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Investigating Smart City Initiatives in Mandi Town, Himachal Pradesh

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Indian Institute of Technology Mandi

Investigating Smart City Initiatives in Mandi Town, Himachal Pradesh

An Interactive Qualifying Project

submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfilment of the requirements

for the degree of Bachelor of Science

by

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Abstract

A growing population and demand for services in Mandi has strained its surrounding environment and infrastructure. Utilizing a Smart City framework used nationally in India, this project identified promising features present in the city and determined potential future initiatives. We created a map of the local amenities and engaged residents and officials to highlight areas that could benefit from further development. Our fieldwork surveys and documentation identified potential areas for improvement in waste management and collection, parking spaces, road networks, and business centers. We proposed: (1) waste organization, separation, and collection, (2) city areas and processes for waste management, and (3) a multistory complex to alleviate congestion.

Executive Summary

The world's largest democracy, India, is projected to surpass China as the most populous nation by 2030. The growing population, coupled with urban migration stemming from recent economic growth, has resulted in globally reoccurring urban pressures in overcrowded Indian cities (Pakhomov, n.d.). In response to a growing metropolitan population, Indian Prime Minister Modi's administration created India's first national urban planning initiative called the Smart City Mission, with the goal to develop 100 Indian Smart Cities by 2020. The Indian government has tailored Smart City approaches utilized internationally to focus on the development of four pillars to mitigate the strain of urbanization. These four pillars highlight Institutional, Physical, Social, and Economic infrastructure (The Republic of India, n.d.). Steady growth in population, an increased demand on its infrastructure, and degradation of its environmental surroundings have made the city of Mandi in central Himachal Pradesh an ideal candidate for Smart City initiatives.

Our Approach

The goal of this project was to identify the Smart City features already present in Mandi and determine possible future actions to increase Smart City Initiatives within the city. We completed the three objectives, shown in Table A to accomplish this goal. Our methods blend both a physical site assessment and interacting with Mandi's residents to develop recommendations that will benefit all stakeholders.

Table A: Methodology

Objective	Tasks
Assessed the current state of the city by identifying and mapping its amenities and services.	-GIS Mapping of Mandi's Amenities
Engaged with local stakeholders to gain their insight on Mandi's current state and its future aspirations as a Smart City.	-Survey Mandi Residents
	-Interview Government Officials
Develop a pilot Smart City recommendation for a sector of Mandi.	-SWOT Analysis Assessment
	-Comparative Case Study

Our Findings

The data our team collected revealed overarching trends across all four pillars of infrastructure in the Indian Smart City Mission. The Social Infrastructure in Mandi lacks sufficient sit-down restaurants and greenspaces for its citizens to enjoy. We created a map to display the locations of 85 different dining amenities. Over 90% of these eateries are smaller juice bars, tea stalls or dhabas. The primary sit-down restaurants include only a few establishments: The House of Ming, Copacabana Bar & Restaurant, the Regent Palms Hotel, The Treat and Domino's. Also, there were only two green spaces in the mapped

sections of the city. Increasing the number of restaurants and green spaces could allow citizens of Mandi to interact and build stronger social connections.

The Institutional Infrastructure in Mandi has sufficient medical stores and pharmacies, but it lacks adequate hospital space and clinics to treat citizens. Both types of amenities are under the medical category in the ArcGIS map. In total there are 31 total medical amenities, with 29 stores and pharmacies stores and only two hospitals and clinics. These were the main Zonal Hospital and the smaller Sri Harihar Hospital. These two hospitals are typically overcrowded, and the addition of another medical center could help alleviate some of this pressure from Mandi's citizens.

Figure A: Interviewing Mandi Business Owners

The Economic Infrastructure in Mandi shows a deficiency of business centers within Mandi Town. Many of the recorded shops were traditional small provisional stores that sold clothing, food items, or other essentials. There are very few specialty stores or industries present within the city. Large industries within cities are beneficial since they can help boost the local economy, which in turn aids in future development of the city. A larger business center district inside of Mandi could aid in developing Mandi Town's economy and aid in future development.

Figure B: ArcGIS Mapping

The Physical Infrastructure in Mandi lacks parking space inside the city and is affected by over-congestion of Mandi's amenities and services. While mapping the city our team found that there are 5 parking centers and limited street parking in our sector of Mandi. All of these parking centers were not very large and could only accommodate few vehicles. This lack of parking makes it difficult for residents who live on the outskirts or in neighboring villages to drive into town. Increasing the number of parking centers and area for street parking within Mandi could help transportation within Mandi.

Interacting with residents allowed us to understand the residents' perception of their city and potential improvements they would like to see implemented. A proportionate split between genders ensured sentiments representative of the population. However, surveying the vicinity around Indira Market presented a sample concentrated with younger respondents, skewing the data. Overall, residents in our sample

ranked the services and amenities within the city's four pillars as adequate, suggesting that it is functional but could use development or improvement. The insights from the interviews and surveys expressed two courses of action, expanding to undeveloped areas (Greenfield Development) or improving the existing structures (retrofitting).

Overall, the data shows that Mandi does have the potential to implement Smart City initiatives. The experience of the town blends old with new, youth with an aging population, and the potential for many newcomers to settle here. Mandi already has strong infrastructure with temples, local shops, and a feeling of safety and security. However, there are concerns about its weak infrastructure in waste management, waste collection, parking, and congestion. To improve smart city initiatives in the city, the gap between the quality of its developed and underdeveloped infrastructure must be narrowed.

Future Recommendations

We proposed 3 recommendations which may help alleviate some of the weaknesses concerning waste collection, waste management, parking, and congestion.

1. Improve the methods for the collection of waste from Mandi residents. The waste collection in Mandi was rated as a 2.5/5 by the survey respondents. Currently, all the waste from home residents in Mandi is collected into one garbage truck. However, a trend across other cities and on the IIT Mandi campus is towards separating waste into three categories: recyclables, biodegradables, and other solid waste. Color coded garbage bins are used for personal residences and publicly citywide. Implementing color coded trash bins for Mandi residents is not feasible with the limited sidewalk space and street narrowness in the residential districts. However, a more feasible solution for the community would be to encourage households to organize and dispose of waste so that pick up will be more efficient. Also, strategically placing dumpsters around Mandi would provide a channel for residents who live in restricted areas to dispose their waste. Finally, implementing a collection system utilizing colored coded trucks could likewise increase efficiency in waste collection.

2. Improve overall waste management across the city. Mandi residents rated waste management in Mandi town as a 2.3/5. Currently, collected waste is transported and dumped in Pandoh Valley, 14 km away from Mandi. This is detrimental for the environment, and a waste management plan for the growing city should be improved to alleviate these poor practices. We recommend that the city plan a waste management plant outside of Mandi for all waste collected in the city. This would cut down on the trash dumped within the city as well as the trash dumped in Pandoh.

3. Improve the quality of three of the lowest ranking amenities in the city: parking, road congestion, and business centers. Responding to the sentiment of local stakeholders calling for the effective use of land, one recommendation is to consider multi-use and mixed-use development to use available space more efficiently. For example, our sponsors, Dr. Derricks Shukla and Dr. Rajneesh Sharma, have designed a 10-story Complex. Their Complex is suggested to be built between Victoria Bridge and Bhulli Bridge, on top of the Beas River. The bottom of one of the buildings would contain a multistory parking lot with commercial space for shopping and stores on top. The other building would house a new fully-functioning hospital and space for government offices. Primarily, this design addresses the crucial need for parking spaces and alleviates the traffic congestion as some of the activity is moved from the center to the outskirts of the town. Moreover, this design

concept would allow Mandi to maintain its important historical and religious identity, while developing new sectors in vacant, compact areas. Smart Cities around the world use this kind of dense urban planning to minimize sprawl and optimize services

Overall, Mandi Town faces a crossroads in its future development. With improvements coming to nearby highways and with the development of IIT Mandi, the city is poised to be an important hub hosting young people, ancient traditions, and visitors passing through. This population increase will heavily burden a city that is already overcrowded and congested. Now is the time that Mandi must begin planning its future development to maintain a high functioning city in the future. Other Indian Smart City recipient cities such as Dharamshala, Himachal Pradesh, have begun their future development by outlining the current state of their city. We modeled our approach very similarly to their beginning phases of implementing Smart City initiatives. The data collected was modeled around the four pillars of the government-led Smart City Mission. After identifying key areas for development, by comparing the map of local amenities to the insights of residents, we can see that the city has tremendous potential to invest in Smart City projects. From there, we proposed a few key recommendations to address the major concerns identified by our data. Most importantly, the data collected in this project has laid a strong foundation for urban planning initiatives within Mandi. Future proposals will be able to build upon the data we have collected. We hope that our recommendations provide a solid base for re-visioning the city and provide a solid baseline for the future development of Mandi into becoming a leading city in Himachal Pradesh.

