

Traffic Congestion Alleviation in Mandi, Himachal Pradesh, India



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Abstract

Traffic congestion in Mandi City will be further exacerbated by the increase of population in years to come. The goal of this project was to make Mandi City more attractive and navigable to tourists, visitors, and residents through the implementation of safer and more efficient traffic patterns. We conducted qualitative interviews with local stakeholders and collected quantitative data through evaluation of traffic flow. The analysis of our data indicated that Mandi's existing infrastructure cannot support its traffic trends, confirming a need for traffic alleviation. Based on stakeholder feedback, we generated a set of recommendations that will mitigate traffic congestion and ultimately make Mandi a safer and more pleasant destination.

Executive Summary

Introduction and Background:

Located in the center of Himachal Pradesh, Mandi often serves as a segue to northern destinations such as Kullu, Lahaul, Leh Ladakh, and to the regions of Jammu and Kashmir. Visitors, not only from India, but from all over the world often seek Himachal as a vacation destination due to the appeal of its location in the foothills of the Himalayas.

The district-wide number of residents, according to the 2011 census, is approaching 1



Figure 1: An example of traffic congestion

million. This number is expected to increase as the new establishment of the Indian Institute of Technology (IIT) at Mandi will bring students, faculty, and tourists from across India. As exhibited in figure 1, the city of Mandi already suffers from congestion as vehicles travel in multiple directions and tend to park wherever convenient. The expected influx of roughly 6,000 students and supporting faculty within the next ten years will place new demands on an infrastructure congestion that is already straining to manage its existing population.

most likely increase the release of air pollutants, pose a higher risk of road traffic accidents, and further hinder the efficiency of travel. Therefore, the purpose of our project was to propose a series of recommendations aimed to alleviate the current level of traffic congestion in Mandi.

This anticipated increase in vehicular activity within the city will

Methodology:

To accomplish our goal, we developed a two-pronged approach to collecting data. We simultaneously collected qualitative data from interviews with local stakeholders, and collected quantitative data through observations and calculations. We decided to concentrate on the central area of Mandi as our target area for data collection. This area encompasses most of Mandi city's commercial businesses and as a result, experiences utmost traffic congestion.

Our first objective in accomplishing our goal of alleviating traffic congestion was to assess and map traffic patterns in the center of the city. Based on feedback on traffic congestion from the residents, in addition to our own observations, we identified three locations of traffic hotspots at which we counted traffic flow rate: Skudi Bridge, Suketu Bridge and Victoria Bridge. At each of the three traffic hot spot locations, measurements of traffic flow rate were repeated at four different time intervals: 9:00am-10:00am, 1:00pm-2:00pm, and 5:00pm-6:00pm on weekdays, as well as 5:00pm-6:00pm on Saturdays. The data was a count of all forms of traffic, per hour, including: cars, auto rickshaws, motorcycles, buses, trucks, and pedestrians. In addition, the team assessed the numerical capacity of all private, public, and reserved parking lots throughout the center of the city. We utilized the numerical data we collected, as well as data provided by the District of Mandi and standards set by the Indian Road Congress, to calculate the

Roadway Congestion Index (RCI). Encompassing the remainder of our quantitative segment, we carried out road dimensional analysis by way of measuring the width of selected roadways, thereby gaining an understanding of the theoretical capacity of certain roads.



Figure 2: Team members measuring road widths

Our second and third objectives involved carrying out interviews with key stakeholder categories: vehicle owners, pedestrians, business owners, cab and auto rickshaw drivers, and tourists. We conducted semi-standardized interviews, asking questions that both prompted personal viewpoints with regard to traffic congestion and encouraged suggestions to alleviate traffic congestion. Each and every response was taken into consideration while generating our recommendations, which were later presented to the District Commissioner.

Findings and analysis:

Objective 1: Assess and map existing traffic patterns in designated areas

From our firsthand site assessment, we observed that the current width of road lanes do not allow for safe simultaneous pedestrian and vehicular flow, as the lack of adequate pedestrian pathways force pedestrians to compete with vehicles for space. We noticed that this narrowing of road lanes is caused by a large presence of garbage disposal on roadsides, the high incidence of illegal road-side parking, and structural damage to the surface of roadways themselves. As a result of traffic congestion, due to the narrowing of lanes, we observed a high level of noise pollution and general inefficiency with regard to travel through Mandi.

After gathering quantitative traffic data, in the form of traffic flow rates, we calculated Passenger Car Units per hour (PCU/H) for each location, at each of the four time intervals. We found that PCU/H varied between both time period and location, as indicated by Figure 3. Supplementing these values, the results of our road dimensional

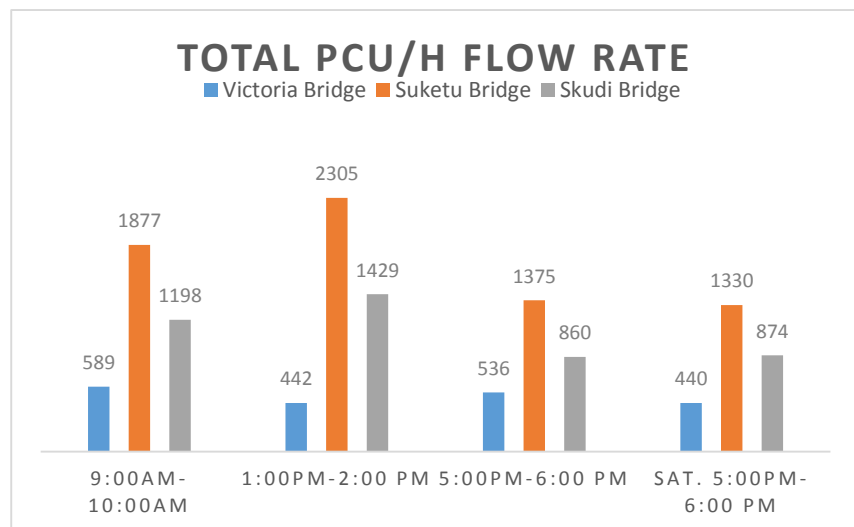


Figure 3: Total PCU/H flow rate

analysis revealed that roads in the city were often as narrow as 5 meters for 2-way roads, and were further constricted to 3 meters with roadside parking. Comparatively, the Indian Road

Congress (IRC) suggests that two-way roads have a width of 7.5 meters, 1.5 times the width of several roadways in Mandi when unobstructed. Smaller roads throughout the city were as narrow as 2.3 meters, yet still allowed for motorcycle travel. Finally, we were able to conclude that the capacity of all the parking facilities available in Mandi is 745 PCUs. Collectively, these results served as quantitative support to our observations that Mandi suffers from a severe level of traffic congestion.

Objective 2: Record residential concerns

In order to gain an understanding of traffic congestion through the eyes of residents we conducted a series of interviews, which were divided by stakeholder category: vehicle owners, pedestrians, taxi/auto rickshaw drivers, store-owners, and tourists. The responses from each stakeholder category were generally enthusiastic, as both contributor and victims of traffic congestion are eager to consider any reforms in the way in which traffic occurs in Mandi. When



Figure 4: Illegally parked vehicle

approached with this topic, most residents welcomed discussion with a fervent demeanor and a willingness to share their perspective on traffic congestion. The responses that were universal among all five categories: individuals tend to park their vehicles anywhere, public transportation is not preferable, the city suffers from lack of parking facilities, traffic law enforcement is ineffectual, there is constant stopping of taxi vehicles, and the roads are in poor condition. In fact, many vehicle owners park their vehicles in areas where parking is prohibited, as displayed in figure 4.

When questioned about locations of severe traffic congestion, respondents typically identified the areas surrounding Indira Market, the bus stand, Bhoothnath temple area, and the school bazaar as the most congested areas. Understanding that the population is expected to increase in years to come, most interviewees were eager to communicate issues that contribute to traffic congestion.

Objective 3: Gather stakeholder input into urban planning strategies

The vast majority of interviewees, from each of the five stakeholder categories, appeared eager to answer our questions regarding their interpretation of traffic congestion, perhaps due to the general understanding that traffic congestion will worsen in the future without any immediate traffic reform. The most recurring suggestion we received was the implementation of more available parking facilities, stating that lack of available parking space is the root cause for traffic congestion. These suggestions ranged from constructing parking lots in empty spaces to demolishing existing structures to construct multi-level parking facilities. Many stakeholders also proposed short-term and relatively inexpensive suggestions, such as repaving damaged roads. The presence of pot holes were noted as major obstacles to safe and efficient driving, as vehicles tend to avoid these obstructions, limiting the amount of space allocated for driving. Likewise, policy related reforms are relatively inexpensive in cost and carry the potential for instilling a sense of orderliness in traffic patterns. Many stakeholders remarked that the addition

of traffic lights, supplemented by a larger presence of police officers, would establish efficiency in terms of traffic flow. Lastly, it was suggested by a variety of stakeholders that alternative bus routes be established, given that the large presence of buses traveling through the city contributes to much of the congestion. Because each of these suggestions varied in feasibility, these solutions were further analyzed for plausibility and time required for implementation.

Calculations:

Our quantitative data illustrated a pressing need for traffic reform in the city that complemented the qualitative results of our interviews extremely well. A brief analysis of the total number of parking spots in the city: 745 PCUs is far from sufficient when compared to the fact that there are over 42,000 citizens in the city alone, and nearly 67,000 registered vehicles in the District of Mandi.

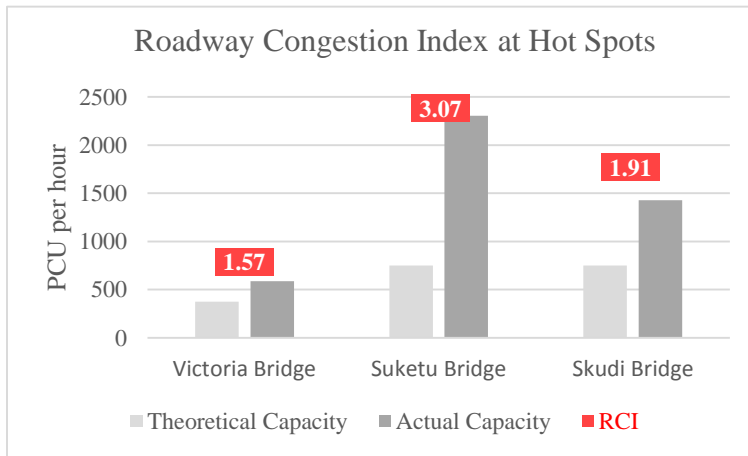


Figure 5: Roadway congestion index at hot spots

Using the flow rate data, in the form of PCU/H, collected at four different time slots, as well as the theoretical capacity obtained from the Indian Road Congress (IRC), we calculated the Roadway Congestion Index (RCI). We determined the RCIs for the three locations, using the flow rate data at the busiest time periods, as displayed in red in Figure 5. Then, using a separate formula, we calculated the Network Weighted Average RCI, which came out to a

final value of 2.46. This number is a ratio that effectively states that the roadway network in the center of Mandi is nearly two and a half times over capacity. Along with the feedback from interviewees, these results provided a justification for action to alleviate traffic congestion in the city.

Analysis:

For the purposes of this project, we identified cost-efficient solutions that can potentially serve as short-term implementations. Given that plausibility of implementation increases as cost decreases, we focused on enacting economically feasible projects. However, we also included more expensive projects, given the large potential for effectiveness. For instance, it was suggested that multi-level parking facilities could be constructed in place of the current largest private parking facility (near Regent Palms Hotel), in place of the Press Office, and in place of the Senior Secondary School. The establishment of a multi-level parking facility, would greatly alleviate the presence of illegal parking, thereby creating more lane space for traffic flow. If Mandi adopted a stricter fining system to fine vehicles for illegal parking, then perhaps a project of this magnitude could eventually be financed. Projects of this scale were designated as potential long-term project ideas for the city of Mandi.

Recommendations:

After analyzing each solution suggested by the interviewees, we prepared a series of recommendations targeted to remediate the factors that led to traffic congestion within the city of Mandi. Our recommendations were tailored to fit the community, while varying in cost, effectiveness, and when, if implemented, the changes can be expected to be completed.

We recommend that a multi-level parking facility be established at the current transitional parking facility along NH-21 entering the city from the south. This lot, south of the interstate bus terminal is currently undeveloped and unmanaged, but has considerable available space.

We recommend that the Press Office be converted into a multi-level parking facility. Since the Press Office is no longer in use, this property could be converted into a parking facility.

We recommend that a proactive urban planning strategy be put in place to allow future expansion of Mandi City. Serving as a start to this proactive urban planning reform, the addition of a small shopping center outside of the city could draw much of the traffic from inside the center of the city to outside of the city.

