessible by roads. With an unreliable network of roads between villages, it is difficult for people to commute between different villages. The condition gets worsened during monsoon season when heavy rains and landslide sweep away the existing roads. In 2017 a massive landslide near Joginder Nagar swept away a 250 sq meter area, killing 46 people.

In their report about the typical behaviour of people in rural communities and rural transport issues in developing countries, Njenga and Davis argue that distance directly influences people's inclination to travel to healthcare clinics in areas where transportation is limited (Njenga and Davis, 2003). With lower cost and accessible roads, healthcare accessibility will increase to the rural population of Mandi.

An ISTP team in 2015 comprising students of IIT Mandi and WPI assessed the primary obstacles to healthcare in the Mandi District. The team investigated multiple healthcare facilities, which included the Zonal Hospital at Mandi. A network containing multiple sub-centres near IIT Mandi and the CHC of Kataula was ultimately mapped. The ISTP team developed a Rural Healthcare Assessment Model identifying some crucial bottlenecks in rural health care in the system. The major bottleneck was inhibited physical access to facilities due to challenging mountainous terrain coupled with poor road quality. The second bottleneck was related to limited supplies and medication due to irregular delivery schedules and poor access, leading to high delivery costs. The major bottleneck was

limited access to specialist doctors, even in a big CHC like Kataula. In order to overcome these issues, they proposed a better connection between PHC along with telemedicine service and stretcher.

Assessment by the 2015 ISTP team only stated a more generalized solution but their survey did not convey specific details on the scope of and implementation of these solutions. Another ISTP in 2017 looked into the the connectivity problem. The issue of telemedicine and stretcher were unaddressed. Thus, our project revolves mainly around implementing telemedicine according to the scenario of Kamand Valley which can be extended to other hilly terrains.

We assessed the public healthcare infrastructure in this region, specifically, the PHCs in nearby villages and CHC in Medical Block of Kataula. In this mountainous region, some villages are not properly connected by road and hilly terrain makes it difficult for the patient to reach the Health Centres. Also, the sparsely distributed population makes it difficult for the administration to open the sub-centres near to the population and also for the Asha workers and Anganwadi workers to go to each home.

The health care infrastructure in rural areas is build up of three-tier system as follows.

1. **Sub Centre:** Most basic unit of Primary Health Care System manned with one male health worker and one Auxiliary Nurse Midwife (ANM)/Female Health Worker.
2. **Primary Health Centre (PHC):** A Referral Unit for 6 Sub Centres having the staff of a Medical Officer and team of 14 subordinate paramedical staff.
3. **Community Health Centre (CHC):** A referral unit for 4 PHCs having the capacity of 30 beds with Specialized services.

According to reports, there is a shortage of manpower in the existing healthcare infrastructure in rural areas. The gap between required and existing is higher for positions with a higher level of training. Health Centres are equipped with the Machines and Lab but there is a dearth of Lab technicians to operate them.

In 1953, the doctor-population ratio in India was 1:6300, and the healthcare infrastructure was limited to the big cities only. The World Health Organization has recommended the doctor population ratio of 1:1000, Since 1953, the Population of India has trebled, the number of doctors in India has grown 17 times, and today India has a doctor-population ratio of 1:921. Despite having a healthy doctor-population ratio many people living in remotely located villages and towns do not have access to the specialist doctors and healthcare. Most of the Doctors want to practise in the large cities and district centres and are not interested in going to work in remote locations.

So on the basis of our research we came up with the concept of telemedicine for the remote villages which is one of the solutions that we suggest. Telemedicine is defined as health services provided via telecommunications that enable medical personnel working in hospitals and clinics to transmit medical laboratory or other investigation results and patient data from distant locations. It enables medical practitioners working remotely to call upon locally unavailable specialist skills at centres of medical excellence, even worldwide (Bashshur, Sanders and Shannon 1997).

Telemedicine can be viewed as vehicles to bridge the healthcare divide between rural and urban population and to resolve shortcomings in the rural health sector. It enables linkage of medical practitioners who are separated geographically and helps in better diagnostics of diseases. According to Eysenbach (2001), e-health is an emerging field in the intersection of medical informatics, public health and business, with referral and information delivery enhanced through the Internet and related technologies.

A 2012 report by the Institute of Medicine for the National Academies, entitled 'The Role of Telehealth in an Evolving Health Care Environment', found that telehealth increases the quality of care, and reduces costs by limiting unnecessary emergency department visits for rural communities. Through telemedicine, rural hospitals can serve rural patients at better costs and help cut down on the time it takes rural patients to receive care, particularly speciality care.

Case Study: Telemedicine implemented by Apollo Hospital

In 1997, Chennai Based Apollo Group Hospital decided to extend their services to suburban and rural areas of India using telemedicine. Apollo Hospital is considered as one of the largest corporate chain of hospitals in Asia. They have the largest multispecialty telemedicine

network in South Asia. They are the pioneer in the field of telemedicine in India and developed the Apollo Telemedicine Networking Foundation. They set up the first Rural telemedicine centre in 1999 in Aragonda(in Andhra Pradesh).

ANTF was a success which lead to joining of other hospitals into the program and played crucial role in the development of telemedicine in India. Patients from large distances are treated under telemedicine. The successful services from 2000 to 2001 by ANTF, has made the Indian Space Research Organization (ISRO) realize telemedicine as one of the areas to be developed for improving the healthcare in rural areas.

"I think it is a very wonderful contribution to the healthcare of the people who live in rural villages and I hope that people all over the world will follow your lead, because if they do then the benefits of the hi-tech medicine can go to everyone and not just people who live in big cities." - Bill Clinton, during his visit to India on 24th March 2000.

This was a non-profit venture by Apollo hospital. This scenario showed the feasibility as well as the practicality of implementing telemedicine solution in Kamand Region.

Methodology

We found that a number of ISTP projects regarding the health care infrastructure in Kamand valley has been done in the past years but the healthcare facilities has not been improved to a greater extent and the general public has to suffer for the basic health facilities. We tried to build upon the previous projects instead of starting from scratch. Our project tried to dig over the reasons due to which the earlier proposed solutions were not successfully implemented.

We focused on:

1. Analyzing the Current Situation of Health Care Infrastructure.
2. Understanding the major problem.

The research methods pertaining to each objective are summarized in **Figure 1**.

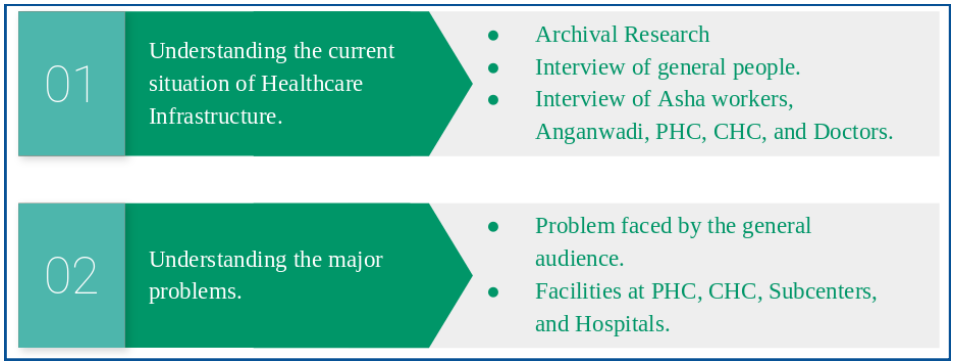


Figure 1: Methodology

Understanding the current situation of Healthcare Infrastructure.

As discussed above, to get an insight into current Health Care Infrastructure we studied the government schemes in Himachal Pradesh and the accessibility and awareness of those schemes to the general public. Apart from this, the availability of medical facility in sub centers or PHC, the services given to the newborn baby and pregnant lady and the facilities for children. Our project mainly focus on health care issues related to these three groups: old age people, women and children as they are the ones suffering due to their dependency on the working men.

We planned to interview the doctors and nurses in the hospital and discussed the frequency of patients, general problem and types of equipment available in the hospital. Due to the sparsity of villages in Kamand valley Asha workers and “Dais” plays an important role in pregnancy and labour. Whereas Anganwadi workers play an important role in children's health care. Also, people rely on some of the ayurvedic and some traditional methods like Nadi for some diseases and vaidyas for snake bites. So, we also planned to interview some Anganwadi workers, Asha workers and ‘Vaidyas’ (traditional healers) who practice the ayurvedic and traditional methods.

The interviews would be incomplete without the inputs from the general public, what are their needs and expectation from health care facilities. The major problem is of connectivity. So, we kept this thing in mind while doing the survey. The people for personal interview were chosen from all over the region and villages to be surveyed were identified on the basis of their remote location.

Analyzing the major problems

Women face problems during pregnancy whereas children frequently face the problem of cold and flu and most of the old age people have problems with knee pain and eyesight. Apart from these, cases of tuberculosis, snake bites are common in this region. Due to hilly terrains, transportation is also a major problem for the people living away from the road.

It is a general trend that specialized doctors prefer working in cities so there is shortage of trained medical professionals in the rural areas. So, we decided to interview the doctors and nurses in CHC, PHC and sub-centers and calculate the statistics for the available doctors, technicians and lab equipments. We plan to identify some common set of diseases in the villages so that we can recommend solutions for them.

Asha workers and Anganwadi workers play a very crucial role in rural areas for the pregnant woman and newborn child. So we decided to look into their training process, role played by them and possible roles that they can be trained for.

Results

Parashar and nearby villages

People prefer private hospitals for major disease/injury and mostly rely on Ayurvedic medicines. One case was encountered where an Asha worker was unable to deliver a baby successfully resulting in miscarriage. After that, the villagers lost trust in Asha workers and old experienced women in the village did the deliveries. There was no proper training program for Asha workers. Almost no useful government scheme. Parashar PHC (cooperative trust) had a shortage of doctors and technicians. Roads got blocked with snow in winters so people had to face problems with transportation. Ambulance service was very poor with a response time of more than 30 minutes.

Arnehar

No First Aid facility is available in the village. People have to travel to Khwachi for consulting Asha worker or 'Vaidya'. Snake bites are common in the area and people only go to 'Vaidyas' for treatment. In case of injury, patients are transported to zonal hospitals by tying them up on chairs. There is very little awareness about government schemes.

Batheri

People were very aware of the government schemes and Asha workers were also very active in the region. People did not go to Batheri PHC for treatment but instead, travel to private hospitals because of the unavailability of testing infrastructure and specialists at Batheri PHC. No infrastructure was available for major testing. People have to travel to CHC Kataula or Mandi Zonal Hospital or Nerchowk medical college.

Aarang/Sanvad and Tarang

People from Tarang have to travel to Aarang sub-centre for treatment. There is a lack of First Aid. Asha workers were not even well trained for crucial tasks as baby delivery. Regular camps were organised for X-Ray and blood tests. Only 2 Asha workers are assigned to 6 villages. There was unavailability of the medical facility at night. Poor quality of road transport. People carried on a chair in case of emergency. People rely on 'Vaidya' *for snake bites. Roads were in very poor condition.*

Neri

There was no proper transport facility to move patients from uphills or Riverside to the road. Local PHC has unavailability of specialist doctors. People don't go to Kataula CHC for treatment and diagnosis instead prefer Ayurvedic treatment and travel to Mandi zonal hospital for major diseases.

A full analysis of these areas can be found on the following page in Figure 2.

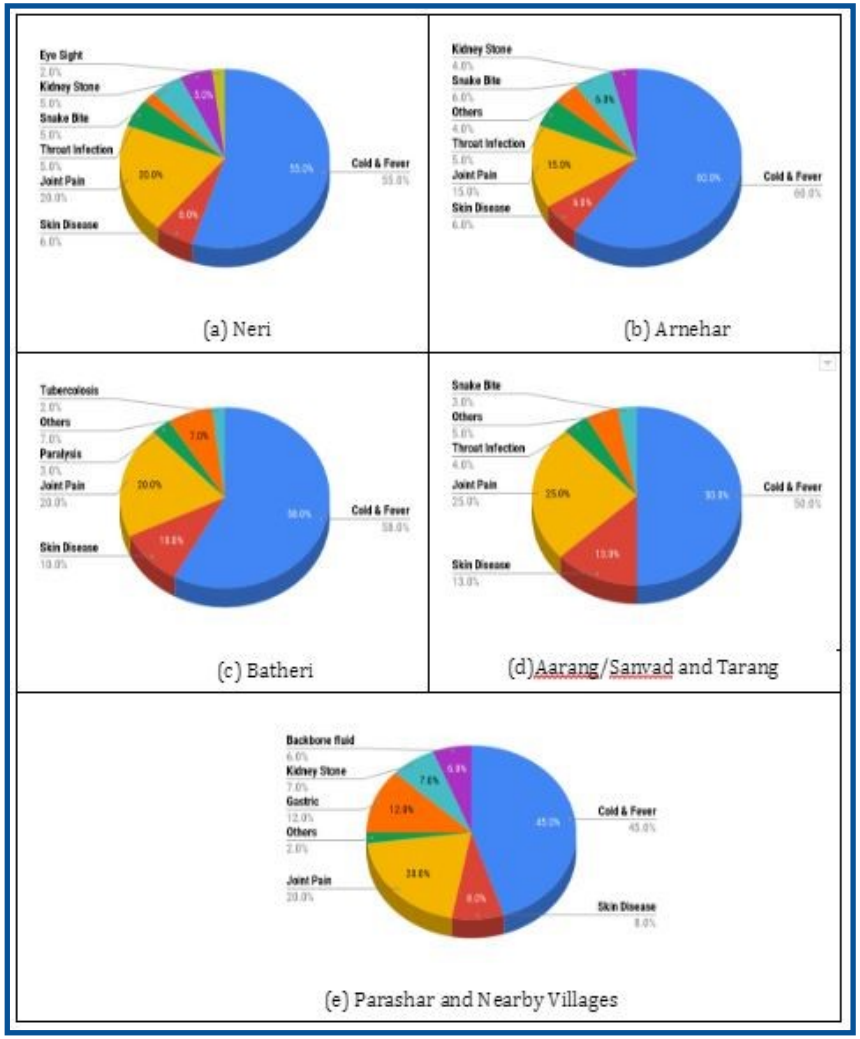


Figure 2: Distribution of most prevalent diseases as per the survey

Discussion

After analyzing the data that was collected from surveys we were able to identify the following reasons that were responsible for poor healthcare infrastructure in these villages.

The villages in Himachal are remote. Due to hilly terrain, some of the regions are not connected with the nearby villages. Ambulance and 108 emergency vehicle have been successful in villages near Kataula but the response time (~1 hour) is very poor for villages near Parashar. A case was recorded where delivery had to be conducted on a truck due to poor transport facility and high response time of Ambulance. The situation worsens in winters when roads in some villages (Teel, Kandhalu, Bandhi, Duhaat) get blocked due to snow. Due to this, the villages don't get supply of medicines on time. Medicines to small villages are supplied by nearby PHC's. Every village with a population of ~5000 has a PHC. Medicines to PHC are supplied by nearby CHC which in turn requests medicines from Zonal Hospital (one in each district). The connection between PHC and CHC is done through an online platform but it takes days for the medicine to be supplied to destination after the request is raised. The local healthcare centre has a limited stock of medicines that are able to treat only a subset of the surveyed diseases. Some villages have a local chemist for medicine but the shop closes after 6 PM making medicines not available 24*7. Further, due to inaccessibility people have to depend on local "Jadibooti" and "Vaidyas" for the treatment.

There is an acute shortage of Doctors in CHC and PHC. CHC's only have MBBS qualified doctors and people have to travel long distances to the nearest zonal hospital to visit specialists. Due to lack of quality medical colleges in Himachal, medical students don't prefer working here resulting in shortage of doctors. CHC's contain some basic equipments for eye testing, dental treatment etc but there is no technician to operate them. Same is the case with PHC's around Kataula. PHC and CHC were also found to be lacking the basic infrastructure necessary to treat their target population. Joint pain was found to be one of the most common diseases but there was no D3/D4 testing machine available at any PHC or CHC. Machines for Blood Testing and X-Ray were also unavailable at PHC or CHC. People are totally dependent on Zonal hospital for these tests.

According to the survey, Asha workers are found to be inadequately trained, unable to operate without supervision. In Parashar, a case was encountered where miscarriage happened during delivery by one of the Asha Worker. This resulted in distrust on Asha Workers and thereafter people resorted to Local 'Dai's' (midwives) and 'Vaidyas'. In villages near Kataula, Asha workers were working properly but in Neri, Batheri and Parashar Asha workers weren't active.

Project Outcomes

From the readings and interviews, the proposed solution in all the ISTP reports and survey whether its a stretcher for better transportation, vending machine for medicine dispensary or telemedicine for basic health care issues can be helpful but the solutions proposed will only do better in the Mandi district if they are structured with keeping the conditions and problems of Mandi District in mind. So, we tried to refine the proposed solution in previous ISTP reports and survey by building something on top of them which is more oriented and specific for the problems in Mandi District. So on the basis of that we came up with the following solutions.

Medical Vending Machine

To solve the problem of inaccessibility and lack of medicines we came up with the solution of medical vending machine.

A **Medical Vending Machine** will be an automated machine that will provide medicines and first aid kits to patients. This machine would be handy when people have some serious problems and quick medication is required. On pushing the SOS button on the machine, a video call to the nearest hospital can be arranged quickly and the doctor will get live footage of what's happening on the patient's side. The doctor can then approve some quick medications which would come out of the machine in the form of tablets very quickly and the patient's life can be saved. Not only this machine can act as a life saving equipment but it can also act as a general medical item dispensing machine. We can use these machines to dispense general medicines, sanitary pads, first aid kits, etc.

So, it will help us to achieve these 3 goals:

1. In every village or village panchayat, sufficient amount of machines would be installed as per the data of the number of people living in it, so the issue of lack of medicines is also resolved and in case of an emergency or an accident the patient can be provided with First aid kit or can be instantly given the required medicine to lower the risk of death during emergency cases.
2. In remote villages or even in PHC's which are not highly developed certain medicines are not available instantly. So this machine can be helpful as it doesn't require any human resource.
3. The main purpose would be to solve the emergency cases like sudden high B.P or Heart attack for which a medicine(e.g. Disprin tablet to prevent clots in blood vessels during heart attack) is required instantly that can be obtained through this machine and for these cases there will be an SOS button which will instantly connect the patient to doctor through live video streaming and in case of emergency the ambulance will be sent to the user in minimum time.

Telemedicine

To counter the problem of unavailability of doctors in remote areas and avoid travelling large distances for basic treatment we propose a telemedicine-based solution that can be implemented at local subcenters and PHC.

The telemedicine framework would comprise of a PC that has camera extensions and internet connectivity will be setup at local subcenters, PHC's and CHC's. This would be accompanied by mobile and web apps that can be installed in personal devices. The apps will be capable of transmitting images or doing video conferencing with doctors by a centralised server through internet. Further, the apps would have basic text editing forms that would have options regarding the symptoms of some common diseases and based on the entered data it would be able to provide basic medicine prescription.

After surveying doctors and patients we concluded that this solution would be feasible for skin and throat diseases because these don't require any specialized testing for first level diagnosis. For these diseases, the telemedicine based system would take the skin images of patients as input and would forward these images to doctor and, possibly, also provide recommendation for the type of disease using a deep learning based model. As per surveys, many people avoid visiting a doctor due to above-mentioned reasons and therefore resort to local clinical solutions or taking medicine by people's opinion. This creates the problem of wrong medication. Each patient would be identified by a unique identification system based on Aadhar. After analysis of the symptoms by the telemedicine machine, the patient would be provided a prescription of medicines.

For other common diseases, which typically have clear symptomatic first-level diagnosis (e.g. Throat Infection, Wounds, Stomach diseases etc) an Asha Worker would be trained to operate a telemedicine

based system. The patient would tell Asha worker about the body part he is facing the problem in. Then the Asha Worker would feed it into the system and the system would then show a list of commonly faced problems specific to that body part. Then Asha Worker would ask the patient for symptoms and check them on the list shown on screen. Based on the data entered, the system would recommend basic prescription. The data could then be transferred to doctor for the detailed analysis of the symptoms if required.

One of the major problem that doctors revealed after the survey was that people don't carry their previous prescriptions with them when coming for treatment. Treatment history of a patient is very crucial in studying the medicine response on the patient and helps in providing better recommendations. So, we plan to record patient history on the telemedicine server. When a patient uses the telemedicine, the entire history would be forwarded to the doctor so that he would be well informed and would be able to make better decisions.

Training Asha workers through Video Conferencing

Asha workers are the important backbone for healthcare infrastructure of villages and if they are properly trained as per the diseases prevalent in their villages many medical emergencies can be cured within the village. So we came up with the solution of organising regular training camps of Asha Worker through video conferencing.

This training programs will be well-structured and will teach them about how to check the disease of a patient in a proper structured manner and what treatment can be provided on the basis of that checkup. So this can solve the problem of villagers of going to Zonal hospitals for every small disease and it can be also helpful in cases of accidents by treating the patient with proper first aid before he/she is transferred to the hospital to avoid excess bleeding or any infection which can turn into a major problem.

Stretcher

Some previous work has been done to propose a stretcher design that can be used for carrying patients. But after conducting surveys we found that there have been some cases in Parashar and Baggi where patients are being transferred from hill tops by tying them up on chairs. This can be harmful or even fatal for the patients. So we examined the existing solutions and proposed a better design having foldable wheels that could be used for transportation in hilly terrain as well as in plains. Further, we have used cushion material to improve the shock absorbance to avoid any further injury to the patient during transportation.

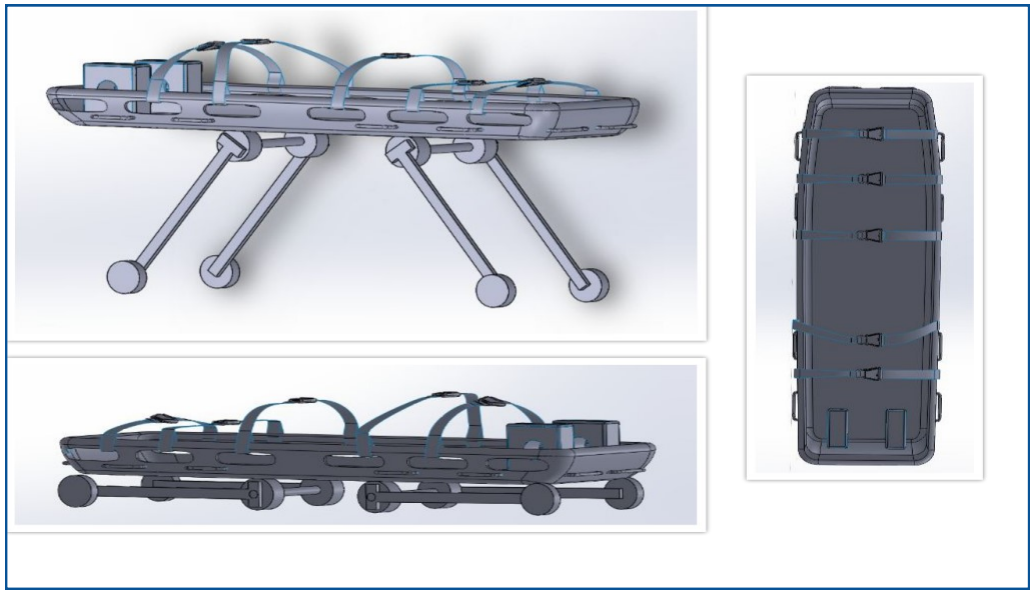


Figure 3: Design of Stretcher

The proposed design mentioned above in **Figure 3** gives the feasibility of carrying the patient easily in the hilly terrains and it also supports shock absorption. So this design can be built up on the stretcher design developed by ISTP 2015 public healthcare team and the aim of this design will be to provide it to the villages along with the ambulance.

Conclusion

Our project aimed at proposing a technical solution that could support the healthcare infrastructure in rural areas around IIT Mandi. We identified five bottlenecks through our survey in the Villages, PHC, CHC, Sub-centers and Hospitals : Lack of medicines, Inaccessibility, Lack of Equipments, Shortage of Doctors and Technicians, and Ineffective Asha workers. In order to solve these problems, we analyzed the con-

cerns of regular local villagers, asha workers, dais, doctors of health centers and came up with idea that these problems could be treated with the technical intervention of telemedicine, medical vending machine and training of asha workers. This is a long-term, easily accessible and low cost solution that could provide the supply of medicine at all hours of the day and the vending machine helps to make sure that these areas don't fall short of the medicines.

While our project focused on the technical interventions in rural healthcare infrastructure, our further research research shows that the training of Asha workers (local practitioners) would prevent the patients to travel to far-away places for common cold, flu and subsequently also solve the major problem of first aid during accidents. Asha workers could be furthermore trained for normal deliveries, prevalent diseases in their region and other common illnesses. This would save money, lives and assures good and instant medication to the patients.

Acknowledgments

Our team would like to thank the following people for their assistance and guidance during the course of our project:

- Our mentor Dr. Arnav Bhavsar for his guidance and support.
- Dr. Rinki Sarkar and Dr. Devika Sethi for starting us off in the right direction for our project and for providing us with valuable social research skills.
- The doctors, nurses, and technicians in the PHC, CHC, Sub-centers and Hospitals who generously donated their time and insight and worked to help us in understanding the healthcare infrastructure in himachal.
- The villagers who generously donated their time to participate in this study.

Works Cited

Bashshur, Rashid, Jay H. Sanders and Gary William Shannon, Eds. (1997). Telemedicine: Theory and practice. Springfield, Illinois: Charles C. ThomasCase Study of Apollo Hospital , Report's Website link :
-- http://www.apollotelehealth.com:9013/ATNF/about.
--https://www.researchgate.net/publication/317231540_A_case_study_on_Telemedicine_practices_implemented_with_respect_to_Apollo_Hospitals
Commission on Macroeconomics and Health (2001, December 20). Macroeconomics and Health: Investing in Health for Economic Development. World Health Organization. Retrieved from http://go.galegroup.com/ps/i.doid=GALE|0OSS&v=2.1&u=mlin_c_worpoly&it=aboutJournal&p=HRCA&sw=w
Dasgupta A, Deb S (2008). Available at: Telemedicine: A new horizon in public health in India. Indian J Community Med 33: 3-8
Evaluating the role of Primary Health Centers in India by Neesha Patel, Express Health care Management, 16-31 August 2005.
Eysenbach, G. (2001). What is e-health? Journal of Medical Internet Research 3(2): e20. Available at: http://www.jmir.org/2001/2/e20/ (accessed 12 October 2006).
Ganapathy K, Ravindra A (2009). Available at: Telemedicine in India: The Apollo story. Telemed J E Health 15: 576-585.
India. (2016) World Health Organization. Retrieved March 17, 2019 from http://www.who.int/countries/ind/en/
Landslide near Joginder Nagar in Mandi District: https://indianexpress.com/article/india/himachal-pradesh-landslide-mandi-national-highway-many-dead-injured-ndrf-rescue-operation-on-manali-4795047/
Mandi District: Census 2011 Data. (n.d.) Retrieved January 27, 2015 from: http://www.census2011.co.in/census/district/233-mandi.html
Ministry of Health and Family Welfare Government of Himachal Pradesh | Himachal Pradesh Swasthya Bima Yojna https://www.hpsbys.in/
Njenga, P. Davis, A. (2003) Drawing the road map to rural poverty reduction, Transport Reviews: A Transnational Transdisciplinary Journal, 23:2, 217-241, DOI:10.1080/0144164030988
Prateek Gauba (ISTP 2015 Report): ISTP 2015 team which did research of the topic : Assessment of the Healthcare infrastructure in the Kamand Region
World Health Day, 2018. Article Available at: https://www.timesnownews.com/health/article/world-health-day-2018-universal-health-coverage-uhc-who-at-70-health-for-all/214617
WHO (1998): A health telematics policy in support of WHO Health-For-

Assessment of sites for the suitability of the River Rope-way system in Mandi-Kullu Districts

Abstract

Mountain people are known for their resilient lifestyle. They work too hard and even risk their life just in order to fulfill their daily needs and day-to-day affairs. This becomes even more difficult due to the unavailability of proper bridges and road connectivity at many sites. One way in which population at such places cross the river is through use of traditional ropeways risking their safety and security. Our project aimed at assessing sites for the suitability of modern and innovative ropeway and studying the attitudes of people towards these. Interviews and surveys were conducted to understand the importance, opinions, and concerns about ropeway from the local residents in the village communities. Finally, we prepared a list of sites where River Ropeways are actually needed.

Team Members

Piyush Agarwal (B16068)
Kuldeep Anjana (B16100)
Ashutosh Kumar (B16126)
Saurabh Kumar (B16143)
Naveen Kumar (B16105)
Piyush Patil (B16109)

Advisors

Dr. Rajneesh Sharma
Dr. Dericks P. Shukla

Need of Ropeways in Himalayan Region

Being situated at the foothills of the Himalayas, the elevation of Himachal Pradesh is from east to the west and from the south to the north. As most of the area in Himachal Pradesh have hilly regions that makes the local's life complicated, due to hilly terrain. Roadways can't reach up to each village and even if they do, distance of village from the market places extends by several kilometers and reaching such places become time consuming and difficult for pedestrians. Himachal is also known as an agrarian state and people here are mostly dependent on the agricultural stuff. Around 50% of the economy of the state comes from agriculture, which is also the primary source of income as well as employment among the inhabitants. As many major river systems like Chenab, Beas, Ravi, Yamuna and Sutlej flow through the cities and villages. These rivers separate the population from their agricultural lands, schools, hospitals, panchayat Bhawan, markets, general stores etc. Due to many reasons like lesser number of proper bridges, poor road connectivity and bad weather conditions people face many difficulties to access these places.

Our project focused on understanding currently used techniques along with analyzing traditional methods for crossing river. Also, problems faced while crossing rivers with such traditional methods and how introduction of ropeway at these places will benefit a larger group of people. Our project consisted of finding suitable sites for installing Ropeway System in Mandi and Kullu Districts of Himachal Pradesh which would benefit and ease the life of local population.

In order to be successful in our research we followed a methodology consisting of some objectives- (1) we marked suitable sites on google earth and gathered information from local peoples about that site, (2) asked the local population about current practices and advantages and disadvantages of the same, (3) Analyzed the benefits and feasibility of installing the ropeway at these sites.

Figure 1: Water bodies in Himachal Pradesh

Background

Himachal Pradesh has many problems due to uneven terrain such as landslides, closure of roads during snow, extreme weather etc. People in Himachal have adapted to this rigorous lifestyle. They have made their own arrangements to tackle these problems they are effective but quite risky. One of such problems is crossing river. Around 8-9 months in a year Rivers have high flow so such temporary arrangements can and have led to life threatening practices. So, River ropeway is one of the sophisticated ways to tackle this problem.

Traditional Methods Followed and difficulties related to it

At many sites due to larger distance between bridges and improper connectivity people use long-established methods to cross the river like traditional ropeways, referred as 'jhullas' locally. These types of ropeways are pulled by the user himself or by another person, which involves a lot of energy and hassle. Further these ropeways are uncontrol-

lable as they start and as they reach the middle of the river, they sag and then require double energy to pull. More so, they have a single wheel and iron rope, so chances of tilting and breakage increases. The other methods are use of fallen tree logs and river side stones. During rainy seasons these logs and stones becomes slippery thus increasing the chances of accidents. Another way which people generally prefer is to cross the entire hill. Although this method is less risky during summers but is more energy and time consuming.

(Above) Figure 2: Traditional ropeway 'Jhulla' along the Parvati Valley (Below) *Figure 3: People crossing the Uhl river using stones behind North Campus, IIT Mandi*

Problems faced due to lack of connectivity

In many areas especially rural areas traditional methods are solving the purpose but people are facing many problems including safety and security. In many villages due to snow Roadway Transportation in closed for about 4-5 months and condition of these roads in remaining months is below average. In these times in case of Medical emergencies people need to carry patients on stretcher through the hills and few patients have lost their lives in this journey.

People need to do trekking to reach the bridge on the river and these roads are not well-defined so women in village cannot cross the village on their own at dark or low light. During monsoon and in snow crossing village to come on main road is dangerous. Few villages don't have schools so students need to cross river to reach school, in extreme weathers it's not safe to cross hence they miss schools quite frequently.

Benefits of River Ropeway

It's very risky and time consuming for the people to cross the river without bridges or by swimming. Therefore, there's a need of a means of transport that minimizes the problem. The concept of ropeway is very efficient as it can reduce the risk and will dominate all other alternatives. Ropeways will help to cross long obstacles like rivers, buildings, ravines, or roads without a problem. Further it requires low space on the ground, and no barrier for humans or animals. Material containers can be designed so as to rule out any soiling of the environment. A ropeway will also allow for the simultaneous transport of different types of material.

Innovative Ropeway

For the rivers whose span is less than 100-150 meters one of the best options is ropeway which is purely Mechanical. Such a ropeway is designed by Dr. Rajnish Sharma from IIT Mandi. This Mechanical ropeway allows the person to cross the river peddling the ropeway (similar to bicycle) himself. Other than low maintenance this mechanical ropeway is also cost effective.

Figure 4: Prototype-1 (left) and Prototype-2 (right) of Mechanical Ropeway

Methodological Approach

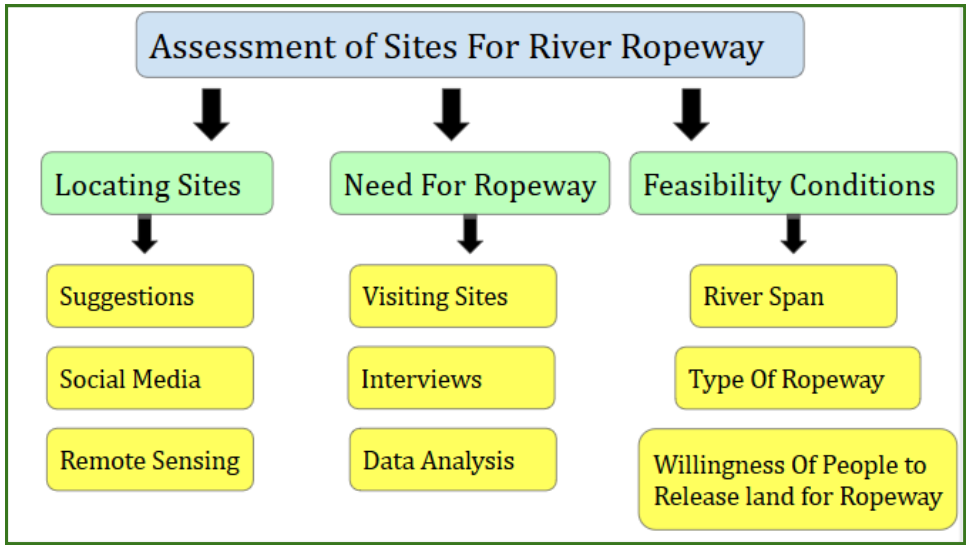


Figure 6: Methodological Approach

For the assessment of Sites for installing River Ropeway we divided our objective in 3 subtasks. We completed these 3 activities for each site we visited:

1. Locating Sites.
2. Need for Ropeway at that site.
3. Feasibility Conditions for installing the ropeway system.

Objective 1: Locating Sites

Our first objective was to locate sites where Ropeways might be needed without visiting site directly. We started with Parvati valley where there are small span tributaries followed by villages on Beas River. Using Google Earth, we located all the sites where we could see villages on both the sides of River but distance of the bridge from the village is too large. Then we measured distance between all the consecutive bridges on the River near those villages. If the distance between those bridges was more than 4-5km we marked the locations.

We considered suggestions from the local people if they knew such places. Those people include Faculties working in Civil stream, local guards, working staff who have lived or been to remote areas around Mandi or Kullu District. After suggestions we repeated above Remote Sensing step. We surfed social media and found out current places where Ropeways are already installed.

Figure 7: Locating Sites near Parvati Valley

Objective 2: Need for River Ropeway

After our objective 1 was completed and we marked specific sites on google earth. To confirm is there a really need for Ropeway at those sites, we visited those sites. After visiting these sites, we analyzed them and then conducted surveys. We conducted interviews for the various age group from small kids to old age people, with few interviews with men and women. People with different occupations such as Teacher, Farmers, Labors, etc. were interviewed so as to get overall idea of different sectors in population.

After the surveys we analyzed data and came up with different observations such as how many people regularly cross the river, percentage of school children, farmers crossing river. What percentage of people will get benefited after installing the Ropeway. How important is ropeway for the village people? This analysis helped us to conclude if the site is actually suitable for Ropeway Installation.

Objective 3: Feasibility Conditions

When we were done with 1st and 2nd objectives and concluded that the site is suitable for Ropeway installation and will benefit a good percentage of population in the village we looked for the feasibility conditions. We checked the span of the river. Considering the span of river and elevation between both the ends type of Ropeway which could be installed was given a thought. If span is around 100-150m and both the ends are approximately at same height Mechanical Ropeway was preferred (which is cost effective and low maintenance) and in the case of larger river span or larger height difference Electrical Ropeways were favored.

During surveys we asked locals if Ropeway is to be installed in the village, are the village people ready to release some of their land for installation and are they ready to pay certain amount for maintenance. For some villages we got affirmative response for releasing land as they have already contributed and gave some land for building school in village, and for the maintenance part village already have some social groups and were ready to take responsibilities of maintaining the Ropeway.

Figure 8: Interview in Shila (Kullu, 2019)

Result and Discussion

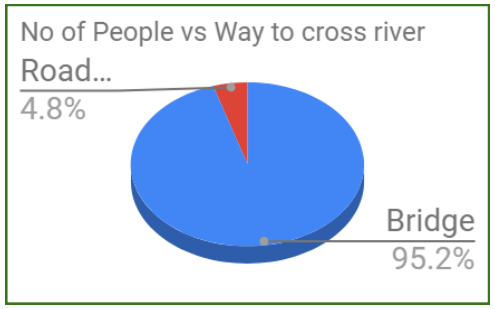
The following section includes our data collection and observations, and corresponding analysis. The fieldwork interviews were conducted and the data collected were analyzed. What we could imagine as the problems that might be faced by farmers were more or less confirmed by the data from the interviews. The data collected is presented objective wise.

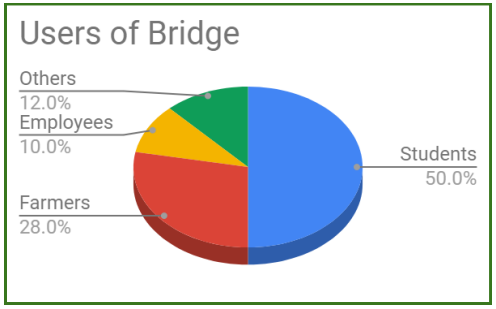
Objective 1: Inquire about current mode to cross the river and problems related to it

We visited 5 sites in Kullu and Mandi Districts with poor connectivity of roads and bridges and suitable for installing River Ropeway.

i) Shila

Our first site was near shila Village, kullu District along Parvati valley people here cross the river either through wooden bridge 1.5 km away down the hill or in case of medical emergency walk to nearest road 5 km away. Figures below shows the percentage of people using Road and Bridges in Shila Village.





(Left) Figure 9: Ways to cross the river in Shila village (right) Figure 10: Users of the bridge in Shila village

Our survey sample was around 70 people out of which approximately 95% people use bridge to cross the river while rest 5% people use road ways 5 km away to cross river. The principal users of the bridge were students which is around 50%.

ii) Tulga and Pulga

Tulga and Pulga villages have geographical terrain similar to shila with smaller elevation from bridge. Here 100% of people use the bridge while crossing river as there is no road connectivity to the village, this bridge is 1.8 km away from both the villages.

iii) Navlay

Navlay village (Mandi District) is the along tributary of Uhl river. Here the major population who cross the river are school children's who travel 30 minutes on average daily to reach the school. Road connectivity is also not that good and is more time consuming if compared to the bridge.

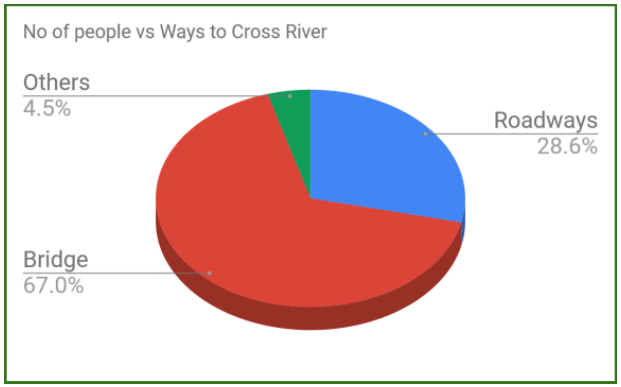


Figure 11: Ways to cross the river in Navlay village

IV) Lanjhanu – Riyagari

This site is located between Lanjhanu - Riyagari villages on the Uhl river in Mandi district. People here either use traditional jhullas or bridge to cross the river. It takes around 35 minutes to cross the river if bridge path taken and by traditional ropeway it takes around 25 minutes but it risks safety.

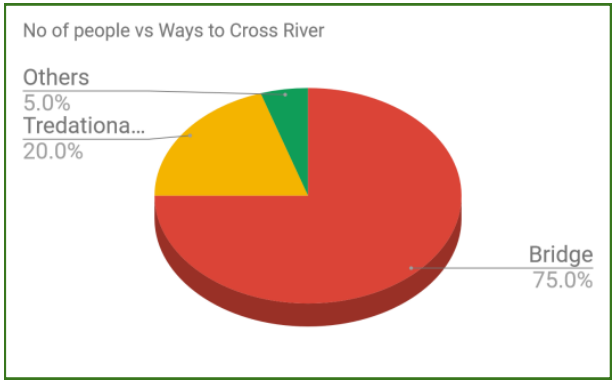


Figure 12: Ways to cross river in Lanjhanu village

At lanjhanu around 20% people use traditional jhullas, while 75% people use the bridge and 5% people use stone to cross river.

V) Mallori -Rani bai

This site is located on the bank of suketi river. The other bank of river is connected to Mandi – Sundernager road. People here generally cross the river by foot on a bridge located around 4-5 km away or they travel through Mandi.