Acknowledgements

Authorship Page

All members of the team collaborated to ensure the completion of the project. The whole team participated in GIS mapping and interacting with Mandi residents.

Mayuresh Gupta: Mayuresh assisted in the design of the final ISTP presentation poster and in collecting GIS Map coordinates. He also surveyed residents and translated Hindi survey responses into English.

Jeremy John: Jeremy was a primary writer for the entire report and was a co-creator of the GIS map database. He edited the survey response database and all of its associated figures and charts. He collected GIS Map coordinates and Surveyed residents. He also interviewed Dr. I.D. Sharma.

Akshit Kaushik: Akshit assisted Sharad Gupta in uploading the GIS map and in collecting GIS Map coordinates. He also surveyed residents and translated Hindi survey responses into English. He also interviewed Dr. I.D. Sharma.

Walter Kwiecinski: Walter was a primary writer for the entire report and was a co-creator of the GIS map database. He edited the survey response database and all of its associated figures and charts. He collected GIS Map coordinates and Surveyed residents.

Yasmeen Logan: Yasmeen created the survey response database and all of its figures and charts and the Final Presentation Poster. She was a primary editor for the entire report and a co-creator of the GIS map database. She collected GIS Map coordinates and surveyed residents.

Bipin Sharma: Bipin assisted in collecting GIS Map coordinates. He also surveyed residents and translated Hindi survey responses into English.

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The Pressures of Urbanization

Urban populations in developing countries are increasing more rapidly, relative to developed nations, due to their dynamic rural-urban migration. Consequently, rural-urban migration outpaces urban job creation and the development of social services (Todaro, 1980). Furthermore, higher population growth is occurring in developing nations due to their limited access to information and contraceptives (Pakhomov, n.d.). To combat the burden placed on cities and the environment from growing populations, demographic changes and urban migration, the UN has introduced Smart City initiatives to enhance the ability of a country to create urban ecosystems that can alleviate these vulnerability stressors while improving the residents' quality of life (United Nations, n.d.).

The world's largest democracy, India, is projected to surpass China as the most populous nation by 2030. The growing population coupled with urban migration, stemming from recent economic growth, have resulted in globally reoccurring urban pressures in overcrowded Indian cities (Pakhomov, n.d.). In response to a growing metropolitan population, Indian Prime Minister Modi's administration created India's first national urban planning initiative called the Smart City Mission, with the goal to develop 100 Indian Smart Cities in the coming years. The Indian government has tailored Smart City approaches utilized internationally to focus on the development of four pillars to mitigate the strain of urbanization. These four pillars highlight Institutional Infrastructure, Physical Infrastructure, Social Infrastructure, and Economic Infrastructure (The Republic of India, n.d.).

Steady growth in population, an increased demand on its infrastructure, and degradation of its environmental surroundings have made Mandi an ideal candidate for Smart City initiatives. Located in the heart of Himachal Pradesh, Mandi is an ancient, agrarian city at the intersection of key tourism and cultural hubs for travelers heading through on north-south journeys (see Figure 1, below).

Figure 1: Map of Mandi District (District of Mandi Map, 2015)

Serving as the district headquarters, Mandi is the base for rural-urban interaction within the district as farmers and residents from surrounding villages congregate. In 2011, the population of Mandi town exceeded 26,000 (Ministry of Home Affairs Mandi, 2011). The addition of the Indian Institute of Technology outside of the city is expected to bring thousands of new students, faculty, and jobs to the region. These factors have culminated into a crowded, bustling city depicted below in Figure 2.

Figure 2: Mandi Town (Top view of Mandi Town, Himachal Pradesh, 2007).

The goal of this project was to identify Smart City features present within Mandi and determine potential Smart City initiatives to improve quality of life within the city. To accomplish this goal, we completed three objectives. First, we assessed the current state of Mandi by identifying and mapping its amenities and services. Next, we engaged with local stakeholders, an important aspect of the Smart City Mission, to gain their insight on Mandi's current state and their future aspirations. Finally, our team piloted a Smart City recommendation for a sector of Mandi. Initiatives to help Mandi become a Smart City may promote its future sustainability, development, and community growth in the coming years.

India's Solution

The Context for India's Smart City Mission

The Smart City Mission is a two-stage competition between 100 Indian cities. Started in 2015, the initiative led by the Indian government aims to be completed by 2020 and could potentially be renewed after its culmination. To create a more sustainable urban environment, the cities' proposals must utilize one of three models that provide "smart" solutions to proportionately improve four aspects of a city, which are described as 4 pillars of smart cities: social, institutional, economic, and Physical Infrastructure. "Smart" solutions would address each pillar by resolving issues such as providing adequate water and energy supply, public transportation, education, citizen participation, and e-Governance ("What is Smart City", n.d.). Table 1 below summarizes the three different

methods of implementing smart solutions according to the Indian government: retrofitting, redevelopment, and greenfield development.

Table 1: Methods for Smart City Initiative Development ("Strategy", n.d.)

Retrofitting	Redevelopment	Greenfield Development
- "City Improvement" - Implements services and smart applications to build upon existing infrastructure	- "City Renewal" - Completely replaces existing infrastructure with new/enhanced infrastructure	- "City Expansion" - Develops new infrastructure in vacant areas of cities

The Four Pillars

The four pillars chosen to be highlighted by the Smart City Mission are summarized in Table 2 below. Each pillar can be assessed by the 5 stages of development using a rubric. The stages are nonexistent, unstable, unreliable, high-quality, and fail-proof (Kumar, 2012, p.214).

Table 2: The 4 Smart City Pillars

Social Infrastructure	- Builds a sense of community within the city - Unites societal groups that don't usually interact - Requires transparency between government and its people - If underdeveloped it isolates certain minority groups
Institutional Infrastructure	- Initiatives and services of regulatory organizations in a city - Provides political, financial and environmental administration/stability - Stresses corporate responsibility - These institutions must equally represent all stakeholders in the city
Economic Infrastructure	- Networks and facilities that make varying business activities possible - Reduces expenses and improves production in the city - Utilizes capital goods to produce consumer goods - Could persuade large businesses to seek settlement in cities
Physical Infrastructure	- Services and systems that are necessary to maintain a city - Focuses more on physical resources in the 3 other pillars - The foundation and base that other pillars build upon

The four pillars of Smart City development are interwoven to form a complex web. From an economic development perspective, Social Infrastructure can be defined as the resources used to "improve the efficiency and skills of manpower" (Kumari & Sharma, 2017, para. 1). However, even though these methods the community would improve their quality of life and increase their social capital, while building up their economy. For

governmental institutions or Institutional Infrastructure to be most effective, they require the trust of the community. Trust in institutions is strengthened by the social capital and infrastructure provided to communities by those very institutions. Effectual governments are then able to allocate resources and proper regulations to develop Economic Infrastructure.

Methodology: Determining Possible Smart City Initiatives in Mandi

The goal of this project was to identify the Smart City features already present within Mandi and determine possible future actions to increase Smart City Initiatives within the city. We completed the three objectives in Table 3 below to accomplish this goal.

Table 3: Methodology

Objective	Tasks
Assessed the current state of the city by identifying and mapping its amenities and services.	-GIS Mapping of Mandi's Amenities
Engaged with local stakeholders to gain their insight on Mandi's current state and its future aspirations as a Smart City.	-Survey Mandi Residents
	-Interview Government Officials
Developed a pilot Smart City recommendation for a sector of Mandi.	-SWOT Analysis Assessment
	-Comparative Case Study

Objective 1. Assess the Current Physical Amenities of Mandi

Our team created a GIS map of various amenities and services within Mandi to accomplish this objective. An amenity was defined as any shop, restaurant, service, school, and so forth, located inside of the city. The map of the amenities and services available in Mandi Town was created using ArcGIS software.

To create this map, team members walked around Mandi with a GPS unit and a camera. Our team focused on a small sector of the city along NH 21 and the Indira Market Square. At each location the amenity's: name, category, GPS coordinates, address, phone number, and photo were collected. To streamline the data collection process, the phone app, CAMCARD, was utilized. This app scans business cards and was used to collect and store basic information for the amenity or service. The area of focus for the map are sections of Ward: 1, 3, 6, and 9 circled in the map below (see Figure 3).

Figure 3: Map of Mandi Town Sector

The collected data was then uploaded into a Microsoft Excel spreadsheet. This spreadsheet was used to compile and organize all the data our team collected which was then uploaded into the GIS software. The software was used to display the coordinates of the various amenities and display all of the shops contact information when users interact with it.