We recommend that the width of roadways be expanded through deconstruction. Businesses are contributing to traffic congestion, as their presence on the streets is further narrowing driving lanes. This issue can be alleviated with stricter encroachment violations or the deconstruction and relocation of current businesses from the interior of the city to outside the city.

We recommend that the areas bordering Indira Market become a pedestrian-only zone. If parking facilities were to be increased in both number and capacity, outside of the city or along the outskirts of the city, then the prohibition of vehicular traffic would be feasible.

We recommend that a flyover bridge for pedestrian use be constructed. This structure would allow pedestrians to safely travel across certain areas without hindering the flow of traffic.

We recommend a larger presence of law enforcement in Mandi. The higher presence of traffic police would establish a sense of order in the city. Currently, the city is littered with illegal parking; vehicle owners park in areas that are blatantly marked as “no parking” zones, knowing that they will most likely not face a penalty.

We recommend that private parking facilities charge hourly. Currently, parking facilities tend to charge per entry at a flat rate. This system deters vehicle owners from utilizing parking facilities who intend to park their vehicles for a brief amount of time.

We recommend that garbage disposal be transferred outside of pedestrian areas. If large-volume-capacity dumpsters were to be relocated to areas away from pedestrian movement, then pedestrians would be better able to occupy roadsides, away from vehicular traffic.

Conclusion:

Given the expected increase in population, it can be assumed that traffic congestion in Mandi will increase in severity during years to come. If this is the case, current effects of traffic congestion, including air and noise pollution, traffic-related accidents, and inefficient road travel, may place a harsher toll on the Mandi's residents. Our assessment and research on traffic congestion in Mandi has confirmed the existence of severe traffic congestion and its adverse effect on the city of Mandi. Through our discourse with store-owners, drivers, and pedestrians, we gained the impression that the residents of Mandi share an awareness of the severity of traffic congestion and are therefore receptive to potential traffic reformations. In fact, many stakeholders suggested detailed methods by which traffic congestion could potentially be alleviated, which were analyzed for feasibility and incorporated into a series of recommendations.

For the purposes of this project, we identified a set of cost-efficient solutions that can potentially serve as short-term implementations. Given that plausibility of implementation increases as cost decreases, we focused on enacting economically feasible projects. However given the large potential for effectiveness of economically costly solutions, we designated such ideas as potential long-term project ideas for the city of Mandi. With ample time and consideration, we are confident that the implementation of our recommendations is conceivable and if enacted, would immensely benefit both residents and visitors of Mandi.

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Chapter 1: Introduction

Mandi lies in the center of Himachal Pradesh, located on the junction of National Highways 20, 21, and 70. As a result, it serves as a gateway for visitors traveling on to Kullu, Lahaul, Leh Ladakh, and to the regions of Jammu and Kashmir. At the same time, Mandi also provides many of the commercial resources needed in Himachal Pradesh. Due to its location, Himachal depends greatly on Mandi for trade, commerce, services, and civil administration ("Dp Mandi," 2012).

Mandi District is becoming progressively more populated. The district-wide number of residents, according to the 2011 census, is 999,518. In contrast, the region had 776,372 residents in 1991 reflecting an increase of 223,146 in just 20 years (Heyden, 2011). Furthermore, the population in the area is projected to increase by 28.85% in the next decade ("Dp Mandi," 2012). Given this increase, it is important to plan for an increased load on the infrastructure of the town.

Mandi City's roadways and infrastructure will also endure an additional strain, given the recent closing of the Kullu airport (which had previously allowed tourists to bypass Mandi on their way to the northern regions of Himachal Pradesh). According to a recent article, new limitations and the cancellation of Kingfisher airlines have compromised reliable air connections to Kullu (Rapoza, 2013). Both Air-India and Kingfisher airlines have suspended operation to the Kullu airport since mid-2012 (Makhaik, 2013; Dutta, 2012). This means that Mandi has the potential for falling in the path of tourists traveling to Manali by car or bus, contributing to Mandi's overall vehicle traffic. Therefore, it is especially important that the city of Mandi becomes more navigable to prepare for these new visitors.

In the meantime, new construction of the Indian Institute of Technology (IIT) at Mandi will bring students, faculty, and tourists from across India, increasing visitation to Mandi City. This institution is being built with the goal of becoming a "leader in science and technology education, knowledge creation and innovation, in an India marching towards a just, inclusive and sustainable society", but what this means for the city of Mandi is hard to predict ("Indian Institute of Technology", 2011). The influx of up to 6,000 students and supporting faculty will likely bring new demands to the city. Through the proactive implementation of initiatives that aim to make the Mandi City center more safe and navigable, the goals of the IIT could be supported and some of the strain brought by new residents could be alleviated ("Indian Institute of Technology", 2011).

Not only will the increase in traffic congestion present an element of chaos and stress, but Mandi's traffic and congestion issues also have the potential to pose health risks. Currently, Mandi experiences traffic congestion due to the inadequate design of interior roadways and their connections, causing an unnecessary amount of traffic and thus, dangerous levels of air pollutants (Nautiyal, 2007). Time series studies conducted in major Indian cities have similarly revealed a direct correlation between daily mortality and increases in emission of air pollutants. More specifically, epidemiological studies have indicated that long-term exposures to these gaseous materials are leading to cancer, cardiopulmonary-related diseases, and other forms of premature mortality (Nautiyal, 2007). Finally, there are trauma-related issues with traffic congestion. As the population increases throughout Indian cities, traffic accidents are becoming more prevalent since roadways were not designed to sustain such heavy traffic, both pedestrian and vehicular. According to the Indian Journal of Medical Sciences, "in India over 80,000 persons die in traffic crashes annually, over 1.2 million are injured seriously and about 300,000 disabled permanently" (Ganveer, 2005, pp. 9-12).

Given the health risks and transportation inefficiency posed by Mandi's traffic congestion and in consideration for planning to accommodate many more visitors, our goal was to record the factors that contribute to these health risks and congestion concerns to ultimately design a planning strategy to make Mandi a more inviting destination. At the end of this project, we proposed recommendations and targeted solutions, which, if implemented, could help decrease the traffic congestion, making Mandi a more welcoming and enjoyable city in the long term. This was accomplished through various step-by-step objectives including but not limited to studying the traffic patterns in Mandi City, studying the composition of traffic broken down to different vehicle types, identifying critical traffic hotspots and suggesting solutions of improvement, exploring existing parking structures, engaging local stakeholders and collaborators in the development of project, and devising efficient prototypes and strategies to reach the long term goal. We worked with local stakeholders to design potential models of traffic pattern planning that allowed the center to prepare for and adjust to the imminent influx of tourists, students, IIT faculty members, and visitors.

Chapter 2: Literature Review

To begin our research, it was first necessary to identify the economic, social, political, and geographical background of the location, and to distinguish those residents who will be both directly and indirectly affected by our actions. The purpose of this chapter was to evaluate previous research on traffic congestion in India and the approaches taken to analyze this issue in depth, through the analysis of several case studies pertaining to the effects of traffic congestion. We begin with some historical context for the region.

2.1 Geographic and cultural background

Mandi, historically known as Mandav Nagar [Gazetteer of the Mandi State, pg. 21, 1920], is a major city of Himachal Pradesh. It is located in the northern part of India, north of Delhi and to the west of Nepal, in the northwest foothills of the western Himalaya (at an altitude of 1,044 m), along the banks of the Beas River (WPI IGSD, 2013; "Himachal Tourism," 2013). It is enriched with beauty, in both landscape and ancient man-made structures. Tourists are often attracted to Mandi as a location to relax, dine, and prepare for their upcoming adventures farther North. The climate of Mandi differs from that of the rest of the country. It is typically drier and cooler than southern regions of India. Because of its climatic conditions, natural beauty, and historic importance, Mandi serves as a waypoint for large number of national and international tourists headed towards northern parts of the state (see figure 1, below).



Figure 1: Map of Mandi ("Himachal Tourism | Mandi," 2013)

In addition to Indian tourists, visitors from all over the world are lured to the element of tradition in Mandi particularly, the annual Shivratri Festival; a seven day long fair held in the month of March that attracts thousands of tourists annually. This fair has been organized since the year 1526, the foundation of present day Mandi. Mandi currently serves as a tourist attraction for its element of tradition and climatic appeal.

The main language spoken by the locals in Mandi is Mandeali and the people are called Mandyalis. Mandi's ancient religious history also attracts tourist activity. The city of Mandi holds 81 ancient stone temples. The more famous temples include Bhootnath, TrilokiNath, Panchvaktra, and Shyamakali ("Himachal Tourism," 2013). Mandi is known for these temples, with the city often called the "Varanasi of the Hills", referring to the famous city in India that is known for its 80 temples. Filled with lakes, temples, palaces, bazaars, and markets, the region's beauty attracts tourists from India's southern regions and even from all over the world ("Mandi, Varanasi," 2013). In addition, tourists flock to the region to visit the three holy shrines, located in Rewalsar, that are unique to the district. These shrines are dedicated to different religions: a Buddhist Monastery (Buddhism), Gurudwara (Sikhism) and the Kali Temple (Hinduism) ("Mandi, Varanasi," 2013). These sacred temples and shrines are only a small part of what makes Mandi appealing. Mandi City is also known for hosting cultural events, exhibitions, and sports. This brings in local residents as well as tourists wishing to experience the festival and the element of tradition ("Himachal Tourism," 2013). Both Mandi's location in the foothills of the Himalayas and the rich religious and cultural tradition play a role in attracting tourists in large numbers.

2.2 Mandi central business and shopping profile: trade and commerce

Not only does Mandi's appeal to tourists contribute to its increasing population, but Mandi's flourishing business and commerce activity also has led to a concentrated population in Mandi City, causing Mandi's congested traffic patterns. According to an interview carried out by the Himachal Pradesh town and Country Planning Department, there are 2,450 shops in Mandi City, 1,783 of which are retail and 132 are wholesale. Collectively, these shops provide all essential services for the region including: food markets, clothing stores, furniture, jewelry, agricultural supplies, building supplies, coal, and medicines ("Dp Mandi," 2012). Shops that feature these items represent a majority of shops in town. These shops are essential to the economy of the city and support the livelihood of the residents. Many of these shops are located in Mandi's Indira Market, a sunken garden with two levels of shops surrounding a green area (see figure 2, below)



Figure 2: Open air mall in Mandi City

Among these shopkeepers, nearly 50% own their shops while the majority of them are operating in rentals ("Dp Mandi," 2012). Recently, there has been growing demand for commercial space, and residents increasingly sell products in the central district from homes, now converted to storefronts ("Dp Mandi," 2012). This tendency is changing the traditional architecture of the city, as classic houses are being transformed into cement concrete structures.

Furthermore, according to news reports, the city is expanding so intensely that it is reaching its outer limits (“Dp Mandi,” 2012). Not only does this trend place a burden on families who undergo transformation of their home, but this tendency to convert homes into street-front shops is also augmenting the sense of crowdedness throughout the city as businesses have a tendency to encroach upon government owned road space over time.

2.3 Traffic trends in Himachal Pradesh

Adverse effects of traffic expansion are not unique to Mandi. A recent report compiled by the World Health Organization concluded that India has the highest number of road traffic accidents in the world (Deutsche Welle, 2010). In the more local and rural framework of Himachal Pradesh, there has been extensive research into traffic issues within the state. A study conducted in 2008 by Ravinder et al. on traffic issues in Himachal Pradesh concluded that “transport management in the state is totally out of gear with high congestion at major tourist areas, lack of parking facilities, high accidents and pollution due to vehicular movement” (Ravinder, 2008, p. 98). Popular tourist destinations in the north of the state in particular see considerable congestion (see figure 3, below).



Figure 3: Traffic congestion in Himachal Pradesh (“HolidayHome Times”, 2012)

The study also provides specific data about traffic accidents in Himachal Pradesh. According to the report, the Himachal Pradesh Police Railway and Traffic Wing report that road accidents are growing at 12-15% per annum and casualties are growing at a rate of 18-20% per

annum (Ravinder, 2008). The study also cites insufficient parking facilities as a cause to traffic congestion as incoming vehicles often park on the road, narrowing the width of the road space as drivers resort to roadside parking. This tendency is especially common in the high tourist season and compounded by the fact that the tourism industry has grown significantly in the 1990s while the infrastructure of the state has not been able to keep up. While these reports likely refer to tourism hubs such as Manali, Mandi suffers from similar problems.