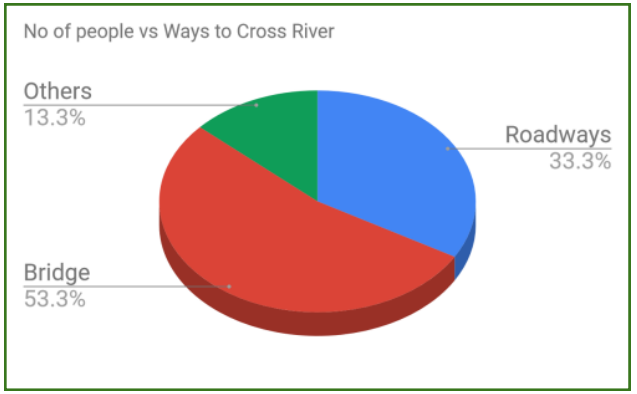


Figure 13: Ways to cross the river in Mallori village

In Mallori 13%people use stone ,33% people use bridge and 53% people use bridge.

Objective 2: Study attitudes of people regarding the implementation of River Ropeway

Following is the percentage of data who will get benefited after installing the ropeway.

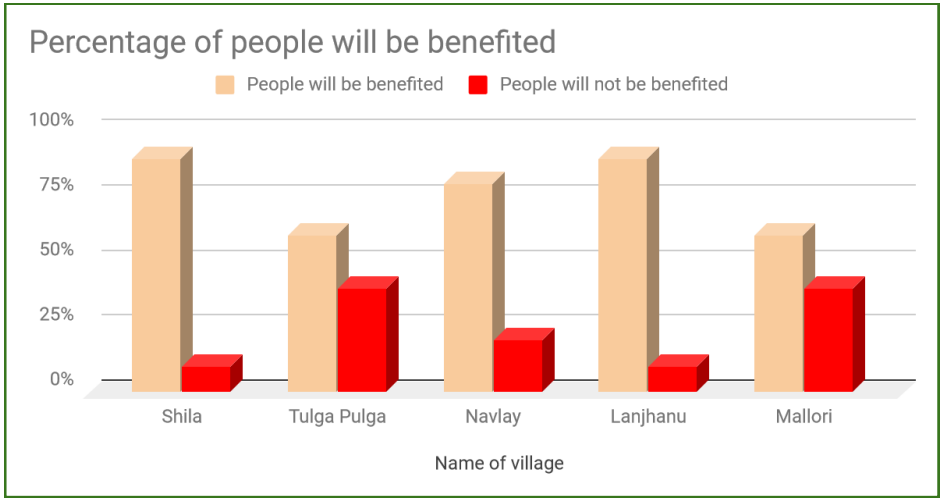


Figure 14: Percentage of people will be benefited and will not be benefited after ropeway is installed

According to our surveys conducted in Shila village of around 70 people out of which 90% people were affirmative and in support of installing ropeway and other 10% people were those who live on the bank connected to the main road. In Tulga-Pulga out of 25 survey sample around 60% people were in support of installing ropeway. Here a road is also under construction under hydro power plant project from last two years, so in long term installing ropeway here is not a good idea as people were sure that they will use the road instead of ropeway once constructed. Similar to Shila, Navlay School also don't have any direct connectivity with road, so out of 100 surveys 80% of people including students, teachers and local people are in support of installing ropeway and are willing to release their land for installing ropeway system. In Lanjhanu also we got similar response to that of Shila because of no road connectivity people here are totally dependent on traditional jhullas and foot bridge for accesing their daily needs. In Mallori however there is road connectivity on both side of river but bridge to cross river are around 4-5 km away so we got a positive response of around 60% people are in support of installing ropeway.

Discussion

Table 1: Details of sites with their population, road connectivity, transportation facilities

Sites	Population (Approx.)	Connectivity of road throughout the year	Public Transportation	Percentage of people will be benefited after installation of ropeway	Better alternative to ropeway
Shila	700	No	Worst	90%	No
Tulga-Pulga	1000	No	Average	60%	Roadway
Navlay	300	No	Worst	80%	No
Lanjhanu	250	No	Worst	90%	No
Mallori	180	Yes	Average	60%	Bridge

There is no better alternative to Ropeway at Shila since roads are covered with snow for about 4-5 months and no public transport is available during that time even at regular basis there are only 3-4 buses.

In case of Tulga and Pulga Hydro power plant is under construction and a road is being constructed around the dam from about 2 years. If government completes the road construction then majority of people will prefer roadway instead of Ropeway.

If Ropeway is installed at Navlay it will help a large number of school students visiting secondary school in Navlay which joins several other villages.

Figure 15: Suitable sites (Shila, Tulga Pulga, Mallori, Navlay, Lanjhanu)

Mallori village has road connectivity but for pedestrians the distance to bridge is almost 4-5 km which takes around 45 minutes to come to road to sunder nagar.

In general (For all the sites) the ropeway will save users time and resources. In today's scenario, in any serious case of medical emergencies, the patient's family needs to gather 10-12 young volunteers who can carry the patient to the main road through the hilly way. The ropeway will increase the chance of getting earlier treatment as it will reduce the journey time and also the dependency on other people for carrying patients. It will bring ease in local's life as from ropeway they don't have to travel that much to reach to the main road and also give them a safer medium to travel. Ropeway will also impact on social lives of the villagers as some of our respondent told us that they feel separated from the society as none of their relatives prefer to come there due to the difficult path they have to cover, the ropeway here will keep them connected and

help them to grow socially. Ropeway in these villages will also increase the education level as there are students in these villages who are currently attaining their secondary education and have to travel the risky and time taking path on daily basis. Due to the following reasons many of them have to leave their homes for studies, ropeways at such place will increase the chances of them to study from their home. As the population in these villages had increased from past years and will increase more in coming years, the ropeway at these sites will give a proper way of crossing the river.

Project Outcomes

As we have selected 5 sites from our survey, where ropeways can make changes or are needed.

We observed that in these village's government had already made bridges for crossing the rivers (The river in separating the village from link road) or constructed the roads.

But the problem with the roads is that, the point 100 meter on opposite side of river will take around 30-45 minuets via road (lack of government vehicle facilities makes that worse for a middle-class man), whereas for bridge on the river which was supposed to connect the village to the main road can only be used pedestrian after a rigorous tracking of around 15-20 minutes as there is no proper path (Even not) to the bridge.

(Left) Figure 16: Google earth image of Tulga- Pulga village

So, to save their time and to ease their journey we suggest to install river ropeways from end to end (Village to main road) along the yellow line in the images.

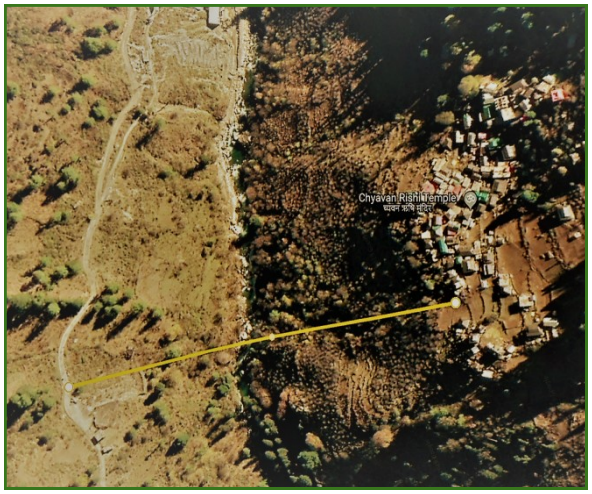


Figure 17: Google earth image of Shila village

As we observed from our survey that installing any ropeways at any site won't help, we will need different type of ropeways for different sites as we have discussed with the project manager of an NGO(DST) working in this filed (making and installing of ropeways), he suggested that mechanical ropeways can be installed for the sites with the span of 100 meters (As they have tested), with the help of government and NGO we can also teach the locals (interested) to operate them or how to maintain them.

There are many time-consuming processes in between of this proposal and installing ropeway which includes buget approval, site inspection which includes the soil test, earthquake test, checking of availability of the required area on both sides, span between the two ends and government permissions

Conclusion

In hilly areas like Himachal Pradesh Road Connectivity and Number of bridges are increasing but the pace is very low if compared to plain areas. In this scenario the development of mountain people is gradually decreasing with respect to people in plain areas and thus there is a shift. By installation of ropeways in areas like shila, lanjhanu, Mallori and Navlay whose connectivity is not that good with important places like schools, hospitals, panchayat Bhawan, markets, general stores etc will prove as a boon to people there.

Our many interviews with the people at these sites indicate that the population including farmers, employees, students and housewives would greatly benefit from the installation of ropeways and their problems like consumption of extra time and effort will greatly reduce.

Unfortunately, there are some obstacles related to the maintenance funds. We propose that government should form a body regarding this issue. In times ropeways will play an important role for people at these sites and help them to claim a better place in the economy of Himachal Pradesh.

Acknowledgements

We would like to thank following individuals

- Our mentors Dr. Rajnish Sharma and Dr. Dericks P.Shukla for guiding and helping us throughout the project.
- Dr. Rinki Sarkar for guiding us regarding field interviews, in conducting surveys and in reforming questioners.
- Gangaram (From DST NGO) for guiding us regarding type of ropeways and suggesting the sites.
- Vijay Kumar, Principal of GSSS, Nishu for help in conduction surveys.
- Devika Sethi for coordinating and providing the recourses needed.

Work Cited

Doppelmayr, Ropeway system advantage https://www.doppelmayr-mts.com/en/solutions/aerial-ropeways/ropeway-system-advantages/

Exam Flip, Rivers and their tributaries of Himachal Pradesh. Retrived from http://examflip.com/river-system-in-himachal-pradesh/

Exam Flip, Image of water bodies in Himachal Pradesh. Retrived from http://examflip.com/wp-content/uploads/2016/11/-HPWaterBodies.jpg

Invest India, National investment promotion and facilitation agency. Aerial ropeways : Connectivity and tourism https://www.investindia.gov.in/team-india-blogs/aerial-ropeways-connectivity-and-tourism

MapsofIndia, Map of Himachal Pradesh with districts and water bodies. Retrived from https://www.mapsofindia.com/himachal-pradesh/

News18, Guwahati :India's longest river ropeway https://www.news18.com/news/india/guwahati-all-set-to-start-indias-longest-river-ropeway-across-mighty-brahmaputra-2062045.html

Phull, Archana (December,2016). The Statesman: Innovative ropeways to replace traditional 'jhullas' over rivers in Himachal. Retrieved from https://www.thestatesman.com/cities/innovative-ropeways-to-replace-traditional-jhullas-over-rivers-in-himachal-1482233847.html

Rites limited, a Government of India Enterprise, EIA study for development of passenger ropeway between Dharamshala to Mc ledoganj, Himachal Pradesh. Retrived from http://hppcb.nic.in/Ropeway.pdf

TourmyIndia, 25 popular ropeway gateway in india. Retrived from https://www.tourmyindia.com/blog/25-popular-ropeway-getaways-in-india/

Full report can be found on the ISTP website.

Enhancing the School Libraries of Himachal Pradesh

Abstract

School libraries can promote independent learning but little is known about them in Himachal Pradesh. Through research, school visits, and interviews we were able to evaluate a sample of schools in Mandi District. We found that state schools often lacked the most library interest and programs. To increase library use, schools can add a 15 minute reading period three to five times per week and books can be brought from storage to classrooms to circumvent infrastructure problems.

Team Members

Lynne Moore
Catherine Sherman
Alexander Glanville
Abhijeet Rajput (B16083)
Kumar Abinash (B16101)
Abhinandan (B16002)

Advisors

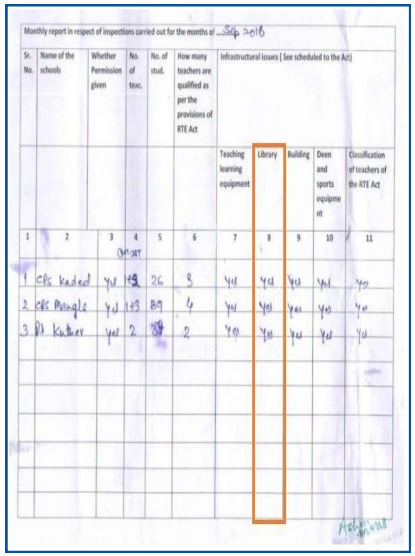
Dr. Bharat Singh
Dr. Gbeton Somasse
Dr. Ingrid Shockey

School Libraries in Himachal Pradesh

School libraries are often considered to be the cornerstone of schools by educators, as they are responsible for providing students with the proper resources to complete their work. Library services can facilitate independent learning programs and educate students on modern technology (Ramaiah & Pillai, 2013). Global best practices for school libraries have evolved with the addition of technology and more efficient information platforms. Along with economic disparities, this rapid advancement has caused many schools to lag behind in developing library standards for students and teachers.

Himachal Pradesh is a largely rural state located along the northwestern Himalayas. In the heart of the state, Mandi District consists of both rural villages and the urban hub of Mandi town. These communities host a variety of public and government schools with varying resources. While it can be difficult to find literature reporting on each district's library services, there are some general statistics that hint at possible trends within Mandi District. Urban India has been seeing great gains in literacy and education as compared with rural areas in India, which can be devoid of amenities for education. In 1961, literacy rates across India averaged approximately 20%, but by 1981 reported rates jumped dramatically to 73%. The literacy rate increase in India is attributed in large part to the role of education and local public libraries (Jatana & Khosla, 2003). More recently, as of 2011 in Himachal Pradesh, the literacy rate was listed as 82% (Himachal Pradesh The Official Website, 2018).

Reports indicate that many of the schools in Himachal Pradesh lack in-depth evaluations, and there is a stronger concern over the lack of information with regard to the state government schools (Inspection Report, 2018). More specifically, there is little in the way of reporting on the quality of their school libraries. As recently as 2013, the region was one of eight states that lacked a "State Library Policy and Act" that would help unify standards (Shimla, 2013). Despite yearly inspection of elementary schools in the state by the Department of Elementary Education, the reports never elaborate on the condition of the libraries, as shown in Figure 1 (Inspection Report, 2018). From a documentation point of view, very few of the schools that have libraries share images of them or make public what resources are available to students.



Monthly report in respect of inspections carried out for the months of Sep 2018

Sr. No.	Name of the schools	Whether Permission given	No. of teac.	No. of stud.	How many teachers are qualified as per the provisions of RTE Act	Infrastructural Issues (See scheduled to the Act)				
						Teaching learning equipment	Library	Building	Deen and sports equipment	Classification of teachers of the RTE Act
1	2	3	4	5	6	7	8	9	10	11
			M F T							
1	GPS Kadeal	Yes	49	26	3	Yes	Yes	Yes	Yes	Yes
2	GPS Pangla	Yes	149	89	4	Yes	Yes	Yes	Yes	Yes
3	PS Kuther	Yes	2	38	2	Yes	Yes	Yes	Yes	Yes

Figure 1: School inspection report

The goal of this project is to enhance the library services of the schools in Himachal Pradesh. Toward this goal we have identified three objectives

1. Identify best practices in setting up and managing school libraries
2. Assess the amenities currently available in a sample of school library facilities
3. Evaluate the needs and requirements of students, faculty, librarians, and school administrators

We aim to understand ways each library is positioned to host more learning opportunities for students, and to provide findings that will help libraries to better support their students and faculty. Furthermore, this project contributes to the global UN Sustainable Development Goal #4: Quality Education, helping children in the community to read.

A Library's Presence within Education

In order to understand the background, as well as some of the opportunities and challenges faced by school libraries, we review the impact of libraries on students and other stakeholders. Specifically, we consider the

opinions on the role of the library in supporting needs within education. Finally, we present the findings and methods of case studies done at schools in Portugal and Australia.

Libraries as a Catalyst for Education

As library sciences evolve, the opportunities for advanced library resources have increased. Though evolutions are happening, the principles laid out in the 1994 UNESCO Public Library Manifesto are still followed today. They emphasize that it is important for a school library to create and strengthen reading habits in children from an early age, and support individual, self-conduct, and formal education at all levels (Manifesto, 1994, para 10). For example, a group of Australian librarians, specifically known as "teacher librarians" spoke about the power libraries could have amongst students from grades K-12 (Godfree & Nelson, 2018, p. 1). This group developed a list of the specific skills a student should master before entering the global workforce. These skills include "critical thinking, working with people, and getting the most out of technology" (Godfree & Neilson, 2018, p. 31). A library's role in facilitating workshops focusing on note taking, critical evaluation techniques, and efficient database use is important, but can vary based on the school's resources. Where feasible, there are projects being implemented in Indian schools to reach the minimum goals of libraries (Ramaiah & Pillai, 2013). For example, programs such as "Operation Blackboard" and "Shiksha Karmi" aim to improve the facilities and educational standards within remote villages (Singh, 2005, p. 9). Both of these programs involved providing proper training to educators within remote villages of India, while also improving the baseline for school facilities to include larger classrooms and provide storage for library books within the school property.

Along with helping students with useful workforce skills, school libraries can also provide students with important language skills. Requirements to learn a new language can be difficult for students (Lessow-Hurley, 2003). Constant correction can be demotivating; however, libraries can give students additional practice. Students can use interesting stories to further their understanding of sentence structure and vocabulary.

To increase interest in education, libraries can help expand teaching techniques. Some techniques include "incorporating pauses for group discussions, questioning,... short quizzes" and using games or technology in class (Dalrymple, 2002 p. 262; Leach et al, 2005). Educational games can provide different motivations for students, and increase retention of material (Randel et al, 1992). Libraries can provide a space for struggling students to get one-on-one attention, or a place for students to find out more about a topic of interest. Involving students in library resources and programs allows them to further their learning.

Building a case for the value of quality school libraries

Libraries are a resource for student learning, supporting school wide curricula, and augmenting education with other opportunities for creative engagement. Without a properly run library, teachers and students may not be able to perform to their fullest potential. A library can improve reading culture, positively impact student work environments, and provide a connection between classroom curriculum and world literary.

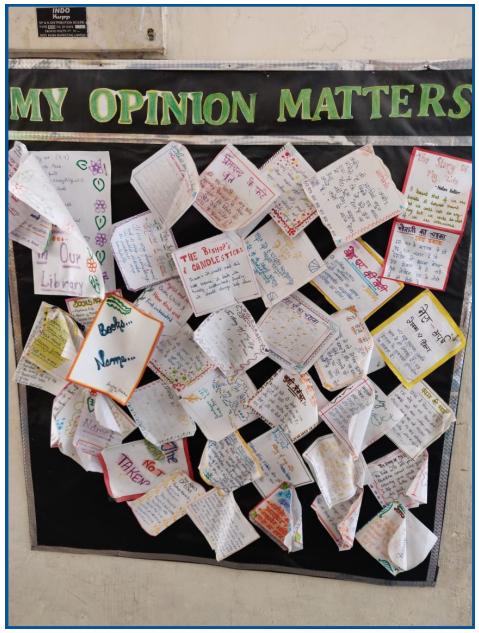


Figure 2: Student artwork in a Himachal school

Supporting Students

A good library can increase enthusiasm for education among its students. When students are provided with optimal library services, students feel that their reading and literacy standards increase. A survey conducted within Portuguese public schools evaluated schools that had previously self-assessed their library as either 'Excellent' or 'Poor.' The study indicated that students with 'Excellent' school libraries felt their reading and literacy skills improved, while the 'Poor' library students did not (Martins & Martins, 2013).

Though the results of this study may also be impacted by the resources each individual school has, it still shows that students are reliant on their school's library. Schools rating themselves as having a 'Poor' library also saw students feeling less confident or interested in education. Schools with less library resources are more likely to rate their school library as 'Poor.' This study showed the important connection libraries can have to student education.

Without the proper resources, students can fall behind and lose interest in learning. This is why the Indian government has created a new motto for their school libraries, "Catch 'em Young," within the education departments (Mahajan, 2010, p. 1). This slogan is used to highlight the importance of creating an early love for reading. Reading rates have increased as many students within rural India fill their free time with reading (Kunhambu, 2012).

Engaging Teachers and School Administrators

When it comes to student reading culture, the school administration is a key factor in how the school library is funded and operated. The administration can provide schools with the necessary resources and incentives to improve student learning.

Just as a library can impact the students directly through its resources, it can also indirectly impact students through the curriculum teachers follow. Libraries can be used for reading and research assignments, but they can also provide teachers with essential materials and background. In the United Kingdom for example, the failure of schools and teachers to strategically integrate library activities was associated with student counter-performance (United Kingdom, 2014; Lance & Kachel, 2018). The international librarian journals highlight the importance of librarians knowing the curriculum goals in order for the library to appropriately "support the curriculum" (United Kingdom, 2014 p. 17; Lance & Kachel, 2018). Good rapport between teachers and librarians encourages the use of the library as a resource, and allows students to further their education (Dales, 1990).

Evaluation of school libraries

Properly evaluating school libraries to see if they are implementing the main topics within the Library Manifesto first presented in Section 2.1 is a challenge. A proper library evaluation must take into account multiple qualitative and quantitative measures. According to one metric, a rubric for library evaluation should include a minimum of the following questions:

1. How are the everyday functions of the library completed?
2. How does the library deliver services to its stakeholders?

Is the library impacting student and school success? (Mahajan, 2010).

Figure 3: Himachal Pradesh school library

For example, a 2013 review of Portuguese school libraries looked at the results of a self-assessment tool within primary schools regarding the libraries impact on reading and literacy improvement (Martins & Martins, 2013). The report featured a variety of charts portraying the results from questionnaires filled out by both students and teachers. These questionnaires focused on how the literacy rates were impacted by the

schools personalized rating of their libraries (Martins & Martins, 2013). The School Library Evaluation Method (SLEM) uses three core domains, supporting curriculum development, reading and literacy, or school library management, to evaluate libraries.

The SLEM technique looks at a single domain each year to make sure each section is being properly evaluated. This then allows the Portuguese School Library Network (SLN) to make further recommendations for both improvements within existing libraries and developments of new libraries. Over time, the self-assessment tools allow the outside evaluators a closer, more personal look into the everyday use of the libraries (Martins & Martins, 2013).

The SLEM evaluation, similar to other studies, emphasized the fact that the number of "print volumes" did not directly correlate with student learning (Shenton, 2011, p. 39). Ahmad supported this claim by saying, "even in school libraries claiming to exercise an open access system, libraries were found deserted with students hardly venturing in due to shortage of relevant and up-to-date reading materials" (Ahmad, 2011, Access to resource section para. 3). Library evaluations should take into account all aspects of the library; the physical attributes within the libraries as well as the educational impact the library has on its stakeholders.

In summary, our research into library literature revealed the roles libraries can play in education as well as the standards they should be held to. We observed the impact a school library has on its stakeholders. However, we found that library evaluation processes can be difficult to design because the needs of the stakeholders, current resources, and operational standards need to be considered equally.

Reaching Our Goal

As the goal of this project was to enhance the library services of schools in Himachal Pradesh, we completed the following three objectives:

- Identify best practices in setting up and managing school libraries
- Assess the amenities currently available in a sample of school library facilities
- Evaluate the needs and requirements of students, faculty, librarians, and school administrators.

The figure below summarizes how we accomplished these objectives in order to meet our final goal. We also detail the methodological strategies used to complete data collection.

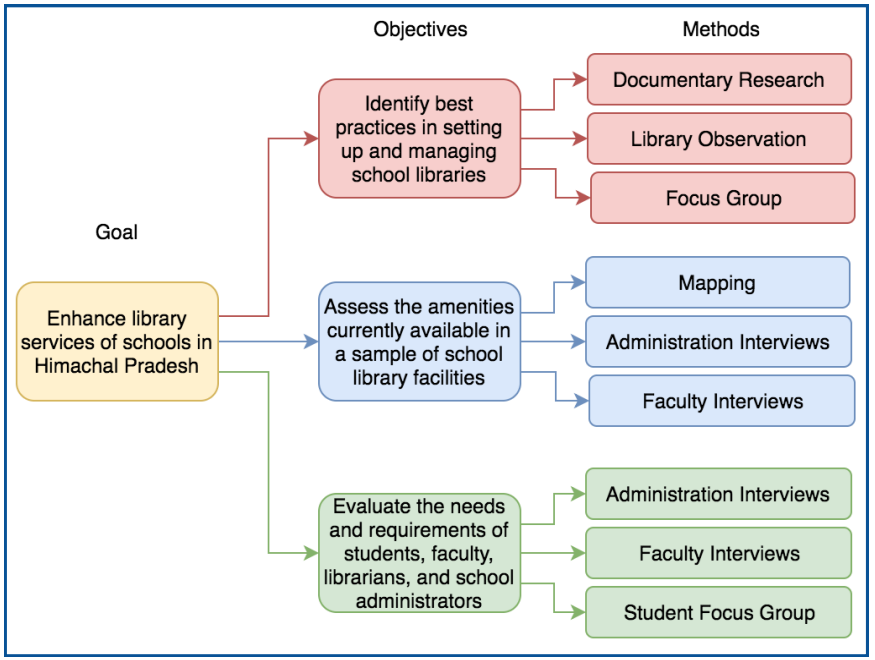


Figure 4: Methodology flowchart

Identify best practices in setting up and managing public school libraries

In order to identify the best practices in maintaining and managing public school libraries, we conducted extensive research using documentary research and focus groups. Documentary research provided us with the background to effectively complete our other objectives. We reviewed legislation requirements for school libraries in Mandi District and Himachal Pradesh. This included their staffing, and equipment. We used it to determine whether schools were able to follow the current baseline.

Next, we identified innovative library models through online research and communicating with community members, interacted with favorite local libraries, and learned more about how libraries optimally

support students and teachers. After identifying a well-funded, and university supported public school library, we organized a focus group with the school's teachers. Through this focus group, we were able to identify the best practices for local school libraries in Mandi District. We also observed some library models to learn about optimal school design.

Assess the amenities currently available in a sample of school library facilities

In order to document the amenities currently available in public school libraries, we conducted site assessments. We used a sample of convenience of schools in Mandi District to observe the everyday activities of school libraries in the area. The assessment included mapping, and interviews with faculty and administration to identify school library resources and how patrons use and appreciate them. We used notes and photos to map each library. We were able to document how the space, resources, and furniture were generally used . Other helpful documents included noting software that contained the number of books in the library, how many times they had been checked out, and questions regarding stock checks of the libraries.

Finally, in order to document the amenities available in a sample of school library facilities, we conducted interviews with librarians, teachers, and school officials. We started with standard questions similar to a survey. We chose to use standardized questions to initiate our interviews for two reasons: they ensure each school is evaluated equally, and they help start a conversation about the properties of each library. Asking these questions in person provided more feedback than surveys. The questions were useful for comparing amenities, tools, and technology among schools. This interview process was continued to aid in completion of our last goal. Our full report (linked at the end) provides the interview guides for our interviews.

These interview questions apply to schools with a library. When the visited school did not have library facilities, we followed the instructions on our questionnaires and adapted accordingly. This situation led us to ask questions based on what the interviewees would desire in a future library, and what was preventing them from having a library.

Evaluate the needs and requirements of students, faculty, librarians, and school administrators

To evaluate the needs and requirements of the stakeholders, we engaged with school administrators, librarians, teachers, and students. To maintain balance between candid responses and key points we collected, we conducted semi standardized interviews with stakeholders (Berg, 2006). Our team interviewed one principal, one librarian or teacher placed in charge of the library, and 2 teachers from each school.

Our interviews with school administrators provided insight into how they support and contribute to the library. We learned about how the schools measure the needs of students and obtain the funding for books, resources, and technology. The interview guides can be found in the full report.

We also interviewed the librarians and teachers to better understand the impact of the library on the student body, and receive feedback on what resources the library is providing in support of the curriculum. Based on whether or not a school had a designated librarian, we spoke with the teacher in charge of the library's daily operations.

Because our project was completed during an exam session, interaction with students was limited. This meant students were not present at some of the earlier schools visited. With this said, we were able to hold two group interviews with 5 to 10 students about their current library use and what their ideal library experience would be. We did not interview students individually, as they are a more sensitive stakeholder and most students would not enjoy being singled out for their opinion (Berg, 2006).

Results and Discussion

This section outlines and discusses the findings from our fieldwork. We categorized our data based on the objective it fulfilled. To maintain anonymity for schools, we do not mention any school by name nor do we tie any faculty member or student to their respective schools without consent.

Best practices in setting up and managing public school libraries

We divided this objective into three main parts, library management, library design, and library services.

Library Management

Much of our documentary research was conducted online. We reviewed The Guidelines for School Library and Procedure Manual provided by the Kendriya Vidyalaya Sangathan (KVS) school protocol, as well as Central Board of School Education (CBSE) and the Himachal Pradesh Board of School Education (HPBOSE) school library policies.

While the State did not have a separate library legislation, there are over 100 pages set aside by the CBSE for library regulations. Their detailed instructions talk about the number of books required per student, and outline rules everyone should follow in the library. Beyond this, they also require schools to have up to 4 library staff members and 3 individual rooms for different library activities. Some of these policies are well beyond the capacity of some the schools in Himachal Pradesh, but as student enrollment increases, these rules are becoming a goal for schools to reach (Central Board of School Education Library Guidelines, 2018).

Beyond the legislation, we saw schools with larger libraries shifting to an online management system. Currently, many schools use a register book where the inventory and student book transactions are recorded by hand. Schools with an established library are moving towards a more efficient online management system as their library increases in size; some schools had already moved to this system. The online register included more accurate book inventories, as well as student portals for student transaction records.

Library Design

Local interpretations of public library standards can exemplify how school libraries can be flexible in response to their users. We visited one local school library in the US and observed a public library from Delhi in order to understand how library's priorities differ. The first library we visited was in a Massachusetts public elementary school. The school library provided separate areas for personal reading, technology, and studying.

Figure 5: Massachusetts public school library (Glanville, 2019)

The next library we observed was the Delhi Public Library. While we were unable to visit the physical library, our team used online resources to gather information. The Delhi Public Library provides a special section for children in order to promote literature at a young age (Delhi Public Library, 2009). Given that the Delhi Public Library is ranked highly in India, it is a great source to grasp what libraries in India prioritize (Pal, 2017).

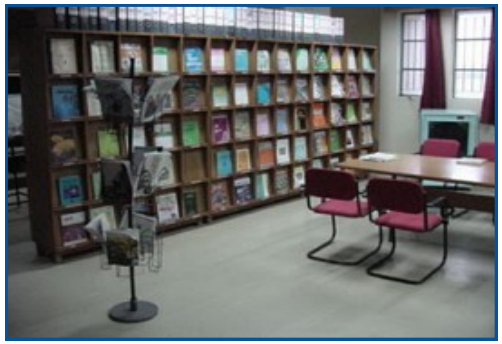


Figure 6: Delhi Public Library (Delhi Public Library, 2009)

The first sample library has areas sectioned off for comfortable reading, while the second library has a more formal arrangement of desks surrounded by large cabinets. Using a mix of both spaces in a library can provide an optimal space for student and teacher learning.

Library Services

Our team identified the Mindtree School as an example for library services in Mandi District because of robust funding and ties to higher education. Through a focus group with fifteen teachers, we learned about how their library is run and organized. Through this focus group we deduced that the additional services the library at Mindtree was providing had a big impact on the students' reading habits. Providing these additional services, such as a one-hour library period and the Reading Rocket program has led to a steady increase of student interest in their school's library. The Reading Rocket program had fifth through eighth grade students take a book home to read over the course of a week and review it in front of their class (March 2019). It was apparent when visiting Mindtree that their school made an effort to instill reading in their student's everyday lives, and from our focus group, we deduced that the Mindtree School's library was very well received by its teachers.

Current amenities of school library facilities

After surveying 11 schools (7 state government, 1 central government, and 3 public), we gained valuable information regarding library facilities, resources and funding, as well as events and programs run by each school's library. We also discovered that the Himachal Pradesh state government schools consistently had minimal funding for a library. Infrastructure issues were a main complaint by all schools that took part in our survey.

While all schools had funds set aside for library books, the amount provided for state government schools was much less. In particular, one school indicated they received a maximum of 10,000 rupees per school year for books, while a second said they received no funding from the state government. Private and central government schools have on average more books per students than state schools. Figure 7 shows the books per student at each school, with an average of 3.06 for state schools compared to 8.2 for central government and private schools.

The state schools also saw less variation in both genre and languages of the books. Three out of the seven of the state schools saw 95% of the books in only Hindi, while the central government and private schools saw closer to a 50-50 split between English and Hindi.

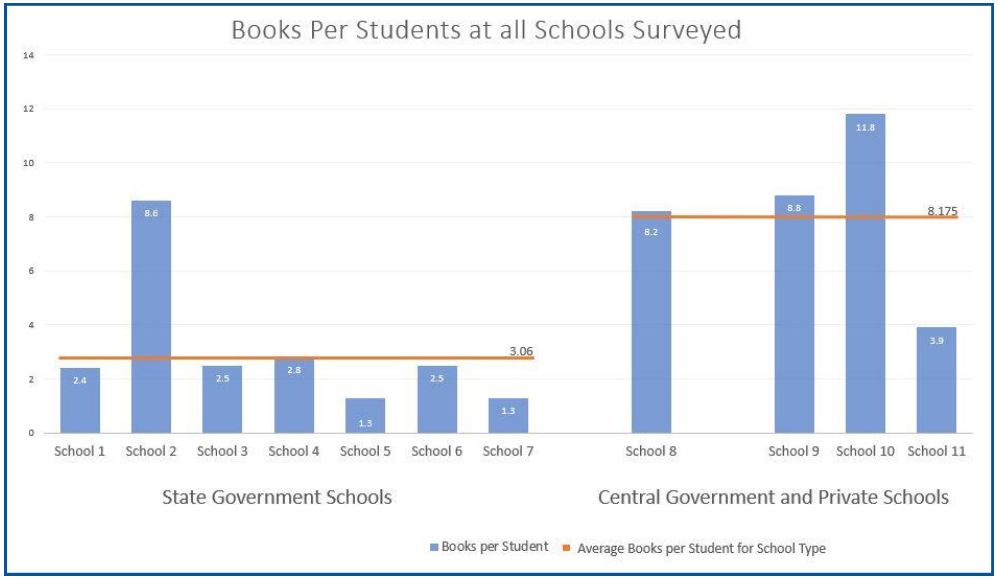


Figure 7: Books per student at all schools surveyed (Moore, 2019)

In addition to funding requests, school administration also often expressed a need for expanding the current space allocated for the library. While the privately funded schools could generally expand their campus with ease, there was evidence of one central government school being held back from expanding due to land leasing contracts with the Himachal Pradesh School Board of Education. State government schools were even more restricted. One commented that they only had 3 classrooms for 5 classes, nevermind space for a library.

Often, state schools had cabinets provided for library books that had to be placed in corners of classrooms, as shown in Figure 8, or kept in storage rooms along with sports equipment. The lack of space was most prominent within the state government schools because many lacked designated library rooms. Central government and private schools were more focused on expanding their libraries.

Looking at amenities beyond books, we found that computer or AV rooms were rarely connected to the library. Thus, the library was not the source for audio or visual learning aids. This was a common practice, but three of the eleven of schools we surveyed wanted to connect the two in the future.

Figure 8: Library in back corner of classroom (Moore, 2019)

The final aspect of the library facilities was the design. Many library spaces consisted of a large conference like table centrally placed in the library with large metal cabinets organized by category along the perimeter. A sample blueprint can be seen in later in this document, in Figure 11. This layout allowed the librarian to watch all students while providing students with a comfortable workspace. The walls of the libraries varied in color, with the common presence of motivational sayings painted on the walls in or around the library, as shown in Figure 9.

Figure 9: Motivational quotes near library taken by Moore and Glanville, 2019

All of these conditions of the libraries we assessed clearly impacted how well the students and faculty could utilize their library services.

Needs and requirements of students, faculty, librarians, and school administrators

We encountered a wide variety of schools with many different levels of funding and available resources. Therefore, the needs and requirements of each school we visited tended to vary drastically. To start, 43% of the state schools we visited required more infrastructure to have a library facility. Students and teachers at schools with no designated library space reported limited library use. At one of these schools, the children explained to us that they never used any of the school's provided books and the only students who did were those who borrowed textbooks from it. Furthermore, a teacher at a school that did not have an established library explained to us that a student hadn't issued a book from the school in several years.

With this said, responses like "a student hasn't checked out a library book in the three years I've been here" and "students just aren't interested in the library" were common responses in schools that did not offer a library period. In schools with library periods, teachers voiced how a library period sparked reading interest in their students. One librarian said that "the biggest change the library has seen over the past five years is more student use." They saw that the library period led to more books being issued and students using the library in their free time. In general, the library period was a forced interaction between students and the library, which increased awareness of the library. Students that had no interaction with their library on a regular basis had little or no interest in reading.

While schools that did have libraries generally saw students being more interested in reading and issuing books, most of our interviewees still voiced that there was room for improvement in their libraries. 85% of the state schools that had books available for students did not have a post for the librarian and this led to the responsibility of the library being put on a single teacher. This generally made it difficult for the teacher to be fully invested in the library. However, we noticed that schools with a full-time librarian generally provided additional services like book review programs, book clubs, and book fairs to their students.

Discussion

Through our findings in our fieldwork we were able to identify best practices in library management, assess the amenities of local school libraries, and identify their needs and requirements. After completing our objectives, it became clear that the real problem in the schools was lack of awareness for the books that the schools had. There were funding and infrastructure barriers, but in most cases, they were not dramatic enough to prevent interactive reading programs.

In our analysis, the practice of library periods in schools promotes better use of library resources. Schools with a library period reported that more students used library books. In most cases, teachers said that students would look forward to going to the library and even go when they had free time. Programs that involved reading and book reviews further encouraged students to use their libraries. Teachers and librarians claimed that one of the biggest changes over the past five years, was increased student interest in the library. On the other hand, schools without library periods had limited student responses to the provided books. Both teachers and students reported that very few were interested in using the books. These schools also lacked other library-related programs. Because of the lack of interest, there was little support from faculty to change anything about the libraries, which further reinforced the lack of interest.

It was clear from our findings that building capacity for library services needs to focus on techniques that would integrate school resources into the daily lives of students. We realized that telling schools that did not have the funding or infrastructure for a library facility to build a library and integrate it into the curriculum would be pointless. However, schools could incorporate library services into the classroom without extra funding or infrastructure.

Once these library services are implemented, it would then be necessary to maintain a proper evaluation of these libraries beyond what is currently in place. After speaking with the Deputy Director of Education in Mandi Town, our team discovered the inspection process specific to libraries is minimal. Along with this, we learned the Deputy Director is designated as the messenger to the main board office in Shimla and little is done through the Mandi Town office. This makes it easy for the struggles of a remote school to go unrecognized. The principal of a school we visited in a remote area explained to us how in his three years at the school he has received virtually no assistance from the government despite consistent efforts to reach out.

Thus, techniques such as SLEM, discussed earlier, could be implemented on an annual or semi-annual basis to provide more in depth evaluations on the library services. This more focused self-assessment evaluation technique would be a valuable asset in Himachal Pradesh as the sheer quantity of schools is not conducive to in-person evaluations, and the people are willing to speak on behalf of their school.

Project Outcomes

After visiting and surveying a wide variety of school libraries, and interviewing numerous administrators, teachers, and librarians we generated some recommendations that could be applied to enhance school library services in the region.

Redefining what it means to have a library

Through our fieldwork our team has come to the conclusion that a library does not need to be defined as a room set aside for storing books. Rather, a library can be defined as something that enhances student engagement in literature. It would be unrealistic to recommend that schools construct a library after continually hearing that many schools are lacking space for expansion, so our group took some inspiration from Libraries Without Borders. Libraries Without Borders is a non-profit organization that works to give people around the world access to libraries. They bring their “Ideas Box,” or mobile library, to communities around the world (Libraries Without Borders, Impact). Because all of the schools we visited, even those that lacked infrastructure for expansion, had books, we felt that the incorporation of a mobile library was feasible. A potential library cart is presented in Figure 10 on the following page.

Figure 10 is an example of a cart where the bins indicate different reading levels. These levels are based on the particular reading skills students should have mastered in their respective age group. This idea is mostly seen within elementary schools as students are just starting to interact with reading. With that said, for the higher levels of education,

these bins could be categorized based on subject or genre. Given that the education system in India revolves around the syllabus, the library should support the needs of its students. Thus, the mobile library should encourage student learning by providing resource books for their classwork.

Figure 10: Library cart (Wayfair, 2019)

In all schools surveyed, there was either a teacher or librarian in charge of the library. The mobile library would then become the responsibility of this person. We are encouraging weekly interaction with the library, which means the mobile library should be accessible in every classroom at least once a week. This period could be conducted within another subject either at the end of the class, or the beginning based on the teacher's preference. This weekly mobile library visit would encourage students and staff to utilize the resources already available within the school.

Setting Aside Space for Reading

Another observation we made throughout our fieldwork is many of the schools that had a library set up their space in a very similar fashion. The libraries we visited generally consisted of a large table surrounded by cabinets full of books, similar to the drawing shown in Figure 11. This setup is efficient when entire classes are in the library, as it allows teachers to easily watch over all their students at once.

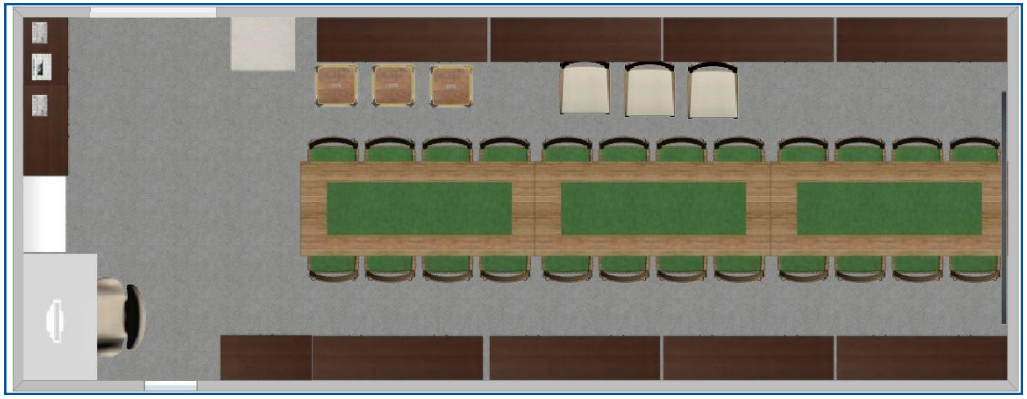


Figure 11: Blueprint of typical library layout by Moore, 2019

Studies have shown, however, that to further encourage positive reading habits and increase student use, the availability of "lounge seating" or comfortable spaces is key (Mohanty, 2002). Providing comfortable seating provides students with different options while working; students learn in different ways, and sitting at a desk does not always help concentration. Also, comfortable seating would create a more welcoming space for students to visit the library in their free time and relax with a book. Having different types of furniture also allows for one room to have many purposes. Figure 12, is a small example of how the conference room like setup could transform to provide students with a workspace as well as a place to enjoy their library. This image was based on the principles first observed in the public school library referenced in Figure 5.