Objective 2. Gain Stakeholder Insights of Mandi

Survey Mandi Residents

We gained quantitative and qualitative observations from 170 residents by having them complete surveys regarding the current state of Mandi's amenities and infrastructure and their future aspirations for the city. The survey, in both English and Hindi, that we used to engage the residents is in Appendix B and C. We surveyed the residents of Mandi focusing on the same section of NH 21 and the Indira Market Square as our first objective. We collected our data utilizing a sample of convenience. To avoid communication issues the IIT team members took a more active role with surveying the residents since they were able to communicate to the locals in Hindi. If an IIT team member was not available to survey on any given day, the team's TA accompanied the WPI teammates in the city to aid with communicating. Figure 4 below depicts two of our team members: Mayuresh Gupta and Yasmeen Logan interacting with the business owner of Komal's World in Mandi Town.

Figure 4: Interviewing Mandi Business Owners

Interview City Officials

The group of individuals most privy and knowledgeable of Mandi's current state and future aspirations are its city officials. With the help of our well-connected sponsors, Professors Shukla and Sharma, we secured meetings with some of local officials in Mandi. The officials our team met with included Mr. Lavan Thakur and Dr. I.D. Sharma. We conducted semi-structured, formal interviews, altering questions to focus on the expertise of the interviewees. These interviews were conducted in English or Hindi depending on the preference of the official. With the consent of the interviewee we recorded the entirety of the interview then transcribed and translate the interview. Interview guides can be found in Appendix D.

Objective 3. Develop Pilot Smart City Recommendation

Smart City initiatives can help Mandi in its future growth and development in the coming years. To improve the current infrastructure within Mandi, our team developed a pilot Smart City recommendation that addressed a weakness discovered during our first two objectives. Our team utilized a comparative case study used on a similar urban problem in another city to tailor a solution.

First, we completed a SWOT Analysis to identify the city's strengths, weaknesses, opportunities, and threats. The SWOT analysis utilized the data collected during our first two objectives. We compared the current physical amenities of Mandi to the responses on Mandi's current condition and future aspirations from residents. This allowed us to see where there was disparity between the two sets of data and identify the disparities as weaknesses for the city. The SWOT Analysis can be found in Appendix E.

Second, after completing our SWOT analysis our team utilized a comparative case study to choose one of these weaknesses or opportunities and performed more research on how to improve that aspect of the city. The comparative case study required our team to research similar problem and solution in another city, preferably in India. From this

research, we developed a similar solution for Mandi based on the other city's solution. By analyzing how other areas addressed these problems we were able to tailor a solution more relevant to Mandi.

Results

To meet our first objective, we collected information for 641 shops and amenities along NH 21 and inside the Indira Market. These amenities include over 25 banks and ATMs, 31 medical shops, and 85 restaurants spread across the focus areas. A majority of these stores were centrally located in and around Mandi Town's Indira Market. These amenities are categorized into 21 major sectors (listed in the legend of Figure 6 below) so that users can easily sort and locate amenities they are interested in. They were also categorized by the type of Smart city infrastructure. For example, the banks and ATMs fall under Economic Infrastructure.

The information for this set of amenities was uploaded into an Excel workbook and then exported into the ArcGIS software which can be used to display contact information for the amenities. Filtered searches for each pillar of infrastructure are displayed in Figure 5 below.
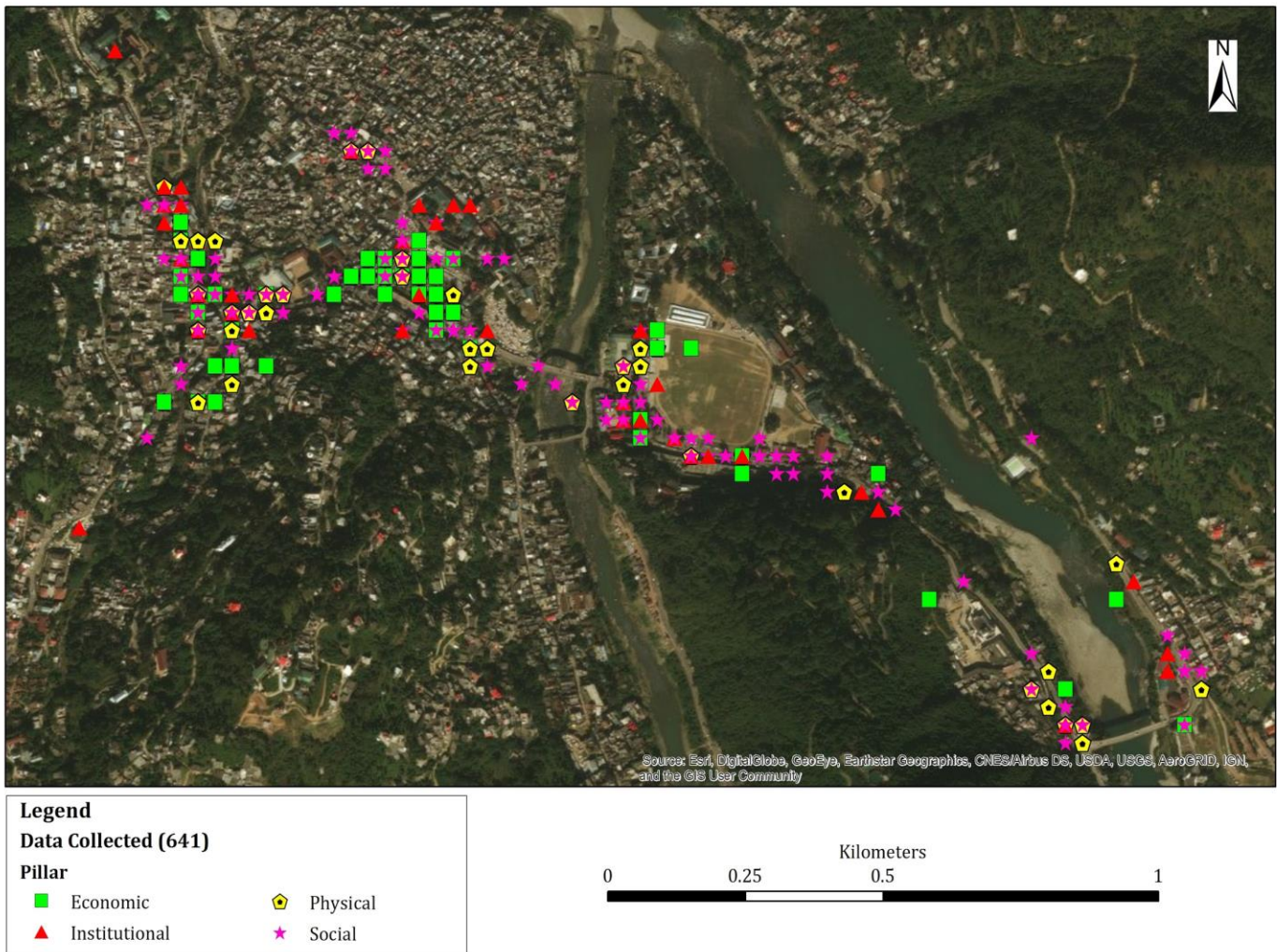
Figure 5: GIS Map of Mandi Town Smart City Pillars

Our second objective focused on engaging local stakeholders to gain their insights on the state of the infrastructure in Mandi. We surveyed 170 residents near Indira Market and the adjacent regions of NH 21 mapped in our first objective. We retroactively stratified a sample of convenience to gather data to represent the demographics more proportionally. Table A1 in Appendix A displays the age ranges and genders of the stakeholders which completed our survey.

Our survey contained 4 parts, each corresponding to the four pillars of Indian Smart City Infrastructure. Each quantitative question required the respondent to rank the condition of certain aspects of each pillar from 1-5 (with 1 being the lowest rating and 5 being the highest rating). We calculated the mean rating of each pillar, displayed in Figure 6 below. More detailed graphs on averages by demographics and for individual questions can be found in our index of Supplementary Materials. More detailed graphs on rankings by different demographics and means for individual questions are in the Appendix A.
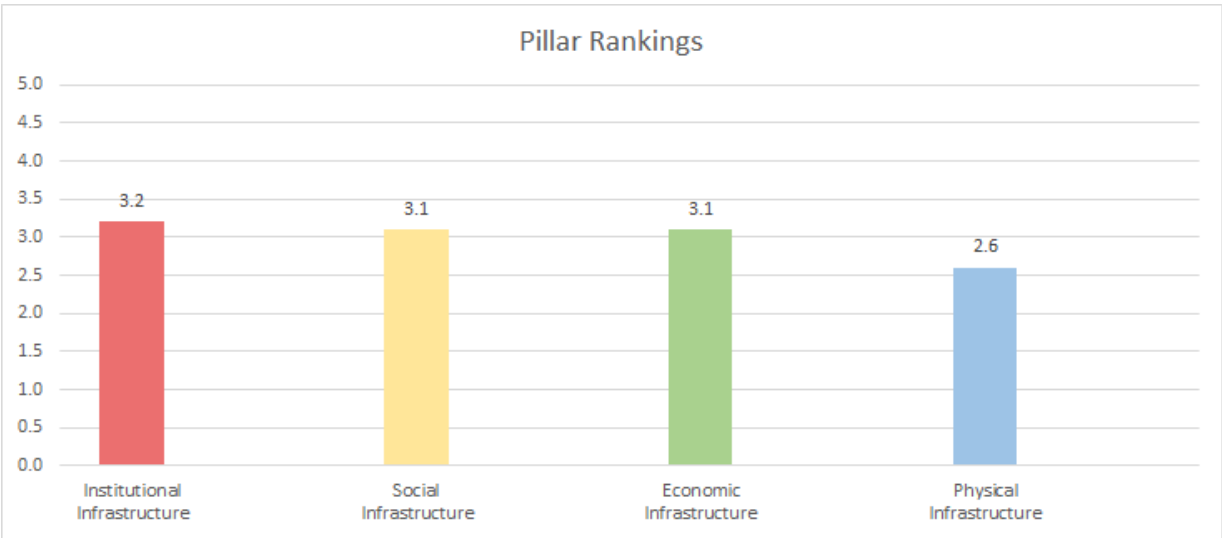
Figure 6: Relative Conditions of the Smart City pillars According to Residents