A study completed by the Department of Transportation of Himachal Pradesh found that the average width of national highways is 2.5 meters and the width further decreases in towns due to a number of reasons including, but not limited to, roadside parking and garbage disposal. Furthermore, the closing of the Kullu airport of Manali will re-route traffic through small towns between Delhi and these northern destinations, further imposing on the local infrastructural capacity to manage traffic. As a result of a large gap between the infrastructure capability and actual use, the Himachal Pradesh State High Court has established a “high-powered” committee to make recommendations for steps to solutions to solve the traffic congestion (Ravinder, 2008)

Mandi is no exception to the traffic congestion issues that plague India and more specifically, Himachal Pradesh. Of the people that own shops, a recent interview indicates that 1,306 own vehicles and 74% of those vehicles are two wheelers (scooters and motorcycles) (“Dp Mandi,” 2012). Out of the total number of vehicles (two wheeled and four wheeled) more than half of them are parked illegally on the side of the road and the other 45.95% are parked legally in authorized parking areas (“Dp Mandi,” 2012). That means that there are over 700 illegally parked vehicles on streets, main roads, and footpaths, making it more difficult for pedestrians to co-exist with vehicles on the streets, causing substantial pedestrian injuries and vehicle accidents (see figure 4, below).



Figure 4: Illegally parked vehicles on Mangvayin Road, Mandi

Although the city has other concerns such as lack of adequate garbage disposal practices, public bathrooms, and access to public running water, traffic congestion continues to be the biggest issue in town ("Dp Mandi," 2012). As noted in one report, "The highways and link roads are the veins and arteries of any town. As proper blood circulation is necessary for survival of the human beings, similarly well planned circulation network is a must for the health of a town" ("Dp Mandi," 2012, p. 34). Managing the current traffic situation in Mandi is a daunting task, but it has become clear that Mandi's traffic congestion should be addressed, as the town struggles with traffic jams, poor drainage systems, housing development issues, structural damage to the roadways, lack of parking availability, and the impending arrival of the new IIT community. Further contributing to traffic congestion in Mandi, are thousands of vehicles going through Mandi every day; bus terminals are chaotic and disorganized, and proper parking space for trucks are rare. Mandi's bus terminal has around 300 arrivals and departures per day ("Dp Mandi," 2012). In a recent effort to improve the organization and efficiency of the terminal, addressing the concerns illustrated in the Dp Mandi document, construction plans have been initiated by the government of Mandi. However, for unknown reasons, these construction plans have been delayed. In addition, from observation it is evident that there are no loading/unloading docks available to move goods, since approximately 60-70% of goods are imported from outside

the state and the loading and unloading activities take place in center of town along the road which seriously impedes smooth flow of traffic through already overcrowded roads in central parts of the town. This means that roughly 100 trucks per day stop at inconvenient places along highways, obstructing the traffic flow and limiting the mobility on roadways. In addition, parking facilities, as mentioned before, are often full and offer limited space. Private parking is especially limited and drivers tend to park on the roadside, in centralized commercial areas and close to public places. In other words, people will park their cars nearly anywhere, since penalties for improper or inconvenient parking are absent or not enforced. These sporadic parking habits in Mandi are making the roads narrower, thwarting traffic flow ("Dp Mandi," 2012).

All of these factors contribute to major concerns for the city of Mandi. According to the Himachal Pradesh Town & Country Planning Department, regional factors include: haphazard parking, auto-repair happening on roadsides, encroachments on streets narrowing the street width, construction deteriorating road conditions, garbage blocking roads and obstructing driver's vision of the road, and a high percentage of fatal vehicle accidents ("Dp Mandi," 2012). For instance, figure 5, below, exemplifies an incidence of road obstruction as a large garbage dumpster resides on a roadside, which hinders traffic flow during times of heavy traffic congestion. In addition, pedestrians are repelled by the presence of dumpsters on roadsides and as a result, tend to travel in the midst of vehicular traffic. These factors collectively create a dangerous degree of congestion within many areas of Mandi.



Figure 5: Garbage dumpster obstructing roadside

2.4 Stakeholders

The circulation of traffic is linked to the habits, needs, traditions, and constraints of the population. If, as stated earlier, “highways and link roads are the veins and arteries of any town”, alteration or disruption to this vital circulation network would affect the “health of a town” in a number of adverse ways, indicating that a stakeholder analysis is important for any project attempting to reform traffic patterns (“Dp Mandi,” 2012). Stakeholder analysis is a necessary procedure employed to facilitate any reform process by addressing the needs of those who will be directly or indirectly affected by the policy or those who have an interest in the reform (“Stakeholder analysis,” 2001). As with any policy reform, stakeholder analysis should be completed in order to recognize any people, government, institutions, or organization and predict their expected backing or opposition of our project. The necessity of stakeholder analysis is often overlooked, as it is all too easy to place the personal agenda of the researcher above the needs of the community. In this case, the stakeholder analysis is an attempt to evaluate economic, environmental, political, and social dimensions of the project in order to acknowledge a number of factors and effectively respond to the needs of the community.

Stakeholder analysis, specifically as it pertains to transportation policy and reform, has been completed extensively and exhaustively by a number of reputable organizations including the World Bank and the Department for International Development (DFID), demonstrating that it is a crucial part of any development process (Department for International Development [DFID], 2003). Both organizations have done extensive research throughout Africa and Asia on rural and urban road development and the DFID has even gone as far as to create a stakeholder analysis “toolkit” relating directly to transportation policy (DFID, 2003). A study conducted in Hanoi, Vietnam in 2005 entitled “Community Participation in Rural Transport” created and executed an impressive hierarchy of stakeholder analysis procedures. This process began with provincial and district level transport and government authorities and ended with the analysis of stakeholders such as “women, poor households, female headed households, and ethnic minorities” (Mekong Economics Ltd. 2005). Researchers here used a participatory approach to study stakeholder’s opinions by asking them to draw a roadmap of the important roads and centers (Mekong Economics Ltd. 2005). Because this approach facilitates a high level of engagement with the residents, we adopted a comparable method that encourages participatory action.

Our stakeholder analysis, outlined here and discussed in greater depth in the methodology

chapter, considered a number of issues and concerns. We deliberated issues such as the project's benefit to stakeholders, the project activities and outcomes that could potentially cause damage or conflict to the stakeholder, and any changes that the project may require the stakeholders to make.

Best practices in stakeholder analysis evaluate the problem from a number of different angles: economic, political, social, and environmental. The environmental impact of our project on potential stakeholders will assess the effect the project may have on health, pollution, accident frequency, and other health issues associated with traffic congestion. In addition, we could consider the environment itself as a stakeholder and address how it may be affected by our project. There seems to be an obvious connection between traffic congestion and environmental pollution, hence if our project is aiming to alleviate traffic congestion, it is safe to presume that it will benefit the environment by alleviating environmental pollution.

The political and social impact of our project upon the community of Mandi is slightly more complicated than its environmental impacts. Politically, we can assume that the local government, in the form of the District Commissioner's Office, will be a stakeholder because the District Commissioner has an interest in matters concerning the city constituents. Politics are always a factor, as a political agenda can often decide whether or not a project will gain backing or face opposition. Locally, the residents of Mandi are the most obvious stakeholders. Indeed, they could benefit from any of the project's positive environmental impacts, especially if it resulted in a decrease in noise or garbage pollution, or gaseous emissions. However, the social effect of a project must be delicately considered in case the outcome of the project disrupts the daily life of the stakeholders.

The economic impact of our project upon the community of the town of Mandi is far from straightforward and this concept presents an interesting multi-faceted dynamic to any well-intentioned project. To begin, it seems evident to consider the effect that roads and transportation have on business. Mandi's business would be isolated in the foothills of the Himalayas if not for its convenient location on the junction of three national highways. Hence, altering traffic patterns in any way would have to be carefully considered, especially if such alterations have any potential adverse effects on local businesses. Suppliers need to reach businesses and customers need to reach stores downtown. In addition, the through-traffic of Mandi, though seemingly a nuisance, may be a necessity to thriving business in the town. In the worst-case scenario, re-

routing traffic around Mandi rather than through it could potentially negatively impact Mandi, and be counterproductive to the end goal of our project. Finally, the growing tourism industry of area (particularly with regard to the new IIT traffic) must be considered to be a stakeholder. Therefore, we will step lightly in recommending any reform that could negatively affect the very industry we are trying to indirectly nurture.

Based on the over-arching stakeholder categories we identified and we opted to interview five different groups of stakeholders. These groups include: cab and auto rickshaw drivers, residents, tourists, shopkeepers, and vehicle owners; each falling under a combination of the economic and social categories mentioned above. In addition, the District Commissioner, falling under the political category, is another key stakeholder. Finally, the environmental impacts of our study, such as any noise, air or garbage pollution alleviation, are likely to affect the environment as a stakeholder.

2.5 Case Studies

In this section, we evaluated four projects that undertook similar initiatives, with regard to traffic congestion and its related issues, in Indian communities, in order to learn effective practices in assessing, evaluating, and resolving issues related to vehicle traffic.

2.5.1 Evaluation and analysis of road traffic noise in Asansol

In 2008, Dr. D. Banerjee a Researcher in the Department of Production Engineering, the center of Advanced study at Jadavpur University, conducted a thorough investigation into the causes and degree of noise pollution in Asansol, an industrial town in the eastern Indian District of Burdwan. Given the psychological and physiological effect associated with noise pollution, it is important that its causes are addressed to enable permanent solutions to the sources of noise pollution. Through interviews with the local residents of Asansol and the use of a digital sound level meter, the team was able to assess the noise intensity levels (in Decibel units) at various times of a typical work day of suitable climatic conditions. A noise intensity level of 86 decibels or higher is considered “extremely high risk”. In order to pinpoint the degree of risk in certain areas, the team divided the Asansol metropolis into four zones, from which sound intensity data was extracted; these zones included the industrial, commercial, residential, and sensitive zones (educational institutions, courts, health establishments and places of worship).

With a daytime noise intensity level average of 65.7 to 76.7, the roadways of the

industrial zone experienced a concerning level of noise pollution. Although this zone did not include many residential quarters, it hosted a large proportion of commuters as several bus stands lie in this region. Because the instantaneous noise produced by the heavy traffic flow is significantly high, it was crucial that this degree of noise emission was addressed, especially because commuters and, potentially, tourists, could be deterred from traveling through this region if the noise pollution issues continue to be ignored. Likewise, commercial establishments experienced a substantial amount of noise pollution, having a daytime noise level range of 66.6 to 87.3. This area was home to both isolated and clusters of shops, explaining the heavy flow of traffic and thus, noise pollution. From general observations and interviews conducted with locals from this zone, the team concluded that this zone experiences a noise intensity of up to 87.8 decibels because proper footpaths were absent and pedestrians were compelled to share the roadways with motor vehicles. It was also found that there was a lack of parking lots and traffic management, leading to the overall congestion and the frequent honking of horns around the marketplaces. The residential and sensitive zones also experienced noise pollution, though not nearly as severe as the noise emissions experienced by the industrious and commercial zones. Previous measures to alleviate noise intensity in residential areas include the many postings of “No-Horn” signs; though these signs seem to be ignored or not visible to drivers. Therefore, there exists a need to implement a more radical method to alleviate traffic congestion.

The team effectively identified the precise areas of Asansol that experience the most severe noise intensity. They were also able to identify traffic congestion as the cause for noise generation and several reasons for such traffic congestion. In addition, this study voiced the need for alleviating noise emission since several of these zones, where noise intensity is dangerously high, are often visited by tourists, given that tourists often rely on public transportation and visit shopping complexes. Although this study presented a thorough assessment of the noise pollution issues of a medium sized, urban, Indian city, the team neglected to provide any recommendations targeted to alleviate traffic congestion. The study included recommendations geared towards controlling the noise at the sources, such as tuning vehicles, more use of two-wheelers, and the use of noise absorbing materials for construction of infrastructures. Indeed, the team furnished several recommendations that can be applied to the noise issues of Mandi, India. However, none of these recommendations are targeted to alleviate the root cause of noise pollution, which is traffic congestion.

2.5.2 Patterns of road traffic injuries in a vulnerable population in Hyderabad, India

In June 2006, researchers R. Dandona, G. Kumar, T. Raj and L. Dandona, senior research scientists at the Public Foundation of India, sought to describe the effect of road traffic injuries (RTIs) on the population of Hyderabad, the sixth largest city of India. Targeting only pedestrians and drivers of MTVs (medium tactical vehicle), which includes mopeds, scooterettes, scooters, and motorcycles, the team interviewed random individuals above the age of 15, at random locations within Hyderabad. Because Indian hospitals and police stations generally fail to keep records on minor RTIs, this study interviewed the people of Hyderabad directly, in order to obtain information on those impacted by traffic accidents regardless of the severity of such impacts. Those that agreed to be interviewed were asked to provide demographic details of the nature of any RTIs (which include any accident involving the collision of a vehicle) experienced by any member of their household in the last year. These locations included 76 of the city's 102 bus stops and 51 of the 92 retail petrol filling stations. These locations were chosen based on the availability of space to conduct interviews present at the site. Therefore, this criterion may have caused the data to become less randomized, as the team only targeted areas that afford the space for formal interviews.