Figure 12: Blueprint of library layout with reading spaces by Moore, 2019

The CBSE guidelines specify that a library should consist of a reading room, conference room and a "stack or volume" room (Central Board of School Education Library Guidelines, 2018). Most schools did not have the capacity to allot three separate rooms for these spaces, but different furniture and decor would allow the schools to accomplish these baselines. Adding specific areas for comfortable reading, as shown above and previously in Figure 5, can be an easy change for an established library and can have a great effect on student engagement of all ages.

Expanding engagement with information

To address the lack of awareness of library books, we recommend that teachers set aside time for reading during their class periods, involve students in reading programs, and include library research in projects. These three techniques would remind students that there are books available at their school, and help start healthy reading habits.

Within class, we suggest having mandatory reading sessions once a week. English classes could conduct monthly book reviews using the library books. The reviews could consist of students reading a book of their choice, and either writing a report on the book or giving an oral presentation in class.

Additionally, students could be given assignments which require them to issue a book from library. These projects would be selected by the teacher and student based on the availability of books in the library. This would maintain the syllabus based curriculum by showing students how the library can connect to their studies without deterring them from the highly competitive Indian school system.

In regards to library management, expansions could include giving students library cards, or completing annual stock evaluations. These two ideas are important functions in schools with an established library. Thus, they should be implemented to create a smoother library interaction once a school has established its library as a useful resource for students. The first step, in the case of no library use, should be to involve students in reading to increase the awareness of library resources.

Conclusion

School libraries are a cornerstone of public school education. It is important to note that the definition of a library is changing as education systems and technology evolve. No matter how the medium changes, the purpose behind a school library remains the same: to provide students and teachers with the resources they need to fully engage with the specified curriculum and develop critical skills. The new mentality no longer restricts a library to a physical room within a school. Students can interact with the library services through mobile library carts, classroom libraries, and online resources. It is the responsibility of the school administration and teachers to find the right combination of these mediums to best support the student body and the school's teaching philosophy.

Interactions with the students, faculty, and library facilities within Mandi District schools allowed us to develop recommendations that will enhance each school's library services. We discovered that most Mandi District schools struggle with infrastructure, funding, and student awareness. From this, we developed our recommendations to expand upon the available resources in order to better accommodate the needs of the students. Because of the emphasis on the syllabus in schools, the library should support the curriculum while encouraging students to go beyond it. Our main recommendations of spreading awareness, developing a mobile library cart, and dividing the space encompass these aspects. For our project to reach all the schools, we reached out via email with an email individualized per each schools requirement. These enhancements will take time to develop within each school, but with an individualized approach each school can maintain an engaging and supportive library.

The reports in this book represent the work of WPI and IIT Mandi undergraduate students. For more information and to see the complete report, you may search using keywords or author at https://digitalcommons.wpi.edu/iqp/ or http://www.iitmandi.ac.in/istp/.

Acknowledgements

Our team would like to thank the following individuals for their assistance and cooperations throughout our study:

- **Dr. Bharat Singh Rajpurohit**, our sponsor, for creating this project and his guidance
- **Dr. S. K. Pathak**, for providing our team with Library Protocol Legislation for the state of Himachal Pradesh, and the government of India
- **Dr. Gbeton Somasse and Dr. Ingrid Shockey,** for their feedback and support throughout the entire IQP experience
- **All schools that took part in our survey**, for allowing us to enter their workplace, being open minded with our suggestions, and always welcoming us with open arms
- **Dr. Priscilla Gonsalves,** for giving us information on the education system in India
- **Indian Institute of Technology Mandi,** for hosting us on this experience

Works Cited

Ahmad, S. (2011). A Survey of Senior Secondary School Libraries in Jammu and Kashmir, India. Library Philosophy and Practice., 218–252.

Berg, B. L. (2006). *Qualitative research methods for the social sciences. Boston: Allyn and Bacon*

Dales, B. (1990). Trusting Relations Between Teachers and Librarians. In Language Arts, 67(7), 732-734, 1990. Retrieved from htw3tps://www.jstor.org/stable/pdf/41961788.pdf

Dalrymple, C. (2002). Perceptions and Practices of Learning Styles in Library Instruction. College & Research Libraries, 63(3), 261–273. https://doi.org/10.5860/crl.63.3.261

Delhi Public Library. (2009). Retrieved February 6, 2019, from http://www.delhipubliclibrary.org/

Godfree, H., & Neilson, O. (2018). School Libraries Matter! The missing piece to the education puzzle. Retrieved from http://www.asla.org.au/site/DefaultSite/filesystem/documents/school_libraries_matter_access.pdf

Himachal Pradesh Board of School Education (2017-2018). *Affiliation Regulation/Bye-Laws. Retrieved from: http://hpbose.org/Admin/Upload/Affiliation%20regulation%20For%20the%20Session-2017-18.PDF*

Himachal Pradesh The Official Website (2018). At a Glance. Location: https://himachal.nic.in/en-IN/at-a-glance.html

Himachal Pradesh The Official Website (2018). Inspection Report Location: https://himachal.nic.in/index1.php?lang=1&dpt_id=16&level=0&linkid=4833&lid=17714

India Central Board of School Education. (2018). *Library Guidelines.*

India Kendriya Vidyalaya Sangathan. (2018). *Guidelines for School Library and Procedure Manual.*

Inspection Report. (2018, September 19). Department of Elementary Education. Retrieved from: https://himachal.nic.in/index1.php?lang=1&dpt_id=16&level=0&linkid=4833&lid=17714

Jatana, M. & Kholsa, N. (2003). Public library-A dynamic community centre for socio-cultural uplift of rural India. Retrieved from Herald of Library Science, 42(1/2), 66-74. https://wpi.illiad.oclc.org/illiad/illiad.dll?Action=10&Form=75&Value=106358

Kunhambu, K. (2012). Role of Rural Libraries in Rural Areas. Retrieved from EBSOC host database. Reprinted from SRELS Journal of Information Management, 49(6), 631-647 https://wpi.illiad.oclc.org/illiad/illiad.dll?Action=10&Form=75&Value=106158

Lance, K. C., & Kachel, D. E. (2018). Why school librarians matter: What years of research tell us. Phi Delta Kappan. Retrieved from Phi Delta Kappan database. https://www.kappanonline.org/lance-kachel-school-librarians-matter-years-research/

Leach, G., Sugarman, T. (2005). Play to win! Using games in library instruction to enhance student learning from Research Strategies, 20(3), 191-203, ISSN 0734-3310, Retrieved from: https://doi.org/10.1016/j.resstr.2006.05.002

Lessow-Hurley, J. (2003). Meeting the Needs of Second Language Learners: An Educator's Guide. (p. 15-30). Association for Supervision and Curriculum Development, 1703 North Beauregard Street, Alexandria, VA 22311-1714 Website: http://www.ascd.org

Libraries Without Borders. Our Impact. Retrieved from: https://www.bibliosansfrontieres.org/impacts-2/

Libraries Without Borders. Our Impact. Retrieved from: https://www.bibliosansfrontieres.org/impacts-2/

Mahajan, P., (2010, May). School Libraries in India: Present-Day Scenario. Library Philosophy and Practice. Retrieved from: http://digitalcommons.unl.edu/libphilprac/371/

Martins, J. T., & Martins, R. M. (2013). Portuguese School Libraries Evaluation Model: an analysis of primary schools' results for the 'reading and literacy' domain. The Australian Library Journal Retrieved from https://www.tandfonline.com/doi/pdf/10.1080/00049670.2012.10739060?needAccess=true

Pal. (2017, July 17). 10 of India's Best Libraries. Retrieved February 7, 2019, from http://www.asiaoptions.org/indias-best-libraries/

Ramaiah, C. K., & Pillai, K. N. (2013). Training Needs of School Librarians in India. Retrieved from EBSCO Host database. (Excerpted from DESIDOC Journal of Library & Information Technology, 33(5), 367-377 2012) https://wpi.illiad.oclc.org/illiad/illiad.dll?Action=10&Form=75&Value=106157

Randel, J., Morris, B., Wetzel, C., Whitehill, B., & Navy Personnel Research And Development Center San Diego, CA. (1992). The Effectiveness of Games for Educational Purposes: A Review of Recent Research. Retrieved from http://handle.dtic.mil/100.2/ADA259666

Shenton, A. K. (2011). Two pupil-centred approaches to the assessment of school Libraries, Retrieved from Performance Measurement and Metrics, Vol. 12 Issue: 1, pp.38-49, https://doi.org/10.1108/14678041111124289

Shimla (April 23, 2013 Tuesday). GVS seeks state library policy and Act in HP. *UNI (United News of India). Retrieved from Nexis Uni.*

Singh, J. (2005). Status of School Library Development in India. Sri Lankan Journal of Librarianship and Information Management, 1(1), 7-10. https://doi.org/10.4038/sllim.v1i1.425

The School Library in Teaching and Learning for All. (1999). Teacher Librarian, vol. 27, no. 2, 1999, p. 24. Retrieved from http://link.galegroup.com/apps/doc/A58297152/AONE?u=mlin_c_worpoly&sid=AONE&xid=dbf9bc4b.

United Kingdom Libraries All Party Parliamentary Group (2014, May). The Beating Heart of the school. Retrieved from https://eastriding.gov.uk/EasySiteWeb/GatewayLink.aspx?alId=620060

Ward, K. (2014). *Researching the City. SAGE.*

Teammates interacting with faculty at a local village school


HUNGRY For a Good Book
A book, too can be.
A star, a living fire to
lighten the darkness leading
into the expanding
Univers
FALL
in love with
READing
JUDGE
Magazine
CHAMPAK
Spectrum
SEA ANIMALS

Evaluating Sericulture Feasibility in Himachal Pradesh

Abstract

A feasibility study was conducted to evaluate whether silk production in Mandi, Himachal Pradesh, India can be expanded by interviewing members of different parts of the industry. Information was gathered on practices within this field; strengths, weaknesses, opportunities, and threats to the industry were examined; the interest and ability of farmers to produce silk were investigated. Regional silk production in HP may soon become endangered, but making it more self-contained and efficient could instigate expansion.

Team Members

Abhishek Bhaskar (B16084)
Jake Scarponi
Jeffrey Page
Nick St. George
Rijul Bathla (B16140)
Surya Vadivazhagu
Mohit Barthwal (TA)

Advisors

Dr. Gbeton Somasse
Dr. Ingrid Shockey
Dr. Shilpa Sharma
Dr. Shyam Masakapalli

Sericulture: Expanding Opportunities for Himalayan Livelihoods

The two largest worldwide producers of silk are China and India, with China currently leading in both production and exportation by a large margin. The dramatic gap between these two leaders can be attributed to infrastructure lag in India. The country's venture into world markets has been slowed by comparatively less advanced technology for silk production.

The Society for Technology and Development (STD) is a non-profit NGO that has worked since 1990 for the welfare of marginalized sectors in the Mandi district of Himachal Pradesh (HP), India (STD, 2016). Under this umbrella, professionals from fields of engineering, education, social, agricultural, and horticultural sciences work alongside field researchers and artisans. Their main objectives are: to improve the employment and income of local populations by introducing technology which can complement traditional skills; to improve production mechanisms in order to add value to local products; and to form connections with the government and other organizations working within their field. The STD sees an opportunity for Himachali farmers to expand silk cocoon production, also known as sericulture. Figure 1 shows silkworm cocoons, which are processed to produce silk fabrics.

Fig. 1: Silkworm cocoons (Vadivazhagu, 2019).

Sericulture has taken up an important role as a cottage industry and a supplemental income source for agrarian Indian communities. Despite efforts of Himachal Pradesh's government, sericulture is an uncommon livelihood in this state. Technical and marketing support may address bottlenecks in sericulture's implementation, but the concerns of silk farmers are unclear. A 2014 study gives some clues, indicating that many barriers for improved industry standards are present. For example, most of the silk reeling industry consists of scattered micro-companies operating with "low margins" and "little capacity to invest in upgrading technology" (Astudillo et al., 2014, pp. 158-167). Also, development of new practices has generally focused on increasing silk yields, but studies suggest that more conservative practices that preserve product quality—e.g., better irrigation and effective raw material use—could improve sericulture's revenue stream. This could enhance the sustainability of silk and advance its economic viability.

The significance of expanding sericulture, by virtue of its potential for boosting both local incomes and therefore the state economy, responds to a few of the United Nations' sustainable development goals. These include opportunities to: reduce poverty and hunger; improve and innovate industry and infrastructure; and increase employment and economic growth within HP. Creating agricultural opportunities that are resistant to climate change are also of interest in a region that sees 70% of local livelihoods tied to farming (Government of India, 2016).

Thus, this project's goal was to conduct a feasibility study on increasing sericulture activity in Mandi District, HP. We approached this goal by studying viable and optimized silk cocoon production methods, gaining an understanding of economic factors surrounding regional sericulture, and assessing the local capacity for and interest in this field's expansion.

Sericulture Process, Industry, and Infrastructure

Before assessing the feasibility for sericulture in Mandi, we wanted to understand the steps that end with a final silk product. Sericulture is the process of growing silk cocoons for their silk filament in order to reel fibers and subsequently weave fabric. During its natural life cycle, a silkworm—of the species *B. mori L.*—hatches, grows, spins a cocoon, and becomes a moth capable of laying eggs (Babu, 2012). In nature, silkworm eggs normally hatch once a year, but ideal lab conditions can allow for up to three annual hatchings (Prakash et al., 2003). The silkworm larvae that hatch from these eggs—which produce different types of silk depending on their diet—are most often fed mulberry leaves (Murugesh,

2013).

Genetic variations of the silkworm *B. mori L.* are referred to as "races." Indian races have a long larval stage and are more tolerant of high temperatures and humidity, producing good silk filament quality in their cocoons (Murugesh, 2013). Generally, silkworms that reproduce more frequently are smaller, with lighter silk cocoons and shorter life spans; the lowest filament quality is found in worms that breed twice yearly (Murugesh, 2013). Molting patterns may also vary across silkworms, but all commercially-bred, domesticated silkworms undergo metamorphosis at the same point in their development (Murugesh, 2013).

Over the course of twenty to thirty days of nurturing, typical larvae grow into caterpillars roughly 9 centimeters long (Babu, 2012). Each caterpillar eventually forms a cocoon by secreting a protein-like substance that hardens as it reaches air, becoming silk. Marketable cocoons, shown in figure 2, are usually taken to local markets and sold to other farmers, silk fiber reelers, or exporters for further processing elsewhere.

Fig. 2: A crate of mulberry silk co-

At this point, the cocoon is ready for stoving and reeling. These processes first heat the cocoon in water to more easily extract its filaments. This will kill the silkworm inside if it is still alive, although some cocoons are spared to become moths for breeding purposes (Babu, 2012). Once the filament has been drawn out, several cocoons are reeled together to form threads of three to ten silk fibers. The fiber may be sold, woven into yarns and fabrics, or turned into final products such as clothing (Babu, 2012; Prakash et al., 2003). In addition, slight technical variations from this general norm result in variations in silk quality. Generally, the final product is a strong silk fabric that can be dyed while retaining its lustrous and absorbent properties.

These processes do not require much equipment, aside from a few specialty processing tools. For example, most small-scale reelers rely on the charka (Prakash et al., 2003). This is a simple, inexpensive device with a long tradition of use in a variety of different Indian textile industries. The charka can be operated by two workers, who could be members of a silk cocoon farmer's family. Somewhat larger Indian operations may use a cottage basin system, using a comparatively expensive machine that allows for more cocoons to be boiled and reeled together simultaneously. Many Chinese production sites, meanwhile, have even larger and more complex mechanized operations.

Sericulture in the context of the Indian agrarian economy

The Indian sericulture industry occupies a sizable portion of its textile sector. In 2013, 7.6 million people throughout India were employed in sericulture out of 45 million employed throughout India's entire textiles industry (Sharanadavar, 2014). Furthermore, India is in a unique position compared to China in that it can produce four distinct kinds of silk: mulberry, tasar, eri, and muga silk (Kumaresan, 2002). Worth noting, however, is that 90% of the world's commercial silk is mulberry silk (Types of Silk, 2013).

Given its reliance on mulberry plant leaves, as in other countries, India's sericulture industry may be vulnerable to the effects of climate change. Changing atmospheric conditions are causing changes in both soil quality and characteristics of the leaves of the mulberry plant. This plant does benefit from increased CO_2 levels, since it photosynthesizes inefficiently (Ram et al., 2016)—higher CO_2 levels mean that photosynthetic reactions occur more frequently. However, the mulberry plant thrives best in a cooler climate; higher global temperatures can cause stress that degrades leaf quality (Ram et al., 2016). The most limiting factor to mulberry plant growth and quality, though, is an inability to control pest parasitism (Ram et al., 2016).

Agriculture is one of the primary sources of income within the state of Himachal Pradesh, India; estimates state it accounts for nearly 70% of employment (Government of India, 2016). However, the state has seen a shift in recent years towards industrial development (Directorate of Employment, 2015), and agriculture faces many challenges for future development within the state. Some of these challenges in-

clude: low profits from traditional crops; a high dependence on regulated irrigation, which is scarce; and inadequate infrastructural support from the government (Government of India, 2016). Despite facing a negative trend in silk production, the state government of HP has not issued any additional subsidies towards or better communication efforts about existing programs working with marginalized farmers. The national government, meanwhile, announced initiatives in 2018 to make India completely self-reliant in the silk production industry, being committed to infrastructure development and increasing silk product quality (Ministry of Textiles, Press Information Bureau, 2018).

As noted earlier, the charka that is commonly used in Indian reeling is less efficient than more recent technologies (Kumaresan, 2002). All charka operation is done by hand, but the tool requires little capital investment or skilled labor to maintain. Automated silk reeling machines have been popularized in China, Japan, and Korea, but most require large capital investments and skilled labor for maintenance. This makes the technology difficult to implement for most rural, family-run silk farms (Kiyokawa, 1993). Efforts continue to be made to introduce automation in India to encourage sericulture. These are primarily made through subsidization (Central Silk Technological Research Institute, 2017). Figure 3 shows a modern reeling machine built for a group of reelers in Bilaspur by the government. Sericulture does already have a presence in HP, with many micro-companies facilitating silk exports. These micro-companies may be collectively referred to as a cottage industry. They include family-run farms working with privately-owned equipment, although cooperation exists for sharing some expensive equipment. Cottage industries are common within HP, composing about 40 percent of its total industrial output (Sharda, 2018). Sericulture is viewed as a viable cottage industry thanks to its manual labor-intensive nature and the fact that it can be done at a local level with minimal large-scale organization or expensive technologies.

Fig. 3: Modern reeling machine (Vadivazhagu,2019).

Outside of climate change effects, the climate of HP is capable of seasonal mulberry plant growth and silkworm rearing through March and April, with cocoon harvests and sales in May. Mulberry varieties introduced by the government are capable of two or even three annual harvests, allowing for more cocoon farming. At higher altitudes in HP, oak trees are naturally common. If oak leaves replace mulberry leaves as fodder, silkworms will produce brown, slightly coarser tasar silk, making tasar a reasonable alternative to mulberry silk in these areas.

In sum, the Indian sericulture industry is well-established, albeit underdeveloped, but is and will continue to be affected by climate change. Himachal Pradesh also has the resources and the climate to support a sericulture industry growing multiple types of silk.

Mission of the Society for Technology and Development (STD)

The Society for Technology and Development seeks to improve local economies by integrating technology to enhance and support traditional skills. This NGO has seen success throughout much of northern India with an established "Core Long Term Program" focusing on increasing export diversity, strengthening local communities, and agricultural standardization (STD, 2016). The NGO once studied honey production with rural HP farmers, for example, and drew up an economic plan to diversify raw honey into different products (STD, 2016).

While improving sericulture has the potential to improve the income and the quality of life for farmers, such a development could have impacts of a broader scope. Supplemental income granted to farmers could stimulate the local economy through increased spending. With a greater silk supply, it is possible that silk's price may decrease.

Looking ahead: supporting research

Established literature indicates both promise and issues with regard to regional sericulture feasibility. Astudillo, Thalwitz, and Vollrath's 2014 life cycle assessment is thorough in its examination of a full sericulture scheme and its effect on a single component's viability. It was conducted in southern India and posits key factors for sustainable sericul-

ture development and increasing export viability. It discusses many market aspects and compares Indian and Chinese sericulture. Researchers found that India saw a lack of management and suboptimal post-farm cocoon processing procedures (Astudillo, Thalwitz, & Vollrath, 2014).

Shukla conducted a survey in 2011 to determine constraints on Indian mulberry silk production. This investigation involved direct contact with rural farmers and developed conclusions based on their opinions. It concluded that the top three constraints on sericulture farmers' operations were input cost, a lack of reliable irrigation, and a lack of family involvement, respectively. Problematic irrigation was noted in Nagaseshanna's 1993 farm study of Anantapur District as most harshly affecting small-scale farmers. Here, it is noted that droughts occur frequently and unpredictably in India. Other factors that limited farmers' expansion, ranging from silkworm egg quality to a lack of credit support by the government, were also found. The fact that Shukla's 2011 survey recorded irrigation problems as only the second biggest farmer concern indicates that in the years following Nageseshanna's study, the government provided more benefits to cocoon farmers. In 1996, a certain plan did indeed provide farmers with enhanced bivoltine hybrid cocoons, which are more resistant to drought (Rangappa, 1996). In sum, these studies helped to inform us on what issues silk farmers typically encounter.

Interviews and Lines of Research

The following section details data collection strategies that were used to investigate sericulture feasibility in Mandi. Figure 4 summarizes our objectives and associated methods.

Collecting information on silk production practices

To understand sericulture and farming practices, we interviewed experts in relevant fields, including agricultural and climate specialists at the GB Pant National Institute of Himalayan Environment and Sustainable Development (GBPNIHESD). To gain the perspective of silk processors, we interviewed representatives of Krishna Wool and a reeling station in Bilaspur, as in figure 5 (next page). We also conducted archival research for a basic understanding of sericulture.

Our interviews were semi-standardized; a list of topics and questions was composed to lead conversation with experts, but dialog was left open to follow-up discussion/explanation (Berg, 2009). Interviews with farmers were similar. Semi-standardized interviews were more casual and conversational, encouraging trust between parties. We documented detailed observations on how farmers in HP raise silkworms at various sites through photography and notetaking.

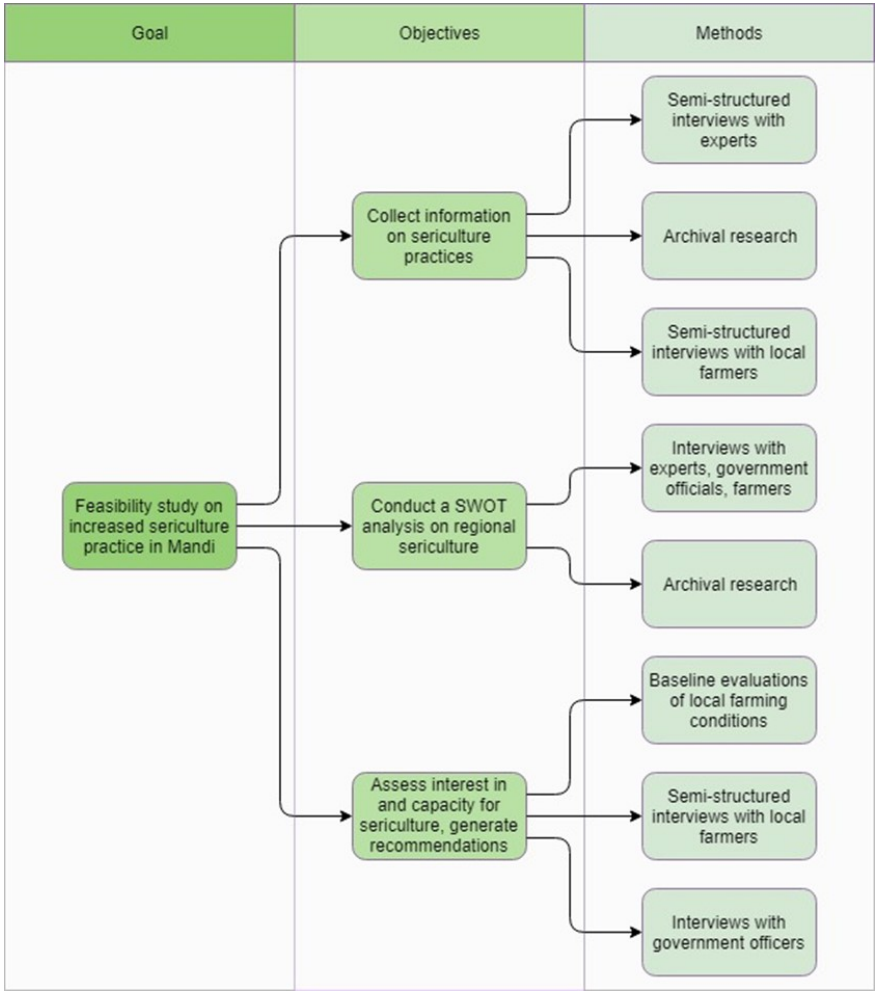


Fig. 4: Flowchart outlining project methodology for collecting data.

SWOT analysis

SWOT is an acronym for the Strengths, Weaknesses, Opportunities, and Threats associated with a business or industry. SWOT analyses are often used as one of the first steps when a business plans to make an adjustment in their operating strategy. We collected data through archival research and interviews with both local farmers and experts in the sericulture field. All interviews were sought out via snowball sampling.

Fig. 5: Interview with a worker at a Bilaspur reeling unit (Vadivazhagu, 2019).

Dr. Shilpa Sharma of STD Mandi connected students to a sericulture development district officer in Mandi town, who offered several contacts with potentially useful insight. Dr. Shyam Masakapalli reached out to Dr. Samant, the head scientist at GBPNIHESD, who offered insight on regional agriculture and climate change. Representatives of Krishna Wool were able to provide market information useful towards describing SWOT analysis factors. Silk cocoon farmers themselves also gave their perspectives on the state of their industry in this context.

Semi-standardized interviews allowed for the identification of key aspects of individual silk industry efforts that are or are not successful. One key detail drawn from interviews was to ask about the perception of sericulture within farming communities. This encompasses the focus of the next objective, but still played an important role in our SWOT analysis.

Assessing interest and capacities

The final objective of this project was to assess the regional interest and ability of industry peoples to improve sericulture in and around Mandi, and to generate recommendations to do so with research findings in mind. We conducted baseline evaluations to gather information regarding a farmer's situation, which helped us understand their farm's performance and their standard of living. Site assessments involved observations of physical landscapes, irrigation methods, and infrastructure that were useful in evaluating what resources a given farmer had available. Photos and written notes created a record of this information for the sake of comparison between farms.

Our connections with government officers and silk processers offered insight on government program success and industry roadblocks, although gathering cocoon farmers' perspectives was most critical towards generating recommendations. This is because farmer interviews highlighted the challenges they have faced within their livelihood. We collected data from silk farmers regarding their motivation for harvesting silk and sought suggestions for industry improvement based on their experiences. Farmers who used to practice sericulture and subsequently gave up were also interviewed to reveal industry weaknesses. Semi-structured interviews provided opportunities to tailor questions to individual farmers, and to gain additional insight not originally sought after. Team members and Dr. Sharma translated interviews between English and Hindi or local dialects. Snowball sampling was used to find additional farmer interviewees; referrals came from fellow farmers as well as district officials.

Results and discussion

The following section highlights results of data collected, organized by respective project objective.

Silk Production Practices

To identify best practices in the sericulture industry, we spoke with a range of professionals and experts in this field, including the president of the STD, the owner of Krishna Wool, and several locally active silkworm rearers. We learned that roughly 2% of land in Himachal Pradesh is cultivated, making mulberry plant growth challenging. Omprakash Malhotra, aforementioned owner of Krishna Wool, recommends increasing production of and government subsidies for tasar silk because of the convenience of natural oak forests. Malhotra described a method of covering oaks with nets to keep pests away, allowing silkworms to eat leaves without much farmer upkeep or protection; this method is typical

in tasar silk production. Malhotra has written many letters to the HP government to raise awareness about the potential of tasar silk but has not received any responses. He claims that his thicker, warmer tasar silk products are in higher demand in Mandi than his mulberry silk items.

The STD president—who has had experience working in silk—and Malhotra both approve of the cottage industry sericulture model, with a collective organization of small-scale farmers over a large-scale industrial cooperative. They believe it is most viable and suitable for the social and geographical landscape of Mandi.

Fig. 6: Krishna Wool weaver showing mulberry (left) vs. tasar (right) silk (Vadivazhagu, 2019).

Dr. Samant had many thoughts regarding good, sustainable farming practices. He has been working with farmers and colleagues to spread information about climate change impacts and sustaining ecological development. From his research, it was found that HP farmers tend to harvest resources too aggressively. For example, cutting too many limbs too quickly from trees can damage them, lessening the moisture retained in surrounding soil. Sustainable lopping cuts only smaller branches from mature trees over younger ones. This ensures that more trees survive, and soil quality is maintained better, especially during droughts.

Cocoon farmers discussed strategies to mitigate pests and other setbacks frugally; most lack significant merit-based government subsidies for sheds and other major resources to grow their worms. Ants, for example, can bite and kill many worms sitting crowded on a rack shelf very quickly, and are hard to find amongst the caterpillars. Cocoon farmers therefore spread limestone powder near their silkworm racks. Infectious diseases may also plague silkworms, causing mass death. Some rearers think feeding worms wet leaves just after rainfall may cause these; others are less certain. A dedicated botanical study has yet to be conducted on this issue. Silkworms also need to be kept in cool, dim environments, which are maintained by draping windows to block out light. If the weather is too cold—below 22ºC or so—farmers use small heaters to keep their worms warm.

Spirituality in HP also seemed to play a role in its sericulture. HP has been described as relatively religious and philosophically respectful of the intrinsic value of life. Malhotra claimed this can lead to people feeling conflicted on the stoving and reeling processes, which kill the developing moth inside its cocoon. Thus, Malhotra has a hard time finding workers to reel silk cocoons. Farmers themselves typically leave the cocoons outside under the sun to dry out. This kills the moth without giving farmers a sense that they have directly killed it. Interviews with them further revealed that years of engaging in sericulture as a family tradition led to ambivalence towards the silkworms' fate. The reeling labor issue probably remains because these farmers typically do no reeling themselves.

We discussed with the Sericulture Officer of Gorth Village how one would become engaged in silkworm rearing in HP at this time. He described how one would need to follow a series of steps that could take years. Most of this time would be dedicated to preparing infrastructure capable of harboring the worms. A would-be rearer would first need to essentially grow a mulberry plantation. After submitting various applications, the farmer would receive visits from officers of the state government, who would train them in basic rearing techniques. After thorough evaluations over time and more application submissions, he or she would be selected for subsidies based on their cocoon rearing performance.

SWOT analysis

Figure 7 on the next page summarizes aspects of regional sericulture which apply to analyses of its own strengths, weaknesses, opportunities, and threats as an industry.

To expand upon important and/or surprising findings: the conditions and climate of Himachal Pradesh are well-suited to silkworm rearing. There is very little silk processing or value addition done at a local level. The overwhelming majority of the cocoons produced in HP are sold

to other states. Reelers feel as though most available support from the government goes to cocoon farmers, and that this makes cocoon prices too high for reelers to be successful. Meanwhile, many farmers struggle to get the support they need from the government. The production of tasar silk can be supported by regional resources, but is currently not being utilized or encouraged. This presents an area of potential growth for the industry. Religious or moral conflicts with killing silkworms is an unexpected factor which forms an obstacle to regional sericulture's growth by impeding the reeling sector.

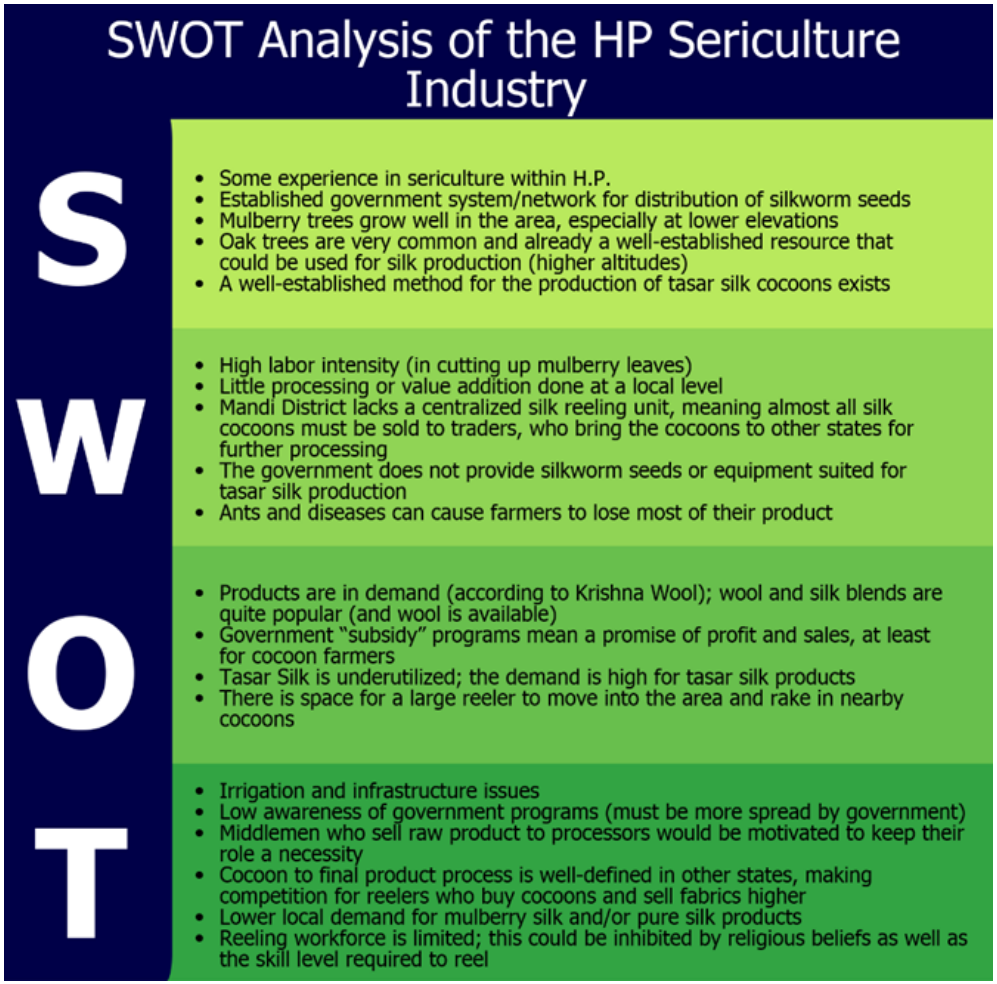


Fig. 7: Regional sericulture industry SWOT analysis summary.

Interest and capacities surrounding sericulture

Findings from our interviews confirm some initial expectations, but also bring to light new issues and aspects. It is not uncommon that cocoon farmers use silk rearing seasonally as their primary income source; most are otherwise subsistence farmers of wheat and maize crops. All also stated that they would continue their respective sericulture operations, although it is worth noting that sericulture is a traditional family endeavor for them. There was also consensus between farmers that harvesting mulberry leaves often involves dangerous climbing of trees.

The farmers we interviewed typically earned between 900 and 1000 rupees per kg, producing an average of 20kg in a season. Most described disease as the biggest threat to their cocoon farming. Apparently, some recent seasons have seen cocoon product reduced to as little as 5kg due to silkworm disease. Despite the existence of state government subsidies, all farmers mentioned having trouble getting some of the equipment they needed from these programs. The vast majority had no shed; their silkworm rearing racks occupied space in their homes. One farmer has sold cocoons to the government for fifty years, but still has been granted no shed.

A pair of former silk farmers indicated that while aided by government subsidies, sericulture was not their preferred means of making money. Both farmers were part of the same cooperative and received the same governmental benefits, and both found that sericulture work was tiring and not worth doing when they had alternatives. In order to feed their silkworms, they hand-picked tender mulberry leaves and used scissors to cut them into small, consumable pieces. It is unclear why they cut up the leaves, since other farmers simply place leaves or large pieces of them directly on worm racks. Hand-plucking leaves, though, is a consistent activity amongst all cocoon farmers. While the cocoon-generating season lasts only 45 days, one of our two former rearers explained that her "[silk]worms eat too many leaves! Those 45 days were exhausting." The pair further elaborated that owning cultivated land encouraged smaller-scale farmers to grow less input-heavy cash crops like tomatoes, which they described as much preferable over cocoon farming. They explained that there were no substantial obstacles keeping them from rearing worms again besides a lack of interest brought on by the tedious work. In order for farming cocoons to be worth doing from their perspective, it would either have to be conducted on a larger scale, or be made a far less tiresome process. These farmers experienced no irrigation issues while farming cocoons—all farmers interviewed relied on rainfall—and the cocoon season did not appear to interrupt any of their other annual activities. From these farmers' responses, it seems that those not currently engaged in cocoon farm-

ing may be encouraged to do so if they were ensured the process was scaled up or less input-heavy.

Discussion with government officials on silkworm rearing revealed interesting points. The Sericulture Officer located in Gorth Village, who had been in office for over 30 years, described how the 1990s were a much greater time for sericulture than the present. There was more rearing, higher demand for cocoons, and more fabric production in HP; the industry was experiencing a boom. Unfortunately, as time passed and more buyers of cocoons came from foreign countries and other Indian states, rearers grew older, and producing the same volume of cocoons became more challenging. As the cocoon supply lessened, people took less interest in sericulture due to its manual labor requirements and decreased foreign profits. Reeling business opportunities became scarcer, which in turn left less reeled silk for weaving businesses to process. The number of companies producing silk fabrics went down, and the industry entered a bust.

Long-term interest in sericulture is low; children of current cocoon farmers express interest in leaving villages to pursue a college education and professional employment. There is minimal interest especially in the tedious labor involved silkworm rearing.

Discussion

Looking at our data, we see interesting trends and details in unfamiliar territory. Tasar silk cocoon production occurring somewhat autonomously on oak trees saves farmers the hard labor of having to hand-pick leaves, which our former mulberry silk cocoon farmers found tedious, and which our current farmers found potentially dangerous. The demand for tasar silk products Malhotra expressed also reveals an unexpected source of potential. However, tasar silk production does have issues limiting its implementation. A lack of both government support and farmer awareness leaves would-be farmers of tasar silk without useful knowledge or resources for getting started. Furthermore, there may be fewer guaranteed buyers or fair prices for tasar silk than for mulberry silk; government schemes which purchase mulberry cocoons at certain prices already exist. Finding non-government buyers even of mulberry silk has proven challenging and less profitable—there are few processors in HP traders from other areas hold a lot of pricing power if they are the most accessible buyers. Farming tasar silk over mulberry also does not change the reeling process or the death of the silkworm inside its cocoon. Still, any governmental support at all could potentially stimulate an emerging market for more tasar silk.

Many respondents of this study prefer a small-scale model, but the idea of a sericulture cooperative amongst farmers should not be completely disregarded. Villages or farms which lack the capital or mulberry assets to start practicing sericulture on a profitable scale could benefit from sharing equipment and resources with nearby farms. Automating some processes, introducing higher-end technology, or hiring out certain tasks to a greater pool of labor could all assist in making sericulture work easier for individual farmers. This would involve splitting profits more, although expansion could draw in more revenue. Difficulty encountered in finding fair prices for cocoons also makes a strong case for forming cooperatives—farmers could gain more control over the market in the immediate area.

Project Outcomes

Ultimately, we found that sericulture provides farmers with an opportunity for supplemental income that does not compete for land or seasonal time commitments with other crops, can be effectively done by one person, and can be a primary source of income for subsistence farmers. For these reasons, sericulture could be worthwhile for many farmers who have few opportunities to make money. If more reeling and weaving were done locally, local silk cocoon farmers could see more consistent means of selling cocoons.

Sericulture is a time-consuming and demanding activity. Gathering mulberry leaves often forces farmers to climb trees. Tending to worms requires a lot of time, especially in the last 10 to 15 days of their larval stage, during which they consume far more foliage. It can be difficult to prevent the spread of diseases in a worm population, and extra care must be taken to ensure that leaves are dry and that pests do not invade worm racks.

Many of these issues could be remedied by cooperation between farms. Experts agree that a small-scale model is best, but cooperation does not necessitate a “cooperative” or upscaling; closely-situated farms

does not necessitate a "cooperative" or upscaling; closely-situated farms could stand to share resources like mulberry trees, or pool funds for shared equipment to ease labor burdens. This could allow more farmers to be jump-started into an engagement in sericulture. This vein of cooperation already exists where the government has given small groups of farmers subsidies that provide additional equipment to them as a unit, as in Gorth Village. These farmers still work individually on their rearing tasks.

Silk production could benefit from some small innovations to make certain steps in the process easier. Climbing trees to pluck mulberry leaves is difficult and sometimes dangerous; the interviewee shown in figure 8 broke both legs after falling from a mulberry tree. An inexpensive, simple device with a long arm and a set of clippers at one end could help with this issue, being able to trim most leaves from the ground. A team of government-funded dendrologists could collaborate on researching and/or developing a shorter mulberry plant, but this plant would take up too much land area and be incapable of producing as many leaves. A mulberry plant with broader leaves and a higher protein content would be more helpful; farmers would simply have to pick fewer leaves to feed their worms sufficiently.