From our team's observations, we developed a list of strengths, weaknesses, opportunities, and threats to assess needs and opportunities for Mandi's "smart" future development. These four categories are represented in the SWOT analysis below in Table 4.

Table 4: Mandi Smart City SWOT Analysis

Strengths	Weaknesses
- Medical stores - Mandi temples - Safety and security - Local shops	- Parks & green spaces - Narrow roads - Parking centers
Opportunities	Threats
- Surrounding greenspace - Business centers - IIT Mandi development - India Smart City Mission	- Congestion in Mandi - Future population growth - Waste management - Other major Himachal cities

Discussion

Creating the Arc GIS Map of Mandi and engaging with the residents through surveys and interviews enabled our team to identify areas Smart City Initiatives would be valuable in Mandi Town. The ArcGIS Map provided our team an assessment of the current amenities and services in offered within Mandi Town. Meanwhile, our interactions with residents allowed us to understand the residents' perception of their city and potential improvements they would like to see implemented.

The Final Arc GIS Map (previously displayed in Figure 5) presents the current amenities of the featured sector of Mandi Town. From this map a couple of conclusions about the current state of Mandi can be determined. The map itself can also be sorted by the 4 main pillars of the Indian Smart City mission. This allowed our team to focus on one key observation for each of the smart city pillars.

The data our team collected revealed overarching trends across all four pillars of infrastructure in the Indian Smart City Mission. The Social Infrastructure in Mandi lacks sufficient sit-down restaurants and greenspaces for its citizens to enjoy. We created a map to display the locations of 85 different dining amenities. Over 90% of these eateries are smaller juice bars, tea stalls or dhabas. The primary sit-down restaurants include only a few establishments: The House of Ming, Copacabana Bar & Restaurant, the Regent Palms Hotel, The Treat, and Domino's. Also, there were only two green spaces in the mapped sections of the city. Increasing the number of restaurants and green spaces could allow citizens of Mandi to interact and build stronger social connections.

The Institutional Infrastructure in Mandi has sufficient medical stores and pharmacies, but it lacks adequate hospital space and clinics to treat citizens. Both types of amenities are under the medical category in the ArcGIS map. In total there are 31 total medical amenities, with 29 stores and pharmacies stores and only two hospitals and clinics. These were the main Zonal Hospital and the smaller Sri Harihar Hospital. These two hospitals are typically overcrowded, and the addition of another medical center could help alleviate some of this pressure from Mandi's citizens.

The Economic Infrastructure in Mandi shows a deficiency of business centers within Mandi Town. Many of the recorded shops were traditional small provisional stores that

sold clothing, food items, or other essentials. There are very few specialty stores or industries present within the city. Large industries within cities are beneficial since they can help boost the local economy, which in turn aids in future development of the city. A larger business center district inside of Mandi could aid in developing Mandi Town's economy and aid in future development.

The Physical Infrastructure in Mandi lacks parking space inside the city and is affected by over-congestion of Mandi's amenities and services. While mapping the city our team found that there are 5 parking centers and limited street parking in our sector of Mandi. All of these parking centers were not very large and could only accommodate few vehicles. This lack of parking makes it difficult for residents who live on the outskirts or in neighboring villages to drive into town. Increasing the number of parking centers and area for street parking within Mandi could help transportation within Mandi.

Interacting with residents allowed us to understand the residents' perception of their city and potential improvements they would like to see implemented. A proportionate split between genders ensured sentiments representative of the population. However, surveying the vicinity around Indira Market presented a sample concentrated with younger respondents, skewing the data. Overall, residents in our sample ranked the services and amenities within the city's four pillars as adequate, suggesting that it is functional but could use development or improvement. The insights from the interviews and surveys expressed two courses of action, expanding to undeveloped areas (Greenfield development) or improving the existing structures (retrofitting).

One challenge our team faced while creating the map stemmed from the congestion of amenities and services in Mandi town. While it was easy for our team to walk from shop to shop, record GPS coordinates, and talk to business owners to get contact information for their shop, in many cases these shops were located so close to one another that it made plotting the location of the shops very difficult. Our team used GPS coordinates from the Compass app on our smartphones to track coordinates. The close proximity of amenities paired with the inaccuracy of the smartphone GPS app caused many shops to be mapped onto the same coordinates. This caused the map to overlap in some sectors.

From the point of view of the residents, there were supporting responses. Table 5 below expresses the inferences concluded from our surveys and interviews.

Table 5: Comments from interviews and surveys

SOCIAL INFRASTRUCTURE	• Social infrastructure is adequate, but underdeveloped • Religious temples were ranked as the most developed aspect of the city • Religion is the cultural identity and binding factor between diverse social groups • Younger groups ranked the pillar relatively higher even though it lacks sources of entertainment, means of communication, and greenspaces • Social capital may be tailored to be more accessible for younger generations
PHYSICAL INFRASTRUCTURE	• This infrastructure requires the most development • Various rivers, riverlets, and streams provide access to water and are potential sources of energy creation • Geographic features of the region limit available land for development resulting in narrow, single-lane roads • Poor road networks lead to traffic congestion and magnifies the lack of pedestrian walkways and vehicle free roads • Congestion impedes waste collection as residential areas are harder to traverse
INSTITUTIONAL INFRASTRUCTURE	• Government institutions work methodically but complete their tasks • Sufficient source of electrical infrastructure reduces instances of power outages. Ample police presence provides the safety and security of the residents • Judicial and intentional utilization and redevelopment of private and public property to build efficient infrastructure • Lacks an outlined area and facility to treat waste resulting in practices that are not sustainable or environmentally friendly
ECONOMIC INFRASTRUCTURE	• The strength of the economy is the opportunities for local stores, promoting entrepreneurship • Local shops are inclined to sell or provide a similar array of goods and services, limiting the diversification of industries present

A proportionate split between genders ensured sentiments representative of the population. However, surveying the vicinity around Indira Market presented a sample concentrated with younger respondents, skewing the data. Overall, residents ranked the services and amenities within the city's pillars as adequate, suggesting it is functional but

could use development or improvement. The insights from the interviews and surveys expressed two courses of action, expanding to undeveloped areas (Greenfield development) or improving the existing structures (retrofitting).

Overall, the data shows that Mandi does have the potential to increase Smart City initiatives. The experience of the town blends old with new, youth with an aging population, and the potential for many newcomers to settle here. Mandi already has strong infrastructure with temples, local shops, and a feeling of safety and security. However, there are concerns about its weak infrastructure in waste management, waste collection, parking, and congestion. To improve Smart City initiatives in the city, the gap between the quality of its developed and underdeveloped infrastructure must be narrowed.