After analyzing the responses of the interviewees in a Microsoft Access database, it was found that, out of the traffic accidents involving collision with a pedestrian, 52.6% of the accidents occurred as the pedestrian was crossing the road, 32.5% occurred as the pedestrian was walking on the road, and 8.8% were standing on the side of the road. Also, according to the data, it was found that 83.5% of RTIs involve MTV users. Overall, this study was able to conclude that pedestrians and MTV drivers are at severe risk for being involved in collisions.

From sheer observation and interviews with the locals, the team found that pedestrian accidents are due not only to lack of awareness of the pedestrian himself, but also to a lack of pedestrian crossing areas. In addition, the crossing areas that are present are often occupied by hawkers (vendors) or are covered in trash. The study also addressed the possible causes for the prevalence of MTV related traffic accidents; it was found that roads aren't wide enough and therefore large vehicles compete for space, often pushing MTVs off the road. Also, it was reported that the poor road quality (potholes and other unexpected glitches in the road) have led to several MTV accidents.

This study effectively displayed the severity of RTI and more specifically, the impact on pedestrians and MTV drivers. The data collected by the team revealed the prevalence of traffic accidents, including both minor and severe accidents, showing the vulnerability of Hyderabad's pedestrians and MTV drivers. Drawing from the data collected from the interviews, the team was also able to pinpoint several physical issues of Hyderabad's roadways as a cause for many of the city's traffic accidents. These issues include lack of pedestrian crossing areas, narrowness of roadways, and the abundance of pits and ditches in the streets. Like Hyderabad, many Indian cities suffer from inadequately designed roadways; such roadways cannot handle the increasing population throughout India. As tourist activity continues to climb among India's cities, it is becoming increasingly important that Indian cities adjust to this change by redesigning roadways and pedestrian areas. This study communicated the specific issues regarding Hyderabad's roads and cited them as reasons for the several traffic accidents in the city. However, the study neglected to recommend specific methods that city officials could adopt to alleviate traffic congestion. Additionally, as stated above, the participants in the study may not be representative of all pedestrians or MTV users in Hyderabad. Also, it is likely that interviewees were not completely aware of all RTIs experienced by all members of their households. Although the way in which the data was collected was not completely randomized, the data collected was able to communicate a need for change that can be applied to the roadways of many developing cities.

2.5.3 Effect of lane width on capacity under mixed traffic conditions in India

In 2003, Satish Chandra, Associate Professor Department of Civil Engineering, Indian Institute of Technology, Roorkee, and Upendra Kumar, Former Post Graduate Department of Civil Engineering, Indian Institute of Technology, Roorkee, evaluated the traffic patterns in ten different sections of two-lane roads throughout India. With the hope of designing implementations that will ultimately improve the traffic carrying capacity of roads, the team sought to analyze all geometric parameters of a typical Indian road, including lane width, vertical alignment of the road, and lateral clearance. Though, in order to generate a focused study, the team analyzed and evaluated lane width and in particular, its effect on traffic capacity under mixed conditions. They used a calculated term called, PCUs (Passenger Car Units), to describe traveling capacity, or the ability of a vehicle to travel from point A and point B through a stream of traffic. Factors such as, speed of vehicle, size of vehicle, and roadway width, are all

parameters that the team considered in order to calculate different values of PCUs of certain vehicles at certain roadway sections.

Of course, each vehicle has a different PCU, depending on the size and shape of the vehicle, proving that the traffic carrying capacity of a road is highly dependent on the width of the road's lanes. In addition, the team calculated PCU/hour, based on various flow rates of traffic. It was found that the current average PCU/hour is much lower than it was in 1994. From general observations, the team was able to attribute this decrease in traffic carrying capacity to the mixed nature of travel speeds experienced by Indian roads. Due to inadequate lane discipline, large-bodied vehicles tend to obstruct the flow of smaller vehicles, causing the speed of individual vehicles to decrease. Using these findings, the team was also able to draw the conclusion that narrower lanes are more severely affected by mixed traffic (traffic consisting of varying vehicle sizes and speeds of travel).

This case study effectively analyzed traffic patterns in typical Indian two-lane roadways and identified the causes for congestion: (1) narrowness of lanes and (2) various speeds of travel among vehicles sharing a single lane. Given that this study wasn't unique to one city, it can be assumed that their findings and their methods for furnishing these findings can be applied to any Indian city, including Mandi. Also, the team made good use of information available to them in the form of databases as indicated by their reference to the 1994 PCU data, which allowed the team to draw comparisons between current traffic density and traffic flow in the 20th century. This comparison was vital in that it served as an indication that traffic congestion is worsening and therefore, there is a need to implement a means for alleviating this congestion. Though, like the previous two case studies discussed, this case study fails to suggest any designs that can be implemented in an economically feasible way to alleviate the issues at hand.

2.5.4 Study of traffic congestion in Sylhet

In 2006, a study was conducted by Civil and Environmental Engineering department of Shahjalal University of Science and Technology to assess the severity of existing traffic system in Sylhet, a newly born metropolitan city of north eastern Bangladesh. In this study, traffic volume count at traffic hotspots, survey of road geometry, and calculation of flow capacity, count of pedestrians, and interviews were performed at twenty major intersections and links. From the data extracted from these investigations, the researchers narrowed down their focus to

five intersections that appeared to experience the most congestion. More specifically, the Ambarkhana to Chowatta link was identified as the most congested roadway in the city. In addition to distinguishing this area as the most congested, the group also identified two time periods that endure the highest traffic volume rates, through twelve hourly volume counts at each intersection. By pinpointing the exact locations and time intervals of the most congested roadways in Sylhet, the researchers were able to confine their efforts and resources to five specific samples of severe traffic congestion, from which further data was collected and analyzed. At each of these traffic congestion hot spots, traffic volume was measured for various vehicle types, including rickshaws, motorcycles, auto rickshaws, bicycles, private cars, and so forth. By calculating the average traffic volume, among the data extracted from the five hot spots, for each vehicle type, an accurate quantitative understanding of the composition of traffic congestion was gathered. This segment of the study concluded that non-motorized vehicles constitute most of the traffic, as rickshaws occupy 55% of traffic congestion during peak hours of traffic. Similarly, the researchers were able to collect qualitative observations at these five hot spots, providing accurate understanding of the reasons for traffic at such hours. For instance, from conducting house interviews at these hot spots, the researchers found that most individuals venture to the city via these intersections for educational purposes: parents drive to schools to drop off (and pick up) their children and faculty members drive to these same institutions. This portion of the research provided an understanding of the necessity of transportation, as countless residents depend on transportation to sustain their daily routines. In addition, it was observed that illegal roadside parking and occupation by local hawkers is a major cause for congestion in the city, as road width is further narrowed by illegal parking. This study provided conclusive and reliable information with regard to traffic congestion and some of its causes. However, before arriving at these conclusions, the researchers dedicated their time to understanding the traffic patterns of the city as whole and identifying specific areas to narrow their attentions, allowing extractions of qualitative as well as quantitative data that were averaged among the five hot spots. A similar approach was applied to the site assessment in Mandi City.

2.6 Summary

From investigation into the background of Mandi's traffic patterns and from examination of previous case studies relating to traffic congestion throughout India, we gained a platform

from which to design a procedure that allowed us to accomplish our goal of implementing safe and efficient traffic patterns. Given the expected increase in population, due to the recent closing of the Kullu airport of Manali and the establishment of the IIT campus, it can be assumed that traffic congestion in Mandi will increase in severity during years to come. If this is the case, current effects of traffic congestion, including various forms of pollution, traffic-related accidents, and inefficient road travel, may place a harsher toll on the residents of Mandi.

Chapter 3: Methodology

The goal of our project was to make Mandi City more attractive and useful to tourists, visitors, and residents through the identification and design of safer and more efficient traffic patterns. In order to meet this goal we established four objectives: (1) assess and map existing traffic patterns in the designated area; (2) record residential concerns with regard to traffic congestion; (3) gather stakeholder input into urban planning strategies; (4) create a set of recommendations for traffic and pedestrian patterns in the city of Mandi. For the purpose of this project, our efforts focused on the center of Mandi City that would benefit most from infrastructural change.

3.1 Assess and map existing traffic patterns in designated areas

Our first objective was to assess existing traffic patterns in the designated areas. This objective was necessary in that it provided us with a thorough understanding of the baseline conditions. We identified areas of Mandi that experienced severe traffic congestion, to determine where our research should be focused. In order to meet our first objective, we conducted site assessments through participatory observation, photographic documentation, and quantitative data collection.

Participatory observation was conducted extensively during the first two weeks of arrival. We joined the flow of travel as pedestrians by walking on roads and pathways commonly used by residents while taking note of any obstructions to safe and efficient walking. We also observed traffic related issues from the perspective of a visitor, by taking note of all obstructions to safe travel, including lack of enforced traffic laws, narrow lane width, undesignated lanes for two-wheeled vehicles, multiple directions of travel in a single lane, and so forth. According to Bruce Berg, participatory observation or action research is effective because it “encourages people to examine reflectively their problems or particular issues affecting them or their community” (Berg, 2009, p. 251). This method of research was a necessary component of the project because it provided us with an understanding of the issue at hand from the point of view of some of the stakeholders, which later aided us in developing a model that suited their needs.

Through additional quantitative data collection, the evidence gathered during participatory observation gained further support. We collected data in a number of key dimensions to allow us to later model a solution to vehicular and pedestrian traffic in the city.

Our first set of data collection targeted the flow rate of vehicles, or the number of vehicles per unit time that passed through certain key roadways, as well as the flow rate of pedestrians through certain key junctions. Because pedestrians travel in all directions regardless of the direction of a roadway, the traffic flow rate for this category was measured in four intervals of 2 minutes, as opposed to counting the number of pedestrians traveling through a junction in one hour. The number of pedestrians that crossed an imaginary line, traveling toward the center of Mandi, during a 2-minute span, was collected 4 times, averaged, and multiplied by 30, providing us with a pedestrian flow per hour. This method was repeated to arrive at the outflow rate of pedestrians traveling out of the city. The traffic inflow and outflow rates for the remaining six categories, 4-wheeled vehicles, motorcycles, auto rickshaws, buses, trucks and animals, was obtained through the method discussed above or through simply counting the number of vehicles passing an imaginary line in 1 hour, depending on the severity of traffic at a particular location and the ease of counting vehicles. Regardless of the method by which we arrived at traffic flow rates for each of the five categories, we obtained accurate quantitative conclusions with regard to traffic flow at specific locations and times, which were later analyzed and compared. Figure 6 (below) provides site details for the city. The approach of identifying specific areas to narrow our attention before conducting further analysis was inspired by the Case Study of Traffic Congestion in Sylhet. As Sylhet is a rapidly developing city very similar to Mandi City, the problems analyzed in this study are not very different from Mandi's problems, as both cities suffer from narrow road-ways and high population density. Therefore, the strategies used in this study were employed in Mandi to estimate traffic flow patterns and to later recommend mitigation strategies for the traffic congestion problems.



Figure 6: Map of key junctions as part of quantitative analysis (Google Maps, 2013)

The key junctions at which we collected quantitative data included Victoria Bridge (A), Skudi Bridge (B), and the Suketu Bridge near the Indira Market (C). These areas are highlighted on the map of central Mandi shown above. At each of the three traffic hot spot locations, measurements of traffic flow rate were repeated at 3 different time intervals: 9:00am-10:00am, 1:00pm-2:00pm, and 5:00pm-6:00pm on weekdays, as well as 5:00pm-6:00pm on Saturdays. By way of collecting traffic measurements at multiple locations and time intervals, we were able to identify location and time interval combinations that experience the highest traffic flow rate, providing us with specific areas to focus our analysis into the root causes of traffic congestion.

As a continuation of the quantitative segment of our study, we requested data from DataNet India Pvt. Ltd., which provided vital data on the number of registered vehicles in the town as well as the vehicle capacity, known as link capacity and link strength, of Mandi's major roadways. In conjunction with the results of the traffic flow rate data for the vehicle categories, this information later served as a variable in the calculation of Road Traffic Index (RTI).

Furthermore, we determined the capacity of the current parking facilities in order to gain insight into whether or not these facilities adequately met the parking demands of residents.



Figure 7: Team member, Shiv Baishya measuring road width

Finally, we carried out a dimensional analysis of roadways to determine which roadways could not be widened or altered in any way due to close proximity of buildings lining its edges, as displayed in figure 7, above. Likewise, roadways with the potential to be widened, provided with additional sidewalk space, or even divided down the middle by a physical obstacle to keep traffic from flowing into the opposing lane, were identified, given the results of the calculations and measurements discussed above.