Fig. 8: Interview with a cocoon farmer living near a Bilaspur reeling unit (Vadivazhagu, 2019).

Worth briefly noting is that if young people are disinterested in sericulture because of its basis in manual labor, they may become interested in developing solutions such as those listed above. A higher education could be used to develop mulberry trees with broader leaves, or a device for plucking those leaves.

Reeling units currently shoulder a large operation cost. Owners must purchase all the cocoons for a year at once, which often forces them to take out large loans with steep interest rates. These may be hard to pay off thanks to fluctuating silk prices, especially considering an uncertainty in the coming year's demand that may lead to over-buying. Figure 9 shows bags filled with extra cocoons a reeling station is not prepared to process because there is no buyer for them in the immediate future. The price of reeled silk is, on average, about 1800 INR per kilogram, but booms and busts in this are common over time. Reelers would appreciate if the government stored cocoons and released them for purchase once every month or two, but the government does not want to take up the responsibility of storage. It is not uncommon for rats and pests to chew up and destroy silk cocoons they come across. Moreover, if reelers were allotted with more start-up capital, e.g. a subsidy or low-interest loan, they could invest in equipment for processing beyond the reeling stage, even to the development of final products, which demand steadier, higher prices. They could also afford to hire professionals to train their own workers in weaving and other processing steps.

Developing final products could bring more revenue into reeling stations, and the surrounding economy could be stimulated by this in a few ways. Reelers could employ more workers, sell products locally rather than sell materials to other states, and buy more silk cocoons from nearby. HP silk is typically of the highest-ranked A4 grade, but Himachali reelers often still buy cocoons from southern India, which are cheaper

Fig. 9: Bulk mulberry cocoons being stored at a reeling unit (Vadivazhagu, 2019).

greater market supply. If reelers could diversify their products, they could help to keep much more labor and many more sales local, making sericulture in and around Mandi more self-sufficient and sustainable.

The sericulture industry in HP could also benefit greatly from more consistent, organized state government support. The Karnataka Silk Board, for example, consists of a dedicated team of people working on improving and ensuring quality in that state's silk industry. With this, they are able to quickly get legislative changes that help farmers effectively out to the state government for implementation. Himachal has several issues in communication between marginalized worm rearers and the Textile Board; support provided is either not enough or not prioritized to support farmers that need it the most. Merit-based support may mean that those struggling already will only continue to struggle. From farmer interviews, we see that few receive the sheds that make their jobs much less intrusive on their lives. Even a farmer who has been raising silkworms for over fifty years lacks solid government support, other than receiving worm eggs, which are provided by the government to all rearers. Reelers could also benefit greatly from government support in order to get into the weaving business, which could provide them with a better profit margin and allow them to more comfortably buy cocoons in bulk. This support could probably most easily come in the form of low-interest loans to cover costs of entry into weaving.

Rearers, when selling cocoons, are often held at the mercy of non-government cocoon buyers. One interviewee told how she was essentially forced to accept only 700 INR for a kilogram of cocoons, despite their high quality. Another described his difficulty in rearing worms in the rainy season, but that he received far lower price than normal for cocoons harvested then. An average bulk cocoon price is 900 INR per kilogram, but a lack of any hands-on involvement by the government in this niche market means that farmers often must compromise.

Finally, we recommend additional support from other researchers. Farmers reported several issues with disease and pests damaging their silkworms' health. A large chunk of their seasonal cocoon yields can be quickly lost to disease, and yet causes of these infections are generally unknown. One farmer postulated that he historically would observe the worms dying after a rainstorm, and how his worm yield was very low during the rainy season. Another fed her silkworms moist leaves just after a rainstorm, and noted many of them dying off that year. These two both believe that having too much moisture in their mulberry leaves is dangerous for the health of their worms; perhaps it relates to the temperature of the bed of leaves on which the worms sit. Hiring an entomologist or biologist to investigate the causes of these diseases could prove invaluable to farmers. The deadliest pest to worms are biting ants; these can be defended against with limestone powder around worm racks, although some farmers were unaware of this approach. Communication between farmers could always help spread useful tips.

Conclusions

The government and the STD believe that sericulture is not practiced to its full potential in Mandi, and that this livelihood can aid in uplifting marginalized farmers and stimulating Himachal Pradesh's state economy. Our work leads us to believe that they both are correct. We believe there are measures which could address bottlenecks in sericulture's implementation in and around Mandi, enabling stakeholders from a variety of positions to get involved with sericulture's improvement in a profitable way.

There are many open avenues for further research in the vein of our project specifically. Interviewing more farmers not involved in sericulture to gain an outside perspective on the industry, and to hear what might motivate them to engage with it, could help generate new ideas on how to improve it. Researching ways in which farmers can sustainably raise more pragmatic mulberry varieties using the resources available could make raising silkworms safer and easier. By gathering and distributing detailed information on government subsidies, i.e., the application process as well as the approval and awarding processes, one could more effectively research and recommend improvements to that particular scheme. Finally, an investigation of tasar silk's implementation elsewhere could suggest whether it is truly suitable for Himachal Pradesh. We feel that our project has confirmed the general feasibility of increased sericulture implementation in Mandi. We also assert that this will take certain measures from stakeholders across the board, and that there is, of course, always room for deeper investigation.

Acknowledgements

We would like to extend an extreme thanks to Dr. Shilpa Sharma of the Society for Technology and Development, our sponsoring non-government organization, for her outstanding assistance during all of our field work, and for all the knowledge with which she helped us complete our project. We would also like to acknowledge Mohit Barthwal for the help he has lent as our teaching assistant.

Above: A collection of cocoon farmer portraits.

The reports in this book represent the work of WPI and IIT Mandi undergraduate students. For more information and to see the complete report, you may search using keywords or author at https://digitalcommons.wpi.edu/iqp/ or http://www.iitmandi.ac.in/istp/.

Works Cited

Astudillo, M. F., Thalwitz, G., & Vollrath, F. (2014). Life cycle assessment of Indian silk. *Journal of Cleaner Production*, 155-167.

Babu, K. M. (2012). *Silk production and the future of natural silk manufacture.* Cambridge: Woodhead Publishing Limited.

Berg, B. L. (2009). *Qualitative Research Methods for the Social Sciences.* Boston: Pearson Education, Inc. publishing as Allyn & Bacon.

Central Silk Technological Research Institute. (2017). *CSTRI Annual Report.* Madiwala, Bengaluru: Govt. of India.

Directorate of Employment, Government of Himachal Pradesh. (2015). *Annual Area Employment Market Report.* Shimla: Ministry of Electronics and Information Technology.

Government of India. (2016). *State Industrial Profile of Himachal Pradesh.* Chambaghat, Solan: Micro, Small & Medium Enterprises Development Institute.

Inbanathan, A., & Prakash, O. (2019). Silk Reeling and Health: Lifestyle and Quality of Life workers.

Kiyokawa, Y. (1993). Possibilities for Producing High Quality Raw Silk and Fostering a Skilled Work Force in the Indian Silk-Reeling Industry. *Hitotsubashi Journal of Economics*, 87-109.

Kumaresan, P. (2002, October 4). Quality Silk Production: Some Economic Issues. *Economic and Political Weekly*, pp. 4019-4022.

Murugesh, B. (2013). *Introduction to Silk and Sericulture.* Cambridge: Woodhead Publishing Limited.

Nagaseshanna, A. (1993, December 31). Sericulture development in Anantapur district: a farm level study. Anantapur, Andhra Pradesh, India: Sri Krishnadevaraya University.

Ram, D. R. (2016). Impact of Climate Change on Sustainable Sericultural Development in India. *International Journal of Agriculture Innovations and Research*, 1110-1118.

Rangappa, A. C. (1996, July 31). Economics of silk handloom industry in Andhra Pradesh with special reference to Anantapu district. Anantapur, Andhra Pradesh, India: Sri Krishnadevaraya University.

Sharanadavar, S. B. (2014). *Production and Export Performance of Indian Silk Industry: An Economic Analysis.* Dharwad: University of Agricultural Sciences.

Sharda, P. (2018, October 13). *Cottage and Small Scale Industries in Himachal Pradesh*. Retrieved from Abhimanu Community College Web site: https://abhimanuias.com/state/Searchdetail.aspx?type=BL&id=8383

Shukla, R. (2011). Constraints in Adoption of Recommended Technologies in Mulberry Seri Culture in South Rajasthan. *Agricultural Science Digest*, 235-236.

Society For Technology & Development. (2016). *Home: Society For Technology & Development*. Retrieved from Society For Technology & Development, Mandi Himachal-India: http://www.stdruraltech.org/index.html

The Ministry of Textiles. (2018, March 22). *India to be Self-Relaint in Silk Production by 2020*. Retrieved from P.I.B., Government of India Web site: http://pib.nic.in/newsite/PrintRelease.aspx?relid=177872

Types of Silk. (2013). Retrieved from International Sericultural Commission: https://inserco.org/en/types_of_silk

Assessing the 'Smart Village Potential' of Villages in Mandi District

Abstract

The Project 'Smart Village' is aimed at conducting a study which would enable the administrators to quantify the 'Smartness Potential' of the villages of Himachal Pradesh. The pilot study consists of surveys and personal interviews across 8 villages of Mandi, each from a different block along with the perceptions of a Smart Village within the IIT Mandi community. Through these modes, we collected 36 responses from the villagers (stakeholders) and 126 responses from the well aware IIT community. For a thorough study, we chose 25 parameters covering all the aspects of a village. The weights for these parameters were calculated by the survey data and the present standings were determined by the interviews from village representatives and this data was verified from the Census. The final deliverable of the project is a tool that helps formulate the Smartness Potential of a village mathematically.

Team Members

Gagandeep Tomar (B16056)
Lokesk Kumar (B16061)
Aditya Singh (B16085)
Naman Chaudhary (B16104)
Neeplotpal Dutta (B16106)
Anand Ramrakhyani (B16184)

Advisors

Prof. S. C. Jain
Dr Kaustav Sarkar

Need for 'Smart Village'

India houses a population of over 1.3 Billion (World Bank Data - India, 2017) of which around 66% of the population resides in rural areas (World Bank Rural Population Data, 2017). 70% of the total workforce of India resides in the rural areas. However, the rural economy constitutes on 46% of the national income (Aayog, N.I.T.I, 2017). The Indian villages also lag in other aspects. If we consider the Crude Death Rate in India, the national average for urban areas is 5.4 whereas it is 6.9 for the rural areas. In Himachal Pradesh, the values are 4.3 and 7.0 respectively (Estimates of Mortality Indicators, 2016).

Even with rapid urbanization and rural-urban migration, the United Nations estimates predict Indian population to be predominantly rural till 2050 (DESA, 2012). The Smart City Mission was launched in 2015 (SMART CITIES, n.d.) with the mission to improve the city infrastructure and living conditions but there is a need to shift our attention to the fact that a lot of villages still lack basic infrastructure for healthcare, education and basic amenities like electricity, water, sanitation and connectivity and lag behind in parameters like literacy rates and life expectancy.

Figure 1. Village resident in Maloh, explaining his mode of livelihood. The grinding machine is now obsolete and barely functions. A shift in vision needs to happen and need specific modern technological interventions should be considered for villages.

With the aim of the holistic development of the rural India, schemes like PMAGY (2009) and SAGY (2014) were launched by the government. The funds are limited and hence it is needed to prioritize the areas for expenditure. The Smart City Mission selects the cities based on their potential, defined by the current situation. Similarly, potential 'Smart Villages' must be identified to be considered for investment. One of the most important features of such a planning and prioritization is the development of a quantification technique. Often, such a consideration involves a lot of qualitative aspects which makes the technique quite complex. Hence, the challenge is to develop a tool which is accurate and at the same time simple enough to be understandable by the users (Sarkar & Dash, 2011).

The SAGY VILLAGE DEVELOPMENT PLAN FRAMEWORK is a 65-page document that guides the user to evaluate a village, but it does not provide a method to quantify the result. Thus, comparison becomes difficult in such a case. Moreover, such models are universally applied for the entire country and hence neglects the fact that the characteristics of a village may vary within the country. For example, the idea of a village as a properly defined entity cannot be applied in hilly states like Himachal Pradesh where the inhabitants are scattered over a valley or a mountain.

The project aims to reckon the potential of villages to convert them into self-sustainable communities as described that satisfies the global goals of the United Nations.

The goal of the project is to conduct a pilot study and develop a tool which can analyze the potential of the villages to convert them into self-sustainable Smart Villages based on certain parameters. For this, 4 objectives were identified.

1. Identification of parameters to evaluate a village
2. Identification of indicators of the selected parameters
3. Determination of the weights/importance of each parameter or their indicators
4. Determination of scores of a village in these parameters

Backbone of Study

2.1 Smart Village Concept

The Indian Census defines the village or the "rural sector" as any place meeting the following criteria:

- A population of less than 5,000.
- Density of population less than 400 per square km and
- More than "25 per cent of the male working population" is engaged in agricultural pursuits (Rural Indian, n.d.)

Figure 2. Shikawari village in Seraj Block

The notion of smart village is based on the ideas of an ideal village as described by Gandhi Ji. Gandhi's idea of an ideal or 'Adarsh' village is associated with 'Swaraj'- self-rule which refers to self-sustainable communities. In his own words:

> "In this village of my dreams the villager will not be dull - he will be all awareness. He will not live like an animal in filth and darkness. Men and women will live in freedom, prepared to face the whole world. There will be no plague, no cholera and no smallpox. Nobody will be all owed to be idle or to wallow in luxury. Everyone will have to do body labor. Granting all this, I can still envisage a number of things that will have to be organized on a large scale. Perhaps there will even be railways and also post and telegraph offices. I do not know what things there will be or will not be. Nor am I bothered about it. If I can make sure of the essential thing, other things will follow in due course. But if I give up the essential thing, I give up everything"

A smart village is an implementation of the ideal village through use of modern techniques and technologies. Thus, a smart village provides its inhabitants with all the basic facilities in an efficient manner. In a smart village, the community, individually and collectively, will be empowered to take smart decisions using smart technologies and with the support of smart manpower and by managing to be self-sufficient. (Indira & Anupama, 2016)

There have been various studies that describe the necessary amenities in a smart village. This is influenced by the location of the village. David Freshwater (Kidd K.A., et al, 2000), emphasises on the idea of sustainable employment whereas another study by Dr Milind Kulkarni (Kulkarni, 2015) focuses on cleanliness and sanitation. Rutuja Somwanshi, et al (2016) who studies the implementation of Smart village concept in a village of Maharashtra discusses a range of facilities necessary for the holistic development of the village. It ranges from using cleaner energy sources, development of roads to increasing the green cover.

The decision to determine on the type of facilities or amenities necessary for a smart village is quite critical and hence, needs an intense evaluation based on the opinion of the direct stakeholders and expert community.

2.2 The rural administration structure

The three-tier system of Panchayati Raj Act for local administration in villages has the provision of Zila Parishad, Panchayat Samiti and Gram Panchayat. The jurisdiction of Zila Parishad and Panchayat Samitis corresponds to the district and Community Development (C.D.) blocks boundaries respectively. A district is divided into smaller units. The unit of division can be a tehsil, which is formed on the idea of revenue collection or a C.D. block, which is for the implementation of a common development plan. (Mandi District Census Handbook, 2011)

2.3 The Mandi District

Mandi district falls in the central portion of Central Himachal Pradesh which is one of the four micro regions of the State. It lies between 3100 13′ 30″ and 3200 04′ 22″ north latitudes and 7600 36′ 08″ and 7100 23′ 26″ east longitudes and is bounded by Kangra district in the north and north-west, Hamirpur and Bilaspur districts in the west, by Solan and Shimla districts in the south and by Kullu district in the east.

The district has an area of 3950 square Km according to the Surveyor General of India.

The district is divided into seven sub-divisions of Mandi, Chachyot, Jogindarnagar, Padhar, Sarkaghat, Sundarnagar and Karsog and 17 Tahsil/Sub-Tahsils. Further district is divided into ten Community Development Blocks for the developmental purposes. Those are Chauntra, Drang, Dharampur, Gopalpur, Sundarnagar, Balh, Mandi Sadar, Gohar, Seraj and Karsog (Mandi District Census Handbook, 2011).

Figure 3. SAGY framework and guidelines

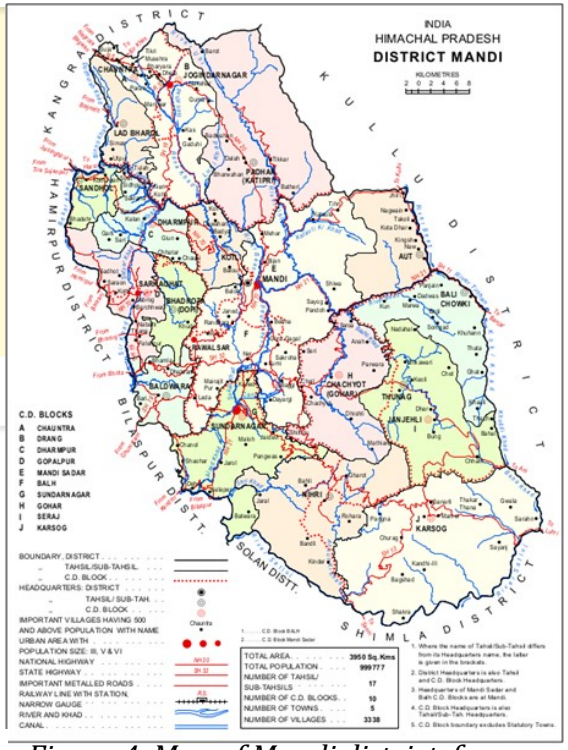


Figure 4. Map of Mandi district, from census Handbook

2.4 The Sansad Adarsh Gram Yojana (SAGY)

The SAGY scheme was launched in 2014 by the Prime Minister Shri Narendra Modi. The scheme aims for a holistic development of the selected villages. Under this scheme, the Members of Parliament (MPs) choose a Gram Panchayat and engage with the local community for its holistic development. MPs will also directly support activities at village level like health camps, organising grievance redressal camps, community mobilisation etc. he goal is to develop three Adarsh Grams by March 2019, of which one would be achieved by 2016. Thereafter, five such Adarsh Grams (one per year) will be selected and developed by 2024. (SAGY, n.d.)

The SAGY guidelines and village development plan framework describe the goals and approach of the scheme. It broadly classifies the activities in an Adarsh Gram into 8 classes:

1. Personal Development (E.g. fostering healthy habits)
2. Human Development (E.g. Education, immunization etc.)
3. Social Development (E.g. Inclusion of excluded groups)
4. Economic Development (E.g. Agriculture, Rural industries)
5. Environmental Development (E.g. Plantations.)
6. Basic amenities and services (E.g. House, drinking water)
7. Social Security (E.g. Insurance)
8. Good Governance (E.g. E-governance)

Furthermore, the village development plan framework describes different type of facilities and their survey methodologies (indicators) in an exhaustive manner. E.g. number of households electrified. We chose some of the indicators based on the ease of data collection and their expected impact on the society. Those were then classified into 8 'pillars' shown in the figure below taking an inspiration from the SAGY classes. (SAGY, n.d.)

Figure 5. Parameters that determine a smart village in our study

Methodology Used

The main goal of our pilot study was to Develop a tool which can analyse the potential of the villages to convert them into self-sustainable Smart Villages based on certain parameters. The *tool* is nothing but a mathematical formula, which gives the smartness potential of a particular village, as described below:

$$SPI_n = \sum_{i=1}^{25} w_i * p_i = w_1 * p_{1,n} + w_2 * p_{2,n} + \ldots\ldots + w_{25} * p_{25,n}$$

Where, SPI_n = Smartness Potential Index of village 'n'
w_i = Weight (or importance) of parameter 'i'
$p_{i,n}$ = Score of village 'n' in parameter 'i'

This goal boils down to the following objectives:

1. Identification of parameters to evaluate a village,
2. Identification of indicators of the chosen parameters,
3. Determination of w_i
4. Determination of $p_{i,n}$ for each village.

Part 1 and 2 were completed during literature review. For part 3 and 4 the following regime was followed:

i. Data Collection
ii. Data Formalization
iii. Data Interpretation

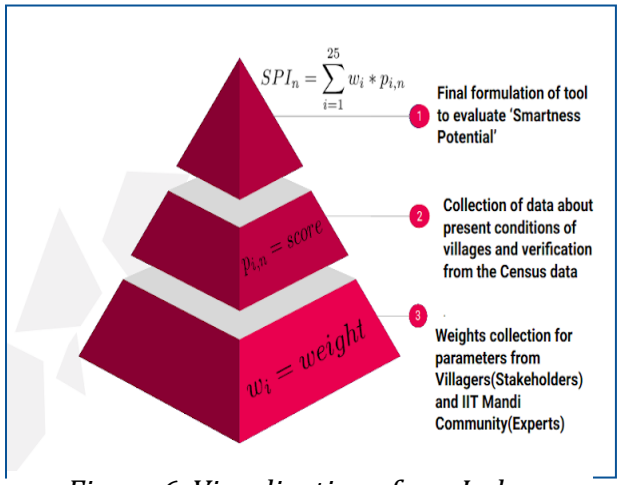


Figure 6. Visualization of our Index

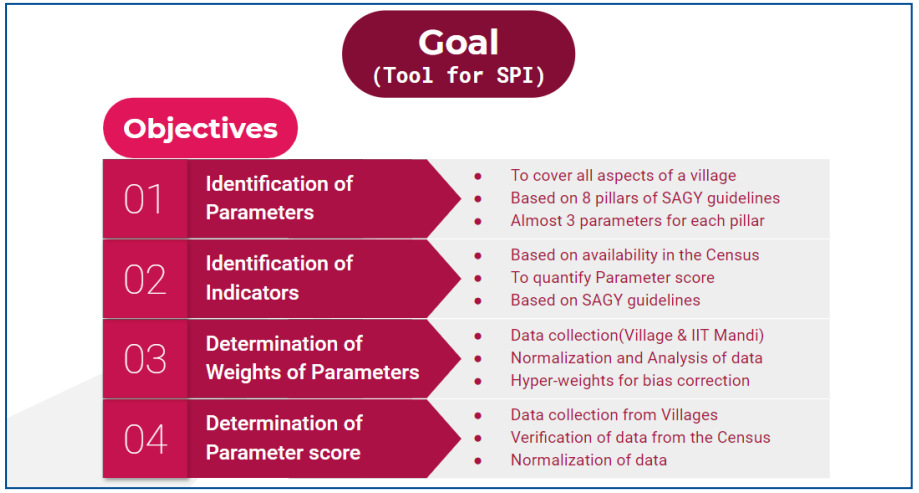


Figure 7. Our methodology in a nutshell

3.1 Data collection

3.1.1 Preparation of questionnaires and survey

We prepared three different questionnaires targeting different respondents groups:

Name	Type	Target Respondents	Primary Purpose
Q_R	Printed Forms	Village Representatives	Determination of $p_{i,n}$
Q_V	Printed Forms	Village Residents	Determination of w_i
Q_E	Google Forms	IIT Mandi community	Determination of w_i

Table 1. Different types of questionnaires prepared for different purposes

Questionnaire Q_R

- Contained questions which intended to gauge the performance of a village on the basis of certain indicators of the above described parameters.
- 1 or 2 team members interviewed the village representative (Pradhan, Up-Pradhan, Panchayat Secretary, Ward Panch, etc.) and asked them to fill these printed forms.
- We call this mode of data collection **'Mode-R'** (Representative).
- Also included certain subjective questions on those parameters, for whom no such quantifiable indicators could be recognised
- Had one separate page to enlist any parameter that we may have missed (according to point of view of respondent)

Questionnaire Q_v

- This questionnaire had 4 different parts, each of which served a unique purpose.
- We selected the villages from different CD Blocks of Mandi district (one village per block)
- Team members in groups of 1 or 2 interviewed the residents of the village, in order to collect their opinions
- We call this mode of data collection **'Mode-D'** (Door-to-Door).

Part 1: Villagers were asked to rate the 25 parameters on a scale of 1 to 5 (*Likert-scale)* on the basis of current situations of these parameters in their respective villages. . We call this the **'Mode-D2'**. The inclusion of this part helped us to remove two kinds of biases:

1. *The Problem Bias of Villagers* (First observed in the field trip to Ropa village with Dr Rinki Sarkar) – The villagers were giving high weight scores to those parameters, whose current situations in their villages were very bad, or, they were giving low weight scores to those parameters, whose current situations in their villages were quite good. While we wanted the weights of the parameters to be rated on the basis of a global context the local problem-oriented opinions of the villagers were still getting reflected in their weights.
2. *The Personal Bias of the Representative* –Representatives either might not know the exact answers to the questions asked, or they might give exaggerated figures in response to the questions, so as to present a better image of the village. By the inclusion of this part, we could compare the final scores of a village in a given parameter obtained on the basis of data provided by the representative with the final scores given by the dwellers of that particular village, and then we could adjust for the biases by including the reliability factors.

Part 2: Villagers were asked to provide weights (or importance) to the parameters on a scale of 1 to 5. We call this the **'Mode-D3'**.

Part 3: Villagers were asked to answer a total of five questions, for indicators which can neither be found in Census data nor can be estimated by representative. This mode is known as the **'Mode-D1'**.

Part 4: Contained certain qualitative questions on certain topics. The purpose of these questions was to ensure that we do not miss out on any important parameters.

c) Questionnaire Q_E

The aim of this questionnaire was also to have responses on the values of w_i. We called this mode of data collection **'Mode-E'** (Expert).

Two main differences from Q_R part 2 were:

1. The respondents were the members of the IIT Mandi community (faculty, staff, alumni and students).
2. This questionnaire was floated online (as a Google Form) so we did not need to interview each respondent face-to-face.

Figure 8. Photos with respondents during field trips.

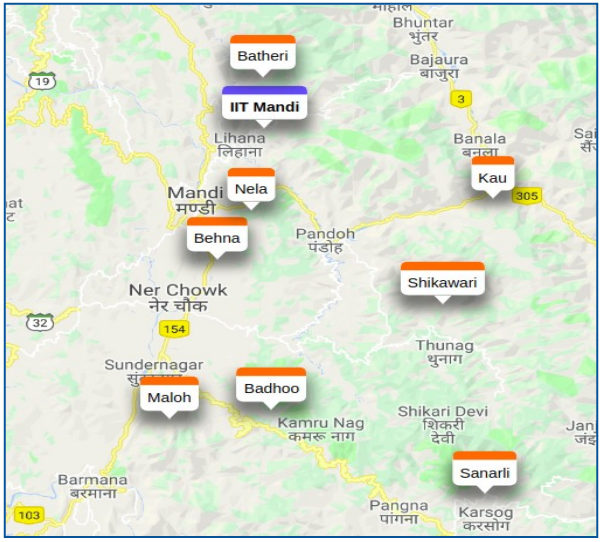


Figure 9. Map of all the locations surveyed

3.2 Data Formalization

The collected data was pre-processed so as to generate correct results.

3.2.1 On the values of weights

1. The weights and the current situations collected from the residents of the villages for a particular parameter were filled in a Google spreadsheet. Similarly, another spreadsheet containing the parameter-wise weights provided by the IIT Mandi community members was formed.

2. Next, the means and standard deviations of these weights and current situations were calculated. The weights and situations obtained for each parameter (for villagers and experts separately) were all decreased by 1, and these were termed as the *reduced weights* and the *reduced scores*. This was done so as to allow the percentage weights for any particular parameter to come in the range of [0%, 100%].

3.2.2 On the values of parameters

- The values of the indicators of the parameters (in the Questionnaire Q_R) were filled up as it is in one Google spreadsheet document.
- For each village, one column containing the Census information related to the indicators was created and filled.
- Many of these values were not numerical figures, rather subjective answers. Such subjective answers were quantified mathematically into some score on the basis of certain empirical rules.
- The indicators scores were calculated by normalizing the data obtained over all the 8 villages and then a final parameter score was generated by assigning certain hyper-weights to those indicators.

Response	Numerical Score (Out of 100)
Very Low	10
Low	30
Medium	60
High	10

Table 2. Protocol for quantification of some of the subjective responses

A reliability factor (per parameter per village) was also assigned using the following protocol:

1. If a considerable number of indicators for a given parameter could be verified by using the Census records, the reliability factor for that parameter for all the villages is assigned a value of '1'.

2. If the parameter values could not be obtained in the Census records, *and* if the current situation scores for a parameter of a vi

lage given by the village residents do not agree much with the scores obtained using the representative data for the same parameter of the same village, then the reliability factor is assigned a value of less than '1' (precisely depending on the difference of the two scores).

3.3 Data Interpretation/Analysis

The pre-processed data was then analyzed so as to draw appropriate conclusions.

3.3.1 Analysis of weights

We tried to fit some curves on the weights of the parameters (by the academic community as well as the villagers). This was done so as to take complete data distribution into account which could not have been possible, had we only taken the mean values. So, after fitting a curve (using a software called easy fit), we chose the 50% characteristic value of the curve as the weight of that particular parameter (for that particular category – either academic community, or the village residents). Finally the two different weights obtained from these two strata were given some hyper-weights (that is, the relative importance of the weights obtained from these strata) to obtain the final weight of that parameter. The formula used for generating the hyper-weights is given as:

$$w_f = \frac{w_{IIT}\sigma_v N_v + w_v \sigma_{IIT} N_{IIT}}{\sigma_v N_v + \sigma_{IIT} N_{IIT}}$$

- w_f = final weights
- w_{IIT}= weights by IIT community
- w_v = weights by villagers
- N_v = number of responses by villagers
- N_{IIT}=number of responses by IIT community
- σ_v and σ_{IIT}= standard deviation in responses by villagers and IIT respectively.

We also conducted sensitivity analysis by removing 1 village at a time from our records, and then re-calculating the final weights.

3.3.2 Analysis of the final standings

First of all, we multiplied each village's parameter score by its reliability factor, which was further multiplied by its percentage weight. Then, a summation of all these values (the weighted parameter scores) gave us the Smartness Potential Index (SPI) of a particular village. So, an overall ranking on the basis of SPI was done to arrange the villages according to their smartness potentials.

A parameter-wise ranking was also done so as to observe which village performed better with respect to a certain parameter.

Results and Discussion

4.1 Results

We analyzed the weight data collected from 36 villagers and 126

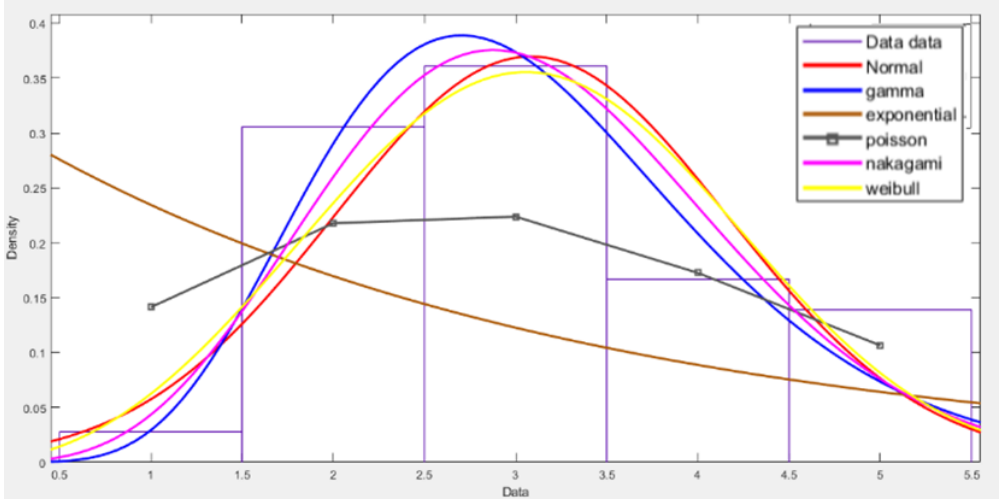


Figure 10 .The fit of different probability density function distributions in the frequency plot of parameters (Police Station).

IIT Mandi respondents separately by fitting suitable probability density functions(Normal, Gamma, Beta, and Exponential) to each of the 25 parameters and decided the most fitting distribution using Goodness of Fit tests(Kolmogorov Smirnov, Anderson Darling, and Chi-squared tests).

We observed that for the weight data of villagers, 16 out of 25 parameters were best defined using Normal distribution function. While for the rest of the 9 parameters, the Gamma and Gamma (3P) distributions were more suitable.

Similarly, for weights data by IIT Mandi community, 14 out of 25

parameters were properly defined using Normal distribution function. While for the rest of the 11 parameters, the Beta, Gamma, and Gamma (3P) distributions were more suitable.

Then, using the 50% characteristic value of the chosen distribution we calculated the individual percentage weights of parameters by villagers and IIT Mandi Community respectively.

After having calculated the percentage weights, we performed a sensitivity analysis on the data collected from the villages. This was done in order to verify that the bias of one village about its current situation does not reflect in their assigned weights.

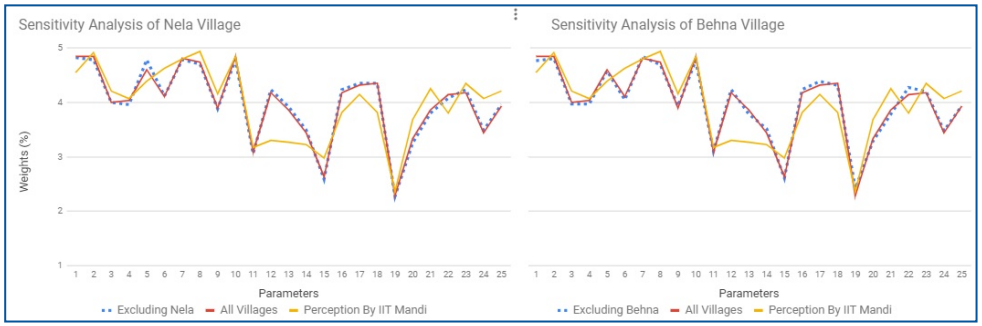


Figure 11. Sensitivity analysis (Y-axis denotes each of the 25 parameters, in order)

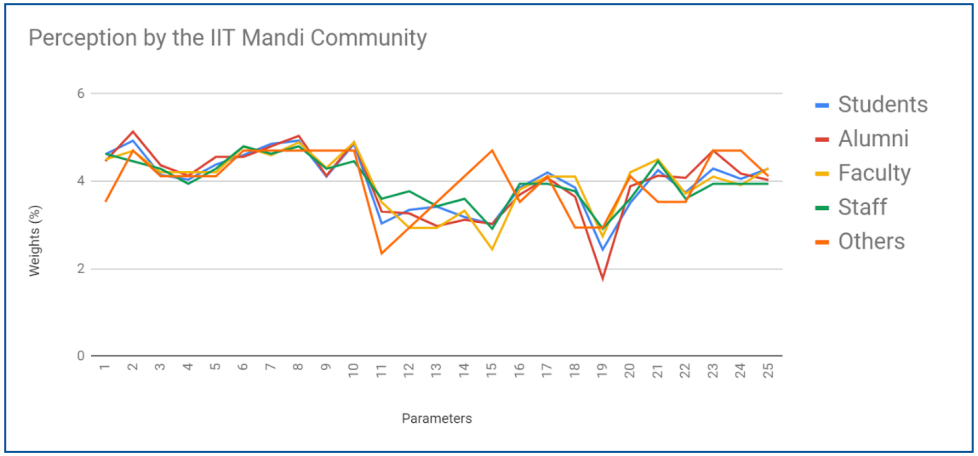


Figure 12. Perception comparison (Y-axis denotes each of the 25 parameters, in order)

Since all the plots superimpose each other to a large extent, hence we infer that no single village differs substantially in opinion (perception of weights) from other villages even after having considerable differences in their present conditions.

After performing the similar analysis on the data obtained from IIT Mandi community, it was also found that the opinion of all the categories (student, faculty, alumnus, and staff) except 'Others' coincided. This was due to the fewer number of respondents in this category.

After calculating the individual sets of weight percentages for the village and IIT Mandi community, we clubbed them both by assigning different hyper weights depending upon the standard deviation and the number of respondents for each and every parameter. Combining these individual weights and hyper weights, we evaluated the final weight percentage for all the 25 parameters.

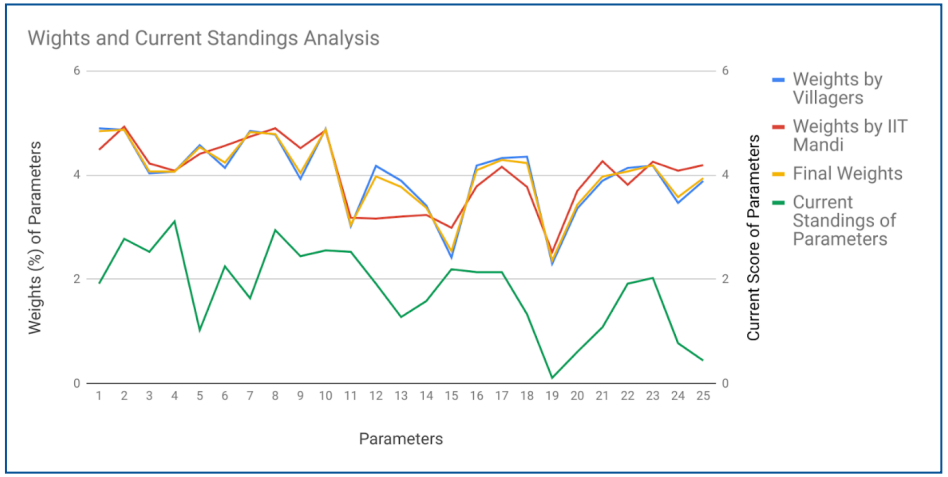


Figure 3. The plot of parameter's weights by Villagers, IIT Mandi, and the Final weights and the current standings of villages (Blue, Red, Yellow, and Green respectively). (Y-axis denotes each of the 25 parameters, in order)

Key observations

- Both groups agreed on 22 parameters.

We inferred that this difference in current standings and weights evaluated for Irrigation (parameter 5) was due to lack of proper irrigation facilities in the village and in the case of Drinking water was due to the abundance of suitable sources. Thus to remove these biases, we considered operating on 50% characteristic value of fitting

probability distribution function instead of simply taking the mean of all data.

- A difference of opinion was observed for parameters – Bank, ATM & Post Office (12), Street Lights (13), and Disaster Preparedness (25).
- To correct for these biases, hyper weights were assigned using standard deviations in data and by incorporating the number of respondents from Villages and IIT Mandi. Hence the final weight for these parameters were inclined more towards the curve which had a lesser standard deviation.

4.2 Discussion

4.2.1 Parameter Values

After checking the census data for each village (Mandi District Census Handbook, 2011), we found that the reported values (estimates of Panchayat representatives) were very close to the actual data (Considering the last Census was in 2011).

Key observations

- Values of scores of parameter Market were very low in Shikawari, Seraj (block) because of the absence of roads in the village.
- Values of Health facilities were good in Sanarli,Karsog (block) because of its proximity to block center Karsog.
- Similarly, the score of parameter Jobs was better in Badhoo, Gohar (block) than other villages due to the presence of an Apple cider industry.
- Conditions of Tourism, Disaster Preparedness, Natural resource management, and Small scale Industries were bad in all villages.
- A general trend observed was that the conditions of Electricity and Drinking Water Supply were comparatively good in all villages.

4.2.2 Rankings

We computed rankings according to 50% confidence intervals in weights.

Key observations

- Sanarli, Karsog block Stood first.
- Shikawari, Seraj block Stood last.
- Nela fared well exceptionally in proximity to a city (Mandi town) but lacked in proper roads resulting in rank 2.
- Maloh fared well exceptionally in Administration and Irrigation but lacked in Medical facilities resulting in rank 3.
- Badhoo fared well exceptionally in Jobs and Small scale Industries but lacked in Electricity supply and Roads resulting in rank 4.
- Kau, currently on Rank 5 has massive potential in Natural resource Management thus can jump higher with more focus towards it.
- These formulated rankings also match with our personal observations of the quality of these parameters in the respective villages.

4.2.3 Limitation

Due to lack of time, we were only able to cover 8 blocks (1 village in each block) out of a total of 11 blocks from the Mandi District. Therefore if we could have covered some more villages and increased the size of our dataset, then although we might not observe much difference in the rankings of the villages, but it could have helped us derive a more accurate formula for evaluating the Smartness Potential of the villages. Moreover, we were unable to capture data related to the existence of social discrimination through our methodology. Inclusion of that factor would further improve the accuracy of our formula.

Project Outcomes

5.1 Deliverables

By selecting suitable parameters and making use of all the data collected from the villagers and IIT Mandi respondents, we calculated the individual percentage weights of all 25 parameters.

Weights of Parameters

Parameter	Weight	Parameter	Weight	Parameter	Weight
Road	4.84%	Electricity	4.87%	Communication	4.07%
Clean Energy	4.06%	Irrigation	4.53%	Sanitation	4.24%
Health Facilities	4.82%	Education	4.79%	Transport	4.04%
Drinking Water	4.89%	Market	3.04%	Bank & ATMs	3.97%
Street Lights	3.77%	Community Facilites	3.37%	Police Stations	2.54%
Administration	4.09%	Agriculture	4.29%	Jobs	4.23%
Tourism	2.36%	Small Industries	3.43%	Waste Management	3.97%
Participation in Policy Making	4.07%	Government Policies	4.19%	Disaster Preparedness	3.58%
Natual Resource Management	3.94%				

These weights were then used on the current scores of the villages for respective parameters obtained through the Census and the villagers' responses to evaluate the Smartness Potential of the villages surveyed and eventually all the villages were ranked on the basis of their SPI's.