Our Deliverables

ArcGIS Map of amenities in Mandi Town

The first main deliverable our team completed for this project is an interactive GIS map of Mandi Town's amenities. This map allows users to filter all of the amenities by major category and find basic contact information. The full map is displayed in Figure 7 below:
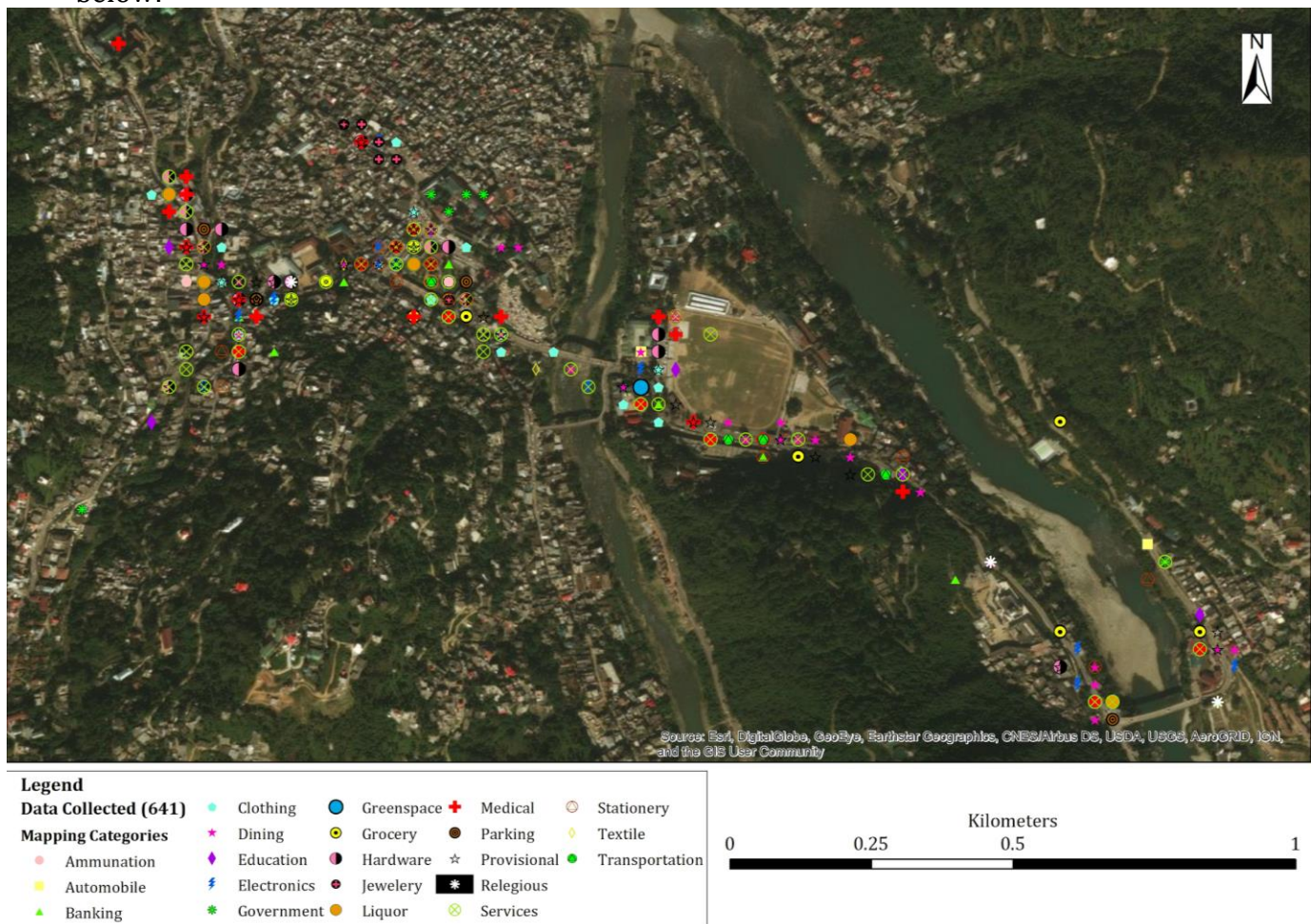
Figure 7: Complete Amenity Map of Mandi Town

Smart City Initiatives

There are many ways in which Mandi could move forward towards Smart City status. However, after our 7 weeks of research onsite, we have developed three fundamental recommendations for the city of Mandi organized by increasing levels of complexity. These recommendations may help alleviate some of the city-wide weaknesses found while conducting our research, and concern the most basic amenities of waste collection, waste management, parking, and congestion.

1. Improve the waste collection routines within Mandi. The citizens rated the waste collection from residential and public areas in Mandi as a 2.5/5, with more than 50% of residents claiming the quality of the service to be inadequate. Currently, all types of waste are consolidated and collected simultaneously in Mandi. Meanwhile, a growing trend in cities, and recently on the IIT Mandi campus, is separating waste into three categories: recyclables, biodegradables, and solid waste. Palakkad, a village in southern India, began a segregated collection initiative which has been partially self-sufficient. The program has been generating funds by collecting newspapers, bottles, and other items of commercial value, while also composting solid waste for the resident farmers (Shaji, 2016). Cities have begun utilizing color-coded garbage bins for residents, while implementing similar measures for the public. Employing a color-coded trash can system residents may potentially be impractical due to the narrow sidewalks and streets in the residential districts of Mandi. However, a more feasible solution for Mandi would be to first educate their residents on how to properly organize, separate, and dispose of waste and the additional benefits of this process. Additionally, systematically placing color coded dumpster around town, in areas accessible by motor vehicles, would allow residents from restricted areas to channel to dispose their waste. Finally, implementing a city-wide system utilizing colored coded trucks to collect the separated waste would likewise increase efficiency and reduce error in waste collection.

2. Improve overall waste management across the city. Mandi residents rated waste management in Mandi town as a 2.3/5. The waste collected in Mandi is transported and dumped in Pandoh Valley 14 km away outside of the city. The accumulation of garbage and the accompanying bacteria is detrimental to the environment and the surrounding villages. There must be a standard of sanitation in order to make a city livable and that starts with preventing the rise of vector-borne diseases. We recommend that the city develop a plan to build a waste treatment plant outside of Mandi for all waste collected in the city. This would cut down on the trash dumped within the city as well as the trash dumped into Pandoh Valley.

3. Improve the quality of three of the lowest ranking amenities in the city: parking, road congestion, and business centers. Pushing the community towards significant growth results in modernizing aspects of the city. Employing multi-use and mixed-use infrastructure development would address the sentiment of local stakeholders calling for the effective use of land. For example, our sponsors, Dr. Derricks Shukla and Dr. Rajneesh Sharma, have proposed a design for a 10-story multi-complex. This complex is suggested to be built between Victoria Bridge and Bhulli Bridge, on top of the Beas River. The bottom of one of the buildings contains a multistory parking lot with commercial space for shopping and stores on top. The other building would house a new fully-functioning hospital and space for government offices. Primarily, this design addresses the crucial need

for parking spaces and alleviates the traffic congestion as some of the activity is moved from the center to the outskirts of the town. Moreover, this design concept would allow Mandi to maintain its important historical and religious identity, while developing new sectors in vacant, compact areas. Also, mixed-development reduces costs and burdens placed on a city's physical infrastructure as transportation systems and utilities are directed to one region. Smart Cities around the world use this kind of dense urban planning to minimize sprawl and optimize services.

Recommendations for Future Research

Due to the limitations of time and certain resources we were not able to complete every objective we had planned. We propose future research to make our data more robust and to solidify our recommendations. We suggest a future team get into contact with the Public Works Department Engineers and share the maps and data we have collect, while also asking for feedback on our Smart City recommendations. To get a better understanding of the initial start-up process and current results of the color-coded waste system, we recommend that they meet with the IIT Mandi Green Team that was in charge of the initiative. Finally, we recommend gathering together a focus group and present our recommendations for further feedback from the residents of Mandi. Accomplishing these final few objectives will give our team a clearer understanding if our recommendations are a viable solution for the town of Mandi.

Conclusion

Currently, Mandi Town faces a crossroads in its future development. With improvements coming to nearby highways and with the development of IIT Mandi, the city is poised to be an important hub hosting young people, ancient traditions, and visitors passing through. This population increase will heavily burden a city that is already overcrowded and congested. Right now is the time that Mandi must begin planning its future development in order to stay ahead of the curve and maintain a high functioning city. Other Indian Smart City recipient cities such as Dharamshala, Himachal Pradesh, have begun their future development by outlining the current state of their city. We modeled our approach very similarly to their beginning phases of implementing Smart City initiatives. The data collected was modeled around the four pillars of the government-led Smart City Mission. After identifying key areas for development, by comparing the map of local amenities to the insights of residents, we can see that the city has tremendous potential to invest in Smart City projects. From there, we proposed a few key recommendations to address the major concerns identified by our data. Most importantly, the data collected in this project has laid a strong foundation for urban planning initiatives within Mandi. Future proposals will be able to build upon the data we have collected. We hope that our recommendations provide a solid base for re-visioning the city and provide a solid baseline for the future development of Mandi into becoming a leading city in Himachal Pradesh.