3.2 Record residential concerns

After gaining a thorough understanding of the existing traffic conditions in Mandi, we then addressed our second objective: to record residential perceptions with regard to traffic. The second objective was met by conducting semi-standardized interviews of convenience with residents.

We began our investigation of residents' perceptions with semi-standardized interviews, in which we asked participants to identify commonly used roadways that suffer from traffic congestion. Residents were approached on the streets, in parking lots, or any location of

convenience, with the option to be interviewed. We strove to capture a diverse sample of patrons by varying the settings and timings in which we approached individuals. After approaching residents, we provided them with the option of answering this portion of the interview verbally or interactively. Verbal responses to our request for commonly used roadways and/or intersections were documented in our interview records. Individuals who requested a visual aid of the roadway network were provided with a map of Mandi, extracted from Google Maps. Whether verbally or visually, individuals were able to identify which commonly relied-upon transportation routes on the map suffer from severe congestion and which of them could benefit from structural change or improvement.

The objective of the map interview option allowed individuals to simply reveal his or her thoughts on the roadways, the importance of such roadways, and the varying severity of traffic congestion among these roadways without being subjected to our preconceived notions regarding locations of severe traffic congestion. In addition, individuals tend to be more inclined to cooperate with the map interview due to its simplicity and straightforwardness, as opposed to the potentially confusing presentation of an interview in paragraph form (Mekong Economics Ltd., 2005).

The results from this portion of the interviews, both recorded and marked on the map, were later analyzed for trends in common opinion, with regard to particular areas that could benefit from traffic flow improvement. This objective served to narrow down our focus to a select number of congested areas.

As a continuation of the map interview, we presented participants with a set of interview questions that pertained to traffic congestion, in order to collect any additional information regarding the residents' perception of traffic congestion that we failed to record from the map interview (see Appendix A for interview questions). We prepared specific questions in advance and made certain that each question was straightforward and clear, enabling the interviewee to answer our questions without feeling influenced to respond in a particular fashion. Although the questions were prepared in English, most interviewees were approached with the option of being interviewed in Hindi, avoiding any sense of unfamiliarity and thus discomfort. Depending on the individual's understanding of English, some interviews were shifted to English following the introduction in Hindi. Regardless of the language in which interviews were conducted, responses were recorded in English, facilitating ease in transferring recordings into findings and later

analyzing such findings. Also, during interviews it was sometimes necessary that last-minute adjustments to the questions be made to obtain more detailed information regarding a specific roadway commonly discussed by the residents during the map interviews. Because individuals view the world in varying ways, Berg recommends that semi-standardized interviews be used to adjust the “level of language” of a particular prepared question or add “unscheduled probes” to the interview process (Berg, 2009, p. 107). Likewise, Mekong Economics Ltd. expressed the value of semi-standardized interviews during their cases study on rural traffic in South East Asia. This approach to interviewing was selected because interviewees could be given the freedom to “discuss major rural transport issues among themselves in a flexible (non-leading) and seemingly spontaneous way” (Mekong Economics Ltd. 2005, 75). This sense of flexibility characterized our data collection, as many interviews, which originally concentrated on a single interviewee, were joined by multiple individuals and developed into a group discussion. The semi-standardized interview ensured that questions were structured, in that some bias was avoided, and yet the format was adjustable.

3.3 Gather stakeholder input into urban planning strategies

After collecting residential statements on the topic of traffic congestion through generalized interview questions, we asked for the residents’ personal input regarding solutions to traffic issues. In order to accomplish our objective of engaging stakeholders, we employed a number of pointer questions to identify the category in which the participant fit. In addition to the semi-standardized interviews used in our previous objectives, we also designed a select interview set that gathered some stakeholder-specific data. The overarching term of “select interview” was used, since stakeholders were divided into several categories: cab and auto rickshaw drivers, residents, tourist, shopkeepers, and vehicle owners. This segment of the interview process allowed stakeholders to provide their own input into urban planning strategies within the city, effectively engaging them in the data review process and giving them a hand in creating recommendations for traffic and pedestrian flow patterns in the city as per our fourth and final objective.

We involved the District Commissioner as a critical stakeholder by conducting an interview with him, during which we gained insight into previous attempts enacted to relieve traffic congestion. After speaking with him, he agreed to review our recommendations in greater

detail and assess their feasibility. Once all stakeholders' input regarding traffic congestion had been collected, we moved to our final objective.

3.4 Create a set of recommendations

Our final objective was to create a set of recommendations for traffic and pedestrian patterns in the city of Mandi. In order to accomplish this objective we collected the information we gathered from our assessments, observations, and interviews with local stakeholders, and designed recommendations aimed towards making traffic flow in specific areas of Mandi City safer and more efficient. Our ideas were proposed in a manner that offers a comparison between the assumed results of our solutions and the current state of traffic congestion. We verbally presented our recommendations alongside our quantitative and qualitative findings, in order to validate the necessity of reform, to our sponsor and then to the District Commissioner. We also provided a written version of our recommendations for the record keeping purposes of the District Commissioner. We listened to their feedback and suggestions on how to accomplish our goal. We then adjusted our recommendations in accordance with their suggestions. We then were able to provide both short-term and long-term recommendations to improve traffic flow by generating a 1-year, 2-year, 5-year, and 10-year outlook that considers long-term implementation details.

3.5 Timeline and visual representation of objectives

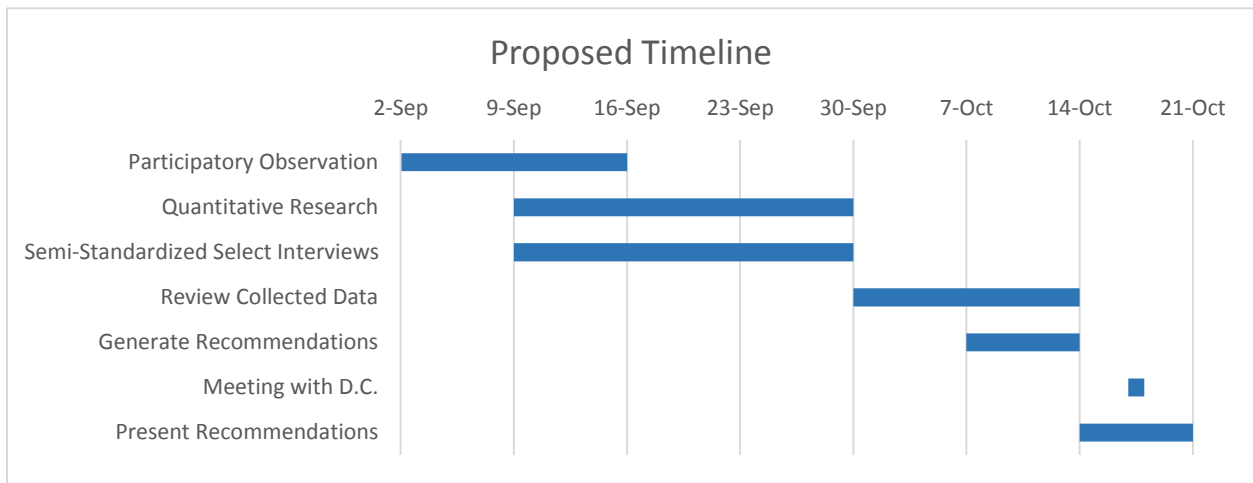


Figure 8: Timeline for project objectives

The graphic below is a visual representation of the four objectives described in our methodology. Under each objective heading, the detailed tasks necessary to accomplish each objective are provided.

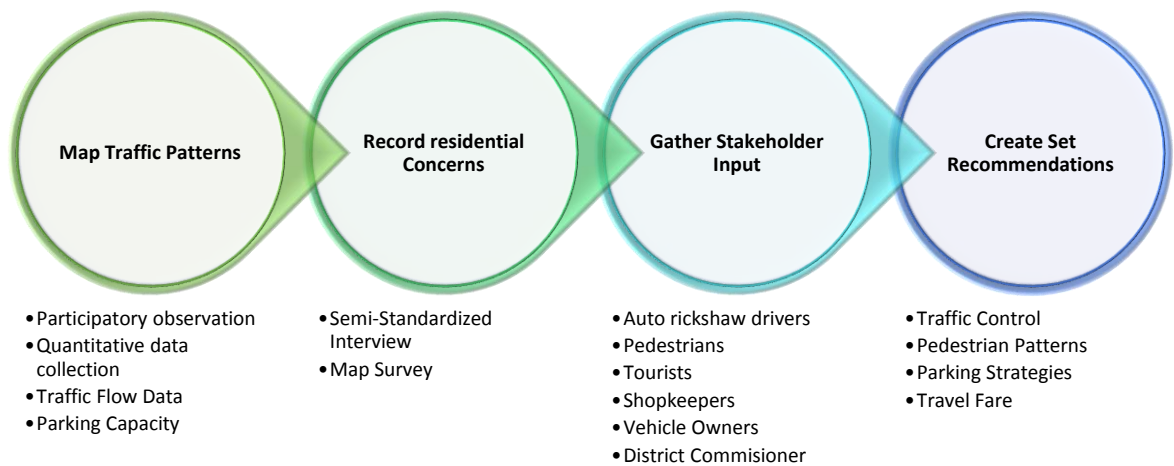


Figure 9: Graphic representation of methodology and the step-by-step objectives

Note: All information gathered during this project, including data collected through interviews remained confidential and was gathered with participant consent. Data storage was kept and maintained in a password-protected computer and was not distributed in any manner. Raw data was destroyed upon completion of the project.

Chapter 4: Findings and Analysis

Part 1: Findings

Our site assessment of Mandi City, quantitative evaluation of traffic, and our engagement of local stakeholder groups provided us with an understanding of the town in terms of the general flow of traffic. Overall, we have found that the city suffers from a lack of traffic flow, as vehicles are forced to navigate around obstacles such as pedestrians, animals, illegally parked vehicles, illegally stopped vehicles, and pot holes. From the perspective of a pedestrian, we observed a general lack of safety since pedestrians and vehicles seem to share a common space for travel. In order to highlight these issues and their collective effect on traffic congestion, we collected both qualitative and quantitative data, confirming the severity of traffic congestion in the center of Mandi. This chapter presents our key findings extracted from site assessments, interview results, and quantitative data collection. Part 2 provides an analysis of those findings as they compare to our previously stated objectives.

4.1 Objective 1: Assess and map existing traffic patterns in designated areas

In town we walked through the streets to gain an understanding of the traffic from the perspective of a pedestrian. From our site assessment, firsthand, we noticed that vehicles, more often than not, have the right of way, forcing pedestrians to yield to vehicles before they can cross or even walk down the street. The roads are narrow and frequently the inflow and outflow of vehicular traffic does not allow for simultaneous pedestrian and vehicular traffic flow to occur. While some streets are known to be one way, the rules are not always followed and vehicles tend to travel in both directions. In conjunction with the chaos induced by the patterns discussed above, the lane widths are further narrowed by the disposal of large piles of garbage on the pathways and the large presence of illegal parking. It was especially intriguing that vehicles, most notably cars and motorcycles, park in areas that were clearly designated as “no parking” zones, as displayed in figure 10, below. This tendency has a huge effect on the narrowing of roadways.



Figure 10: Illegally parked vehicles in no-parking zone

In addition to the physical narrowing of roadways, we also noticed severe deterioration of the roadway surfaces themselves, which include potholes and the absence of large layers of concrete. These deformations commonly cause damage to vehicles, especially auto rickshaws due to their low ground clearance, further causing traffic as vehicles avoid potholes and increasingly compete for space. As a result of the severe traffic congestion, we observed relatively high noise levels and an overall inefficiency with regard to travel throughout the city.

After gathering qualitative data from engaging in participatory observation we obtained quantitative traffic data in three different areas: Victoria Bridge, Skudi Bridge, and Suketu Bridge. We evaluated each area during three different time intervals: 9:00am-10:00am, 1:00pm-2:00pm, 5:00pm-6:00pm on weekdays, and 5:00pm-6:00pm on Saturdays. These times and locations were identified as traffic hot spots based on feedback received during the interviewing segment of our research as well as our own observations. These locations are the major entry and exit points in and out of the center of Mandi City (see figure 11 below).