Rankings of Villages based on the Study

Ranking	Village Name	SPI : Smartness Potential Index (0-100)	Reliability of SPI (%)
1	Sanarli	60.06	96.27%
2	Nela	55.29	98.16%
3	Maloh	49.86	95.76%
4	Badhu	46.59	99.06%
5	Kau	45.13	96.67%
6	Batheri	43.16	98.73%
7	Behna	41.33	98.26%
8	Shikawari	35.28	99.09%

Along with a tool to quantify the Smartness Potential, we also calculated the reliability factor of the generated formula depending upon the availability of the data from the Census and its accordance with the current standings of villages obtained from the interviews of villagers. Hence, we provide not just a formula to evaluate a village's potential but also took into consideration the reliability of the results obtained.

5.2 Our suggestions

5.2.1 For new strategies

We believe our methodology can be used on a larger scale to get a more accurate value of the smartness potential of villages in at least the Mandi district. The standings of the sample villages presented in the previous subsection are in accordance with our observation. Some of the data of the indicators were not available in the current census report. So we suggest that those indicators can also be collected during the census, from which relevant parameters could be automatically extracted to get the rankings of the villages. This would make the task of ranking the villages a lot easier.

We also observed that the inhabitants of the lower ranked villages were less aware and proactive. So we can suggest that the representatives should take necessary measures to increase awareness and urge the public to actively take part in community activities.

5.2.2 For policy-making

The delivered tool also returns the amount contributed by each parameter towards a village's Smartness Potential. Thus it gives deeper insights of the area the villages that need to be worked upon. The tool also helps in deciding the village that need more focus that other villages depending upon their rankings on the Smartness Potential Index thereby allowing the administration to make more wise decisions while devising a policy for the uplifting of these villages.

5.2.3 Additional deliverable

Website - http://istp.000webhostapp.com/

It contains all the information pertaining to our project. Each person interviewed for the collection of data has been mapped to a separate profile that contains all his/her responses.

Thus it can be used to find out the information of any village or respondent of a certain block. It can also be used to view village rankings on the basis of individual parameters.

Conclusions

Our study has been successful in devising a formula which can provide the Smartness Potential Index (SPI) of a village (especially if the village lies in a hilly region like Himachal Pradesh). We can claim with quite certainty that the weights of the parameters obtained from this study should be very much in accordance with the actual values of these weights (that is, as they should be in a smart village). This is because, the weights have been calculated by taking the opinions from different strata, and by removing any sort of bias which was likely to affect the results.

A sample of 8 villages has also been ranked using this Index. The scores of the parameters for those villages have been very meticulously calculated using vigorous techniques and protocols. We believe that this process can be scaled up to cover almost all the villages of Himachal Pradesh, thus providing us with a list of villages which would not only provide us with the names of those villages which can be converted into 'smart villages' quite easily (without much investments), but would also highlight the parameters (or the areas) in which the relatively less potent smart villages lag behind their more advanced counterparts.

Acknowledgements

We have the following people and institutions to thank for the successful execution of our project:

Dr. Kaustav Sarkar for conceptualization of the project and his guidance throughout the span of the project as mentor.

Prof. S.C. Jain for his valuable insight towards the idea of a model village and finalization of methodology as mentor.

Dr. Devika Sethi for arranging our field trips and ensuring the smooth conduction of the course as the course coordinator.

Dr. Rinki Sarkar for sharing her invaluable research experience with us in the village studies workshop and guiding us through the intricacies of one-on-one interviews in our first field trip to Ropa village.

Mandi Saksharta Evum Jan Vikas Samiti – The members associated with this NGO were very crucial for the conduction of our surveys.

The General Secretary Mr. Bheem Singh and his assistant Mr. Sevak Thakur coordinated with representatives in prospective villages.

These members then introduced us to Gram Panchayat representatives, who then provided us with statistics about the village (Questionnaire Q_R)

Gram Panchayat representatives and residents from the villages – Nela, Behna, Maloh, Sanarli, Badhu, Shikawari, Kau and Batheri for their time, hospitality, valuable opinion and honesty while providing us with data about their respective villages.

125 Members of the IIT Mandi Community – Students, Alumni, Faculty and Staff for filling out the Google forms for our perspective analysis.

Figure 13. Team with the members of Mandi Saksharta Evum Jan Vikas Samiti (MSJVS). From Left to Right: Bheem Singh (Gen. Secretary), Naman Chaudhary, Gagandeep Tomar, Sevak Ram Thakur(Asst. to Gen. Secretary), Aditya Singh, Neelotpal Dutta, Lokesh Kumar.

Works Cited

Aayog, N. I. T. I. (2017). Changing Structure of Rural Economy of India Implications for Employment and Growth. *National Institution for Transforming India, Government of India*.

DESA, U. (2012). World Urbanization Prospects: The 2011 Revision. United Nations, Department of Economic and Social Affairs. *Population Division, New York*.

Sarkar, A. K., & Dash, M. (2011). Quantification of Accessibility and Prioritization of Villages for Local Level Planning. *Transport and Communications Bulletin for Asia and the Pacific*, *81*, 1-22

ESTIMATES OF MORTALITY INDICATORS. (2016). Retrieved from http://www.censusindia.gov.in/vital_statistics/SRS_Report_2016/8.Chap 4-Mortality Indicators-2016.pdf

Indira, C.G. & Anupama, V. (2016) The Smart villages: The Real Future Of Emerging India. *International Journal of Innovative Research in Advanced Engineering (IJIRAE) 63Issue 12, Volume 3*

Kidd, K. A., Paterson, M. J., Rennie, M. D., Podemski, C. L., Findlay, D. L., Blanchfield, P. J., & Liber, K. (2014). Direct and indirect responses of a freshwater food web to a potent synthetic oestrogen. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369* (1656), 20130578.

Kulkarni, Milind. (2015). Clean and Smart Village : Aspects and Alternatives, Dr. Milind Kulkarni (2015), International Journal of Research in Engineering, Science and Technologies – Civil Engineering, ISSN 2395-6453, Vol. 1, No. 3, June 2015, PP 19-23, www.ijrests.org. International Journal for Computational Methods in Engineering Science and Mechanics. Volume 1. 19-23.

Mandi District Census Handbook. (2011). Retrieved from http://censusindia.gov.in/2011census/dchb/0205_PART_A_DCHB_MANDI.pdf

Rural Indian. (n.d.). Retrieved from https://archive.india.gov.in/citizen/graminbharat/graminbharat.php

SAGY. (n.d.). Retrieved from http://saanjhi.gov.in/

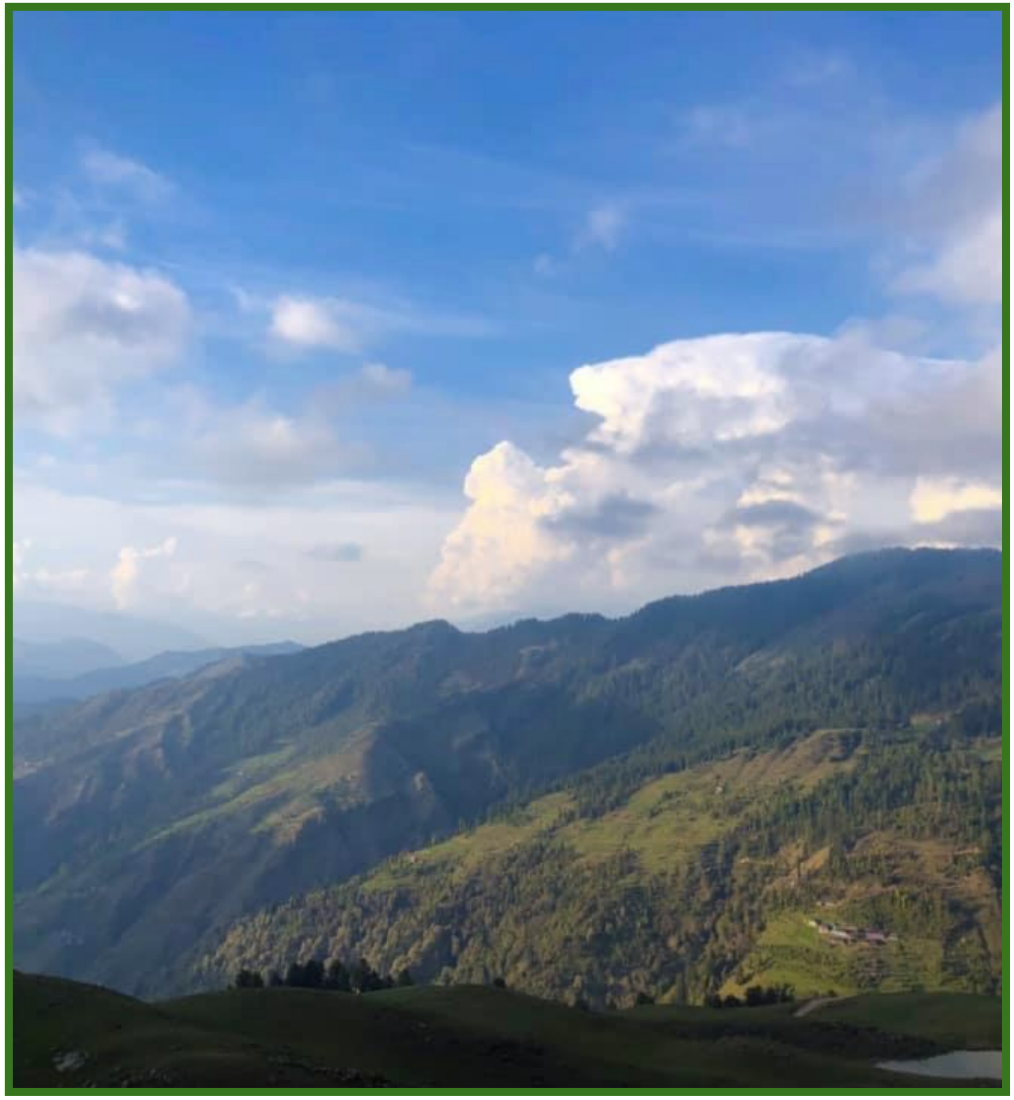
SMART CITIES. (n.d.). Retrieved from http://smartcities.gov.in/content/

Somwanshi, R., Shindepatil, U., Tule, D., Mankar, A., Ingle, N., Rajamanya, G. B. D. V., & Deshmukh, A. (2016). Study and development of village as a smart village. *Int. J. Sci. Eng. Res*, *7*(6), 395-408.

World Bank Data- India. (2017). Retrieved March 18, 2019, from https://data.worldbank.org/country/india

World Bank Rural population Data. (2017). Retrieved March 18, 2019, from https://data.worldbank.org/indicator/sp.rur.totl.zs

Feasibility of Improving sanitation along trekking routes of Himachal Pradesh



Abstract

This report explores the feasibility of improving waste management at trekking sites in Himachal Pradesh. Through stakeholder interviews, on-site data collection, and map generation we were able to compare different sites and develop benchmarks for ideal sanitation practices. Our data shows that the region's current sanitation systems are insufficient to support the increasing number of visitors. Based on our findings, we developed a set of recommendations for local communities which focus on improving waste education and minimizing unsustainable consumption.

Team Members

Thomas Hanlon
Sydney Packard
Joseph Patrick Dainis
Sean Tidd
Dhrubodeep Basumatary (B16017)
Stanzin Tsognis (B16116)
Anurag Sharma (TA)

Advisors

Dr. Dericks P. Shukla
Dr. Gbeton Somasse
Dr. Ingrid Shockey

Sanitation at trekking sites in Himachal Pradesh

Over the years, Himachal Pradesh has seen an increase in adventure tourism. According to the India Brand Equity Foundation, "domestic tourist inflows in [Himachal Pradesh] increased from 11.04 million in 2009 to 17.12 million in 2015" (India Brand Equity Foundation, slide 49). However, the waste management infrastructure has not adapted properly to accommodate the influx of tourists, leading to littering and open defecation along trekking routes. This problem was highlighted by the ecotourism group, Waste Warriors, who recently collected more than 60 full bags of non-degradable litter at Triund, a popular trekking route in Himachal Pradesh, in the span of only two days (Dasgupta, 2018).

Figure 1. Litter along a trekking route in Manali, March 23, 2019 (photo credit: Hanlon, 2019)

The large presence of waste along the trails, as seen in Figure 1, detracts from the visitor experience and poses serious environmental concerns. For example, both domestic animals and wildlife can be seen consuming garbage along the trails, causing irreparable damage to their internal organs. There is also the risk of food contamination by chemicals found in plastic waste. Along with harm to ecosystems, open waste can spread infectious diseases, such as cholera, which endangers the lives of many trekkers (CDC, 2019).

The goal of this project was to construct a feasibility study for improving sanitation along trekking routes in Himachal Pradesh and to contribute to the United Nations Sustainable Development Goals 6 and 12. These directives call for the availability of proper sanitation management to all and sustainable consumption to minimize the global material footprint. (United Nations Development Programme, 2019, p. 1). With this in mind, we focused on three objectives: 1. we described and evaluated current waste management systems at trekking sites; 2. we documented the perceptions of local residents, tourists and other relevant stakeholders; and 3. we proposed and assessed a plan to improve waste management systems at trekking sites. We used the results from our site visits and interviews to present a set of recommendations for the trekking community.

The consequences of waste on trekking sites in Himachal Pradesh

This chapter summarizes the background information necessary to understand the multi-dimensional aspects of trekking sanitation management in Himachal Pradesh. It is important to understand the intrinsic features of Himachal Pradesh's trekking routes, such as their historical, spiritual and environmental significance as well as their geographical beauty. This section also explains in-depth the recent increases in tourism to the state and analyzes the impact of tourism on trekking sanitation management. Finally, we present a discussion of the stakeholders related to our project, and their perceptions and mindsets toward trekking site sanitation.

Selected trekking sites in Himachal Pradesh

The history and culture of Himachal Pradesh is shaped by the region's geography. The remote areas of the region have heightened feelings of isolation, closeness to nature and spiritualism. The landscape alone explains why folklore refers to Himachal Pradesh as the "abode of gods" (Maynard, 2001). In fact, many of the trekking routes that attract both domestic and international tourists formerly served as pilgrimage sites to local temples (Joshi, 2013). Three popular treks are described below that represent how many traditional pilgrimage routes are now re-branded to tourists for adventure trekking. These samples show the range of length, difficulty, and fragility of eco-system commonly found in

similar sites in Himachal Pradesh.

Prashar Lake is a short trek that has become widely popular for its picturesque features - namely the lakeside Parashar Temple. A large number of religious visitors come during the months of August and September for an annual pilgrimage (Attri et al., 2012). While the spiritual lore surrounding the site is significant, Prashar Lake attracts many secular visitors as well. With a guide, several trails can be used to reach the 2,630m summit within 4 hours. Visitors can rent the Forest Reserve Guest House or stay in a tent near the lake (Sharma et al., 2017). Also, restroom facilities have recently been installed at Prashar Lake in order to accommodate the increasing number of visitors (Sharma et al., 2017). The lake is surrounded by an ecosystem with diverse vegetation and wildlife. The local Gujjar community depends on this environment for grazing their animals and collecting medicinal plants (P. Attri et. al., 2012).

A few hours away from Prashar, a more heavily advertised and visited site, Triund, is also known for its spiritual history and ease-of-access. Triund is located in Mcleodganj, home of the Tibetan Government in exile and His Holiness the Dalai Lama (Wovoyage, 2018). Located near this compelling landmark, Triund is a "small and easy trek" with a summit elevation of 2,850m which can be reached in approximately three hours (Kurra, 2018). Many of these trekkers camp in tents on the hilltop overnight, even though the trek can be completed in a day. Along the trek, chai shops sell tourist-targeted commodities like pre-packaged snacks, drinks in plastic water bottles and toilet paper (Drifter Planet, 2015). According to multiple travel bloggers, there are no toilets on the trek, save a few "makeshift tent toilets" (Kurra, 2018; Reddy, 2017). Triund is unique in that it is surrounded by a vast wet temperate forest, which houses a variety of animal species (Himachal Pradesh Planning, 2009). A majority of this forest is demarcated, meaning it has a set of boundaries by which it can be protected by the Himachal Pradesh Forest Department. The surrounding area of the Triund Trek has the Dal Lake, which provides an interesting addition to the ecosystem in terms of its fauna and animal species.

To encompass a broader range of sites, our study also evaluated a third kind of "trekking" experience targeted for day use and any level of experience. The path to Jogini Waterfall, in fact, is more of a walk than a trek. This walk is located in Vashisht, a small community outside of Manali. Vashisht temple is well-known for its natural hot spring, which is said to have healing powers. From there, a trail through the abutting neighborhood begins to transition to a wooded area, ultimately leading to a breathtaking waterfall. Unlike the previous treks, the route begins near a popular shopping area. Here, hikers have access to snacks and water bottles both before and during the trek. The valley surrounding Vashisht is "rich in horticulture" and "naturally pure" river water. In Manali, the environment is being used as a commercial resource, as exemplified by the mineral water bottling plants and the development of wholesale fruit orchards. Conserved areas are the "thick Deodar forests around the main town of Manali," which host a wide variety of indigenous and exotic plant species (Department of Town and Country Planning, 2015).

These sites and others have seen a steady increase in visitors over the years. Originally these sites attracted individuals for religious reasons. Through different forms of promotion and popularity, these sites have a new major group of visitors: adventure tourists. These sites were originally designed to maintain the waste of a small number of people. With the increase in the number of visitors, the fragile mountain ecosystems at these sites are becoming stressed.

The challenges of trekking waste removal in Himachal Pradesh

Scattered litter along Himachal Pradesh's trails has become a problem partly due to increased tourism, but can also be attributed to the explosion of single-use packaging and snack wrappers from portable foods. These kinds of products are a departure from traditional containers originally carried by pilgrims or shepherd communities. The massive volume of waste can be noted best by some of the ecotourism groups that work to clean it up. The leader of one clean hiking initiative group, the Green Trails Mission, says that consequently, "the villages and the mountains lack a proper waste management system, which has caused open garbage dumping practices within and outside the villages, by both inhabitants and visitors" (Engineer, 2018). Litter continues to pile up each and every day because there is an insufficient waste removal system in the area.

In addition, a consequence of increased tourism on trekking routes in Himachal Pradesh with inadequate bathroom facilities is the presence of human waste along the trails. While there is little information about the extent of human waste accumulation along treks, the assumption is that trekkers will defecate in the open due to the scarcity of bathroom facilities. Trekking routes in India are said to have very low toilet to tourist ratios, meaning there are not enough bathroom facilities for the amount of tourist traffic in the areas. (Mountaineerz Leisure and Adventure, 2019). With the large influx of visitors to trekking trails in Himachal Pradesh and the lack of improvements to waste infrastructure, human waste needs to be addressed to maximize tourist experiences and minimize potential health risks.

Cultural implications of waste management

Historically, the caste system has played a key role in waste management in India, as an entire caste, the Dalit, is seen as responsible for handling all waste (Royte, 2017). In addition, many in the upper classes of Indian society hold a mentality that they have no responsibility for the waste they generate; “anybody who is of a higher caste would find it unthinkable [to] do it themselves” (“An inconvenient truth”, 2015, p. 1). This highlights the complexity of delineating cultural boundaries regarding changing waste perceptions and roles. That is not to say that the communities have no motivation for a cleaner India; in fact, many residents and tourists are passionate about the cleanliness of their surrounding environment (Gutin, 2017).

Some Indian activists place precedence on encouraging pride in wanting to help clean the country (Fernandes, 2017). For example, some community members in Karnataka, a state in southwestern India, have set out to convince other villagers to change their mindset concerning waste ("Begging to whistling”, 2016). However, the challenges presented may be extremely difficult to overcome. Much like attitudes and behavior around recycling in the United States, actions change slowly and with social pressure from early adopters. It is a difficult task for a set of people to change a cultural practice that they used for so long.

In addition to the caste system playing a role in waste management, the everyday habits of Indian citizens also have an impact. India has emerged as one of the largest global consumers of pre-packaged snack, ranking as the fourth largest snack market of any country in the world (“Snack Food”, n.d.). With such a heavy consumption of pre-packaged goods, the disposal of the packaging becomes a waste management concern, especially on trekking routes with an abundance of small snack shops.

To compound this issue, the behavioral practices of many local members of the Indian community makes waste management a challenge. In an article by Evegny Pakhomov of BRICS Business Magazine, waste management traditions in India are described. The article mentions that traditionally waste was thrown outside and left to decompose under the heat of sun. However, in the age of modern packaging, this method of waste disposal is no longer effective. Unfortunately, much of this conventional practice has remained (Pakhomov, n.d.). The increased presence of pre-packaged snacks combined with the traditional waste practices further complicates the waste management challenges on trekking routes.

In sum, there were several important points that guided our work. First, each different trekking site had a unique waste management situation due to the volume of tourists and the current waste infrastructure in that particular area. Another key point was the importance of acknowledging the cultural perceptions of the different stakeholders that contribute to the waste. In order to be successful, the new waste management platform needs to account for these perceptions and work alongside them, rather than to look negatively at them.

Approach

The goal of this project was to conduct a feasibility study on improving waste management at popular trekking sites in Himachal Pradesh. To achieve this goal, we focused on the following objectives, summarized in Figure 2:

1. Evaluate current waste management systems at trekking sites.
2. Understand perceptions from local residents, tourists, non-government organizations and trekking outfitters.
3. Propose and assess a plan to improve waste management systems at trekking sites.

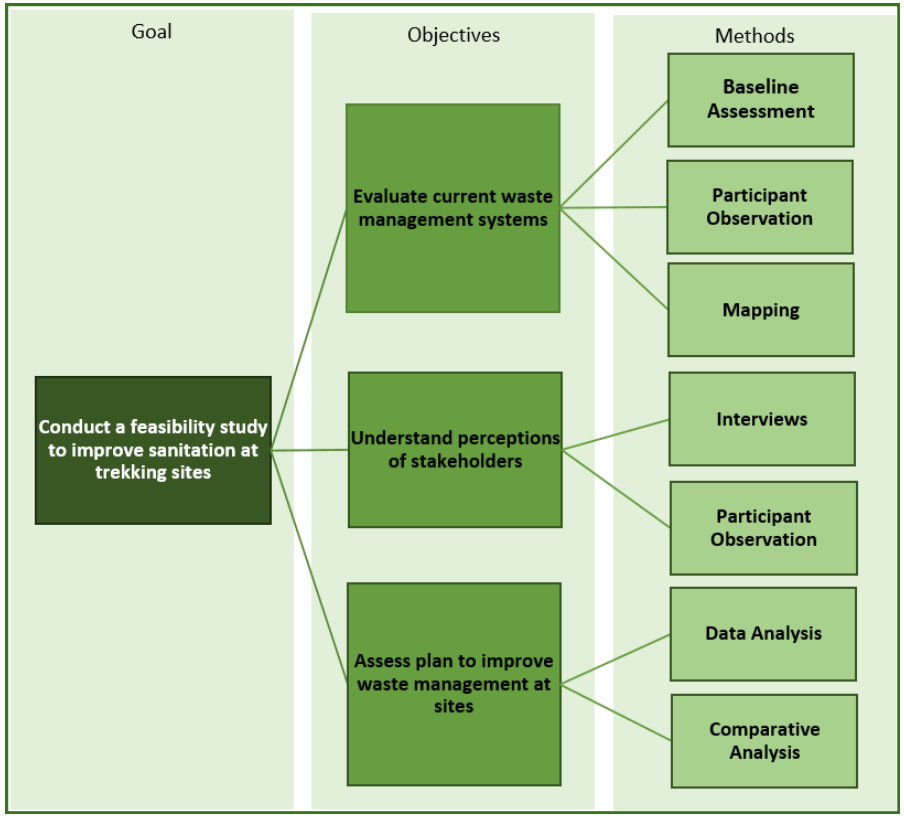


Figure 2. Flowchart of project goal, objectives and associated methods

Evaluate current waste management systems

We first completed baseline assessments, which included trekking on routes in order to observe the current waste management system. Combined with other strategies, "a baseline assessment is a crucial element in formative campaign research and planning, and in any monitoring and evaluation framework" ("What is a baseline assessment", n.d., p. 1).

To better experience waste management challenges, we worked with Healing Himalayas, a volunteer waste cleanup organization, during the Prashar Rishi Lake Cleaning Campaign. We gained knowledge on the amount of different types of waste and assessed the process of waste cleanup. We also evaluated the amount of trash collected versus the amount of available manpower needed.

We also created two different maps for each site. One form of mapping we used for data collection was percent distribution maps. To make these maps, we divided the trail into equidistant segments and counted the first 100 pieces of trash in each section. We segregated the trash into six waste-disposal categories: food wrappers, plastic recyclables, glass bottles, metal cans, paper/cardboard recyclables, and miscellaneous non-recyclable waste. We use this map to determine the waste composition along the trails at each site. In addition, we created heat maps to determine relationships between shops, trash cans and anti-littering signs on waste distribution. To create these maps, we chose a section of the trail that included a variety of waste infrastructure. Then, we put a geotagged pin after every ten pieces of waste observed on the trail. Finally, we divided the section into 50-meter segments and used the geotagged pins to determine the amount of waste on that section. Using this information, the 50-meter sections were color-coded based on the amount of waste within each segment. This information helped us understand waste distribution along the trail.

Understand perceptions from stakeholders

To understand perceptions regarding waste conditions and sanitation management, we interacted with relevant stakeholders: local residents, tourists, non-government organizations and trekking outfitters.

We conducted semi-standardized interviews with the flexibility for the interviewee to direct the conversation towards what they found relevant (Berg, 2007, p. 94). We interviewed from a sample of convenience of an average of 10 individuals per site. The interview questions included a mix of yes/no and open-ended questions. These questions were used to understand the waste management opinions and proposed solutions from the interviewees.

At the organizational level, we also conducted interviews with local, privately owned outfitters. Interviews with the outfitters helped us gather information about their personal experiences regarding waste, as well as waste and tourism trends on the trekking routes they supply. Finally, a participant observation in a clean-up campaign at Prashar Lake helped us understand the perceptions of the founder and volunteers of the green initiate NGO, Healing Himalayas.

Propose and assess a plan to improve waste management systems

To create a final recommendation for improving sanitation at trekking sites in Himachal Pradesh, we wanted to generate multiple options. This was done by interpreting relationships and data from the previous two objectives. We linked the quantitative data from the first objective with the qualitative data from the second objective to synthesize common themes. By comparing the variety of data from each site, we were able to better understand the similarities and differences in waste accumulation along each route. Through this, we developed plans that encompassed the broad range of needs for trekking sites in Himachal Pradesh.

Results and discussion

This chapter presents and evaluates the data and information collected from each objective. After synthesizing the findings across the three objectives, we evaluate the implications and shortcomings of the data in a discussion section.

Evaluation of current waste management systems

After visiting Jogini Waterfalls, Prashar Lake and Triund, we assessed the current waste conditions and available infrastructure. The key findings are shown below in Table 1.

Table 1: Summary of Sites Visited

Site	Period of visit	Baseline Assessments
Jogini Waterfalls	March 23, 2019	- Litter concentrated near shopping district - Several anti-littering signs - No visible restroom facilities - One unused waste bin
Prashar lake	March 30, 2019	- 8+ waste and recycling bins - 5 metal waste drums containing burnt waste - Two in-ground waste dumping sites - Multiple seasonal restrooms facilities - Three snack shops at summit
Triund	April 6, 2019	- Multiple shops along trail with waste bins - Trail leading to Gallu Devi Temple more littered than temple area and trail leading to summit - Waste Warriors waste disposal/sorting "center" at Gallu Devi Temple area (see Figure 3). - One restroom at Magic View Cafe with Rs 30 charge

Figure 3. Waste Warrior's waste sorting area, April 6, 2019. (photo credit: Hanlon, 2019).

During the site visits, we constructed heat maps to evaluate patterns of waste distribution, as shown in Figure 4. One main finding from these maps is that trash cans are an effective form of waste management. Within 100 meters of each trash can, the heat maps show below-average waste accumulation. At Triund and Vashisht, there were different anti-littering signs. Some of these signs had confrontational messages such

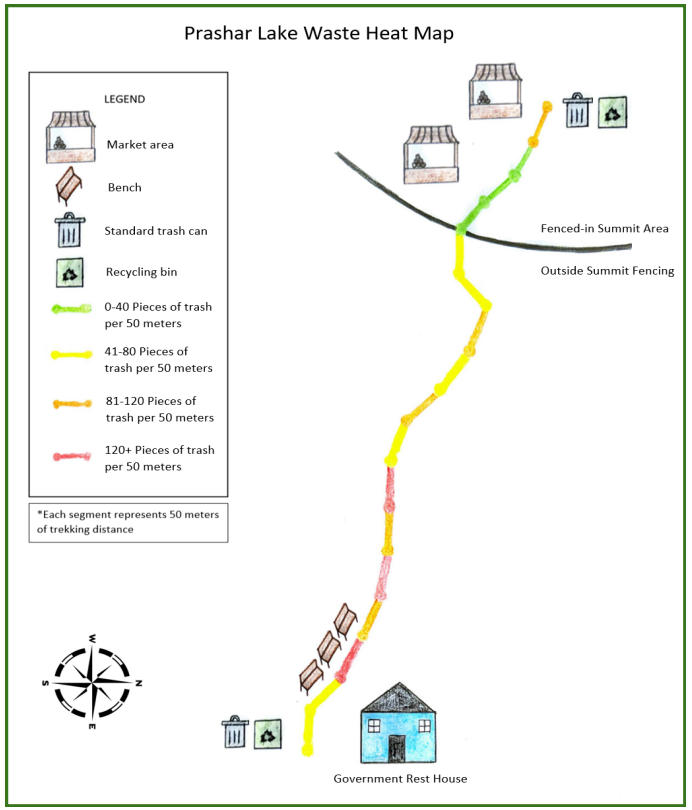


Figure 4. Heat map for Prashar Lake

as “In the forests and mountains, animals don’t leave trash. Humans do. Behave like animals”. After these confrontational signs, however, the waste accumulation was comparable to the average. Finally, about 150 meters beyond a market area, there seems to be an increase in waste present along the trail.

In addition to the heat map, we also created a percent distribution map for each site. Figure 5 shows the distribution of waste at each site. The majority of trash at each site was non-recyclable food wrappers followed by plastics. While the waste composition was very similar between sites, one notable difference was between the waste inside and outside the Prashar Lake summit fencing. Around 80% of the waste inside the fence was food wrappers, while outside the fence had food wrappers at 61%. In addition, there was a significant increase in plastic and glass recyclables outside the fencing.

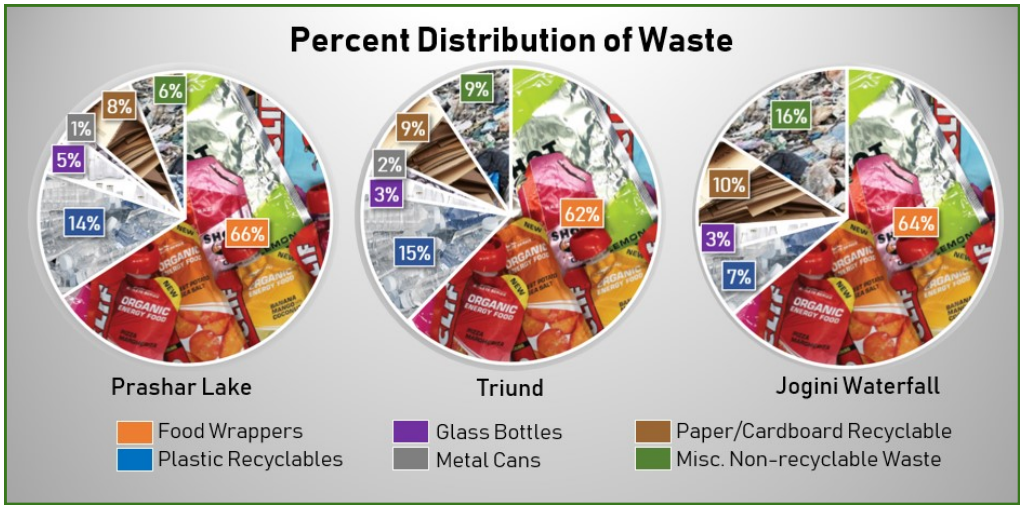


Figure 5. Distribution of waste at Prashar Lake, Triund and Jogini Waterfall

Perceptions of local residents, tourists, NGOs and local trekking outfitters

All three trekking sites have seen an increase in tourism over the recent years. For example, Kishna, a local outfitter for Prashar Lake treks, said that “Prashar Lake never used to be a popular tourist location”, but now his business hosts 200-300 trekkers per week, varying seasonally” (Kishna, personal communication translated from Hindi, March 16, 2019). At Triund, a vendor described how the installation of a large cricket field in Dharamshala played a massive role in driving tourists to the area (Personal communication, April 6, 2019).

Based on interviews with trekking outfitters, there is a common opinion regarding the habits of different types of visitors. Overall, the more “serious” trekkers who travel with guides are less likely to litter than casual tourists. According to an interview with Hippie in Hills, an adventure tourism outfitter, 98 percent of their clients who go on multi-day high altitude treks do not litter because they “know the importance of the place” (A. Kshatriya, personal communication, March 24, 2019). This opinion is supported by Kishna who noted that trekkers who visit on their own, rather than with a tour group, contribute the most towards waste generation - particularly those who visit for religious reasons (Kishna, personal communication, March 16, 2019). In addition, a common finding across many different interviews is that the local and domestic tourists contribute more waste along the routes than international tourists. In fact, a local resident at Vashisht noted that “the increase in tourism is not a threat, but rather the mindset of the Indians who disregard nature” (Personal communication, March 23, 2019).

From the interviews at the sites, we learned about the behavioral practices of a variety of stakeholder groups. At Prashar Lake, locals mentioned that they make a trip around the fenced-in summit area once a month to collect waste. However, they do not pay much attention to the waste outside of this area. We also observed that at natural resting locations, there was often an accumulation of alcohol bottles. This can be noted by an interview with a vendor at Vashisht, who said that kids often come to the area to party.

Our findings indicate that there are a few primary groups that offer sanitation aid to the sites. While the government does have some involvement in the sanitation at these locations, many people believe that more aid is needed. Respondents have indicated that the government only comes once or twice a year for cleanings at best and often take a while to fulfill requests by the local residents. An individual at Prashar Lake commented that they “demanded for a big dustbin 3 years back to local panchayat (local government at rural level) where the trash could

be dumped and later carried by trash carrier trucks, instead of burning and dumping it in a pit. This issue has still not been resolved by the government. So [they] ultimately need to resort to burning of trash."(D. Kumar, personal communication, March 30, 2019). This can be directly compared to Triund, where a vendor claimed that burning trash is uncommon due to the presence of a municipal dustbin (Personal communication, April 6, 2019). However, despite his claims of no trash burning, we saw another shop owner at Triund using chip bags as kindling for a bonfire. Although many individuals understand the negative connotation behind burning trash, it is still common practice in areas with insufficient waste management systems and few alternative options.

At the local level, trekking outfitters have shown to offer more help to keep trails clean. Since the cleanliness of the trail impacts their business opportunities, outfitters like Kishna and Hippie in Hills both say they pick up and properly dispose of waste found along their routes while trekking. Finally, non-government organizations help clean up the trekking routes through community involvement. NGOs often lead community waste removal treks, like the Prashar Rishi Lake cleanup campaign led by Healing Himalayas (P. Sangwan, personal communication, April 13, 2019). In comparison, the Waste Warriors at Triund will remove a vendor's trash every 7-10 days for a monthly 100 rupee fee. Although there appears to be a common thought across many of the stakeholders that non-government groups are inconsistent in their cleaning, the Waste Warriors organization at Triund has proven that consistent cleanup is possible and beneficial.

A plan to improve waste management systems

While evaluating the data from the previous two objectives, we identified key ideas to improve waste management systems and organized them by theme: education, collaboration, positive reinforcement, and improving facilities.

- Education is one of the most important themes that could be implemented. By educating the youth about proper waste management practices, this will lead to solving the cause of the problem rather than the effect. For example, NGO members could go to schools in Himachal Pradesh to teach children the importance of proper sanitation, and the effects of litter on the environment. This practice would then be passed down from family to family through the years until it becomes a routine in the public mind.
- Collaboration would put less stress on the locals who rely on the trail. Many trekking sites do not receive any help for the maintenance of trash, which is why collaboration is needed. They could build mutually-beneficial relationships with NGOs or government agencies, such as the forest department. While using waste facilities properly is important, it defeats the purpose if these facilities cannot be managed in a responsible manner.
- Positive reinforcement is a useful approach when interacting with visitors at a trekking site. An incentive to carry in and carry out waste would help to promote good habits and keep the area clean. The incentives can be rewards that vary from free tea to entrance fee waiver.
- Updating and adapting facilities at a trekking site could also be useful. This includes adding more educational anti-litter signs, providing more trash bins, and installing more toilets. These facilities do not have to be the same as before. For instance, composting toilets can be used to promote bathroom usage during the colder seasons.
- Minimizing potential waste attempts to deal with the root issues of waste generation at trekking sites with effects similar to those of education. This specifically calls attention to the different snacks and refreshments that vendors sell which accounts for approximately 80% of trekking waste, as noted in Figure 5.

Discussion

Through our results, we see that the ultimate problem comes down to four categories: education, the practices of the visitors, the practices of the vendors, and lack of outside involvement. Our maps tell an interesting story of how trash is littered along these trails. Much of the data indicates a common behavior from the visitors; they will purchase their snacks, eat them immediately, and then dump the trash as they continue their trek in the opposite direction of the vendor, especially if there is not an available trash bin. In addition, the data from the percent distribution maps indicate that the lack of trash bins is not the only problem—but

rather the types of snacks available and the packaging that they are sold in. This shows the need for an innovative solution that can circumvent the snack wrapper and plastic water bottle waste while still providing trekkers with an option for food and water.

We also found that education efforts play a key role in the waste management issues seen. The success of educative solutions would depend on having a reliable set of organizations and participants willing to motivate others to do their part in cleaning these trekking routes. Our findings show that many negative waste management habits are a result of a lack of proper waste education. Our heat maps showed that the confrontational and witty signs seen at Vashisht and Triund did not have a significant impact on the waste distribution. However, if the youth of Himachal Pradesh are taught proper waste habits from a young age, then the anti-littering signs would likely be more effective.

Our data also highlights a lack of government involvement as a key issue. While we were unable to interview any government agencies due to their busy election schedules, many stakeholders faced issues which could be directly attributed to the level of government involvement. The locals' dissatisfaction with government involvement emphasized the need for a working partnership between local communities and other outside agencies.

Despite the conclusions we were able to draw from the data collected, our study was limited by a few factors, such as access to the sites and interviewee bias. Weather-related concerns such as snow and rain made it difficult to visit many sites. In terms of data collection, our maps were limited in that the entire trail could not be mapped due to weather and time constraints. Also, bias could have played a role in some of the information we received, as some stakeholders, such as trekking outfitters, could have framed their actions in a more positive light. Reliability of personal accounts was called into question when we heard contradicting information from interviewees.

Project outcome

After examining our findings, we came to the conclusion that in order to improve waste management at trekking sites, there needs to be a balance between short term and long term solutions. Some of the solutions involve infrastructure changes, while other can be imbedded in the trekking culture and promoted by vendors and outfitters (see Figure 6).

Figure 6. Short-term recommendation schematic

In terms of infrastructure solutions, many of our recommendations are site-specific. The most obvious recommendation is to provide more waste bins and restrooms along the trails at distances that are necessary and manageable - but also not distracting from the environment. The waste bins and restrooms could be provided by NGOs, or be built by the community. At Triund, the current placement and number of waste bins is sufficient, however access to restrooms can be greatly improved. Dry toilets made of brick could be installed at trekking sites. Brick is widely available in Himachal Pradesh and these toilets can be used year-round. The waste from these toilets could then be composted.

For the sites with fewer resources than Triund, amended signage could be installed that indicates the distances between waste management facilities. Similarly, existing signs could provide instructions or even materials needed for packing in and out waste - both litter and human-related. In all cases, vendors, outfitters and guides could verbally inform trekkers about the importance of carrying out waste and try to enforce

this practice through education and incentives. Examples of such incentives for trekkers who carry out their bag of waste could be a complimentary cup of tea. Another form of incentive could be to charge trekkers a small entrance fee (Rs 10 to 20), which would act as a deposit that trekkers would get back provided they carry out waste.

A more complex fee-oriented incentive is to encourage a partnership between NGOs and vendors that rely on the trekking sites for their business. Similar to Waste Warriors at Triund, sites like Prashar Lake and Jogini Waterfall could adopt a relationship with other NGOs or even governmental agencies. In this scenario, the vendors could pool a small weekly or monthly fee in return for waste removal services from these organizations. Eventually, the organizations will be able to team up with the communities in an effort to keep the trails clean in the long-term.

Another unique opportunity for a community collaboration is between NGOs and the Bharat Scouts and Guides organization. Similar to the Boy Scouts of America, this organization looks to introduce children to different aspects of nature through activities like camping and trekking. One main focus of the group is to "understand the need of conserving nature/environment and public properties" (The Bharat Scouts and Guides, 2018). By promoting interaction between NGOs and scouts, the youth could gain a passion of keeping trails clean. These scouts could be given the foundation to become the environmental activists or NGO founders of the future generations.

To mitigate the littering problem at the root cause, snack vendors could look into providing traditional snacks in place of pre-packaged snacks. Instead of selling potato chips, the vendors could sell fruit, vegetables or locally-made food like roti, samosas, pakora or siddu. These snacks have less of an environmental footprint, but are still easy to eat and transport. The trekkers could carry these snacks along the trek in newspaper bags provided by the vendors. Unlike plastic food wrappers, the newspaper bags are both biodegradable and safely burnable.

Likewise, the vendors could sell filtered water rather than bottled water. There are several small, non-electric water filtering tanks that could be easily used at hard-to-reach shops. The vendors would only need to find a nearby water source, then they could fill the tank and charge trekkers a small amount to fill their reusable water bottles. If the trekkers do not bring reusable water bottles, the vendors could have metal cups available for use or sell relatively cheap metal bottles.