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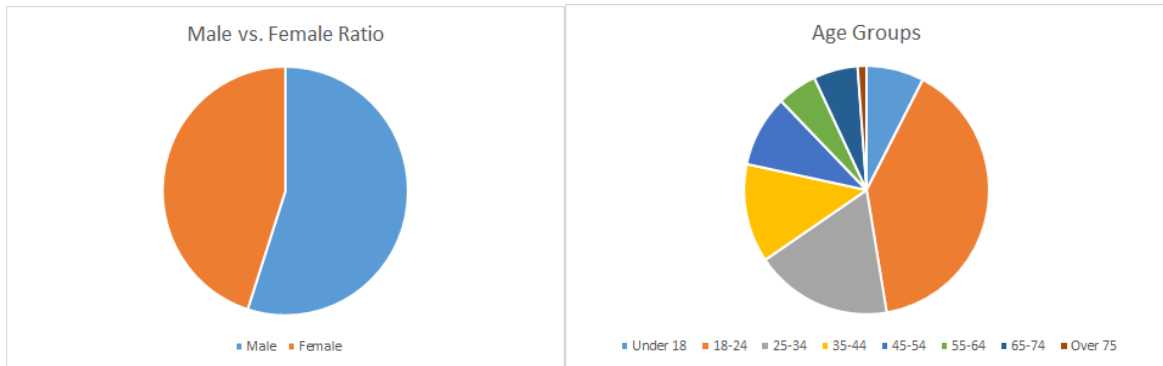
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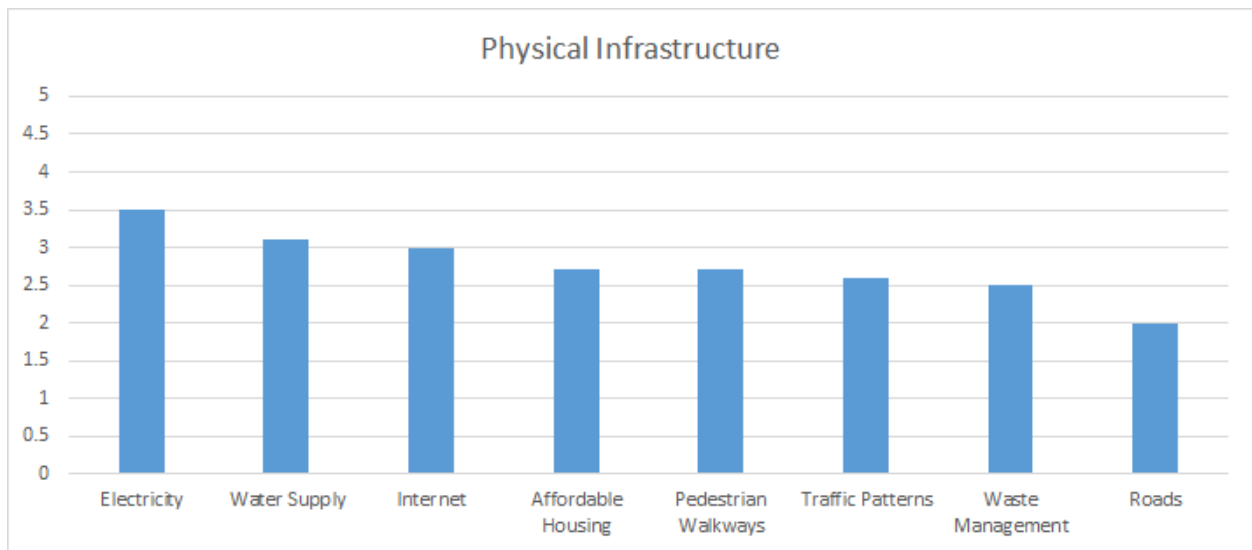
Appendix A: Tables and Figures

Male vs. Female Ratio

■ Male   ■ Female

Age Groups

■ Under 18 ■ 18-24 ■ 25-34 ■ 35-44 ■ 45-54 ■ 55-64 ■ 65-74 ■ Over 75

Table A1: Survey Demographics

Figure A2: Physical Infrastructure
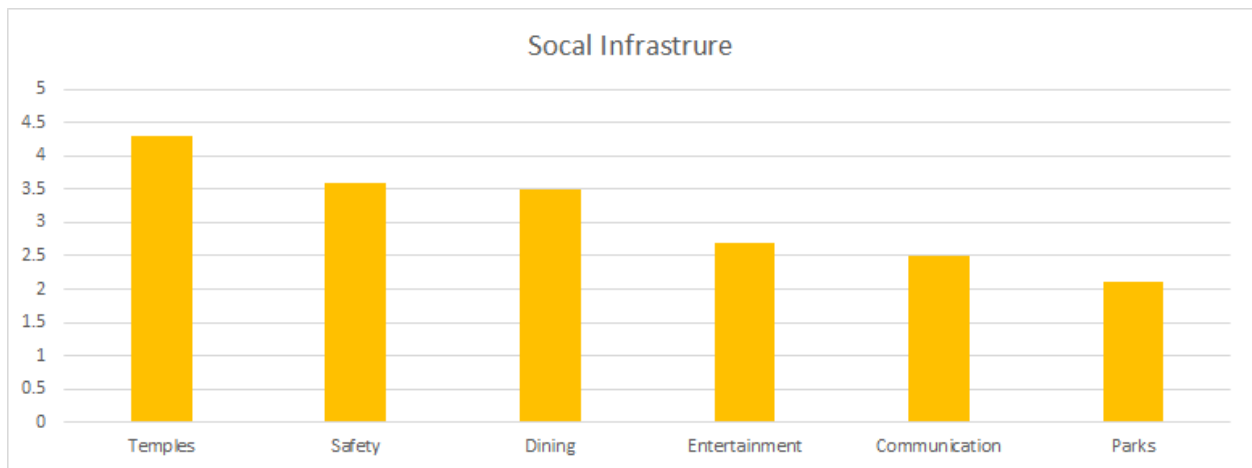
Figure A3: Social Infrastructure