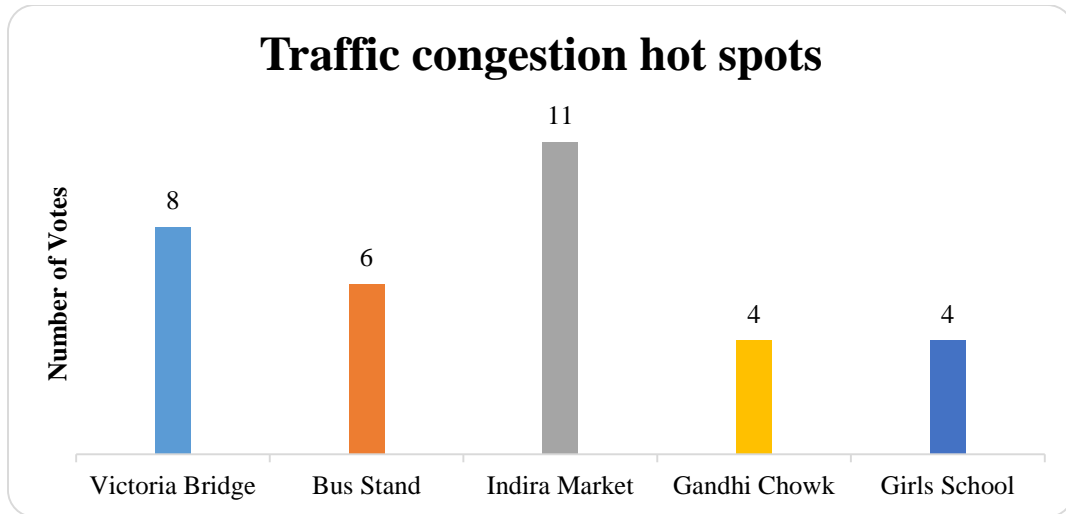


Figure 11: Most frequently suggested traffic congestion hot spots

In order to address these frequently cited hotspots, we evaluated a few locations in greater depth; traffic flow at Victoria Bridge, Skudi Bridge, and Suketu Bridge was examined for factors that seemingly lead to traffic congestion. Furthermore, we obtained traffic flow data at these locations, which were later employed to quantitatively draw a comparison of traffic flow among these locations.

Victoria Bridge

Victoria Bridge was one of the key junctions at which we collected traffic flow data (see figure 12 below).



Figure 12: Victoria Bridge – one-way, very slim bridge

Victoria Bridge is unique in that the Bridge is only wide enough for one direction of traffic and as such has traffic lights at either end that regulate whether the traffic is flowing into or out of the city. The flow of pedestrians is in both directions simultaneously and provides for some dangerous traffic conditions on the bridge itself. In addition, the flow of pedestrians is quite high being near a residential area as well as near a number of temples on the northern edge of the city. The raw traffic flow data is low when compared to the other key locations around town, but the fact that the road is a one-way provides some more perspective on the numbers that we collected.

The raw data that we collected is presented in the table below, in the form of both raw data and then as a simple bar chart to help the reader make sense of the data. In addition, a slight note must be made about Passenger Car Units per hour (PCU/h). Mentioned in our Methodology Chapter and expanded on in our Analysis later, the PCU provides a tool to standardize the size of certain vehicles and how much room they occupy on the road. Issued by the Indian Road Congress (IRC), the PCU simple conversion rates are as follows: motorcycles are half units; cars, small goods carriers, and auto rickshaws are one units; and large buses and large trucks (comparable in size to buses) are equivalent to three units (see figures 13 and 14 on the next page).

		Weekday 9:00am- 10:00am	Weekday 1:00pm-2:00 pm	Weekday 5:00pm-6:00 pm	Saturday 5:00pm-6:00 pm
Inflow	Vehicles	144	66	90	70
	Auto Rickshaws	76	83	60	40
	Motorcycles	258	117	126	120
	Trucks	0	0	0	0
	Buses	0	0	0	0
	Bicycles	1	1	0	0
	Animals	0	0	0	0
	Pedestrians	470	128	690	250
	Total PCU/h	349	208	213	170
Outflow	Vehicles	90	72	105	116
	Auto rickshaws	58	87	105	62
	Motorcycles	184	149	225	184
	Trucks	0	0	0	0
	Buses	0	0	0	0
	Bicycles	0	0	0	0
	Animals	0	3	0	0
	Pedestrians	360	170	945	380
	Total PCU/h	240	234	323	270

Figure 13: Raw data for Victoria Bridge

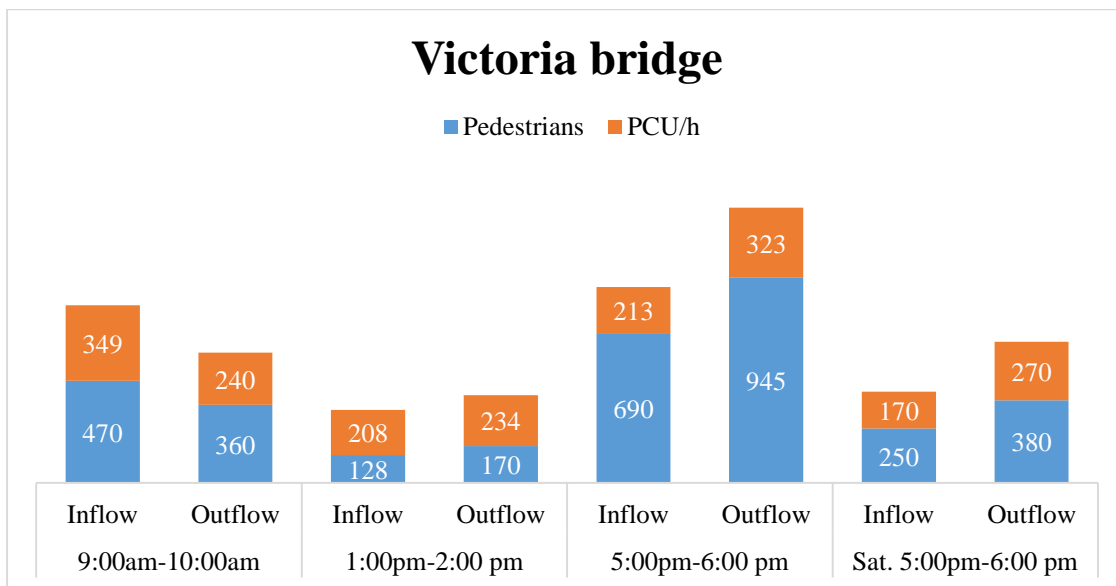


Figure 14: Victoria Bridge: comparison of inflow and outflow at different time slots

A quick look at the traffic trend for Victoria Bridge reveals that the flow rate of traffic into and out of the city is highest in the morning and late afternoon. This is congruent with residents' work schedules as the inflow of traffic is much higher in the morning, while the outflow of traffic is highest after work hours between 5 and 6 p.m.

Suketu Bridge

The Location of Suketu Bridge is one of the key junctions closest to the central Indira Market, and serves as a thoroughfare for all vehicles wishing to pass through the city along highway 70 (see figure 15).



Figure 15: Junction near Suketu Bridge

In the evening and throughout the night this route experiences a lot of bus and truck traffic, but much less residential traffic as the city is asleep by this time. Nevertheless, during the day, this is by far the busiest intersection we interviewed. The road is quite wide, but the two-way traffic coupled with the often-chaotic pedestrian traffic provides for a large amount of congestion. The raw data collected is presented in a table and graph below in figures 16 and 17 on the next page.

		Weekday 9:00am- 10:00am	Weekday 1:00pm-2:00 pm	Weekday 5:00pm-6:00 pm	Saturday 5:00pm-6:00 pm
Inflow	Vehicles	311	216	213	227
	Auto rickshaws	375	204	135	150
	Motorcycles	634	360	376	361
	Trucks	2	48	18	8
	Buses	2	48	18	8
	Bicycles	6	36	3	20
	Animals	18	0	5	5
	Pedestrians	994	1,620	1,245	935
	Total PCU/h	1,035	1,368	824	686
Outflow	Vehicles	264	306	258	264
	Auto rickshaws	292	240	102	150
	Motorcycles	476	398	381	395
	Trucks	3	12	0	2
	Buses	3	12	0	2
	Bicycles	8	18	0	7
	Animals	2	16	3	10
	Pedestrians	510	1,830	1,530	1,530
	Total PCU/h	842	937	551	644

Figure 16: Raw data for Suketu Bridge traffic flow rates

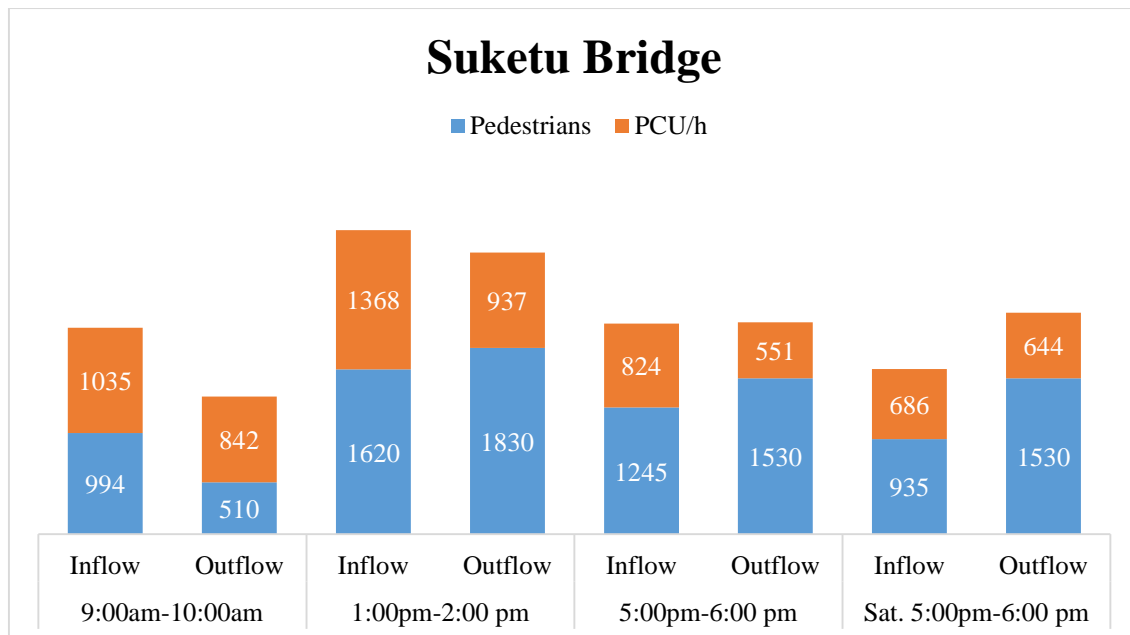


Figure 17: Suketu Bridge: comparison of inflow and outflow at different time slots

The data collected at Suketu Bridge reveals that the traffic flow at this location is quite high throughout the day. The peak occurs during the middle of the day and considering that this location is near the central Indira Market, this result is expectable. Similar to the data at Victoria Bridge, the inflow of traffic is higher than the outflow during the earlier part of the day, but as people finish work and school, this trend shifts and more people begin leaving the city in the afternoon.

Skudi Bridge

Skudi Bridge is a three-way modified T-junction between Jail Road and Highway 70. The Junction is divided by a triangle in the center and the traffic flows in only one direction on each edge of the triangle (see figure 18).



Figure 18: Traffic at Skudi Bridge

Our traffic flow rate measurements were taken at the two roads that lead into and out of the center of the city providing a theoretical bi-directional flow of traffic. The data is presented below in a raw data table (figure 19) as well as a graph (figure 20) to aid the reader in visualizing the data.