Vendors who sell fruit, vegetables and other biodegradable snacks could manage this waste by composting. Additionally, waste from the aforementioned dry toilets could be added to the compost. Although composting is a hard-to-sell and long-term practice for many vendors, it has an added benefit for them: they could utilize the compost to grow a small garden. Vendors could sell the fruits and vegetables from this garden, or use them for their own consumption. In an ideal scenario, the vendor's business becomes a self-sustaining cycle: the food the vendor sells turns into composting material, which is ultimately used to generate better soil to grow more fruits and vegetables.

Conclusion

Our research and data show that the current sanitation systems at trekking sites in Himachal Pradesh are insufficient to support the increasing number of visitors. This leads to problems such as health issues, harm to aesthetic appeal, and degradation of the ecosystem. We documented different patterns and relationships between trash and waste facilities along our three main sites using maps. We gained understanding of stakeholder opinions and experiences through interviews. Lastly, we actively experienced Himachal's trekking waste management by volunteering with an NGO for a clean-up campaign. We then analyzed all of this information, leading to our final recommendation. Through this plan, these mountainous trekking sites in Himachal Pradesh could be both self-sustaining and eco-friendly.

Acknowledgements

Our team would like to thank the following individuals for their assistance in helping us present a successful project:

- Dr. Dericks P. Shukla, Dr. Ingrid Shockey, and Dr. Gbeton Somasse for their significant contributions and guidance on the project and report.
- Dr. Rinki Sarkar for organizing our interview with the outfitters at Suda Village.

•Our teaching assistant - Anurag Sharma.
•Hippie in Hills and Pradeep Sangwan from Healing Himalayas for their time and insights about trekking waste management.
•All survey and interview respondents for sharing their experiences and opinions related to sanitation along the trekking routes.

The reports in this book represent the work of WPI and IIT Mandi undergraduate students. For more information and to see the complete report, you may search using keywords or author at https://digitalcommons.wpi.edu/iqp/ or http://www.iitmandi.ac.in/istp/.

Works Cited

An Inconvenient Truth: India's Trouble with Toilets. (2015, August 22). *The Independent.*Retrieved January 31, 2019, from http://go.galegroup.com/ps/i.do?id=GALE7CA426224434&v=2.1&u=mlin_c_worpoly&it=r&p=ITOF&sw=w

Attri, P. K., & Santvan, V. K. (2012). Assessment of Socio-cultural and Ecological Consideration in Conserving Wetlands - A Case Study of Prashar Lake in Mandi District, Himachal Pradesh. International Journal of Plant, Animal and Environmental Sciences, 2(1), 131-137. Retrieved February 12, 2019, from http://www.ijpaes.com/admin/php/uploads/137_pdf.pdf

Begging to whistling, rural India doing everything to end open defecation. (2016, July 6). *Downto Earth. Retrieved January 31, 2019, from* http://go.galegroup.com/ps/i.do&id=GALE|A458093798&v=2.1&u=mlin_c_worpoly&it=r&p=ITOF&sw=w

Berg, B. L. (2007). Qualitative Research Methods for the Social Sciences (6th ed.). Boston, MA: Pearson Education

The Bharat Scouts and Guides. (2018). ACTIVITIES FOR YOUNG PEOPLE CONDUCTED AT NATIONAL AND REGIONAL LEVEL. Retrieved April 22, 2019, from http://www.bsgindia.org/User/MajorActivities.aspx

Dasgupta, K. (2018, August 21). A Himalayan Mess: Growing garbage pile a threat to mountain ecosystem. *Hindustan Times. Retrieved January 31, 2019, from* https://www.hindustantimes.com/india-news/a-himalayan-mess-growing-garbage-pile-a-threat-to-mountain-ecosystem/storysSmLxHSc24DHmIe9bSKQiP.html

Department of Town and Country Planning (2015, January 27). Manali Development Plan. Retrieved April 16, 2019, from http://tcp.hp.gov.in/Application//uploadDocuments/devlopmentPlan/PlanDoc020150127_174424.pdf

Drifter Planet. (2015, August 1). Trekking To Triund In Himachal Pradesh, India. Drifter Planet. Retrieved January 31, 2019, from https://drifterplanet.com/triund/

Engineer, R. (2018, May 30). Like to Hike? Your Love For the Mountains Can Clean Up the Environment! Retrieved January 31, 2019, from https://www.thebetterindia.com/143470/green-trails-india-hikes-cleanup-mountains/

Fernandes, F. (2017, November 25). Mindset change is the key to clean campaign. *The Times of India. Retrieved January 31, 2019, from* https://timesofindia.indiatimes.com/city/thane/mindset-change-is-the-key-to-clean-campaign/articleshow/61520562.cms

Gutin, O. (2017, December 12). Tracking Trash In Jagatsukh and Manali – Insights From Our Investigation. India Hikes. Retrieved January 31, 2019, from https://indiahikes.com/tracking-trash-in-jagatsukh-and-manali-insights-from-our-investigation/

India Brand Equity Foundation (2017). Himachal Pradesh: The Abode of Gods [PowerPoint slides]. Retrieved from https://www.ibef.org/download/Himachal-Pradesh-January-2017.pdf

Joshi, A. (2013, December 31). Top 10 Spiritual Treks in India. Retrieved February 1, 2019, from https://www.peakadventuretour.com/blog/top-10-spiritual-treks-in-india/

Kurra, S. (2018, October 17). Triund, A Trekking Paradise. Diextr. Retrieved January 31, 2019, from https://www.diextr.com/triund/

Maynard, R. (2001, May 11). India: The Abode of the Gods. Telegraph Travel Collection. Retrieved from https://www.telegraph.co.uk/travel/destinations/asia/india/718398/India-The-abode-of-the-gods.html

Mountaineerz Leisure and Adventure. (2019). Hampta Pass Trek. Bookmundi.com. Retrieved January 31, 2019, from https://www.bookmundi.com/manali/hampta-pass-trek-11539

Pakhomov, E. (n.d.). Is It Possible to Clean up India? Retrieved April 16, 2019, from https://bricsmagazine.com/en/articles/is-it-possible-to-clean-up-india

Reddy, J. (2017, October 26). Jishnu Reddy's answer to "Where can you go to the toilet in Triund?". Quora.

Royte, E. (2017, August). Nearly a Billion People Still Defecate Outdoors. Here's Why. Retrieved January 31, 2019, from https://www.nationalgeographic.com/magazine/2017/08/toilet-defecate-outdoors-stunting-sanitation/

Sangwan, P. (2019). Prashar Rishi Lake Cleaning Campaign [Pamphlet]. Healing Himalayas.

Sharma, R., & Saxena, R. (2017, March 25). Prashar Lake in INR 1800: 5 Reasons Why You Should Trek Here. Retrieved January 31, 2019, from http://www.nomllers.com/prashar-lake-trek/

Snack Food - India | Statista Market Forecast. (n.d.). Retrieved April 16, 2019, from https://www.statista.com/outlook/40110000/119/snack-food/india#market-globalRevenue

What is a baseline assessment? (n.d.). Retrieved February 7, 2019, from http://www.endvawnow.org/en/articles/1323-what-is-a-baseline-assessment.html

An Overview of the Needs and Requirements of Persons with Disabilities in Kamand Valley

Abstract

Due to the negative social, physical, and financial repercussions presented to PwD and their families, it is vital that the needs and requirements of PwD are clearly known and addressed in communities. To meet this goal, we assessed perceptions of PwD in the Kamand region. We set out to understand the limitations that are faced by PwD and their families, and we determined the resources available to support PwD. By accomplishing these objectives, we hoped to clarify standards for accessibility in Kamand Valley and to give greater understanding and independence to those affected by disability.

Team Members

Rebecca Markowits
Erika Miyajima
Amit Ranjan
Bhanu Singh
Michael Savrin
Brandon Waugh

Advisors

Dr. Priscilla Gonsalves
Ms. Sandhya Menon
Dr. Ingrid Shockey
Dr. Gbeton Somasse

PwD in Himachal Pradesh

The Rights of Persons with Disabilities Act of 2016 defines persons with disabilities (PwD) as "a person with long term physical, mental, intellectual or sensory impairment which, in interaction with barriers, hinders [their] full and effective participation in society equally to others"(Ministry of Law and Justice, 2016). PwD comprise at least 2% of the Indian population (Census, 2011). Despite improvements to accessibility in India, PwD and their families still face negative social, physical, and financial repercussions (Richard, 2014). In parts of northern India, these hardships may be heightened because of limited resources, lack of qualified personnel, and challenges in access assistance or mobility due to the geography of the area (Dring, 2016).

While stigma and discrimination against PwD cannot be fixed overnight, there has been increased global sensitivity to the needs of marginalized people. In fact, the UN Sustainable Development goals specifically point to targets for human rights including Reduced Inequalities, Quality Education, and Good Health and Well-Being. Reduced inequalities means addressing challenges, taboos and stigmas associated with PwD. These barriers worsen financial and social inequalities. Similarly, access to quality education, good healthcare and well-being because ultimately we are trying to improve the living conditions of PwD and their families and caregivers in Kamand Valley.

Toward this end, Enabling Women of Kamand (EWOK), is interested in contributing to the well-being of women and their families in a small community in the heart of Himachal Pradesh. As the well-being of a PwD is highly dependent on the support and stability given by their caregivers, it is vital that the needs and requirements of PwD are clearly expressed and addressed in communities (Richard 2014).

To meet this goal, we assessed perceptions of PwD in the Kamand region. We also set out to understand the limitations that are faced by PwD and their families, and we determined the resources available to support PwD. By accomplishing these objectives, we hoped to clarify standards for accessibility in Kamand Valley and to give and to give impetus to programs promoting greater understanding and independence to those affected by disability.

Political and Social Context of PwD in Himachal Pradesh

In this section, we discuss the political and social limitations that PwD face in Himachal Pradesh. We also explore challenges faced by PwD in regards to access to support, to resources, and to rights. Finally, we describe the vision and mission of Enabling Women of Kamand (EWOK) guided us through our research process.

Political Context

In an attempt to mitigate discrimination, government initiatives in India, as well as the state of Himachal Pradesh, have recently updated laws pertaining to the rights and resources for PwD. The most current law is the Rights of Persons With Disabilities Act of 2016. This act provides a variety of rights, including those concerning access to education, the right to vote, and access to public resources, as well as outlining requirements of the government in order to meet basic accessibility standards. The policies included in this act provide quite comprehensive guidelines, but still put the burden of enforcement of policies onto the individual states (Ministry of Law and Justice, 2016).

Figure 1. Katindhi government school (photo credit: Savrin, 2019)

To match the Rights of Persons with Disabilities Act, Himachal Pradesh also has its own policy for PwD, including the right to vote and the right to education (see figure 1). This legal document also provides encouragement for research about standards for PwD. In terms of offering other concrete support to PwD in Himachal Pradesh, however, the laws are vague. The regulations at the state level do not outline any specifics for potential support unlike those governing all of India. In some cases, the policies could be better informed by how needs could be met through the Rights of Persons with Disabilities Act and other international standards (Department of Social Justice and Empowerment, n.d.).

Social Context

PwD typically face two types of challenges. First, the limitations caused by their physical or cerebral conditions. Second, the challenge to be included and accepted in their communities. Individuals facing such scenarios from a young age can grow up to have low self-esteem. This can lead to feelings of inferiority, social withdrawal, and social rejection, which in turn can contribute to health problems, as well as psychosocial disorders and a diminished wellbeing (Sandeep, 2011).

Despite being the world's largest minority, PwD are largely ignored by society. Social response to disability often sees similar discrimination patterns as those against religion, caste, gender, age, and so forth. This is important, as these negative social constructs can also compound. When it comes to rural low economic regions of India, not only do female PwD face the difficulties of being a woman with a disability, but they may also face additional social barriers, associated with caste, and status. If discrimination worsens the situation, neglect can make rehabilitation difficult. In some cases, families contribute to this intolerance and feel ashamed and embarrassed about being related to a PwD. Stigma and prejudice can also restrict PwD from building skills (Das, 2010).

The Challenges Faced by PwD in India

Around the world, disability is often perceived as a hindrance to the person affected. In reality, PwD have a wide range of conditions some of which limit the person affected more than others, and vary according to contextual expectations and opportunities within families and communities. Additionally, but there are common requirements for all persons, regardless of ability.

Access to Support and Services

Immediate family is a strong support system for sick or disabled family members. The role of caregiving in India is "unique as compared to the developed world," since caregiving is most typically done by the family as opposed to "formal" or outside paid care (Jagannathan, 2014). While caregivers may not see their disabled family members as a burden, caregiving can hinder their ability to secure income or participate in other community activities (Jagannathan, 2014). Caregivers also need short or long term relief options for when they themselves cannot provide service to their dependent.

Access to Resources

Even with the same medical condition, experts are clear that there can be no universal definition of individual disabilities. Therefore, as trained medical supervision can be scarce, expensive, or distant, misdiagnosis of disability happens frequently. Not only is it expensive to get the supportive medical treatment PwD deserve, but therapy is rarely in the form of simple medicine. Research has shown that education also can help lessen the hardships PwD face. Poverty is one of the biggest factors that influence PwD. Mothers who live in poverty are more likely to suffer from malnutrition. Poverty and malnutrition compound problems in pregnancy, and female PwD often are not given proper medical guidance or care during pregnancy and birth. Factors such as population growth and aging population can be a big contributor to the increasing number of PwD (Raay, n.d.).

Access to Rights

In a blog titled "Dear non-disabled people, we are human beings and citizens too," Nidhi Goyal, an Indian standup comedian and disability advocate who is a PwD herself, reflects about access to rights for PwD. We are born with "coats of stigma, prejudice, and misconceptions", says Goyal (Goyal, 2018). The reason for these attitudes can be that social perception towards PwD are outdated, and are often highly influenced by cultural and religious beliefs (Edwardraj et al., 2010).

A life of being denied access takes a toll that impacts employment and future with independence. "Imagine someone not believing when you say 'I can do this'," says Goyal as she talks about PwD seeking employment and how it can often end with the response of rejection despite the qualifications they may have. Progress has been made, although positive stories are less common. For example, Haley Moss is a lawyer who has autism and works in a top law firm. Joseph Zumpano, who offered Moss the job, says he wanted to show that "if you align people to their strengths then given the chance, they excel" (Erblat, 2019).

In addition to the considerable challenges in employment or mobility, access to basic comforts such as buying clothes can be hard for

PwD. The limited offering seems to imply, "Why do you want new clothes? Why would you want to dress up?" (goyal, 2018). PwD are denied even the right to "feel beautiful"(Goyal, 2018). Not only the appearance of clothing but also the functionality of the clothing can be a big challenge in PwD lives. It can be difficult for some PwD to use buttons or zippers. They may require help, making it almost impossible to have independence. Although adaptive fashion, clothing that specifically focuses on people with physical disabilities or impaired movement, is still limited in India, some mainstream designers such as Tommy Hilfiger as well as a handful of Indian designers have been launching disabled-friendly clothing(Dhar, 2019).

With rights comes wellbeing, and the opportunity for PwD to have the quality of life others would expect. Social ignorance can discourage PwD from something that is considered normal for a non-disabled person, such as seeking work, marriage, or travel. PwD are stared at when they are in public, lending little privacy. When it comes to dating and marriage, they are seen as an "unfit" partner who will not be a good future parent. When they are with companions, they are often ignored and the conversation are directed toward the companion (Goyal, 2018). Whether in terms of accessibility or discrimination, PwD are systematically denied certain human rights.

Changing How Persons With Disability are Perceived

The perceptions of PwD are being changed through progressive movements of social changemakers and entrepreneurs. From a global health point of view, the UN Sustainable Development goals call for support for healthcare access and affordability for all. But other changemakers are setting up locally-based options for PwD to succeed in their own community. Durell Coleman is a social entrepreneur who is the creator of a design firm called DC design. DC design focuses on Human-Centered Design while eliminating social challenges that are faced by marginalized people. One example of his social entrepreneurship can be seen in the summer program, Design the Future, that he started for high school students. The students implement the concept of DC design while focusing on daily problems faced by people with physical disabilities (Design The Future, n.d.).

Positive social change initiatives with regard to disabilities is active across India. For example, EnAble India is an NGO that supports PwD in training and employment. They have received recognition for their work such as Special Consultative Status by the United Nations Department of Economic and Social Affairs (DESA), as well as a National Award from the president of India. Some stories of people benefiting from this NGO include Cornelius who attended a ten month Employment training with EnAble India, which focused on life skills, computers, English and mobility. He says, "I am now employed at Rediff in the spam operations team. I am the first visually impaired employee in the company and the only family member to have got a degree and to be employed in a well-paid job" (EnAble India, 2017). There are more opportunities for and better awareness of PwD because of organizations like EnAble India.

Enabling rural opportunities through EWOK

The Kamand Valley is a medium sized collection of villages located in Mandi District in the heart of mountainous Himachal Pradesh. It is a generally rural area, but experiencing new growth with the development of IIT Mandi in the region. The communities are traditionally agricultural, but the university has brought some additional service sector employment (Census Population, 2011).

Set in this valley, Enabling Women of Kamand (EWOK) (offices featured in figure 2) state that their mission is "To enable the women of Kamand Valley in ways to better utilize their skills for economic gains and in general

Figure 2. EWOK offices (photo credit: Savrin, 2019)

to improve quality of life" (EWOK - About Us). The NGO also makes clear that with the introduction of IIT Mandi to the Kamand Valley, there is much more potential for change that should be fully utilized by the women of the area (EWOK - About Us). When it comes to care-taking, women in the family are often obligated to take this role and do not have time of their own or to financially support their dependents. EWOK is positioned to bring women more skill set options to better provide for themselves and the community (Menon, personal conversation, March 14, 2019). In order to understand the needs and requirements of those affected by disabilities and mitigate some of the problems and difficulties faced by PwD, it is important to understand the stories and personal experiences of those affected directly.

In sum, we identified several points that informed our framing of the problem. First, when finding inclusive solutions to the problems faced by PwD, it is necessary to take into account site-specific community and support systems. Individuals experience disabilities differently depending on their experience with other social constructs, such as gender, caste, region, religion, and so forth. Finally, the geographical, political, and economic climate of the community will play a role in accessibility requirements and constraints that can shape the outlook and futures for PwD.

Project Approach

Here we discuss the strategies used to evaluate the needs and requirements of persons with disabilities (PwD) in Kamand Valley. Towards that goal, our objectives were to:

1. Assess community perceptions of PwD in Kamand Valley
2. Identify limitations faced by PwD and their families
3. Determine the resources available to PwD

These objectives were accomplished through interviews, observations, and surveys of experts, residents, and PwD as outlined in Figure 3, and then discussed in detail.

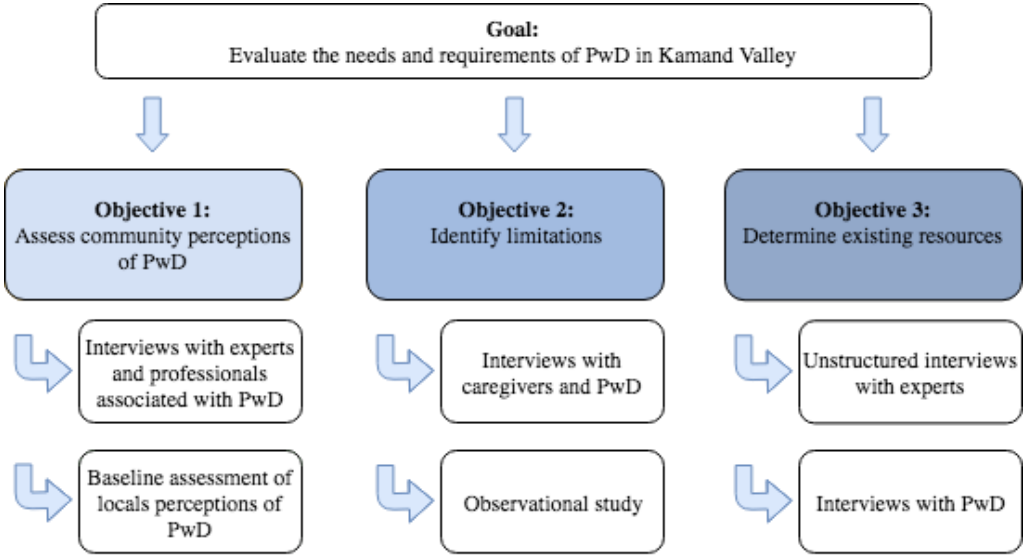


Figure 3. Methodological strategies

Objective 1: Assess community perceptions of PwD

We interviewed relevant experts to understand their views on the perceptions of PwD in Kamand Valley. Experts included doctors, educators, government officials, and NGOs engaging with or supporting PwD. Based on our preliminary discussions and observations, we designed a survey for the residents of the villages in Kamand Valley. We then interviewed participants, including individuals with disabilities and those who have family members who are PwD, in addition to residents with no relation to PwD. These in-person interviews were approximately 15 minutes in length.

Figure 4. Interviews in the field (photo credit: Markowitz, 2019)

Objective 2: Identify limitations faced by PwD and their families

We conducted a baseline assessment of the experiences of the PwD or caregiver by conducting structured interviews related to living with or being a PwD (see figure 4). We used a sample of convenience and snowball sampling to identify approximately twenty participants of PwD and caregivers. Selected participants were shadowed briefly following interviews as a part of an observational study. This allowed us to gain more insight into the limitations that surround their daily life in Kamand Valley.

Objective 3: Determine the resources available to PwD

To help us determine the resources available, we consulted with local experts such as doctors, teachers, and other relevant professionals. Because we wanted to focus on qualitative data analysis, we set up face-to-face unstructured interviews (in-depth interview) that were tailored to each individual so that we were guaranteed to cover the areas of interest. To identify relative experts we used a snowball sampling in which one professional recommends more experts in the field.

Finally, we interviewed PwD and asked them to identify what resources were available and beneficial services that operate on their behalf or offer support in the region. The purpose of the interview was to get accurate answers from PwD themselves while gaining insight into support systems the community provides.

Results and Discussion

The result of our interviews and discussions with PwD and other community members are presented here by objective. Below, figure 5, illustrates the types of interviews we conducted and the number of participants from each category we interviewed.

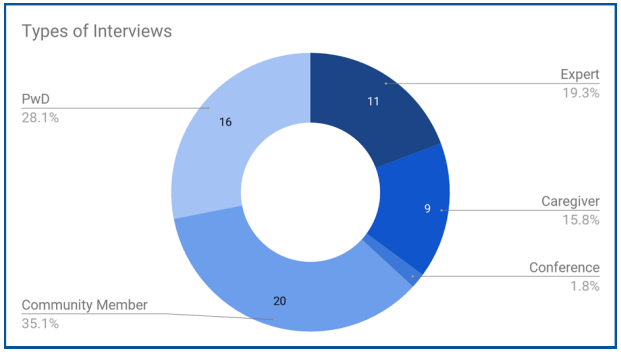


Figure 5. Types of interviews

Community Perceptions of PwD

Community perceptions were gathered through interviewing community members, observing the children with disabilities at the Katindi Government School, and engaging with professionals, including a Site Director for Special Needs programs at an NGO and one special needs teacher. Although many of the community members were reluctant to respond, as seen in figure X, the perceptions identified were that concealment and alienation of PwD from the community is common, perhaps due to social taboos.

Our interview strategy with community members did not generate clear answers on questions about opinions towards PwD, specifically those questions with regard to the involvement of PwD in the community and improvements in PwD's lives. Residents we spoke with also declined to answer many of the questions especially "how often and where do you interact with a person affected by disability?" We sensed reluctance when asked to talk about their own opinion, but interviewees opened up when asked about their thoughts on other community members' perceptions of PwD.

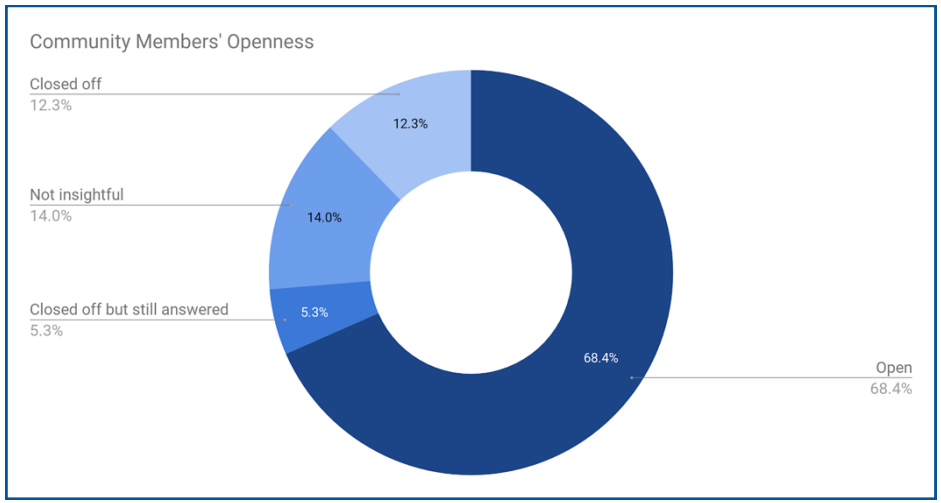


Figure 6. Community members' openness to questioning

Many of the caregivers and community members also separated themselves from the PwD by not including or talking with them or alienating them in the community. Dr. Narendra Paul, a site director for

special needs programs, discussed the adversities of separating PwD from the community. He explained this concept with the example of children in special needs schools. He said that "specials schools are the biggest discouraging model of community exclusion"(N. Paul, personal communication, March 16, 2019) citing how the students are negatively impacted because they are isolated during their developmental stages and as adults, it is hard for them to adjust. In addition, the community members cannot comprehend the challenges that PwD face because they are isolated from view in a single community and othering occurs as a result. Othering is exhibited through labeling PwD as an independent group of people not included in the community. It allows many community members to abstractly talk about PwD without attaching themselves to the taboos associated with them. This can be dangerous because it encourages the ideas of discrimination towards the "other" or in this case PwD.

In an interview with the special needs educator, we learned that not only is othering common, but taken to an extreme, concealment may also happen within communities. For example, we heard of a nine year old boy diagnosed with 90% mental retardation who is kept confined to his house. Although the special educator is trying to counsel his family, they feel their child is cursed and do not want to be further judged by their community. Another man, who is a caregiver to two of his brothers, explained that one of his brothers with 100% mental retardation is physically able to attend social events, but he chooses not to attend these events. While we do not know why he avoids social events, we can see that this decision can lead to social isolation and concealment.

While some of the stories we heard were quite demeaning, we also observed PwD at the Katindi Government School and noticed that the other children were very accepting and excited to play with the students with disabilities. The students with disabilities also confirmed that they had an easy time making friends

Limitations of PwD

Based on our interviews with a variety of PwD, shown in figure 7, the findings of our fieldwork revealed limitations for PwD in the region. These limitations included educational, social, economic and physical geographical constraints. Limitations were clearly identified around a few key themes. A commonly identified limitation is that of educational opportunities. There are resources available in the area including a special needs educator located at a government school in Kathindi. When we interviewed this official, she stated that she was the special needs expert for five other area schools and that her job entailed more than just baseline education work. She told us that her work included counseling students, parents, and teachers as well as creating an awareness of discrimination against PwD. This also means convincing administrations and leadership at local schools to be more accepting of PwD. The value of her work was evident from our visits to other government schools where there were a few special needs students, but no one knowledgeable on special needs education to work with them. This lack of special needs educators can restrict PwD from access to a proper education.

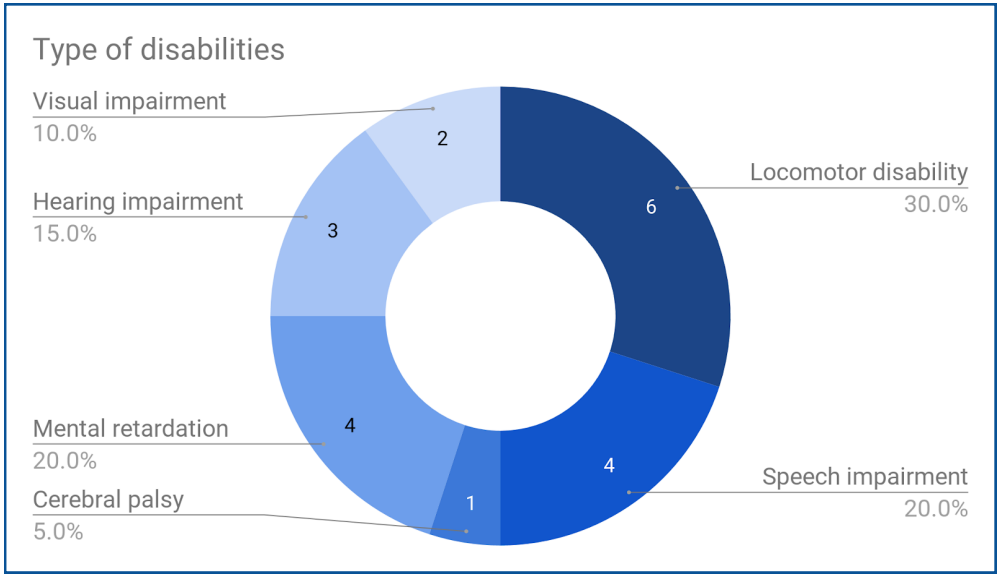


Figure 7. Community members' openness to questioning

Another key limitation for PwD was a system of social beliefs and perceptions about the cause or meaning of disabilities in families. It was said in one of our interviews that some families who give birth to a PwD would assume that the birth was caused by some form of negative karma affecting the family or even black magic. Other individuals believe that their disability is something that god has cursed them with. One woman says, "I believe my hearing impairment developed because I was too shy,"

Figure 8: Father and son with cerebral palsy (photo credit: Waugh, 2019)

she further noted, "I pray to god every day that I will be able to hear as I used to" (personal communication, April 6, 2019). As noted earlier, these perceptions can exacerbate rejection of the PwD or their family in the community, and bring shame or concealment of the disability on top of the strain for resources or support.

We recorded many stories of financial limitations to PwD and their families. In discussions with caregivers, we have heard that financial resources can be scarce with one man who was caring for his two brothers saying "my very limited financial resources are almost completely consumed by basic amenities"(personal communication, April 4, 2019). When asked about financial status most of the interviewees appeared either uncomfortable with the question and gave a vague response. Some gave an honest answer such as with an interview with the father of a 14 year old boy with cerebral palsy shown in figure 8. This father mentioned that he was very worried about his financial state. This father also admitted having stopped working in order to support his son's education, but was in need of financial resources and that there was stress surrounding his ability to obtain these resources.

Finally, the difficult landscape of the Kamand Valley is another limitation for those with physical disabilities as seen in figure 9. According to a school administrator, children with physical disabilities are often kept at home rather than sent to school, as they are not capable of walking to school because of the landscape and distance of the school. She also said that parents would rather prioritize their occupation and finances, than support their child's education. We observed the challenging routines of daily life in the steep terrain and our own exploration of the landscape. One example from our work included the particularly harsh walk for a PwD to the Salgi Panchayat House. As is common in the region, it meant climbing many flights of stairs, which managed to tire everyone in our team out. This kind of walk could prevent a PwD from being able to reach the place where they want to go or would need to go in order to fully participate in society.

Figure 9: Narrow path posing difficulty (photo credits: Markowitz, 2019)

Existing resources of PwD

There are ongoing efforts in providing existing resources to PwD such as government stipends for PwD with disability certification, support groups held through NGOs, and the special needs educator working in government schools. Organizations like EWOK help train women by providing them with educational opportunities varying from English classes to learning how to do data entry on Excel. They are also in the process of expanding their support group system to provide a platform where women can openly discuss their hardships without worrying about people's perceptions. This kind of support is important and welcome. For example, the father of a PwD with cerebral palsy listed support groups as helpful resources along with social opportunities, financial support, and support in special education. At this time, these kinds of resources are in place sporadically, but not available to all.

Chinmaya Organization for Rural Development (CORD) is an NGO in Dharamshala that provides solutions using holistic approaches by looking at the person and the issues surrounding them as a whole rather than simply treating the disability. As government implementations are an issue that cannot be ignored, CORD focuses on providing support groups by helping people "from the community for the community" (N. Paul, personal communication, March 16, 2019). For example, CORD engages local children with disabilities in domestic activities, such as cooking, cleaning, and other tasks so that they can gain more independence as they grow up.

Support for children with disabilities can be seen in local hospitals where they provide anemia acid tablets for children under the age of 15 with red blood cell deficiency. Surgeries and prosthetics are also provided for free to some children in need. The Katindi Hospital also helps PwD rehabilitate through medical and vocational training so that they have better living standards. We interviewed a rehabilitation expert, Dr. Narendra Paul, who explained that a disability that is greater than 40% can get a disability certification. A certification can help financially because it makes PwD and their families eligible for stipends every few months. Additionally, certified PwD can get travel passes for public transportation for free. Although these resources are beneficial, Dr. Narendra Paul says "some individuals illegally obtain multiple disability certifications to claim excess benefits" (N. Paul, personal communication, March 16, 2019). This corruption makes it more difficult for individuals with actual needs to access the same benefits.

Figure 10. Discussion with special needs educator (photo credits: Waugh 2019)

We interviewed a special needs educator at the primary school of Katuala, Ms. Reema (see figure 10). She discussed the previously mentioned case of the boy with cerebral palsy having received physical therapy from CRC Sundernagar and Zonal Hospital Mandi twice a month. He used to get around by crawling on his four limbs up to the age of 8 or 9, however, we were able to observe that, despite needing some assistance, he is able to walk on both of his legs at the age of 14. Apart from working as a special needs educator at the school, Ms. Reema's duties also include consultation with parents as well as the teachers who are having trouble working with children with disabilities. She also assists PwD in getting medical certificates and aid from other governmentally sponsored programs. She tries to convince school administrators to intake children with disabilities via admissions. Although she is making an effort to increase the number of children with disabilities at schools, we observed that schools in the region still lack the resources for proper education. Her primary effort is to raise awareness for PwD in the communities and lessen the discrimination they face.

Discussion

Although the lack of openness made it difficult to assess community perceptions of PwD in Kamand Valley, there were compelling trends in our findings. It seems that there are not open conversations about the challenges PwD face. It appears that talking about PwD may be considered impolite, or a taboo, and that othering and concealment of PwD is common. Nevertheless, those PwD that are integrated into the community are generally well perceived.

Our survey, unfortunately, revealed very little with many declining to answer personal questions. Perhaps there is no certain way to speculate about PwD or perhaps residents are protecting PwD by choosing not to discuss their problems. Given some evidence of superstitions, karma, and black magic, some may have declined to answer because there are strong beliefs associated with PwD. When asking community members what they thought their villages' perceptions of PwD were, we heard more considerate responses, reflecting general understanding of the taboos and stigmas associated with PwD in their society.

Furthering the complexity, there was also clear indication of concealment of PwD in the communities. Othering occurred with almost everyone we interviewed, in the form of separating themselves from PwD. Concealment and isolation were also shown through this obvious social

barrier between the PwD and the community.

At the same time, there were some signs of a surprising openness towards them, specifically amongst the children with disabilities. Both by observation and discussion with the children with disabilities at the Katindi Government School, we confirmed that the children integrated into the non-special education school were well adapted and able to make friends with their peers. Furthermore, we encountered a child with down syndrome and her friends at a local snack shop after school and observed that she was well perceived by the shop owner and the other kids her age.

For children with disabilities, having luck in terms of locally available resources seems to be the primary marker of success. For most, there are few options available. The options are either to potentially travel a long way to go to a school with a special educator, have your child sent to a special school where they may be separated from other students, or have them sent to a government school where they could potentially be rejected because the school does not want to work with PwD. None of these options are optimal which can raise many long-term and compounding problems for a child with disabilities gaining a full education.

The societal views on PwD also cause issues. These perceptions related to black magic and karma enforce the idea that PwD are bad and should not necessarily be helped or incorporated into society. The previously discussed idea of othering and concealment of PwD is an example of the negative viewpoints that can stem from these kinds of ideas.

Financial limitations also raise clear discussion points. Many of the PwD we spoke to, one shown in figure 11, receive a monthly stipend from the government, but when this is compared to the amount of time the family spends with the PwD and the fact that many caregivers have to either stop working or work less in order to support their family, this stipend is not enough. Although the minimum wage in Himachal Pradesh differs depending on the field of work, the minimum wage for an agriculture job, which is typical in Kamand Valley, is 225 rupees per day (Himachal Pradesh Labor and Employment Department, 2018). While a stipend of 500-1000 rupees (~7. 50-15 USD) a month can be helpful to families, it is clear from our research that it is not enough to fully compensate for the complex needs of families facing a variety of challenges. In any case, the ripple effect for caregiving comes at a cost for lost income or work time amongst other family members. In cases where more than one family member faces disability, there can be insurmountable implications for a family to give support.

Figure 11. A caregiver and his brother (photo credits: Savrin, 2019)

Though landscape issues were not heavily discussed, there were clear problems seen. Not going out into the community and struggling to do so has been mentioned in multiple interviews and there could be a clear correlation between these points.

Project Outcomes

We have a variety of recommendations related to the support and improvement of the quality of life for PwD in Kamand Valley. These recommendations could help overcome some of the limitation identified and looking at the big picture, could contribute to the achievement of some targets set as part of the United Nations Sustainable Development goals, as seen below in figure 12.

Figure 12. Recommendations related to sustainability goals.

Addressing Emotional Needs through Support Groups

Our first recommendation relates to the idea of emotional support and the ability to share the hardships that can be related to being a PwD or caring for one. This recommendation works with the UN Sustainable Development goal of health and well being. It would do so by developing support groups where caregivers or PwD can be brought together and share their stories and how they may deal with these hardships. It can be very helpful to speak with likeminded people who are experiencing similar problems regarding mental health and the ability to share. Additionally, it can help to overcome common problems because other people who have dealt with the same issues can help with how they overcame the obstacles they have faced. With the complexity of traveling the area, it would also be potentially helpful to have transportation to these support groups. EWOK already has an established infrastructure in the community so they would be able to potentially host a support group of this form. In our research, we have seen a variety of people who state that a support group is a resource they would utilize if it were available to them. A good amount of these participants were men, however, given EWOK's priority on women in the valley. Nevertheless, a good support group could be formed for all caregivers of diverse backgrounds from the area.

Addressing Medical Needs through Medical Camps and Assistive Technology

Another area relating to the Sustainable Development goal of health and well-being is improving access to medical support. Through our interview with CORD, we learned of a system they use to bring together medical experts and PwD in order to certify PwD and assist them in getting the required treatments. This could be potentially implemented in Kamand in a way where PwD are given a time frame where they could go to the Zonal Hospital in Mandi and have dedicated doctors who would provide them with any necessary certification or assistance. It would also be favorable to arrange transportation to get those who are unable to arrange their own travel to these "medical camps". The validity of this suggestion was enforced by an interview with a local man whose brother is a doctor, and who claimed that it was quite easy for him to access resources for his wife. The recommendation would be to set weekly, monthly, or quarterly times where PwD could go to the hospital and get the same form of preferential treatment this man's wife received. This small change could expedite medical processes for many PwD.

Another medical support needed is access to inexpensive assistive technology. Though there are certain ways and places where there is discounted access to technology, it is somewhat unavailable in this part of northern India. This discount could come through a variety of methods or could even be implemented by making resources that are accessible elsewhere more accessible in Kamand Valley. Examples of useful assistive technology include simple but critical items such as crutches, hearing devices, and prosthetics.

Addressing Education through Training of School Staff

The next suggestion targets the UN Sustainable Development goal of quality education. It specifically relates to the targets of ensuring all children have access to free and quality education. It also relates to the goal of equal access to education that should be available to all, including PwD and a variety of other groups facing adversities. As mentioned earlier, there is a clear lack of educators who are trained to work with PwD, with only one educator for the entire Kamand Valley region. A good way to try to improve this situation would be to train educators so that they can better work with students with disabilities. This training could potentially be done by the trained educator for the region or an outside resource could be brought in. This training would have two target areas. The first would be training for teachers on how to cater to students with disabilities while also keeping a balanced classroom. The other training would be for administrators on the benefits of including PwD in the classroom as well as acceptance of PwD and why they should be integrated with other students.

Addressing Financial Inequalities through Trainings and Labor Opportunities

The final suggestion targets the goal of reducing inequalities. It fits the specific target of creating economic inclusion for people regardless of disability. There are a variety of recommendations that can help to reach this target. The first recommendation would be to sponsor PwD and caregivers for training towards employable skills that are provided by EWOK. While EWOK provides affordable trainings, it would be more

utilized by PwD and caregivers if it were a resource available to them for a lower cost. These trainings would allow for the improvement of the financial situations of PwD by enabling them to work in more sustainable labor where they would be able to provide for their families while not having to work as much.

In the case of unskilled labor, there could be potential improvement through an organization structured so that it can improve area accessibility. This organization could also offer employment to caregivers and PwD who are still able to do physical labor. The development of an organization like this would also allow for flexible work times of PwD and caregivers interested in working fewer hours in order to cover other responsibilities. The employment of PwD and caregivers to improve accessibility of the area would be a dual-pronged approach where one organization promoting one idea is able to improve lives of PwD in multiple ways. This method of improvement provides not only financial support but also improves the area so that PwD can more easily participate equally in the community.

Conclusion

Due to the variety of challenges presented to PwD by the environment, culture, and political climate, this study is important to understanding the complexities of the area in relation to disabilities. We have assessed perceptions of PwD through a variety of interviews and surveys and found limitations through discussions with PwD and their caregivers. The final aspect that we have worked on involved communicating with officials in the community about the resources that are available to PwD. Our study has given a better understanding of PwD in Kamand Valley as well as how communities function in relation to them. Through this increased understanding, the wellbeing of both PwD and caregivers can be greatly improved by making the resources clear and communicating the stigma surrounding disability in Kamand Valley. With more clearly understood needs and resources caregivers will be able to fully utilize these resources in order to better their own quality of life. Our sponsor EWOK hopes to use the outcome of this study to improve lives of caregivers and PwD so that they too can work to empower themselves.

To that end, this study can be used to further promote the implementation of our recommendations by either already existing organizations or by the founding of new organizations. These ideas could be used by EWOK to begin work with PwD and caregivers. Some of our recommendations could also be implemented as government initiatives to improve the quality of life for PwD and caregivers. Our recommendations and research can be a strong foundations for all future work for PwD and caregivers in Kamand Valley.