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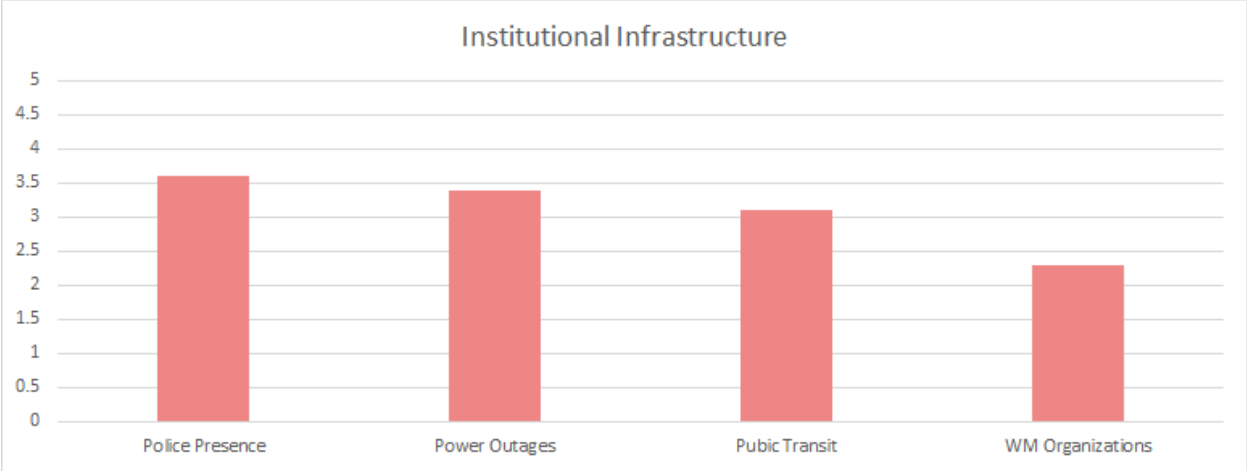
Figure A4: Institutional Infrastructure
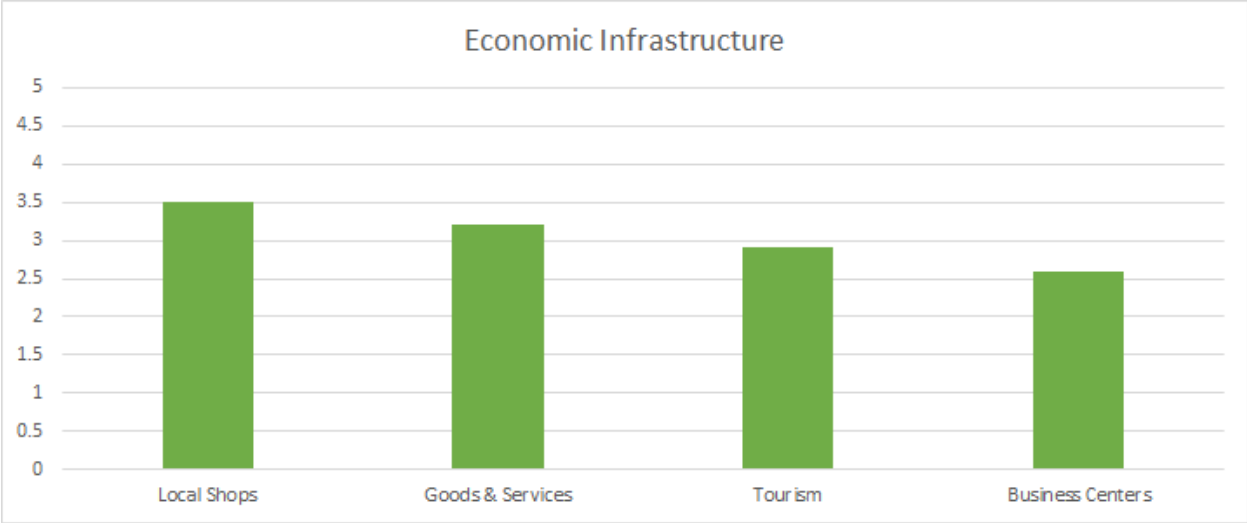
Figure A5: Economic Infrastructure
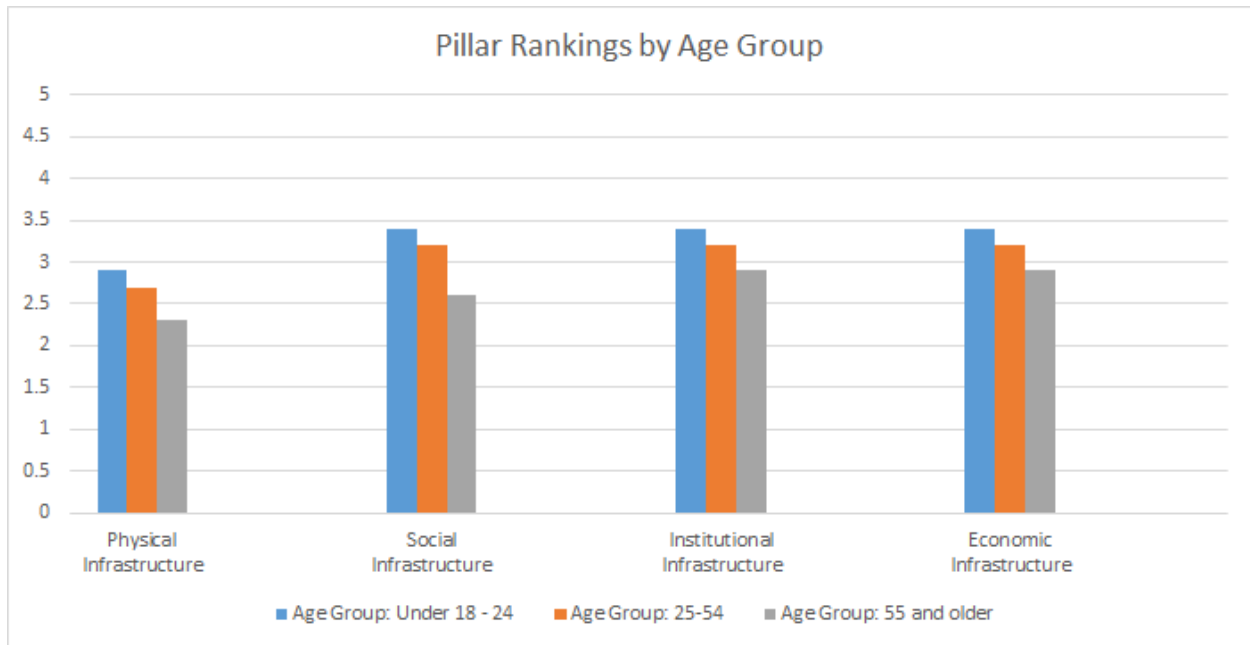
Figure A6: Pillar Rankings by Age Group

Appendix B: Resident Survey

Thank you very kindly to agreeing to take this survey. We are a team of Worcester Polytechnic Institute and Indian Institute of Technology students studying urban planning in Mandi Town. We are looking to identify strengths and weaknesses within the 4 main pillars of urban planning: Physical, Social, Institutional, and Economic Infrastructure. We hope to learn what you think about the city, and how it can be strengthened. There are 4 main sections to this survey, corresponding to the four main pillars. Each section has a number of multiple choice responses and then ends with two open ended responses.

Physical Infrastructure: First we want to learn about the physical Infrastructure of Mandi Town. Physical infrastructure is the services and systems needed to maintain a functioning city. Examples of these type of Infrastructure include: roads, utilities, and amenities/services.

1. Rate the quality of the water supply inside of Mandi.
· 1 - Poor
· 2
· 3 - Adequate
· 4
· 5 - Great
2. Is there an assured/safe electricity supply inside Mandi?
· 1 - Not present
· 2
· 3 - Adequate
· 4
· 5 - Great Quality

3. Rate the quality of the roads.
- 1 - Too narrow
- 2
- 3 - Adequate
- 4
- 5 - Perfect size

4. Rate the quality of the traffic patterns inside of Mandi.
- 1 - Poor
- 2
- 3 - Adequate
- 4
- 5 - Great

5. Rate the quality of pedestrian pathways.
- 1 - Poor
- 2
- 3 - Adequate
- 4
- 5 - Great

6. Rate the quality of sanitation/waste management infrastructures.
- 1 - Poor
- 2
- 3 - Adequate
- 4
- 5 - Great

7. Rate the affordability of housing inside Mandi.
- 1 - Poor
- 2
- 3 - Adequate
- 4
- 5 - Great

8. Rate the quality of Wifi and internet connectivity.
- 1 - Poor
- 2
- 3 - Adequate
- 4
- 5 - Great

10. What is the condition of vehicle-free roads inside of Mandi?
· 1 - Non-existent
· 2
· 3 - Adequate
· 4
· 5 - Great

11. Are there are any other comments or concerns regarding the Physical Infrastructure currently available in Mandi that you would like to share?

12. How would you like the Physical Infrastructure to be improved going forward?

Social Infrastructure: Now we would like to learn more about the Social Infrastructure of Mandi Town. Social Infrastructure is infrastructure which builds a sense of community within a city. Examples of this type of infrastructure are: temples, community safety, and entertainment.

1. Rate the quality of temples inside of Mandi.
· 1 - Poor
· 2
· 3 - Adequate
· 4
· 5 - Great

2. Rate the quality of safety and security of Mandi's citizens.
· 1 - Poor
· 2
· 3 - Adequate
· 4
· 5 – Great

3. Rate the number of designated open spaces and parks.
- · 1 - Nonexistent
- · 2
- · 3 - Adequate amount
- · 4
- · 5 - Perfect amount

4. How well does the municipality communicate development plans to citizens?
- · 1 - Poor
- · 2
- · 3 - Adequate
- · 4
- · 5 - Great

5. Rate the quality of dining options inside of Mandi.
- · 1 - Poor
- · 2
- · 3 - Adequate
- · 4
- · 5 - Great

6. Rate the quality of entertainment in Mandi.
- · 1 - Poor
- · 2
- · 3 - Adequate
- · 4
- · 5 - Great

7. Are there are any other comments or concerns regarding the Social Infrastructure currently available in Mandi that you would like to share?

8. How would you like the Social Infrastructure to be improved going forward?

Institutional Infrastructure: Next, we would like to learn more about the institutional infrastructure of Mandi Town. Institutional Infrastructure is the regulations and services that provide administrative and stability to the city. Examples of this type of infrastructure are: police, fire departments, and public transit.

1. Rate the amount of police presence inside of Mandi.
- 1 - Poor
- 2
- 3 - Adequate
- 4
- 5 - Great

2. Rate the quality of the ambulance service in Mandi.
- 1 - Poor
- 2
- 3 - Adequate
- 4
- 5 - Great

3. Rate the quality of the waste management organizations in Mandi.
- 1 - Poor
- 2
- 3 - Adequate
- 4
- 5 - Great

4. Rate the quality of public transportation.
- 1 - Poor
- 2
- 3 - Adequate
- 4
- 5 – Great

5. Are there typically power outages in the city?
- ·   1 - Many power outages
- ·   2
- ·   3 - Ocasional power outages
- ·   4
- ·   5 - No power outages

6. Are there are any other comments or concerns regarding the Institutional Infrastructure currently available in Mandi that you would like to share?

7. How would you like the Institutional Infrastructure to be improved going forward?

Economic Infrastructure: Finally, we'd like to learn more about the Economic Infrastructure of Mandi Town. Economic Infrastructure is the facilities that make business activities in communities possible.

1. Rate the strength of business centers inside Mandi.
- ·   1 - Poor
- ·   2
- ·   3 - Adequate
- ·   4
- ·   5 - Great

2. Rate the quality of variety of goods and services available in Mandi.
- ·   1 - Poor
- ·   2
- ·   3 - Adequate
- ·   4
- ·   5 - Great

3. Rate the strength of local shops in Mandi.
- ·   1 - Poor
- ·   2
- ·   3 - Adequate
- ·   4
- ·   5 - Great

4. Rate the quality of impact from tourism in Mandi.
- ·   1 - Poor
- ·   2
- ·   3 - Adequate
- ·   4
- ·   5 - Great

5. Are there are any other comments or concerns regarding the Economic Infrastructure currently available in Mandi that you would like to share?