		Weekday 9:00am- 10:00am	Weekday 1:00pm- 2:00 pm	Weekday 5:00pm- 6:00 pm	Saturday 5:00pm- 6:00 pm
Inflow	Vehicles	204	233	224	148
	Auto rickshaws	228	180	130	120
	Motorcycles	504	443	224	364
	Trucks	0	1	0	0
	Buses	0	1	0	0
	Bicycles	12	4	4	3
	Animals	0	1	0	4
	Pedestrians	708	1,163	658	818
	Total PCU/h	684	651	466	450
Outflow	Vehicles	216	278	120	156
	Auto rickshaws	152	240	146	150
	Motorcycles	292	488	256	236
	Trucks	0	1	0	0
	Buses	0	1	0	0
	Bicycles	8	16	18	14
	Animals	0	0	4	14
	Pedestrians	664	1,080	590	570
	Total PCU/h	514	778	394	424

Figure 19: Raw data on Skudi Bridge traffic flow rate

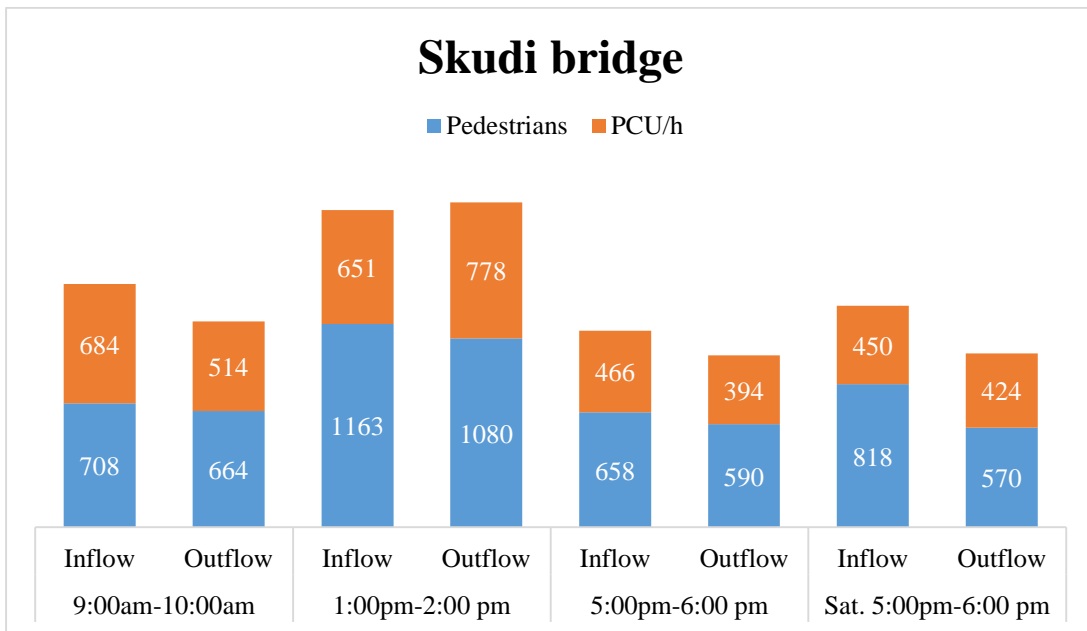


Figure 20: Skudi Bridge: comparison of inflow and outflow at different time slots

Much like the traffic flow pattern at the Suketu Bridge junction, the Skudi Bridge junction experienced the highest flow rates in the middle of the day between 1 and 2 p.m. At this junction, the inflow rate is always higher than that of the outflow, regardless of the time of day. This simple observation, in tandem with the varying flow rates of the other two key junctions, which are the only main roadways in and out of the city center, provides us with numerical evidence that the city center is simply over-capacity and confirms the severity of Mandi's traffic congestion problem.

Road Dimensional Analysis

The Road Dimensional Analysis carried out by our team has given us an idea, not only of the width of certain key roadways throughout the city, but also provided us with a more specific idea of problematic roadways in the city. In addition, the map illustrates any shortcomings in the city based on road width and where illegal roadside parking is an obstacle (see figure 21).



Figure 21: Road widths of the central area of Mandi City

In a number of locations we actually measured the difference between the width of an open road versus that same road when it was blocked and found significant inefficiencies whenever illegal roadside parking occurred. Samkhetar Road, which is technically a one-way road, but is rarely used as such due to an insufficient law enforcement presence, is five meters wide, but with roadside parking it is as narrow as three meters. This area has one of the worst incidents of roadside parking, but the problem is unfortunately all too common throughout the city.

Parking Lot Capacity

The Parking Lot Capacity Analysis carried out by the team aimed to provide an understanding of how adequately this city can accommodate for incoming traffic. Because our study focused on the central part of Mandi, we assessed the capacity of each parking lot available to vehicle owners in the central part of the city as well as along the city's outer edge. The parking lots were categorized as private (paid), public (free) or reserved. Figure 22, below, illustrates the arrangement of parking facilities within our scope of research.

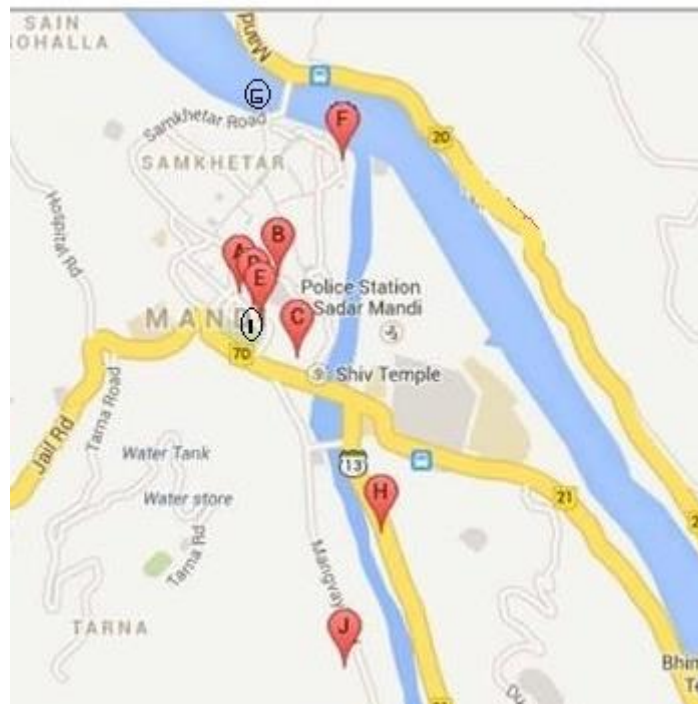


Figure 22: Map of parking locations

The assessment and analysis of parking capacity at these locations allowed our team to gather quantitative data that would support the qualitative findings in objective two. A numerical analysis between PCU entering the city and available parking spots throughout the central part of the city is found in Chapter 4.2. The Raw Data is presented below in a graph comparing the capacity of each parking lot in the center of the city. A legend that displays locations and their corresponding letters is provided below in figure 24.

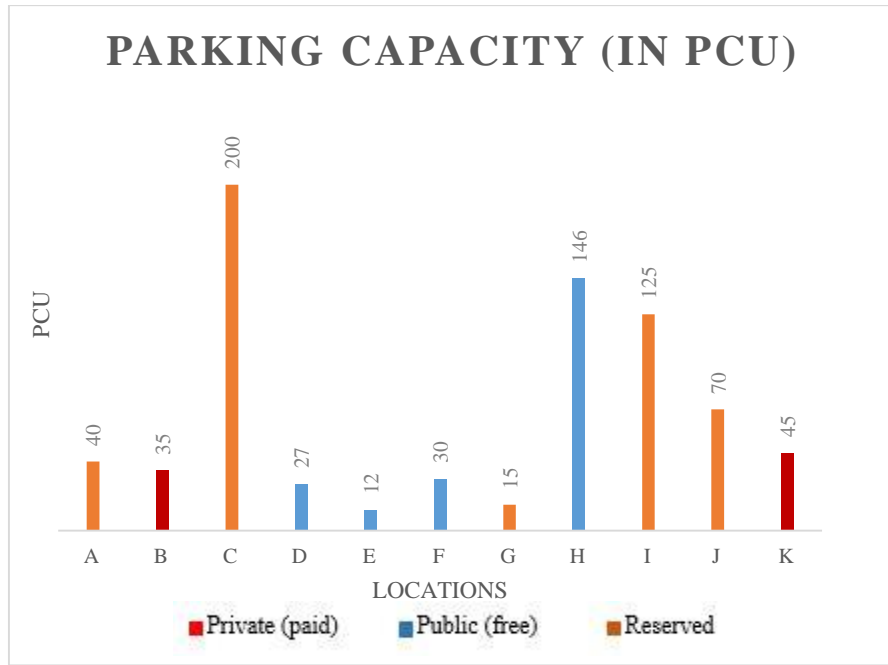


Figure 23: Parking capacity graph

Mapping of Location to Code	
Code	Location
A	DC office Parking, Gandhi Chowk
B	Reserved Parking, Behind D.C. Office
C	Private Parking, near Regent Palms
D	Parking Space, Seri Manch
E	Cab stand, Indira Market
F	Residential Parking, near Victoria Bridge
G	Parking Lot by Victoria Bridge
H	Auto rickshaw Parking, NH 21
I	Parking Lot, Indira Market, Top Floor
J	Parking Point, Mangvayin Road, Mangvayin
K	Reserved Parking, below Administration Building

Figure 24: Parking capacity legend of locations

As indicated in figure 23, above, private parking (near Regent Palms), the auto rickshaw parking (NH-21), and the parking lot at the first floor of Indira Market offers the highest parking capacity throughout the city of Mandi. Meanwhile, the cab stand at Indira Market, the parking lot by Victoria Bridge, and the parking space at Seri Manch provide the lowest parking capacity. These inconsistencies are solely due to differences in square meters. Though, perhaps the city could benefit from taking advantage of the ample space provided by parking (near Regent Palms), the auto rickshaw parking (NH-21), and the parking lot at the first floor of Indira Market and welcome public parking in addition to maintaining reserved parking spaces.

Data provided by District of Mandi website and RTO

The District of Mandi Data has provided us with a number of useful figures that helped illustrate the necessity for traffic reform in Mandi. Although the data pertains to the District of Mandi, it is highly applicable to Mandi City as well, Mandi being the central and by far largest city in the district. We found that in 356 cases of road accidents that took place from 2011 to 2012, 117 people died and 796 were injured, signifying that around 13% of all casualties involved in road traffic accidents were fatal. Throughout Himachal Pradesh, this statistic is closer to 17% fatal accidents out of a total of 6311 casualties (“Road Accidents,” 2011). These numbers help paint a picture of the dire need for traffic policy changes.

4.2 Objective 2: Record residential concerns

Interviews by stakeholder category:

Vehicle Owners

After conducting interviews with a variety of vehicle owners, we gained the impression that most vehicle owners prefer travel by motorcycle/scooter, as opposed to bringing a four-wheeled vehicle into the city center or relying on public transportation. The majority of vehicle owners acknowledged the severity of traffic congestion, explaining the observed tendency to avoid usage of larger vehicles. Regardless of vehicle size, it was apparent that vehicle owners are willing to park their vehicles anywhere that offers space, including the side of the road, in front of shops, or at Indira Market Public Parking (if parking space permits). Most vehicle owners justified parking on the side of the roads and in front of shops as temporary, convenient last-resorts, since space allocated to parking is so limited. If the individual needs longer-term parking, he will usually seek a parking lot, most often the parking lot neighboring Regent Palms, if space is available. As a result of this lack of parking in the center of Mandi, most vehicle owners keep their vehicles at home or at work. Figure 25, below, gives the rough proportion of individuals who own vehicles based on interview results.

Vehicle Owners

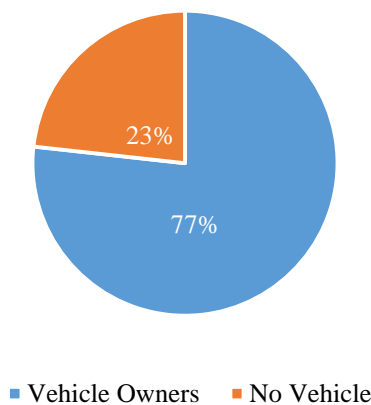


Figure 25: Percentage of interviewees who own vehicles

When questioned about locations of severe traffic congestion, vehicle owners identified the areas surrounding Indira Market, the bus stand, Bhootnath Temple area, and the school bazaar as the most congested areas. Due to this congestion, vehicle owners, especially those that live in the city, made note of the noise pollution. After being asked to reflect on their experience with traffic congestion in Mandi city, most interviewees conceded that solutions to alleviating some of the congestion is plausible and even suggested an array of solutions specific to certain locations throughout the city.

Pedestrians

Like the results from the interviews with vehicle owners, we learned that pedestrians who own a car tend to park them at their homes and prefer travel by foot, due to lack of parking facilities. This is rarely problematic for most pedestrians given the short distance from home to their destination in the center of the city. A handful of people from this interview also said that they do not utilize public transportation frequently unless they need to go a long distance. Corresponding with the feedback from vehicle owners, the majority of interviewees conceded that the main cause of traffic congestion is due to the lack of space allocated for parking. In particular, some pedestrian interviewees held trucks responsible for the narrowing of lanes, as they tend to occupy road-side parking. For instance, one pedestrian in particular, employed by the transportation business, remarked that trucks are not given entry into the city during the day and were forced to wait outside the city, sometimes for four to five days at a time. There is no proper parking for these trucks outside of the city and they are therefore drawn to roadside parking within the center of the city. Like the vehicle owner category, the pedestrian stakeholder category identified illegal roadside parking as a major cause to traffic congestion.

The most congested locations distinguished by the pedestrian stakeholder category matched those identified by the vehicle owners, with the exception of Samkhetar, Chota Bazaar, Hospital Road, and all bridges, Also, many pedestrian interviewees noted a deficiency in the number and competence in traffic police, further leading to traffic congestion and thus noise pollution. Overall, the fifteen pedestrian stakeholders shared the general consensus that the city's infrastructure is not adequately prepared for the incoming increase in population size.

Taxi/Auto Rickshaw Drivers

After conducting interviews with a variety of drivers, including cab drivers, auto rickshaw drivers, bus drivers and also bus conductors, we found that almost every respondent is aware of the current scenario of traffic congestion in the city of Mandi as they themselves are the main contributors to the traffic. A few of the interviews were also conducted in groups of three to four stakeholders as per convenience of the interviewees. However, the bus drivers and the bus conductors were less bothered by the condition since a major portion of their business occurs outside the city.