Acknowledgments

We would like to thank the following individuals for their assistance and guidance throughout our study:

- Our mentors, Dr. Priscilla Gonsalves, Ms. Sandhya Menon, Dr. Ingrid Shockey, and Dr. Gbetonmasse Sommasse for their insight and guidance on our project
- EWOK for their sponsorship of our project
- Vandana Thakur for helping us with translations in the field
- Our teaching assistant Harsh Arora
- All of our interviewees for sharing their stories with us

The reports in this book represent the work of WPI and IIT Mandi undergraduate students. For more information and to see the complete report, you may search using keywords or author at https://digitalcommons.wpi.edu/iqp/ or http://www.iitmandi.ac.in/istp/.

Works Cited

Das, S. (n.d.). Hope for the Invisible Women of India: Disability, Gender and the Concepts of Karma and Shakti in the Indian Weltanschauung. In Hope Against Hope: Philosophies, Cultures and Politics of Possibility and Doubt (pp. 129–147). Amsterdam, Netherlands: Rodopi.

Design The Future. (n.d.). Retrieved from https://www.designthefuture.dcdesignltd.com/

Dhar, S. (2019, January 22). The wheelchair wardrobe: How fashion is becoming moredisabled-friendly - Times of India. Retrieved from https://timesofindia.indiatimes.com/home/sunday-times/the-wheelchair-wardrobe-how-fashion-is-becoming-more-disabled-friendly/articleshow/67605199.cms

Dring, E.W., Maalouf, J.R., Johnson, V.K. (2016). Improving Healthcare Communication in the Mandi District (Interactive Qualifying Project). Retrieved from http://www.wpi.edu/Pubs/E-project/Available/E-project-050216-002701/unrestricted/

Edwardraj, S., Mumtaj, K., Prasad, J. H., Kuruvilla, A., & Jacob, K. S. (2010, August). Perceptions about intellectual disability: A qualitative study from Vellore, South India.
Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/20633202
EnAble India. (2017). Home. Retrieved February 20, 2019, from http://www.enableindia.org/
Erblat, A., & South Florida Community News. (2019, February 21). Breaking barriers: Woman with autism becomes lawyer at a top law firm. Retrieved from https://www.heraldmailmedia.com/news/nation/breaking-barriers-woman-with-autism-bcomes-lawyer-at-a-top/article_794b95c2-6598-50a1-ae2e-fe7cd1608031.html
EWOK. (2016). EWOK Home. Retrieved January 19, 2019, from http://ewok.iitmandi.ac.in/index.php
Goyal, N. (2018, December 04). Dear non-disabled people, we are human beings and citizens too. Retrieved January 24, 2019, from https://www.telegraphindia.com/opinion/dear-non-disabled-people-here-are-soe-thoughts-for-world-disability-day/cid/1677331
Himachal Pradesh Labor and Employment Department. (2018, August 7). Notification of Minimum Wage. Retrieved from https://himachal.nic.in/showfile.php?lang=1&dpt_id=14&level=2&lid=18223&sublnkid=17758
Jagannathan, A. (2014, October-December). Family caregiving in India: Importance of need-based support and intervention in acute care settings. Journal of Postgraduate Medicine, 60(4), 355. Retrieved from http://link.galegroup.com/apps/doc/A392159684/AONE?u=mlin_c_worpoly&sid AONE&xid=bff9f2b2
Raay. (n.d.). Blog. Retrieved January 24, 2019, From https://www.raayfoundation.com/blog-3.php
Richard, B. O. (2014). Families, well-being, and inclusion: Rethinking priorities for children with cognitive disabilities in Ladakh, India. Retrieved January 15, 2019, from https://journals.sagepub.com/doi/pdf/10.1177/0907568214526264
Sandeep Singh, R P Sharma, Suresh Chandra, Seema Nigam, & Punit Varma. (2011). A STUDY OF SOCIAL SUPPORT IN PHYSICALLY DISABLED STUDENTS IN AN EDUCATIONAL INSTITUTE OF KANPUR. Indian Journal of Community Health, 22(2), 20 –22. Retrieved January 24, 2019, from https://doaj.org/article/d4adbeb1e2854319bbd1c1fe4d4e66f0

Evaluating Waste Management practices of IIT-Mandi Campus

Abstract

It is expected that a prestigious institute like an IIT will be able to efficiently handle all waste generated by its residents without harming the surroundings. The goal of our project was to research and evaluate the techniques used by IIT Mandi in managing the waste generated within it and recommend improvements by employing more efficient techniques. For this we researced other institutes and countries. To realize this goal, we conducted interviews with campus officials, satisfaction surveys among campus residents and conducted an investigative study on the waste management practices being used on the campus. We discovered that there was scope for improvement in waste management practices being followed in the campus, and identified suitable technologies which can potentially improve these practices. We also recommended some new techniques.

Team Members

Shishir Asthana (B16144)
Shantanu Kaushik (B16113)
Sonali Jagarwal (B16079)
Deepak Jarwal (B16054)
Ajay Kumar (B16086)
Satpal Meena (B16112)
Chirag Singh (B16129)

Advisors

Dr. Denricks P. Shukla
Dr. Satvasheel Powar

The Problem of Waste Disposal

India is seeing a phase of rapid urbanization. Over 377 million urban people live in 7,935 towns and cities and generate 62 million tonnes of municipal solid waste per annum. Only 43 million tonnes (MT) of the waste is collected, 11.9 MT is treated and 31 MT is dumped in landfill sites. [1] This has led to a massive waste management challenge countrywide. There are about 84,000 municipal wards in India spread across states and 61,846 or almost three-quarters of these wards have achieved 100% door-to-door garbage collection, according to the website. [2] Yet, without proper disposal facilities this makes little difference.

The landfill sites pollute the surrounding land and groundwater. These sites rank third in terms of greenhouse gas emissions in India. [3] Collectors also resort to burning waste in unoccupied lands which is harmful to humans and the environment. There is a need for the implementation of proper and efficient waste management practices in the country.

IIT Mandi is situated along the banks of Uhl River in the forested hills of Kamand, Mandi. Designated as an Institute of National Importance (a status equivalent to the Ivy League), it has become a hub for education and commerce. The projected capacity of the campus is to house 6000+ students, 600+ faculty and staff. Thus it is critical that this institute be able to manage its current generated waste without harming the environment and also implement practices with future waste production in mind. Being a prestigious institute, we should aim to set an example for the rest of the country in terms of proper and effective waste management.

The goal of this project was to evaluate the waste management practices at IIT Mandi and provide recommendations to improve them. To achieve this goal, **we divided ourselves into groups** to tackle various types of waste. Each group **conducted interviews with the relevant officials** and **researched the government guidelines** to be followed. We identified the **systematic and human causes** which were leading to inefficient waste management. We also researched other institutes and countries to **identify and propose techniques to improve waste management.**

Background

The IIT Mandi campus is divided into two parts namely – South Campus and North Campus. These two jointly house approximately 1500 students and 150 faculty, staff. The two campuses have a total of about 17 student hostels, 100+ faculty housings and 30+ staff housings along with 4 operational messes and 6 canteens which are responsible for the generation of the majority of solid waste and sewage wastewater of the campus. The South Campus contains a Chemistry Lab and an AMRC (Advanced Materials Research Center) which are the major sources for the generation of chemical wastes. Each campus consists of a medical unit which houses all types of medicines and other medical equipment and is mainly responsible for medical waste production. There is major construction being conducted in the North Campus which involves the building of new hostels, academic blocks, faculty houses, laboratories and leads to the generation of large amounts of construction waste.

Stakeholders

Stakeholder	Connection
Students, Faculty & Staff	Waste accumulation generates odour, poses health risks.
Sweepers and Collectors	Their livelihood depends on the waste management system.
Villagers	Any damage to the environment due to waste directly affects them and their livelihood.
Canteen and Mess	Waste attracts dogs, flies, and rats, creates odour and hampers business.
Medical Units	Medical waste can be hazardous and needs to be managed safely.
Laboratories	Waste needs to be disposed of safely to prevent accidents in the lab.
Forest Department	Oversees the impact on the environment and ensures no damage is caused.

Municipal Solid Waste (MSW)

In simple terms, we can say that all everyday items discarded by the public can be classified as MSW. MSW comprises of the major share of the waste generated in the IIT Mandi campus.

As part of the solid waste management system in the campus, three labeled dustbins (green, blue, yellow) have been placed on each floor of every hostel on both campuses. These have also been placed in many places throughout South campus but are absent in the North campus. Big community dustbins are also placed in various places in South campus but only a few are available in North campus. The mess and canteens in both campuses consist of only a single dustbin in which all types of waste is thrown.

A van arrives on both campuses every day to transport solid waste to Mandi city. The sweepers of each hostel have been instructed to collect the waste from the dustbins and empty them in the van.

Figure 1: Construction waste around campus

The South campus also comprises of a Biogas plant near the D1 mess. This plant converts the kitchen waste and food waste from D1 mess into biogas which could be reused as fuel for cooking. There are also some pits in South campus where food waste from other mess is sent to be converted to manure.

IIT Mandi has also set up a green panel which is responsible to ensure proper management and efficient functioning of the green activities in the campus.

Wastewater/Sewage

Wastewater comprises of all the waste that is poured down the drains. This includes water from sinks, washing machines, toilets, and showers.

Each campus consists of a Sewage Treatment Plant (STP). All the wastewater from all hostels, faculty housing, canteens, mess, etc. is sent to the STP. The STP works like all other conventional STPs used by municipal corporations. It treats the wastewater according to the prescribed hierarchy of processes. The STP in south campus also consists of an ultrafiltration system which further removes impurities from the water which has undergone aerobic treatment. This treated water is then used for irrigation or disposed into the Uhl river. The sludge generated from the treatment is dried on sludge beds. This dried sludge is then used as manure. The capacity of the STP is reportedly 1.5 Lakh Litre and it is able to manage the sewage of the entire campus during the summer and winter seasons.

Figure 2: Water treatment plant

Chemical Waste

Chemical waste is any type of waste that is composed of noxious, potentially hazardous chemicals. The chemical waste in the campus is generated by the chemical laboratories and the AMRC.

The students who conduct research in AMRC and chemical lab are instructed to segregate the generated chemical waste and dispose it in the right bins. The labs have separate, labeled waste collection bins for

each type of waste. These bins are placed at designated spots in the labs. A collection van from Enviro Engineers arrives in the South campus once every two months to collect all the chemical waste. This waste is transported to Kullu where it is treated and disposed of.

Figure 3: Chemical waste management in campus

Medical Waste

Medical waste is defined as potentially infectious waste materials generated at health care facilities, such as hospitals, clinics, as well as medical research facilities and laboratories. Medical waste can contain bodily fluids like blood or other contaminants. Almost all medical waste in IIT Mandi is generated at the medical units situated in both campuses.

The medical units produce a wide variety of medical waste ranging from human anatomical waste to expired medicines and glassware. There are 4 different colored waste bins placed at the medical units with each designated for a different type of waste. A collection van from Enviro Engineers arrives every Tuesday to collect the medical waste. The company deals especially in the treatment of solid and liquid chemical waste. An official record of weekly waste generated at the medical unit is made by weighing bins. This is cross-checked by the collection van.

Figure 4: Medical waste management in campus

Construction Waste

Construction waste means the waste that comprises of building materials, debris and rubble which results from construction, repair, remodeling and demolition of any structure.

Construction waste in the campus is generated due to the construction of new buildings and maintenance of the already built infrastructure. For the analysis of construction waste, we went to the engineers working at NBCC and conducted some surveys regarding the practices being followed in the campus for disposing of the construction waste generated and visited some sites to look for different types of construction waste generated in the campus as seen in figure 5.

The construction waste generated is kept segregated around the site where construction work is in process. Only those types of waste are segregated from which the contractor can get some revenue. The steel waste generated is separated from other types of waste and sent to the steel factories for recycling, other metallic waste is either sent to a recycling plant or sold out to the informal sector (kabadiwalas). Waste consisting of packaging material (cardboard), wood, are collected and sold out to the informal sector by the contractor. Cement bags are collected separately and sold out to the informal sector. The metallic and plastic containers are sent to the recycling plant. The waste generated from concrete blocks is used as filling material which is dumped beneath the building as filling material. The waste that is generated due to the excavation of earth is dumped in the north campus as shown in figure 5 which can further be used for earthwork. The waste generated is transported either after the construction process is done at a site or when there is not an adequate amount of space left at the construction site to adjust more waste.

Figure 5: Construction waste management in campus

Methodology

The goal of this project was to evaluate waste management practices in IIT Mandi and provide recommendations for improvements. To complete this mission, for each type of waste generated in the campus, we:

1. Studied the prescribed guidelines.
2. Interviewed the relevant officials and workers.
3. Conducted a satisfaction survey

Researched best practices.

Studying Prescribed Guidelines

Our first step was to study the prescribed government guidelines [4] [5] and build our knowledge of common waste management practices through online research and reading books. We each selected a type of waste and researched all necessary procedures to be used to safely and efficiently manage it. We documented these procedures and guidelines. This activity was helpful during interviews with officials as we had a firm grasp on the topic. We were able to ask relevant questions and get the answers we required instead of shooting in the dark. It led to a significant reduction in interview time, where others would take an hour or more we needed about half the time to get the same information from officials.

Interviewing Officials

We drafted a questionnaire to use while interviewing officials. We interviewed Mrs. Lishma Anand who is a member of the green panel since its inception. We also interacted with Col. Devang Nayak who had been a member of the green panel.

We had informal conversations with the hostel sweepers and mess workers to know about their opinions about the current waste management system and gain additional information. To gain an insight into the working of the STP, we interviewed Mr. Atul Sain who is the junior engineer at the STP. We interviewed the construction contractor to know more about the waste generation and disposal in North campus. We also talked to some construction workers and security guards to know about the waste disposal methods being employed and their views on them. We interviewed the nurses and doctor stationed in the medical unit, South campus to know how the medical waste generated is disposed of from the campus.

We also had informal conversations with some local people living in Salgi and Kamand villages to know their perception of the impact IIT Mandi is having on the environment as they too are important stakeholders.

Satisfaction Survey

We conducted a general survey among the students, faculty, and staff. The campus residents are a major stakeholder that may be affected by inefficient or improper waste disposal practices. Hence we thought it is important to know their opinions on the waste management techniques being conducted here.

We circulated a Google survey form among the students which comprised of general multiple choice questions. We also made a separate survey for the faculty and staff to know their views on the topic. The faculty survey had some subjective questions. We conducted door-to-door surveys among the faculty and staff households.

We collected data from 45 faculty & staff households and 180 students.

Best Practices

We searched for the best practices to tackle waste in various countries and institutes in developed countries. Since our institute experiences 3 winter months with low temperatures, the focus was more on studying about countries having similar weather and temperature conditions. Some countries that we shortlisted were - U.S, China,

Germany, and Sweden.

Investigative Study

We also decided to rely on personal observation to understand the methods of waste management being employed in the campus. We targeted the messes, canteens to see how they were throwing away their waste. We also observed the pickup vans to know about the segregation methods they were using, if any. We also observed the construction sites in North campus and found where waste gets collected and then disposed of.

Results and Discussion

Results

This section discusses the results based on the collected data and the surveys conducted by us. The final recommendation and conclusion are given by analyzing these results.

Segregation practices at household

Based on the data collected from the campus households, we saw that all households at IIT Mandi completely segregate their waste (figure 6).

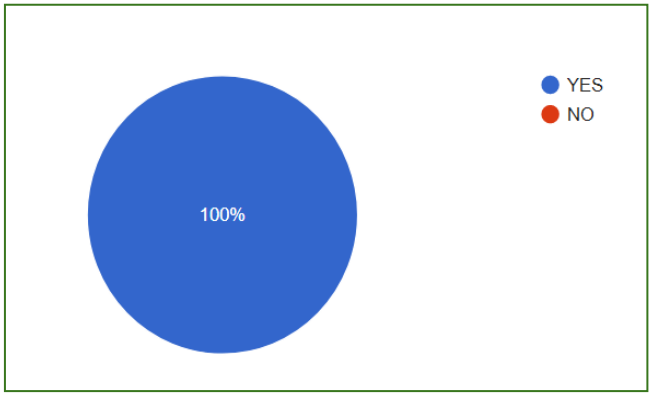


Figure 6: Segregation of waste (households)

Segregation practices at hostels

Based on the data collected from hostel surveys, we saw that 59.9% of students segregate their waste by themselves (figure 7).

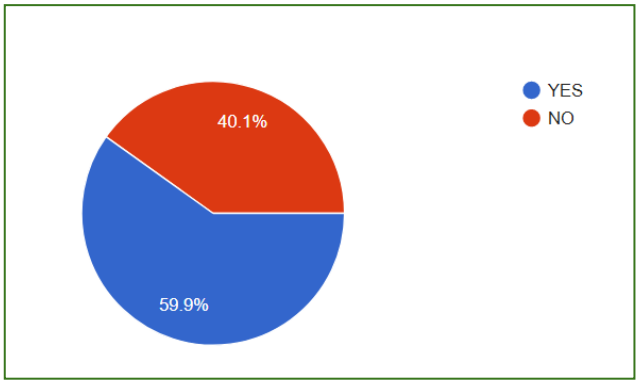


Figure 7: Segregation of waste (students)

Irregular collection of garbage in hostels

We also found the irregularity in garbage collection in hostels (figure 8). 17.6% of the students say that garbage collection is done every 3 to 5 days in their hostels. This leads to overflowing of the garbage bins. This causes the accumulation of flies around the bins and is also an ideal breeding ground for bacteria, insects, and vermin. Handling overflowing garbage can cause many infectious, chronic diseases to the waste collection workers as well since they do not use any gloves and masks during collection. We also found that there are some places on campus where the resident do not have the facility of daily waste collection (e.g. Garpa residents).

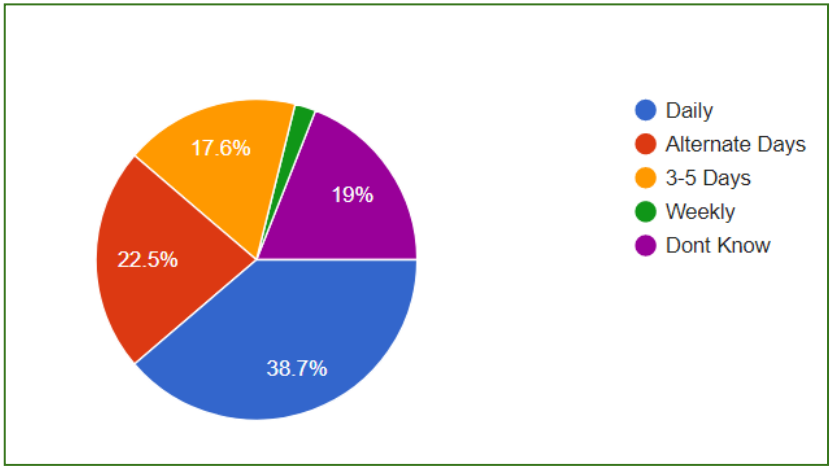


Figure 8: Current waste collection situation at hostels

Comparison between the number of responses for the survey by the faculty members residing in South Campus

Figure 9: Faculty apartments at south campus IIT Mandi

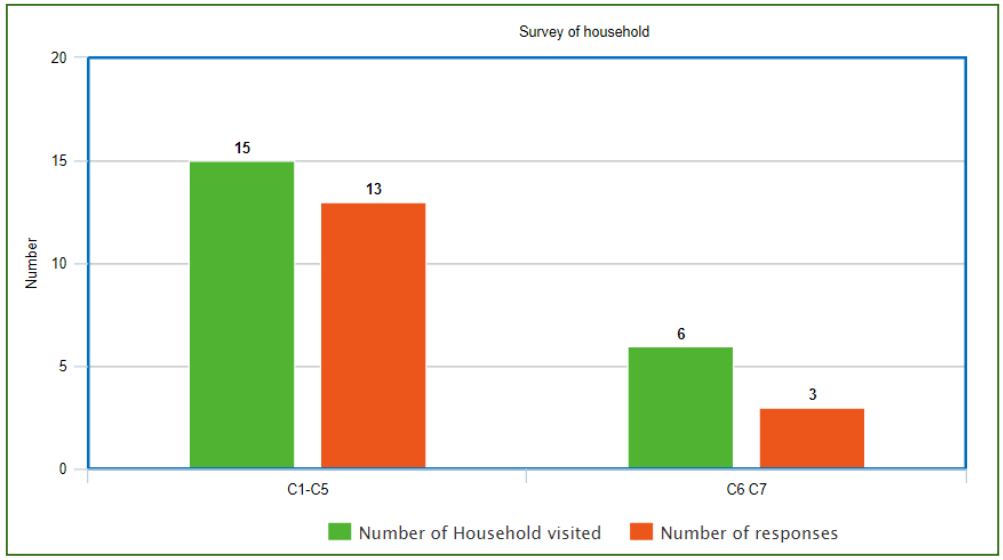


Figure 10: Number of Households visited VS Number of responses given at South campus IIT Mandi

We found that the percentage of respondents in C6-C7 blocks were less in number as compared to that in C1-C5 buildings. We inferred that this may be due to the spatial separation of C6-C7 from community bins. Since most of the bins are placed near C1-C5 blocks hence these residents might be facing the problems of waste dispersal more frequently than the residents of C6-C7 blocks.

Level of satisfaction of students in hostels and faculties in a household with current waste collection services

Through a satisfaction survey, we found that 74% of the students are satisfied to some considerable level with the current waste management situation of the campus. Out of these, 13.4% of the students highly satisfied having no problems with the current waste collection from the hostels. About 26% of the surveyed students were dissatisfied to some extent from the current waste collection services from the hostel.

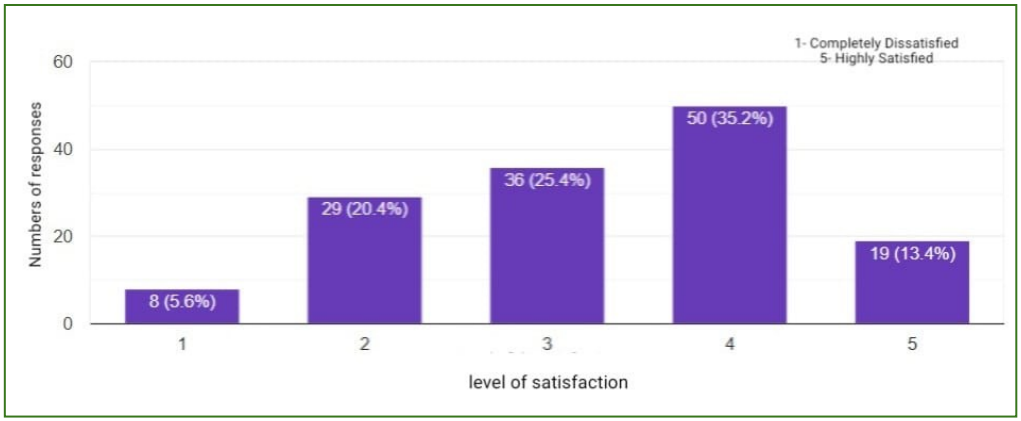


Figure 11: Satisfaction level with current waste collection services in hostels

Among the households (figure 12), we found that 86.9% of residents are satisfied to some extent. Out of these, 43.5% of the residents are highly satisfied and have no problems with the current waste collection practices. This figure is very high when compared to the students living in hostels.

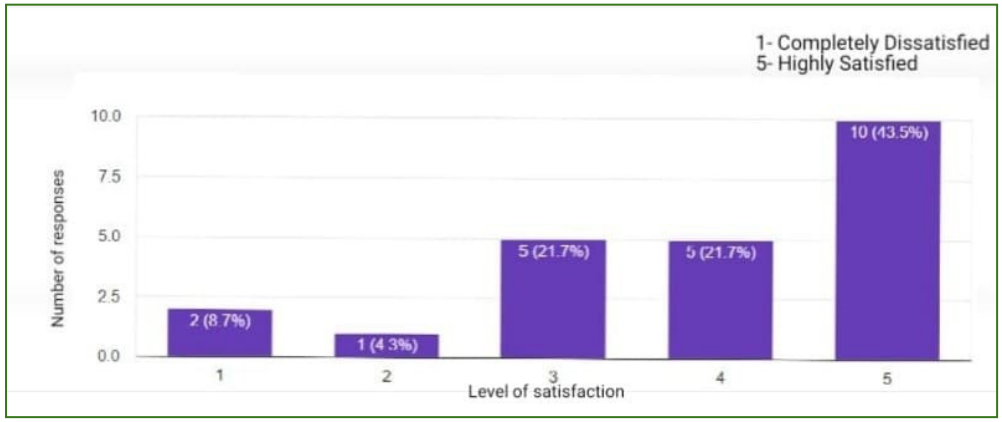


Figure 12: Satisfaction level with current waste collection service in households at South and North campus IIT Mandi

Problems with current solid waste management in the Institute

Based on surveys conducted in hostels and households, we are able to highlight the major problems related to improper solid waste management in the campus. Waste lying around the campus is seen as a problem by 40.7% students and 47.8% households. We observed that the waste collected in bins is being dispersed by the stray animals as the lid of the bins is open most of the time. It could also be dispersed due to improper waste collection practices from the bins. Flies that are attracted by the waste are considered as a problem by 42.9% students and 21.7% household people. The odor is another major problem and makes it difficult to even walk through the area having waste laid around. Rats are considered a problem only by 2.1% of the students and 13% of households.

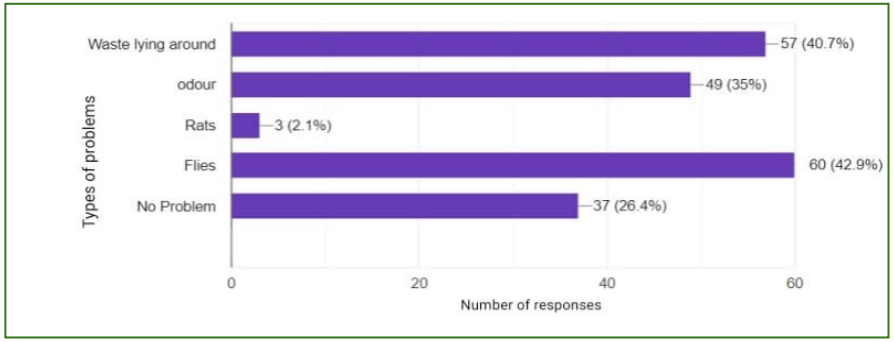


Figure 13: Problems in current solid waste management (students)

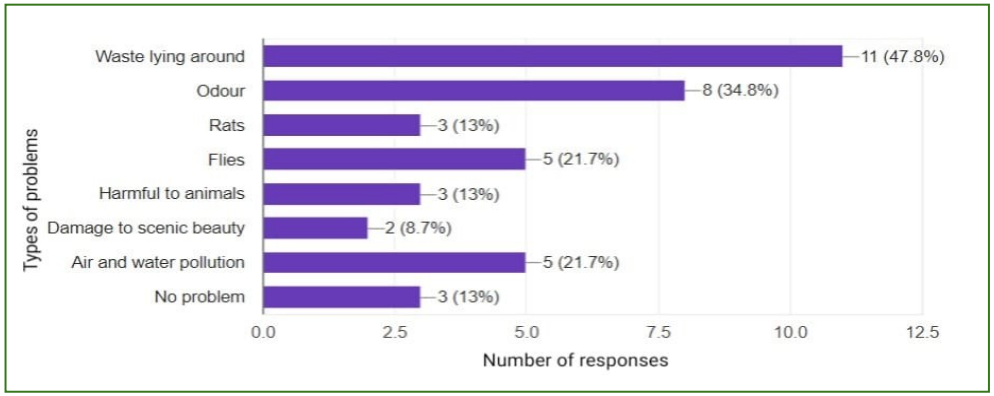


Figure 14: Problems with current solid waste management (households)

Discussion

After interacting with the households we found that there is a door to door collection service provided to the apartments every day which takes away the already segregated waste in two categories of organic waste and inorganic waste. The organic waste gets dumped in the pit near the medicinal garden and the inorganic waste goes to the green community bins and to Mandi thereafter. After personal interaction with students in hostels, we found that some of them do not follow segregation practice as they think it is eventually going to get mixed up with other types of waste so segregation is unnecessary. This partially segregated waste goes to the green community bins and attracts cattle, dogs, and monkeys which spread the waste around the bins in search of food. The accumulated waste near the bins invites flies, rats and also creates a bad odor. It poses a threat as a source of diseases and is thereby a problem for the local residents and the people passing by. Some of the student hostels do not have regular waste collection services which cause a problem like overflowing bins, flies around the bins and bad odor making the place unhygienic and dirty due to which people, though small in numbers are not satisfied with the current waste collection services.

One of the current major problems in institute waste management is the humongous amount of food waste generated in the messes every day. After interaction with the people transporting the waste, we found out that most of the mess food waste is dumped in the pit near the medicinal garden. Additionally, some of the food waste is fed

to the biogas digester used for making biogas and manure.

In the given duration of around six weeks, we conducted some surveys of household people and students living in our campus based on which we generated some pie charts and bar graphs and noted some trends in the waste generation in the campus which is mostly empirical. With surveys taken from different locations, our project intends to show the tendencies of waste production. Some more quantitative data could have been taken given more time which would have been more realistic and reliable.

Project Outcomes

The motto of this project is to recommend certain ways through which waste management practices in IIT Mandi can be improved. Accordingly we have provided some alternative methods according to their respective waste. These methods will be provided to the Green Panel of IIT Mandi and all the stakeholders. Therefore, all the stakeholders should follow these guidelines to improve waste management practices in IIT Mandi.

Following guidelines are recommended according to the respective waste:

1. Municipal Solid Waste(MSW):

Conducting a waste awareness program during 5WIP

Most of the students are not aware of waste management practices implemented in IIT Mandi. There should be a session dedicated to waste management execution in 5WIP (5 Week Induction Program). This will assist the newcomers to become more responsible to manage their own waste.

Training of waste collection members

We went to faculty houses in the morning to get a glimpse of the waste collection workers. We found out not even a single worker wore mask and gloves. This type of practice is not good for their health and also the people around them. Hence, there should be proper training of waste collection workers as well as providing them the proper equipment.

Segregation awareness posters

Putting posters with essential informations will help the students to segregate the waste by themselves,posters should contain images rather than words so that it is easy to differentiate the waste before disposing it.

Figure 15: Recycling Bin posters

Sanitary napkin incinerators

Due to the accumulation of menstrual blood on sanitary napkins, bacteria multiply at an exponential rate which causes harmful diseases both to the workers and nearby students. That is why there should be a separate sanitary disposing machine installed on every floor of each girls' hostel.

Figure 17: Sanitary napkin incineration

Vermicomposting pit

There is a pit in the south campus where the biodegradable waste is thrown. But due to the absence of protecting net on the pit, monkeys come to the pit in search of food and eat waste products from the pit. Another problem is that the treatment of waste is done in the absence of worms due to which the waste rots and foul smell starts spreading in nearby areas. Hence, there should be a properly constructed and maintained vermicompost pit in IIT Mandi so that biodegradable waste can be treated in the campus itself.

Figure 16: Vermicomposting

More Biogas plants

In IIT Mandi there is a Biogas plant in South Campus near D1 mess which is used to decompose biodegradable waste. The combined biodegradable waste from both campuses is around 1000 kg per day. Therefore, more Biogas plants need to be installed.

2. WASTEWATER:

Replace Ozone treatment unit

From our visit to the Sewage Treatment Plant, we learned that the Ozonator used for ozone treatment is broken and is not working. So, for better treatment at the STPs, the Ozonator should be re-installed. Because of its excellent disinfection and oxidation qualities, ozone is widely used for drinking water treatment. It is recommended to use ozone for pre-oxidation, before a sand filter or an active carbon filter (GAC). After ozonation these filters can remove the remaining organic matter (important for final disinfection). Ozone treatment also helps in the degradation of pesticides.

Pesticide	pH 7,2; 5 °C; O_3/DOC = 1,0	pH 7,2; 20 °C; O_3/DOC = 1,0	PH 8,3; 20 °C; O_3/DOC = 1,0
diazinon	86	92	92
dimethoate	97	97	97
parathion-methyl	85	91	91
diuron	91	95	98
linuron	67	81	89
methabenzthiazuron	78	90	94
metobromuron	83	91	94
MCPA	83	87	90
MCPP	91	93	93
chlortoluron; isoproturon; metoxuron; vinclozolin	> 99	> 99	> 99

Figure 18: Table showing the percentage of pesticides that can be degraded by the ozonation process

Pesticide concentration before ozone treatment and after ozone treatment:

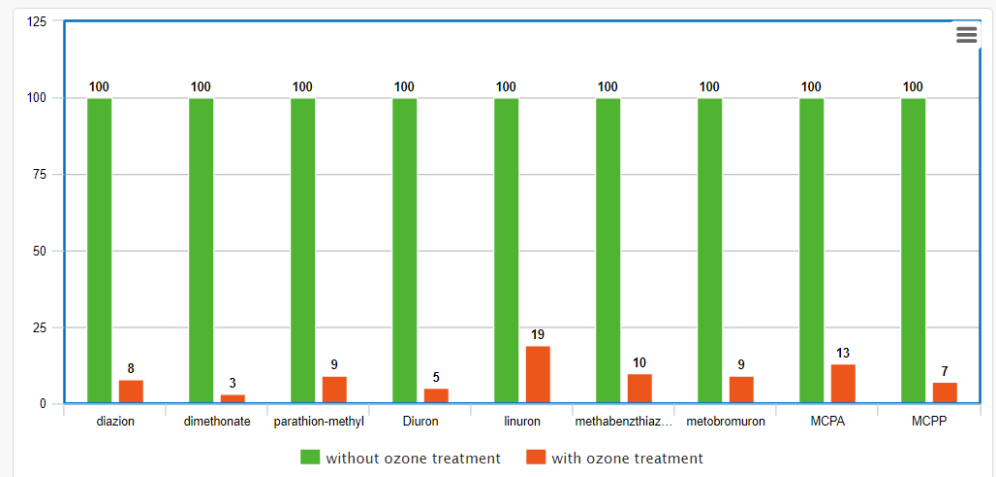


Figure 19: In the x-axis name of pesticide and in the y-axis percentage of pesticide in the water sample

From fig. 19 we can see that after treating water with ozonation concentration of pesticides decreases by sufficient amount. For example, after ozonation percentage of diazinon decreases from 100 to 8. This means that there is a decrease of 92% diazinon in a water sample. Thus we highly recommend ozonation in IIT Mandi.

Adoption of Berkeley Treatment Processes

Water 4.0 Technology[6]

Even after sewage treatment plant there are certain hormones that are present in urine that do not break up. In order to remove them the treated water is pumped into wetland ponds. But in these natural wetland ponds, algae and other aquatic plants come to the surface and block the sunlight from falling upon the water. Thus decomposition becomes slow.

To speed up this, Sedlak and his colleagues designed open wetlands. In these artificial
wetlands they placed sheets of plastic which line the bottom of the man-made ponds, preventing aquatic plants from proliferating.

The water gets blasted by sunlight, which breaks up the most compounds, he says. As a side benefit, algae and bacteria grow on the plastic liner beneath the ponds and degrade otherwise-resistant chemicals.

TDS Machines installation at STPs

Another useful recommendation that could be implemented at Sewage Treatment Plants of IIT Mandi is the installation of machines that could measure Total Dissolved Solids (TDS) in the water sample. As of now, we don't have TDS machines at STPs so the water is tested for TDS in the laboratories. This test is done in uncertain intervals which affects the accuracy in the measurements. Thus, there should be installation of TDS Machines at the STPs for accurate measurements in the particulate matter present in the water sample.

3. CONSTRUCTION WASTE

1. Make a plan of the project anticipating the types and amount of the waste generated and take measures for the same.
2. Regular transportation of construction waste can be implemented.
3. Paper, cardboard, and wood must be recycled and not to be burned in open.
4. Strict application of legislation.
5. Provide workers with some incentives for their good waste management practice

Figure 20: Incineration done in open

Conclusion

After analyzing waste management at IIT Mandi including both North and South campus, we came up with ideas that can be implemented in campus based on our data. We conducted the surveys for both students and faculty members to get the ideas of current waste management practices. We also interviewed the members of Green Panel, mess workers, sweepers and campus administrations which helps us to conclude the best recommendations for waste management in campus that can be implemented in future. We recommend awareness programmes for new students on campus regarding waste management during the 5-Week Induction Programme (5WIP) and training of waste collection workers to help them segregating the waste after wearing proper gear (gloves, masks etc). We will present these recommendations to the administration and the Green Panel and hope that they will implement these recommendations and thus improve the current waste management system of IIT Mandi.

Acknowledgements

There are many people who are to be acknowledged and thanked for the successful completion of this project. Firstly, we would like to thank our mentors Dr. Satvasheel Powar, and Dr. Dericks Shukla for their crucial inputs without which this project would have lacked some serious aspects. We would like to give our special thanks to Dr. Suryaprakash Upadhyay for his support throughout the project, his inputs during the meetings, and for his help to draft the questionnaires. We would also like to acknowledge and thank our Teaching Assistant, Ms. Sonika Bagga for her constant support throughout the project. We would like to thank Dr. Devika Sethi for giving us the opportunity to be a part of this course and project. Finally, we would like to thank the members of the Green Committee, all the workers in the messes, STPs and construction sites for giving us insights about the waste segregation, collection, and management.

References

[1] https://www.downtoearth.org.in/blog/waste/india-s-challenges-in-waste-management-56753

[2] https://timesofindia.indiatimes.com/india/75-of-municipal-garbage-in-india-dumped-without-processing/articleshow/65190477.cms

[3] https://www.epw.in/engage/article/institutional-framework-implementing-solid-waste-management-india-macro-analysis?0=ip_login_no_cache%3D6ef3e1f7fc8c9873f6331c9674402074

[4] http://www.moef.nic.in/sites/default/files/SWM%20Rules%202015%20-Vetted%201%20-%20final.pdf

[5] http://www.idfc.com/pdf/report/2011/Chp-20-Municipal-Wastewater-Management-In-India.pdf

[6] https://phys.org/news/2016-05-40the-revolution-urban.html

Fig. 9 https://www.google.co.in/maps/@31.7830163,77.0046259,3059m/data=!3m1!1e3

Fig.15 https://www.google.com/search?q=bins+poster+with+information&client=firefox-b-d&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiD8ffvxt_hAhXMuY8KHTt8B6YQ_AUIDigB&biw=1408&bih=688#imgrc=Ya6B1vuseppgTM:

Fig.16 https://www.google.com/search?q=vermicomposting+pit+images&client=firefox-b-d&source=lnms&tbm=isch&sa=X&ved=0ahUKEwju7L_jrt_hAhWIqo8KHTA3CYkQ_AUIDigB&biw=1408&bih=688#imgrc=Bxo1Wq2iEPmOGM:

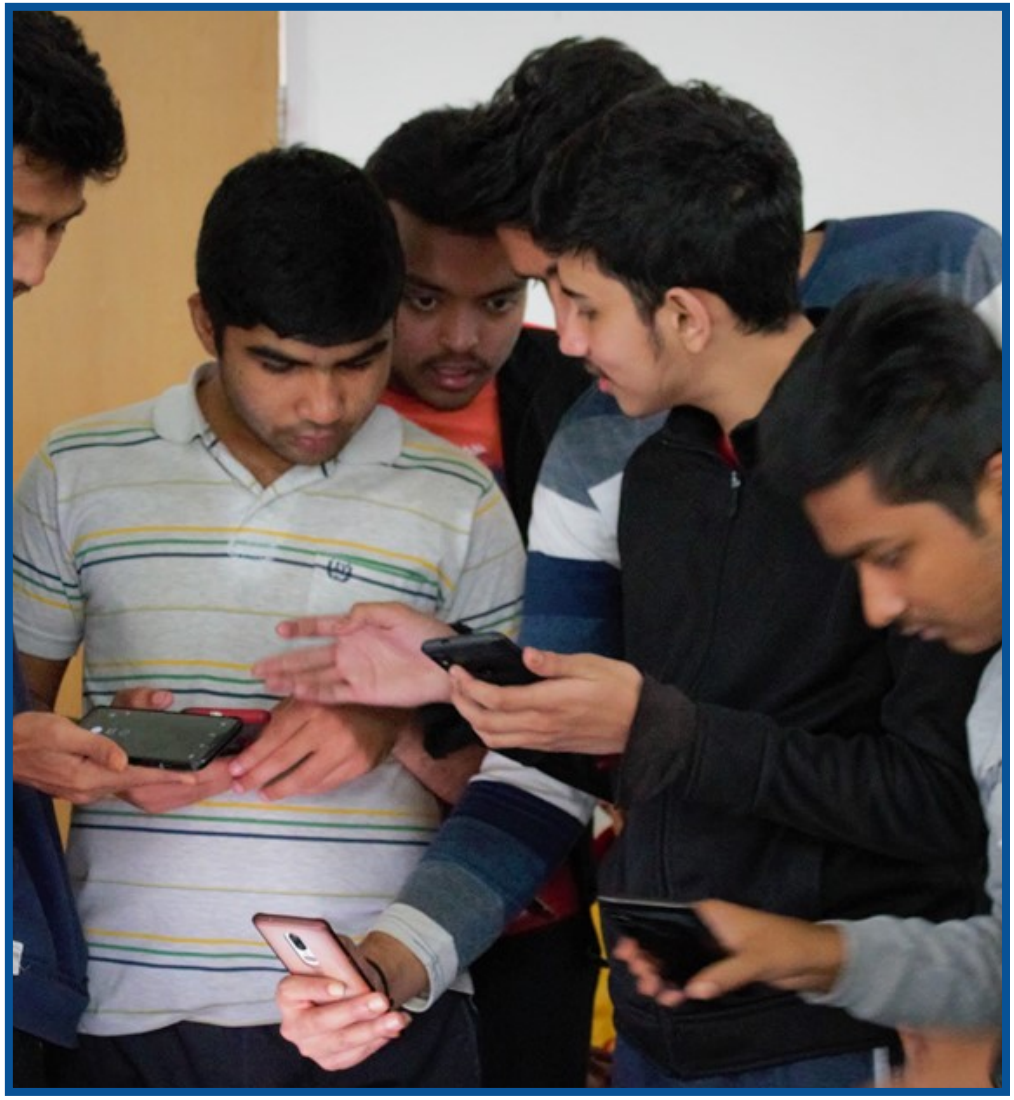
Fig.17 https://www.google.com/search?q=sanitary+disposing+machine&client=firefox-b-d&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjBlLK54t_hAhUci3AKHSeVBDkQ_AUIDigB&biw=1408&bih=688#imgrc=TvgByO241QV2jM:

Fig. 18 & Fig. 19 https://www.lenntech.com/library/ozone/drinking/ozone-applications-drinking-water.htm

IIT Mandi Campus March, 2019

Pic: Lynne Moore

Assessing Technology as a Tool in History Education



Abstract

STEM Students in India reflect a global pattern of STEM students lacking interest or comprehension of humanities subjects, specifically world history. This project assessed the feasibility of using technology to augment world history lessons. The current use of technology for students and teachers was assessed with interviews and surveys on the IIT and Vallabh campuses. Derived hypotheses were tested in class-room testing. The results of this study can be used to inform further study into the use of technology to streamline learning styles in an Indian educational set-ting.