6. How would you like the Economic Infrastructure to be improved going forward?

Demographics:
1. Gender:
- ·   Male
- ·   Female
- ·   Other
1. Age
Under 18
- ·   18 – 24
- ·   25 - 34

- 35 - 44
- 45 - 54
- 55 - 64
- 65 - 74
- 75 and older

Thank you for taking our survey! If you would like to follow up with our team or learn more about our project, feel free to email us at indiasmartcity@wpi.edu!

Appendix C: Translated Survey

इस सर्वे को लेने के लिए सहमत होने के लिए बहुत धन्यवाद। हम वर्सेस्टर पॉलिटेक्निक इंस्टीट्यूट और इंडी इंस्टीट्यूट ऑफ टेक्नोलॉजी छात्रों की मंडी टाउन में शहरी नियोजन का अध्ययन कर रहे हैं। हम शहरी नियोजन के 4 मुख्य स्तंभों के भीतर शक्तियों और कमजोरियों की पहचान करना चाहते हैं: भौतिक, सामाजिक, संस्थागत, और आर्थिक आधारभूत संरचना। हमें उम्मीद है कि आप शहर के बारे में क्या सोचते हैं, और यह कैसे मजबूत किया जा सकता है। इस सर्वेक्षण में 4 मुख्य वर्ग हैं, जो चार मुख्य स्तंभों के मुताबिक हैं। प्रत्येक अनुभाग में एकाधिक पसंद प्रतिक्रियाएं होती हैं और फिर दो खुली हुई प्रतिक्रियाओं के साथ समाप्त होता है

शारीरिक अवसंरचना: पहले हम मंडी टाउन के भौतिक ढांचे के बारे में जानना चाहते हैं। भौतिक बुनियादी ढांचा एक कार्यशील शहर को बनाए रखने के लिए आवश्यक सेवाओं और प्रणालियां हैं। इन प्रकार के बुनियादी ढांचे के उदाहरणों में शामिल हैं

1.मंडी के अंदर पानी की आपूर्ति की गुणवत्ता का मूल्यांकन करें?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

2.क्या मंडी के भीतर एक आश्वासन दिया है / सुरक्षित बिजली आपूर्ति है?
- 1 - उपस्थित नहीं
- 2
- 3 - पर्याप्त
- 4
- 5 - महान गुणवत्ता

3. सड़कों की गुणवत्ता क्या है?
- 1 - बहुत संकीर्ण
- 2
- 3 - पर्याप्त
- 4
- 5 - सही आकार

4. मंडी के अंदर यातायात पैटर्न की गुणवत्ता क्या है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

5. पैदल यात्री मार्ग की गुणवत्ता कैसे है?
- 1 - गरीब

- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

6. स्वच्छता / कचरा प्रबंधन इंफ्रास्ट्रक्चर की गुणवत्ता कैसे है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

7. मंडी के अंदर आवास की सामर्थ्य कैसे है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

8. वाईफ़ाई और इंटरनेट कनेक्टिविटी की गुणवत्ता कैसे है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

9.मंडी के अंदर वाहन मुक्त सड़क की स्थिति क्या है?
- 1 - गैर-मौजूद
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

10.क्या मंडी में वर्तमान में उपलब्ध भौतिक अवसंरचना के बारे में कोई अन्य टिप्पणी या चिंताओं हैं जो आप साझा करना चाहते हैं?

11.भौतिक बुनियादी ढांचे को आगे बढ़ने के लिए आप कैसा पसंद करेंगे?

सामाजिक बुनियादी सुविधा: अब हम मंडी टाउन के सामाजिक बुनियादी ढांचे के बारे में अधिक जानने के लिए चाहते हैं। सोशल इन्फ्रास्ट्रक्चर बुनियादी ढांचा है जो एक शहर के भीतर समुदाय की भावना पैदा करता है। इस तरह के बुनियादी ढांचे के उदाहरण हैं

1. मंडी के अंदर धार्मिक ढांचे की गुणवत्ता कितनी है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

2. मंडी के नागरिकों की सुरक्षा और सुरक्षा की गुणवत्ता कैसे है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

3. क्या आपको लगता है कि पर्याप्त नियुक्त खुले स्थान और पार्क हैं?
- 1 - कुछ नहीं
- 2
- 3 - पर्याप्त राशि
- 4
- 5 - सही राशि

4. नगर पालिका और नागरिकों के बीच संचार की गुणवत्ता कैसे है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

5. मंडी में खाने की गुणवत्ता कितनी है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 – बढ़िया

6. मंडी में मनोरंजन की गुणवत्ता कितनी है?

- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

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7. क्या मंडी में वर्तमान में उपलब्ध सामाजिक इन्फ्रास्ट्रक्चर के बारे में कोई अन्य टिप्पणी या चिंताओं हैं जो आप साझा करना चाहते हैं?

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8. आगे बढ़ने के लिए सामाजिक बुनियादी ढांचे को कैसे सुधारना चाहेंगे?

संस्थागत बुनियादी ढांचा: अगला, हम मंडी टाउन के संस्थागत बुनियादी ढांचे के बारे में अधिक जानने के लिए चाहते हैं। संस्थागत बुनियादी सुविधा नियम और सेवाएं हैं जो शहर को प्रशासनिक और स्थिरता प्रदान करती हैं। इस तरह के बुनियादी ढांचे के उदाहरण हैं

1. मंडी में पुलिस विभाग की गुणवत्ता कितनी है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

2. मंडी में एम्बुलेंस सेवा की गुणवत्ता कितनी है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 – बढ़िया

3. मंडी में अपशिष्ट प्रबंधन संगठनों की गुणवत्ता कितनी है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

4. सार्वजनिक परिवहन की गुणवत्ता कैसे है?

- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

5. क्या वहां आम तौर पर शहर में पावर अपघटन है?

- 1 - कई बिजली आउटेज
- 2
- 3 - ओसीसरियल पावर आउटेज
- 4
- 5 - कोई पावर आउटेज नहीं

6. क्या मंडी में वर्तमान में उपलब्ध संस्थागत इन्फ्रास्ट्क्चर के बारे में कोई अन्य टिप्पणी या चिंताओं हैं जो आप साझा करना चाहते हैं?

7. आप आगे बढ़ने में सुधार के लिए संस्थागत बुनियादी ढांचा कैसे चाहेंगे?

आर्थिक ढांचा: अंत में हम मंडी टाउन के आर्थिक आधारभूत संरचना के बारे में अधिक जानना चाहते हैं। आर्थिक ढांचा सुविधा है जो समुदायों में व्यवसायिक गतिविधियों को संभव बनाता है। इस तरह के बुनियादी ढांचे के उदाहरण हैं

1. मंडी के अंदर व्यापार केंद्रों की ताकत कैसे है?

- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

2. मंडी में उपलब्ध वस्तुओं और सेवाओं की गुणवत्ता की गुणवत्ता क्या है?

- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

3. मंडी में स्थानीय दुकानों की ताकत कैसे है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

4. मंडी में पर्यटन के प्रभाव की गुणवत्ता कैसे है?
- 1 - गरीब
- 2
- 3 - पर्याप्त
- 4
- 5 - बढ़िया

5. क्या मंडी में वर्तमान में उपलब्ध संस्थागत इन्फ्रास्ट्रक्चर के बारे में कोई अन्य टिप्पणी या चिंताओं हैं, जिन्हें आप साझा करना चाहते हैं?

6. आप आगे बढ़ने में सुधार के लिए संस्थागत बुनियादी सुविधा कैसे चाहेंगे?

जनसांख्यिकी:
1. लिंग:
- नर
- महिला
- अन्य
2. आयु
- 18 से नीचे
- 18 - 24
- 25 - 34
- 35 - 44
- 45 - 54
- 55 - 64
- 65 - 74
- 75 और पुराने

Appendix D: Interview Questions with City Officials

Do we have permission to use your name in our research?

Do we have permission to take audio and/or video of this meeting?

1. How long have you held your position?
2. What do you think about the Smart City initiative?
3. Do you think Mandi has the ability to become a Smart City based on the current government initiative?
4. Does the city of Mandi lack in any of the pillars of Infrastructure?

a.   If so which ones?

1. Is the city of Mandi excelling in any of the pillars of Infrastructure?
    b. If so which ones?
1. Do you believe people are living comfortably with the amount they are making?
2. Do you think improvement of the town is needed?
    c. If so, do you think it is possible and how would you do it?

Appendix E: SWOT Analysis

Strengths:	Weaknesses:
Opportunities:	**Threats:**