Team Members

Oliver Brochu
Zachary Emil
Luke Ludington
Vishal Mahar (B16150),
Gagandeep Sing(B16095),
Rocky Verma (B16141)

Advisors

Dr. Rajeshwari Dutt
Dr. Gbeton Somasse
Dr. Ingrid Shockey

History deserves a space in STEM education

Historians are often asked about the benefits of a deep understanding of world history (Corfield, 2008). It can seem arcane and inconsequential that the start of World War I was an assassination of a royal heir by a small revolutionary group, but it is illustrative of the idea that political actions have cascading consequences which have shaped the world and continue to do so. An educated and historically informed population is vital in creating a functional country that avoids repeating the mistakes of the past. Therefore, a complete education must include awareness of world history regardless of occupation, for the purpose of cultured and globally-minded population.

Despite its relevance, Science Technology Engineering and Math (STEM) students are not gravitating towards world history curriculum. The disconnect could come from a lack of student interest, or from less engaging styles of teaching history material. It is sometimes difficult to persuade students in STEM fields that learning history is important, as it often is not clearly shown how it directly benefits STEM careers. However, having a greater understanding of how the world works and has worked "opens us up to a fuller range of ways to both improve the world and find our place in it" (Ferro 23, 2011). The fourth United Nations Sustainable Development Goal of providing quality education aims for "promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development" (Education - united nations). History education is how appreciation for culture and a global mindset is achieved.

A challenge in this project was how the process of learning world history can be more appealing to STEM students. A study of undergraduates in the UK evaluated more deeply the educational motivation of STEM learners. Of the subjects, 72% chose a STEM major intrinsically, meaning they had a strong curiosity or true love for their degree. Conversely, 58% of students from the same sample chose to learn humanities for extrinsic motivations, meaning that their reasoning was based on the wants and needs of other people (González-Becerra, 2017).

Understanding History Education

This project engaged students at two college campuses in Himachal Pradesh, India. Using tests and interviews, we tested if technology would make incorporation of visuals and interactivity more seamless (Harvey, 2010). In particular, visually-based learning modules can be created and adapted to existing technological devices such as projectors, smart phones, or laptops in the classroom. STEM students could be taught important concepts of world history in a more interactive and visual manner, while enhancing the ability to teach vital concepts. Therefore, the goal of our project was to assess the feasibility of developing a technologically enhanced visually attractive platform for teaching world history to STEM students. To achieve this goal, we identified 3 objectives: 1. Confirm preferred learning strategies for STEM students; 2. Assess access, familiarity and interest in technology platforms; and 3. Determine if familiar technology can be used to enhance learning. The completion of these objectives helped us to determine the feasibility of using a tech-enhanced platform for STEM students.

The drive for technology-based education

India is heavily invested in STEM education. As one expert noted, "India has one of the largest higher education systems in the world" (Kumar, 2011, p. 40). Furthermore, amongst Indian higher education, the IITs are "premier engineering and technology universities" (Cheney, 2006, p. 24). The students that attend these universities are among the primary stakeholders for this project, as they are STEM students that can benefit from broad perspectives. Many STEM fields focus on solving problems, so it is important that the students take a socially conscious approach to these problems. This means a grasp of cultural context and historical connections.

Leveraging how STEM students learn

Our preliminary research showed that STEM students learn differently than students of other majors. The concept of learning styles says that certain people can absorb knowledge better depending on how it is conveyed. While there isn't an agreed upon set of such styles, studies have shown students tend to have a preference for how they are taught, often

depending on their field, for our purposes we will refer to these preferences as learning styles.

One study showed undergraduate STEM students performed better on average when taught in a "collaborative, simple problem solving" environment than in a textbook based environment (Pazos, 2010).

One study by a mechanical engineering class at Northern Illinois University was designed around the use of a video game to teach numerical methods (Coller & Scott, 2009). The students used mathematical concepts learned in the class to create algorithms. This case study tested student engagement and interest in the course material using a video game seen in Figure 1. The subjects were given an incomplete video game program and asked to complete it with their own code. About half the subjects took the game-based version of the course, the other half in traditional lecture-based classes. The subjects were surveyed on how many hours were spent out of on each subject which can be seen in Figure 2. It can be seen that the game-based course had the most time spent on it outside of class on average, suggesting the integration of games provoked a deeper interest in the course.

Figure 1: Images of game used in Northern Illinois University study (Coller & Scott , 2009)

The results of this case study yielded that video game-based learning amongst engineering students taught the same key concepts as traditional lectures and exceeded traditional lectures in teaching concepts on a deeper level of engagement. Incorporating the video game into classwork and projects switches the purpose of learning from high grades to exploring a real-life application of material (Coller & Scott, 2009). Because the goal of history courses is to develop connections of

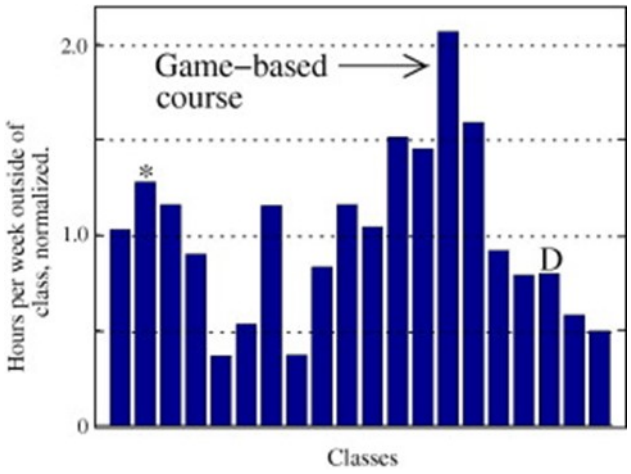


Figure 2: Effects of game-based learning on student engagement (outside of class)

the topics and the real world deep, making history subjects more tangible helps STEM students by appealing to a hands-on approach and making history subject seem more interesting and real.

Use of apps in the history Classroom

In experimenting with using technology to teach, we found that teachers use mobile apps in conjunction with their lessons on social studies and history. One study recorded history teachers' perceptions about a variety of hand selected apps that they used in their classes. Six apps were featured, and the report described their classroom application and the positive and negative feedback of the teachers (Waters, Kenna, & Bruce, 2016). Three are described in greater detail here.

The first app, called Explain Everything, facilitates the presentation of materials by allowing a teacher to display all kinds of content on the screen of an iPad. This "virtual whiteboard" takes the place of a PowerPoint on a projector while recording the teachers voice and the lecture itself. Within the app, students can also read and mark up items such as historical texts, as well as record and share their thoughts on certain topics. This app received positive feedback from teachers because it can

replace expensive equipment such as smartboards, and it is also helpful in keeping students up to date if they are absent.

Next, Aurasma is an app that gives the user the ability to create their own virtual reality (VR), which could be helpful in presenting world history in a new media format. This app received mixed reviews amongst the participating teachers. On the one hand, it took a long time to create a VR, and the result was not always worth the effort they put into it. On the other hand, when the students worked in groups to create their own VR, the class was highly engaged and enjoyed the lesson.

Finally, Class Dojo is an application that tracks the social interactive behavior of students using a points system. This could be incorporated into a history curriculum to mediate student collaboration in group projects. This app received poor reviews from teachers because the students became fixated on receiving points, which undermined the learning environment. One aspect of this app that the students enjoyed, however, was creating an avatar to participate in the class (Waters et al, 2016).

Apps like these have the ability to provide a teacher more freedom and power to teach by expanding the resources in a classroom. It is important to note that an app is only as effective as the teacher and class is able to make it. In the right application, technology can be an extension of a teacher's natural ability to lead a classroom, allowing them to present enriched and interactive modules based on the same core concepts.

Use of other platforms to teach history

In addition to apps, there are platforms that can be used to enhance learning outcomes for history. These include more advanced virtual reality (VR) experiences, including visualizations such as Geographic Information System (GIS). GIS is software that expresses statistical data on geographical maps (Knowles, 2008, p. 2). Visualizing history from a physical and geographical perspective can be difficult from plain text. GIS has an added advantage with regard to static maps in that it can be interacted with, updated with new data, and customized. The University of Virginia's Center for Digital History created a project through GIS, The Valley of the Shadow Project, which compared social and economic data in The American Civil War. This was created with the goal to "make primary documents more accessible for research and teaching" (Knowles, 2008, p. 6). An image capture of the system in action can be seen in Figure 3.

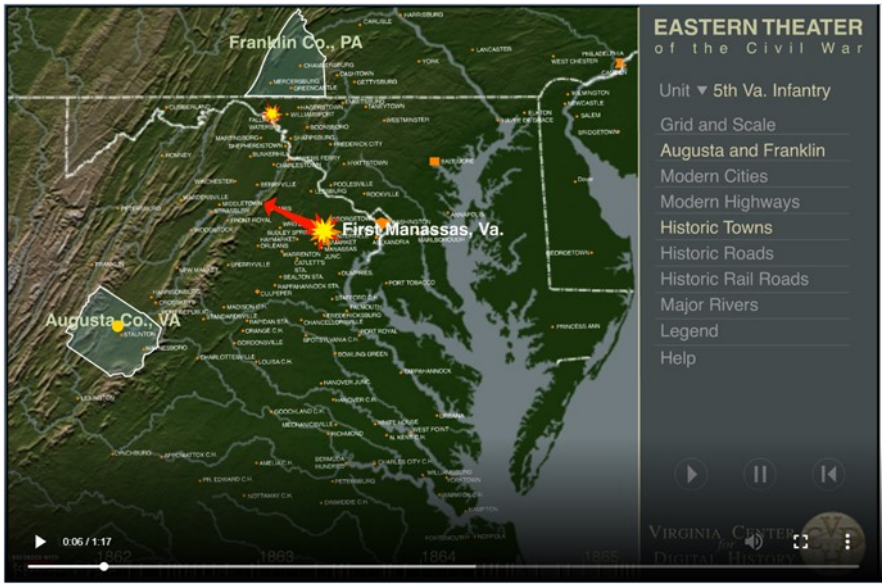


Figure 3: Valley of the Shadow GIS Video Archive (Valley of the Shadow)

Similarly, VR can be used to generate images, three-dimensional or otherwise, that gives the illusion of being in the location. ClassVR is an organization that provides VR hardware and apps made for use in education. One such collection of options is known as the History Times, a collection of wide-angle panoramic photographs of various historically significant sites (School VR subjects , 2018). Using VR headsets in conjunction with these images allows the user to feel as though they are in a different location or time period, which can add to their intrigue and emotional investment in the history subject.

Indian STEM students in secondary-to-higher education are already making use of technology as an educational supplement. For example, "the Ministry of Human Resources Development, Government of India launched the 'National Program on Technology Enhanced Learning (NPTEL)' in the year 2003. The aim of the NPTEL is to develop

based video lectures and web courses to enhance the quality of engineering education in India" (Kumar, 2011, p. 42). Most STEM students are already well acquainted with this system. For example, "7 IIT's and Indian Institute of Sciences (IISC) have worked together to develop web and video-based material. Around 110 video lectures (Approximately 4500 hours) courses were available" (Kumar, 2011, p. 42). Furthermore, a study in 2015 found that "around 70% of … Indian students currently own a Smartphone" (Bandi, Bose, & Saxena, 2015, p. 90). These facts in concert tell us that Indian students are comfortable with technology and that it is a viable medium to augment visual and problem-solving education.

In sum, STEM students can be encouraged to engage with history by leveraging learning styles and personal interest, both of which have the potential to be addressed by the augmentation of technology. We have found that technology can be an effective tool for teachers by providing new ways to engage students and convey information. We also found that any addition of technology is not to be a substitute for teachers and their skill, but an extension of it, meaning that an effective lesson plan and implementation are still crucial.

Data collection and Analysis

The goal of this project was to assess the feasibility of a technologically enhanced platform for teaching world history to STEM students. The objectives were as follows:

1. Confirm preferred learning strategies for STEM students.
2. Assess access, familiarity and interest in technology platforms.
3. Determine if familiar technology can be used to enhance learning

To achieve these objectives, we used surveys, user testing, and interviews of the targeted STEM students, history professors, and education experts. Figure 4 summarizes the approaches used by objective.

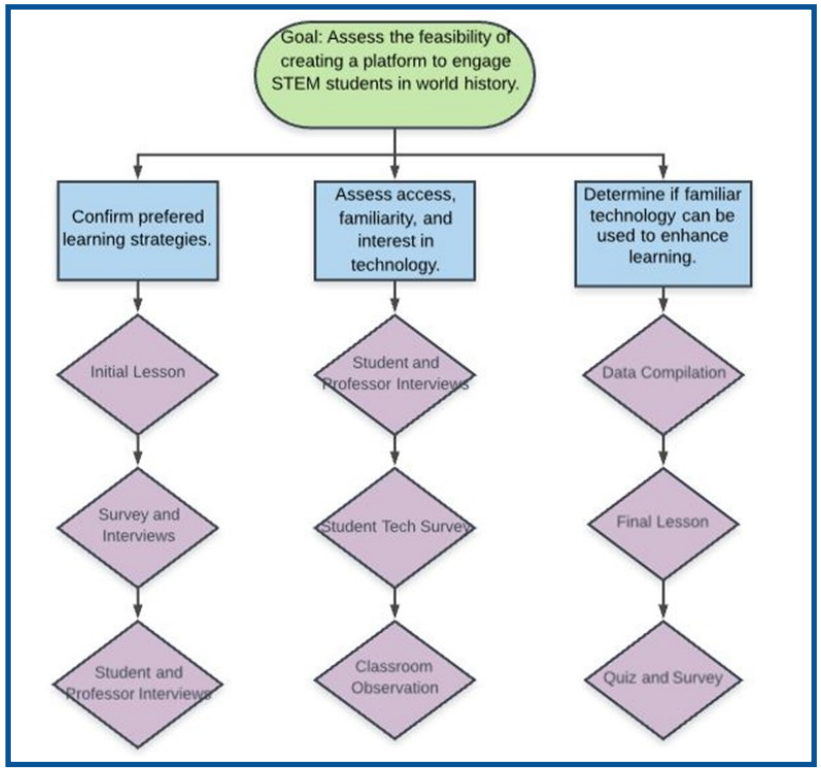


Figure 4: Flowchart for Methodological strategies

Objective 1: Confirm preferred learning strategies

Our prior research indicated that STEM students prefer visual and collaborative lessons as opposed to reading and lectures. To assess the preferred learning styles of STEM students we created sample lessons (one visual and one collaborative) and tested them on STEM students. This was done to confirm that preferences of our student sample at IIT Mandi was congruent with findings from the literature. Students were asked about what they thought about the lessons as compared to classroom formats they normally receive.

To administer the modules, about 20 students were given a QR code which linked to a 1-page reading exercise on the topic of Manifest Destiny during the Westward Expansion. This topic was chosen because the sample population was unlikely to have previous knowledge of the subject that would have affected results. Once they finished the reading,

students were split into 2 groups. The first group was shown a video discussing the painting shown in Figure 5 below.

Figure 5: "American Progress" by John Gast, used in visual lesson.

The second group was given a collaborative lesson where they were asked to perform analysis on key terms from the reading as a team. After the experiments, all students were sent an electronic exit survey on their phones and 5 participated in additional in-depth semi-structured interviews to solicit their thoughts on the lesson. Additionally, we sat in on classes and took notes on class engagement and productivity from the students as well as the professor.

Objective 2: Assess access, familiarity and interest in technology platforms

To assess access, familiarity and interest to technology platforms amongst STEM students at IIT Mandi, we visited classrooms to observe use of technology commonly used by students and teachers, including smartphones, projectors, internet, apps, social media, and so forth. We also interview with students and teachers about their familiarity with technology. We interviewed for the viability of introducing new devices to the classroom, such as VR goggles. A survey was also shared with about 30 students at both IIT Mandi and Vallabh College to gain this information from students that we could not interview.

Objective 3: Determine if familiar technology can be used to enhance learning

Based on our findings from objectives 1 and 2, we narrowed our optimal technology platform. We performed a second classroom test on Dr. Rajeswari Dutt's history class, a subject of 55 students. We prepared and taught a lesson about the Corps of Discovery Westward Expansion Expedition, seen Figure 6. The class was studying Westward expansion but had not covered The Corps of Discovery, meaning data would not be affected by variation in prior knowledge.

A short video taken from the Internet was used to give a brief topic introduction. Next, the students were split into groups and asked to bring up a GIS website on their personal laptops or devices. This website contained a map of the United States with information, dates, and locations of key events of the Corps of Discovery journey. The students were given questions about the topic and were tasked with finding the answers by locating the relevant event. Afterwards, the students were quizzed for retention with a multiple choice quiz and tested for understanding with a short answer question. Finally, they were given an exit survey on their opinions of the lesson.

Figure 6: Administration of classroom test (pictured: Luke Ludington)

Results

Confirm preferred learning strategies for STEM students

This objective was achieved using the classroom tests, student interviews, and Professor interviews.

First, we looked into how STEM students prefer to learn. After a giving a basic lesson to a sample of 19 first year students at IIT, we asked them to fill out a survey. The results of the survey can be seen in Figures 7-9, where the statement is presented and an option of 1 (strongly disagree) to 7 (strongly agree) is given. The Y axis represents the number of people who chose that number.

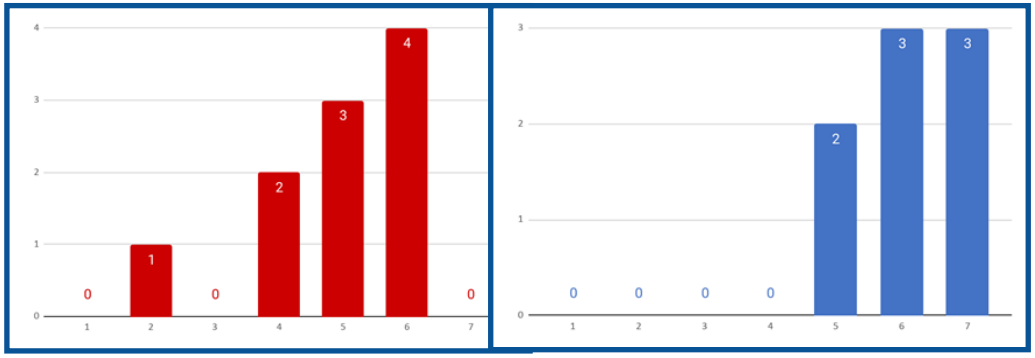


Figure 7: I would have liked more team interaction (Collaborative left, Visual right)

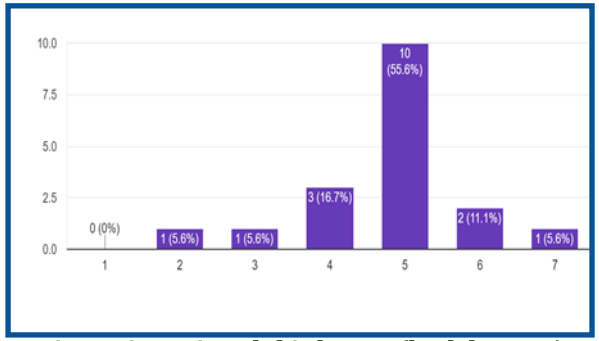


Figure 8: I enjoyed this lesson (both lessons)

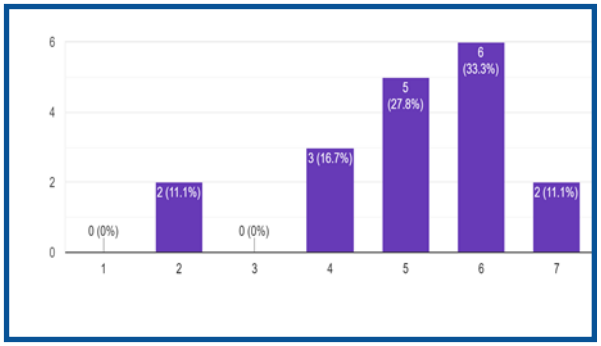


Figure 9: I want all my history classes to be like this (both lessons)

We then held interviews with 4 of these students, 2 from each group. Both lessons were well liked by the students. The students said they found reading text to be boring, with many telling us they were done before they had actually completed the reading. They said a video held their attention more and that the collaborative lessons were helpful in helping them grasp the concepts as seen by Figure 7.

We had semi-structured interviews with eight different professors, the outline questions of which can be found in the full report. The professors we interviewed taught a wide range of subjects including Mechanical Engineering, Economics, History, and Introductory English. All these professors primarily taught STEM students. One of the main points our interviews touched on was the learning preferences of STEM students. Most of the professors incorporated visuals and videos into their slideshows. According to them, visuals can explain certain concepts better than traditional lectures. They noted videos can hold the attention of students better than traditional lectures and are a useful tool. However, many emphasized a whole lesson could not be delivered through videos. About half the professors used collaborative or hands-on activities in their lessons. The professors used collaborative and group work to make sure all students understood the lesson, rather than as a learning style on its own.

For the STEM and technical courses, the most hands-on activities in classes consisted of working through a problem on the board and asking students to works through the steps with the professor. For the history professor interviewed, students were put in groups to discuss assigned readings.

Our interviews with students around campus gave us great information on the learning preferences and difficulties, as well as their general thoughts on the classroom environment with and without technology. The following results are a record of the interviews conducted with 13 IIT students (graduate and undergraduate levels), and 7 undergraduate students from Vallabh University in Mandi. We found that the students preferred a wide variety of teaching styles and had a strong connection with handwriting notes from a blackboard lecture. Visuals and collaborative exercises were recognized as compliments to the lesson, which they greatly enjoyed.

Access, familiarity, and interest in technology platforms.

During our classroom lesson, we noticed all students were competent in the use of smartphones, being able to read a QR code and look at the lesson on their personal devices--of over 100 students interviewed and surveyed every person had a smartphone, the most significant results of which are shown in Figures 10-12.

The answers concerning the use of technology in classes varied among professors. All the professors used the projector and PowerPoint presentations, while only some would supplement the lessons using their own technological devices such as a personal laptop. An issue most of the professors had with IIT technology was frequent power outages and loss of internet. They work around this by either skipping over the affected part of the lecture or use personal laptops to display presentations. Some professors incorporated student's personal devices into the classroom, such as mobile phones. However, others were against this idea, feeling it was either unnecessary or would be distracting.

Students, when interviewed, all said that they were already using their phones in their studies, whether to watch an educational video on YouTube or to look up a quick fact. The graduate students recognized that IIT has access to the best technology in India, and it is common knowledge that they must keep up with this ever changing area.

An unexpected issue that arose when observing classes is that students would become distracted by their phones during class, whether to browse social media, play games, or anything else that was not relevant to the class. When the topic was brought up in teacher interviews, The opinions were mostly unanimous. They observed that some students will become distracted by phones in class. It was more severe among humanities professors than those teaching STEM subjects. Few of the professors supported the idea of confiscating phones, claiming it would be an imposition, and professors felt students were mature enough to make their own decisions. Additionally, The distractions of cell phones in studies is only an issue with the undergraduate students, as the graduate students have a mature outlook on their classes, knowing how important their attention to the lectures is.

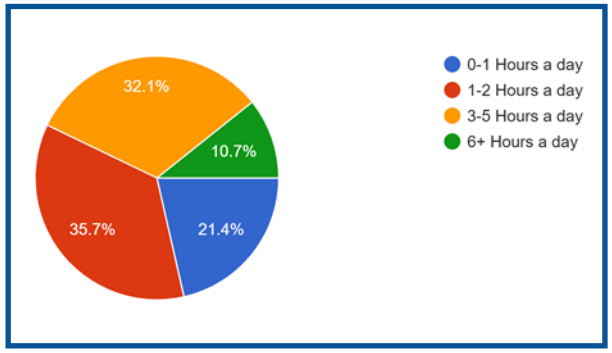


Figure 10: How much do you use your phone for academics

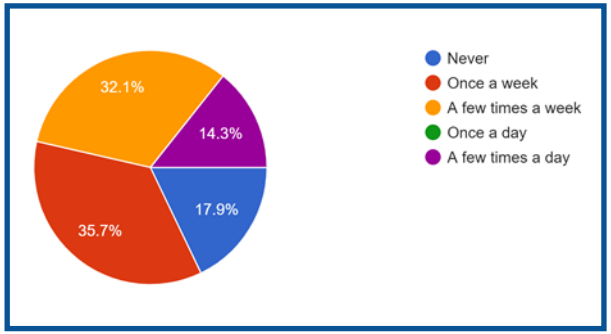


Figure 11: How often is classwork or homework delayed by lack of internet or power

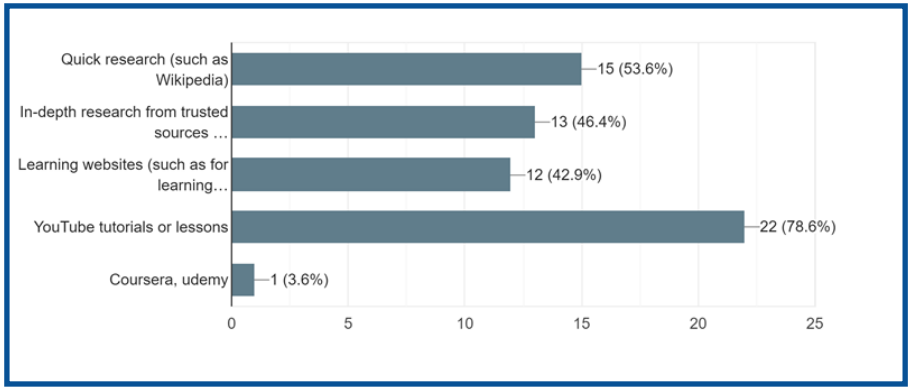


Figure 12: How do you use the internet for school

Determine if familiar technology can be used to enhance learning

About half the class came with a laptop. When they formed groups, typically of three or four, each had at least one laptop among them.

Every group successfully accessed the website within a couple minutes of writing the link on the board. Many students seemed initially unfamiliar with how the GIS site worked. However, they began to use it more fluently as class progressed. Because the majority of multiple choice questions were answered correctly, it can be concluded they learned how to use the system within the allotted time.

Some students began used outside sources to answer questions, such as Google or Wikipedia. While they were not explicitly told not to, they were encouraged to answer only what they could find on the map. Students worked on the test the whole allotted time with few exceptions. Out of the fifty students, only three or four were consistently observed being distracted by their own devices. On average, it appeared most students reached the last or second to last question, which was a short answer paragraph, but were unable to fully finish the quiz.

Most students opted to scan the QR code for the exit survey with their personal phone and finished quickly, the significant results of which can be seen in Figures 13-15. The survey was formatted similarly to the survey in the first test.

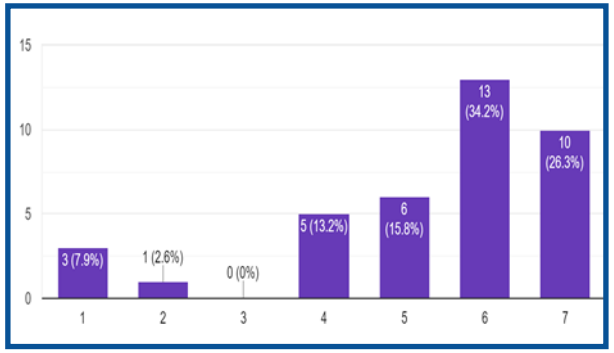


Figure 13: I enjoyed this lesson

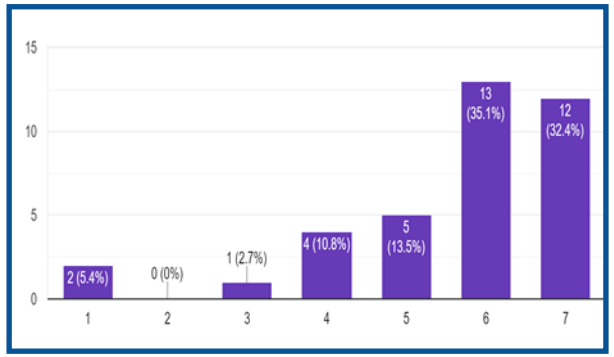


Figure 14: I better understand the geography of the Westward Expansion

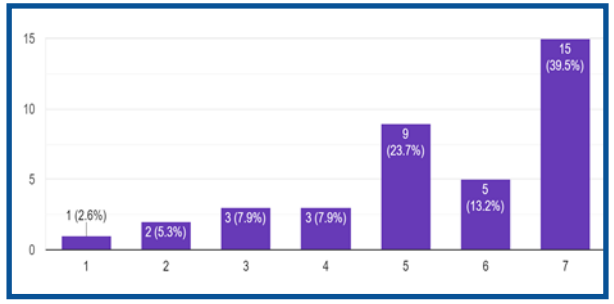


Figure 15: I found this more engaging than normal class

Additional findings

It was noted during the test that some students were uncomfortable speaking English, especially in front of Americans. All the professors noted that some students struggled with English, as it is usually not their primary language. When asked, none of them felt an electronic translator, such as a phone app, was a proper solution to this issue. Instead, they felt it was in the best interest of the student to be forced to become more proficient in English, as fluency will help them immensely in the rest of their lives.

When asked about their humanities courses, many of the undergrads said about half the courses they took were for personal interest and the other half they took due to requirements. The courses they were required to take they said they pay much less attention to and learn much less.

Discussion

First, it is common for students to use some form of technology to regularly enhance or support their studies. As seen in Figure 10, 79% of students surveyed use their phone for academics for more than an hour a day. This is mostly with the use of a smartphone to use an app or to watch a YouTube tutorial or explanation, as seen in Figure 12. Second, all the students recognized that IIT offers the most cutting-edge technology in all of India, and they try their best to use it to the fullest capability, especially the graduate students who need more intricate software's for their research. Third, and most importantly, there is a very strong culture of interpersonal connection that is a crucial aspect of the classrooms here, as seen in Figure 7. Discussions and collaboration amongst students and with the professors is what not only improves conceptual learning but makes the time in class and at a university worthwhile for the students. Technology is seen as a helpful tool in the classroom, but also one that makes the student more goal oriented and promotes individualism. Technology is a proper supplement for all lessons, but it is important to the students that it never replaces the interaction and friendship companionship that is so vital to the Indian school system.

From the exit survey for the second classroom test, we can conclude several things. First, students enjoyed the lesson overall as shown in Figure 13, which matches Figure 8 from the initial test. Second, they found it to be more engaging than normal class as seen in Figure 15. Finally, Figure 14 expresses that they collectively felt they better understand the geography of Westward expansion, suggesting GIS combined with problem solving can be useful for developing geographical understanding.

There seems to be a nearly universal agreement amongst all the students and professors involved in our project that STEM students at IIT, much like those in America, have a general preference for visuals and collaborative learning. However, we were surprised to find that many students at IIT struggle with English. This observation has additional implications for traditionally text-based learning in history studies. At the same time, professors prefer that student practice English and become fluent rather than use an external, technology-based translator, such as a phone app.

Limitations

Our project has several limitations that may have affected the results. First, our sample size was a random sample of college students from only two campuses. As seen in the differences between IIT and Vallabh, different campuses yield different results. A sample of a wider variety of campuses would have given more insight.

Another limitation was the fact that none of us were experienced lesson-givers. A major part of our data came from two sample lessons we gave. These lessons employed learning strategies that we theorized would be beneficial. However, the control group for these lessons were the students regular classes, which are given by experienced professors and are taken for a grade, rather than voluntarily. This could have easily skewed the results in favor of or against our lessons.

Quizzes and surveys were employed in the lessons to determine comprehension and retention, which were the main factors by which success was determined. However, because the classes were given to different sets of students, retention could only be tested over a period of a one-hour class. Testing for comprehension was also limited to a short answer questions, which was graded by us, who are not experienced graders either.

Project Outcomes

At the close of our study, we recommend a focus more on increasing visuals and collaboration in class rather than to simply adding technology for its own sake. Many of the people we talked to feared that technology would decrease the face to face interaction between teachers and students and felt that would be a detriment to learning. We have outlined our recommendations specifically applicable to lessons in Figure 16 below.

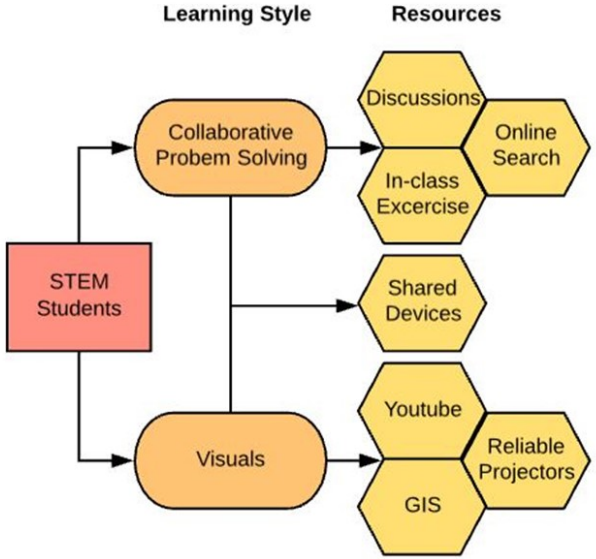


Figure 16: Learning styles and resource suggestions

Infrastructure

The use of visual aids by teachers in class was not impaired by knowledge or desire for visuals but rather it was their apprehension to the potential delays incurred by unreliable technology in the classroom. These intermittent and chronic issues ranged from power outages to inconsistent WiFi coverage throughout the academic buildings and as shown in Figure 11 affect as much as 82% of surveyed students once a week or more.

In order to increase the use of digital visuals aids via projectors (for which substitutes were rarely utilized) it would be beneficial for IIT to show teachers how to use the available uninterruptible power supplies (UPSs) and to extend their reliability and coverage.

We found little need for extensive additions for technology as many of those questioned seemed apprehensive to the idea of adopting a wholly new technology into their classroom as well as not seeing value in the effort required in implementing such a system. Importantly, the current technology infrastructure, in it's fully operational state proved to be completely conducive to enhancing the learning strategies which we found STEM students to prefer. In classroom testing students were regularly enthused with using their phones and laptops to perform the tasks that we asked them to and at no point were we limited by hardware in our implementations of our lessons. Students were comfortable viewing material on their phones with nearly 80% of students (Figure 10) already using their phones for schoolwork more than an hour per day.

Faculty options

Professors should find a manner of incorporating more visual collaboration in their classes rather than strictly incorporating more technology for its own sake. Rather than assigning a reading or talking about a topic for a time designing an interactive lesson engages students more. Technology should be seen as a catalyst for interaction rather than a replacement for class discussion and exercises. Tools such as GIS can be explored via shared laptops for creating circumstances that pushes students towards interaction.

Shared technology can be used to encourage collaboration. When students were given assignments in teams with shared laptops, students displayed normal team interaction.

Professor expressed concern that incorporating phones and laptops in class would increase the amount students were distracted by them, but there was no increase in technology based distraction between class tests using phones and those which weren't. Professors should not be dissuaded from using personal technology in the classroom for fear of distraction.

Conclusion

Existing technology can be utilized more than it already is to streamline learning styles particular to STEM students. This can increase in person interaction, achieving the goal of increasing the interest and comprehension of world history subjects. This approach was different from that which we assumed in the beginning and is not technocentric, but rather utilizes technology as a tool within a classroom and allowing students to take full advantage of the face to face interaction implicit in current teaching methods.

We also found that whatever technology is implemented needs to avoid being overly reliant on existing infrastructures, as they pose reliability problems that make professors apprehensive towards their utilization.

Acknowledgements

We would like to express our gratitude to the people who helped us during our time in India:

Professor Gbeton Somasse, IQP primary advisor
Professor Ingrid Shockey, IQP co-advisor
Dr. Rajeshwari Dutt, IQP sponsor
The IIT Mandi campus
The Vallabh campus
Rameez Raja Khan, Teaching Assistant

The reports in this book represent the work of WPI and IIT Mandi undergraduate students. For more information and to see the complete report, you may search using keywords or author at https://digitalcommons.wpi.edu/iqp/ or http://www.iitmandi.ac.in/istp/

Works Cited

Bandi, R. K., Bose, A. K., & Saxena, A. (2015). Exploring green IT awareness and adoption among Indian students. Proceedings of the 2015 ACM SIGMIS Conference on Computers and People Research, 87-96. Retrieved from https://doi.org/10.1145/2751957.2751964

Cheney, G. R., Ruzzi, B. B., & Muralidharan, K. (2005). A profile of the Indian education system. Prepared for the New Commission on the Skills of the American Workforce, Retrieved from https://www.ugc.ac.in/mrp/paper/MRP-MAJOR-EDUC-2013-25066-PAPER.pdf

Coller, B. D., & Scott, M. J. (2009). Effectiveness of using a video game to teach a course in mechanical engineering doi://doi.org/10.1016/j.compedu.2009.05.012

Corfield, P. J. (2008). All people are living histories – which is why history matters. Retrieved from https://www.history.ac.uk/makinghistory/resources/articles/why_history_matters.html

Education - united nations sustainable development. Retrieved from https://www.un.org/sustainabledevelopment/education/

Ferrero, D. J. (2011). The humanities: Why such a hard sell? Educational Leadership, 68(6), 22-26. Retrieved from http://www.ascd.org/publications/educational-leadership/mar11/vol68/num06/The-Humanities@-Why-Such-a-Hard-Sell%C2%A2.aspx

González-Becerra, I. (2017). Language learning among STEM students: Motivational profile and attitudes of undergraduates in a UK institution. The Language Learning Journal, 1-17. doi:10.1080/09571736.2017.1320421

Harvey, D., Ling, C., & Shehab, R. (2010). Comparison of student's learning style in STEM disciplines. IIE Annual Conference. Proceedings, 1-6. Retrieved from https://search.proquest.com/docview/734714838

Knowles, A. K., & Hillier, A. (2008). Placing history: How maps, spatial data, and GIS are changing historical scholarship ESRI, Inc.

Kumar, M. (2011). Impact of the evolution of smartphones in education technology and its application in technical and professional studies: Indian perspective. International Journal of Managing Information Technology, 3(3), 39-49. Retrieved from https://arxiv.org/ftp/arxiv/papers/1109/1109.0937.pdf P., Streitwieser, B., & Light, G. (2010). Small-group learning in undergraduate STEM disciplines: Effect of group type on student achievement AU - micari, marina. Educational Research and Evaluation, 16(3), 269-286. doi:10.1080/13803611.2010.520860

School VR subjects: Historical times lessons. (2018). Retrieved from http://www.classvr.com/school-curriculum-content-subjects/historical-times-lessons/

Valley of the Shadow: Two Communities in the American Civil War. VA 5th augusta-franklin video. Retrieved from http://valley.lib.virginia.edu/VoS/MAPDEMO/Theater/TheTheater.html

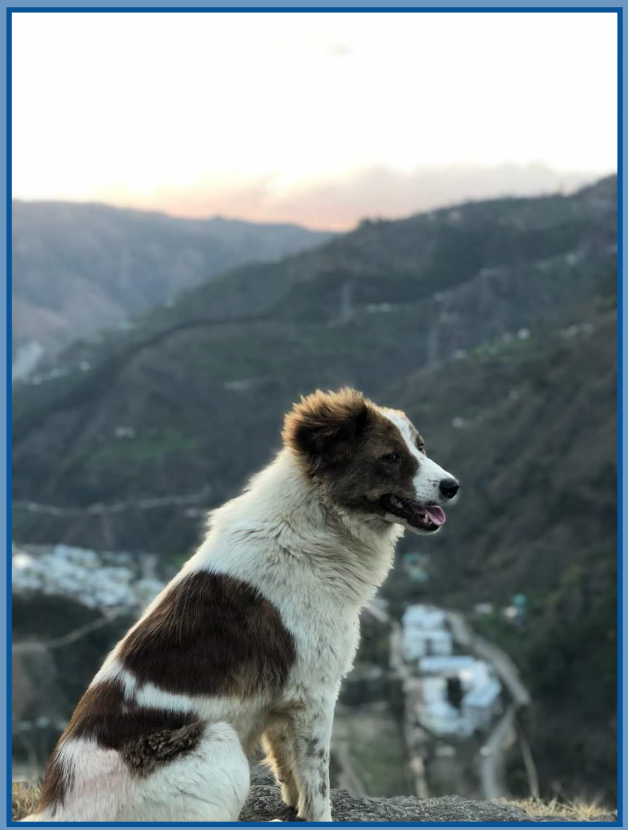
Waters, S., Kenna, J., & Bruce, D. (2016). Apps-olutely perfect! apps to support common core in the history/social studies classroom. The Social Studies, 107(3), 1-7. doi:10.1080/00377996.2016.1149046

View of South Campus from the Road to Mandi Town

Editor Acknowledgments

Thank you to the editorial team for putting countless hours into making this years IQP/ISTP final report booklet:

- Lynne Moore
- Jake Scarponi
- Jake Tappen
- Brandon Waugh



Picture Credits:
Surya Vadivazhagu