From the interviews, it was concluded that most of the cab drivers and the auto rickshaw drivers own the vehicles and also use them for personal purposes, such as taking their kids to school or for family shopping. Therefore, cab drivers and auto rickshaw drivers are less dependent on public transportation. The major concern raised by almost every stakeholder in this category was the lack of parking space for temporary stops, including pickup points for shared auto rickshaws, stops at ATMs, stops at 'pan stalls', or stops at medical stores (where passengers typically request to stop for quick purchases). Despite the lack of such temporary parking spots, the cab drivers and the auto rickshaw drivers tend to continue making temporary stops for their customers, disrupting traffic, occupying space, and thus aggravating traffic congestion. The drivers identified taxi-stands near the bus stand and the Regent Palms, Indira Market as areas allocated for longer-term parking. In particular, the auto stands near the bus stand ATM and the T-section near the Indira Market were reported to be the most popular parking area by this category of stakeholders. Though, due to their popularity, these parking destinations become over-filled quickly, causing drivers to park elsewhere.

Finally, differing from the responses of the stakeholders discussed above, respondents that drive in the city identified poor road conditions and street animals as major obstacles to efficient driving, as drivers aim to avoid these obstacles and further compete for space. Also, petrol pumps were pinpointed as indirect obstacles to efficient driving, as large numbers of vehicles tend to congregate at the locations of these pumps at the same time. All interviewees recognized traffic congestion as a major issue in terms of efficient travel and proposed various causes for such congestion.

Store-owners

After interviewing a total of ten store-owners, we found that most store-owners own a vehicle and tend to utilize private parking lots, parking spaces at the market, Kesari Bangla Parking, roadsides, or their homes for long-term parking purposes. Much like the feedback from the stakeholder categories discussed above, most respondents allocated traffic congestion to lack of parking, stating that the city is most crowded after 5pm and that parking tends to be unavailable and problematic.

In terms of the success of their business, several business owners remarked that their business is negatively affected by the traffic, as the lack of space separating their shops from the roads inconveniences customers. Furthermore, the absence of parking facilities near their shops also negatively affects their business, as customers are forced to immerse themselves among the dense pedestrian and vehicular traffic. In concurrence with other interviews in other stakeholder categories, it was stated that local police do not enforce laws such as wearing a helmet or parking violations. In the opinion of many of the shop owners, the general lack of clear law enforcement adds to the hindrance of traffic flow. Other complaints specific to business-owner respondents were: lack of footpaths or sidewalks, poor drainage facilities, auto rickshaws driving recklessly, and buses causing traffic jams due to three-point turns. Each of these phenomena places a burden on the success of shop owners as customers are often deterred by the lack of space allocated for walking and the general safety risks posed by the congestion. Figure 26, below, illustrates this occurrence; due to the lack of pedestrian walkways, customers are forced to shop on the roadside while simultaneously remaining cautious of vehicular traffic. Because feedback was becoming widely agreement among store-owners, we didn't feel as though it was necessary to continue interviewing individuals from this category.



Figure 26: Pedestrians shopping for fruits along roadside

A specific interview with the owner of a fruit stall, near the Boys' School, said that he has relocated his business several times in the last 30 years. In fact, he is currently willing to relocate again, if given a better location to conduct his business. This fruit shop is charged Rs. 30/- per day, regardless of their sales and is forced to relinquish unsold goods at the end of the day causing low fruit/vegetable quality, which results in even poorer sales. For this reason, the shopkeepers find it especially vital to their success that severe traffic congestion doesn't repel customers.

Tourists

Due to the general lack of tourist activity during this particular season, input on traffic congestion from the perspective of a tourist was limited to two individuals from the city, and an exchange student attending IIT, and an IIT professor. Our first tourist interviewee, originally from the Netherlands, responded to our interview questions with complete nonchalance with regard to traffic congestion, remarking "that it's fun" (tourist interview 1, 09/11/13). In complete contrast from this affirmative perspective, the following three interviewees pronounced that the city appears congested and it seems as though congestion serves as a major inconvenience to those who inhabit the city. With the exception of the first interviewee, the tourists admitted that their time spent in Mandi would be more enjoyable and "safer" if roadways were less congested. In addition, when asked to comment on public transportation in comparison to that of their home

country, the two interviewees originating from Germany criticized the bus stand for the absence of an organized schedule displaying departures and arrivals. In general, both individuals believed that Mandi suffers from lack of organization and traffic law enforcement.

4.3 Objective 3: Gather stakeholder input into urban planning strategies

Suggestions by stakeholder category:

Vehicle Owners

After being asked to reflect on thoughts on traffic congestion, many vehicle owner interviewees offered suggestions that, in their opinion, could help facilitate traffic flow. Most vehicle owners attributed the traffic congestion to lack of parking and therefore, the majority of their suggestions involved making use of available space to implement more parking facilities. More specifically, these suggestions included: on-river parking, converting the private parking property at Regent Palms into multi-level parking, replacing the space where the press office is located with a parking facility, demolishing a portion of the Senior Secondary School and using the recovered space for parking, and converting the central row of shops near the Gandhi Chowk.

Currently, vehicle owners pay a flat charge to use the parking facility and will need to pay this charge again if he returns to the same parking facility after leaving, even if he returns during the same hour. One interviewee suggested that vehicle owners be charged to park on an hourly basis, prompting more vehicle owners to utilize parking facilities instead of resorting to roadside parking.

Other suggestions included the addition of more traffic lights and constructing bypass routes. One interviewee proposed the possibility of constructing a route from Khaliyar to Poolgrad and/or a tunnel from Sundernagar to Chandigarh.

Pedestrians

In addition to some of the suggestions provided by vehicle owners, with regard to establishing more facilities within the city, several pedestrian interviewees suggested the establishment of parking facilities outside of the city, since current parking facilities reside in the most congested areas, hindering vehicles from reaching these parking facilities and facilitating more traffic congestion. Although, one participant opposed this solution, stating that a potential trend of parking outside of the city would contradict the purpose of vehicles, which are intended to transport individuals into the city. In terms of alleviating traffic caused by large vehicles, three respondents suggested creating a bypass route, detouring buses and trucks around the city, instead of through the city. From the feedback from the pedestrian stakeholder category, we couldn't gather the main contributor to traffic congestion in terms of the vehicles themselves. One individual attributed traffic congestion to large vehicles, even asserting that large trucks

should be prohibited from traveling through the center of the city. Contradicting this assertion, a second interviewee attributed the congestion to the overwhelming number of smaller vehicles that converge in the city's most crowded areas. In fact, this individual proposed eliminating all vehicles from the roads, and making Mandi solely a pedestrian city. Some more drastic measures suggested by some of the interviewees included closing Victoria Bridge, making Jail Road one way, and expanding the outer regions of town.

Many pedestrians also suggested more feasible, short-term solutions, involving improvements to traffic law enforcement. These suggestions included: strictly enforcing speed limits, establishing specified and fixed stops for autos, prohibiting vehicles from stopping in the middle of the road, and administering assertive and attentive traffic police. By establishing traffic laws geared towards facilitating traffic flow while instilling a higher presence of law enforcement, many pedestrian stakeholders believed traffic congestion could be improved, as drivers will be forced to adopt a more sensible approach to driving. Another suggestion presented by this stakeholder category was simply cleaning the streets, thereby making the roads more appealing to pedestrians and prompting individuals to travel by foot instead of car. In the midst of obtaining feedback, two interviewees failed to suggest any solutions, either because they didn't agree that traffic is a problem or they simply couldn't fathom any potential solutions.

Taxi/Auto Rickshaw Drivers

Acknowledging that their business suffers from lack of available parking, many drivers, such as vehicle owners and pedestrians, suggested possible alternative locations for parking facilities, including: the area near the bus stand (adjacent to the entrance of the city) and near Skaudighat. We recorded several solutions involving the relocation of current property to generate space for parking. For instance, one solution, as mentioned by an interviewee, was that the Government offices should be shifted outside the city to utilize the extracted space for public parking purposes. Many interviewees also pondered the possibility of permitting the parking of 4-wheeled vehicles on top of the Indira market as opposed to the current which is only two-wheeler parking. Currently, there is space designated for taxi parking outside of the Indira Market. Though, this space only contains approximately 10 vehicles at a time. Many drivers expressed the need for more parking spaces for their vehicles or more taxi-stands. One interviewee suggested renovating the private parking near the District Commissioner's office into an organized taxi-stand. Furthermore, one interviewee suggested the elimination of parking

surrounding Indira market and moving all parking to regions outside of the city, creating a pedestrian zone around the market. Regardless of where the parking is implemented, participants think the surface of the parking spots should be paved, with an organized network of division lines allocated for individual spaces in order to prevent illegal parking.

Another common complaint is that the roads simply are not wide enough to support the current traffic demands. Like the majority of pedestrian interviewees, many drivers suggested widening the roads, or at the very least repairing them, since they are in poor condition. The worse the condition of the road, the less “usable space” is left for vehicles and pedestrians. Covering the drainage systems on the road (specifically near Skaudighat) will in turn widen the roads, according to one interviewee. Many interviewees also perceived that the multi-directional traffic is a leading cause of congestion, as roadways are not wide enough to support two-way travel. It was suggested that all roads around the Indira Market as well as Victoria Bridge road become one way. It was also suggested that traffic be removed altogether from Victoria Bridge because it is so narrow. Instead, Bihuli Bridge could be allocated for vehicular traffic. But, according to another interviewee, Bihuli Bridge needs to be repaired before any traffic changes can be implemented. In addition, similar to the suggestions proposed by some of the vehicle owners, many drivers suggested establishing alternate routes of travel. These alternative routes include: constructing a road line in Kiratpur, from Mandi to the Manali route, creating a bypass road two kilometers from the hospital in the direction of Rewalsar, and adding a flyover walking strip for pedestrians. Each of these solutions would relieve some of the traffic pressure on Mandi city.

Many drivers admitted that their constant stopping at inconvenient locations, in the middle or side of congested roads, is also a large contributing factor to traffic congestion. Suggestions to alleviate this burden include placing proper stopping points around the town to avoid traffic jams. Likewise, many of the interviewees felt strongly about the construction of bus stands and believed that the current construction process should resume, as it is currently paused. According to respondents, incorporating benches and public restrooms would help make this an attractive destination for those seeking public transportation. Other improvements to Mandi as suggested by interviewees include: adding footpaths (especially near the college gate), removing the fruit stands over the footpaths, and getting rid of the animals around town that contribute to traffic jams. Each of these solutions would create more space in the city, which can be used to

widen existing lanes or for parking purposes. Overall, the driver interviewees acknowledged the severity of traffic congestion, as they are both the victims and contributors to the congestion, and appeared eager to voice their suggestions to improving the current state of congestion.

Store-owners

From interviews with store-owners, we concluded that they believe that the transportation authority should focus their attention and finances on the roadways of Himachal Pradesh, instead of railways and airports, since the mountainous landscape of this region forces travelers to utilize roadways and vehicular transportation. Since Mandi is a strategic point on both highway and also on bus routes, interviewees agreed that Mandi is in desperate need of traffic reform. Similar to solution themes gathered from other stakeholder categories, the main areas of improvement can be categorized by pedestrian zones, changing of bus routes and taxi stands, creating more parking, and reforming the city.

Several store-owners stated that Mandi lacks safe pathways solely designated to pedestrians. They suggested that more sidewalks or footpaths be created to help remediate this issue. Others stressed the plausibility of devising “pedestrian only” zones surrounding the market, given that Shimla has already successfully adopted this approach. Store-owners also feel as though much traffic congestion convenes at the bus stand, and that it should relocate to the area surrounding Suketu Bridge and Seri Manch. Recognizing that the large presence of auto rickshaws is another huge contributing factor to traffic, other store-owners suggested that the auto rickshaw drivers be “on call” and reside outside of the city during inactive periods, instead of occupying valuable space inside the city.

Many store-owners focused less on decreasing the amount of vehicles on the city and more on infrastructural implementations as a means to alleviate traffic. One interviewee suggested the implementation of underground drains on the roadside, as the existing drains are unsafe and have been observed to cause accidents. In addition to all of these changes, it was also suggested that more roads be designated for one-way travel. If these designations were accompanied by stricter law enforcement, store-owners believed that travel through Mandi would be safer and more efficient.

Tourists

According to the majority of the tourists our team interviewed, the city of Mandi requires a vast amount of change with regard to traffic congestion and safety. Noting the danger posed on pedestrians by the lack of organization and structure in driving patterns, several tourists expressed the need for education on traffic laws and a larger presence of traffic police. Reacting in fear to the current nature of pedestrian and vehicular traffic (cars having the right of way), some of the tourist interviewees think that this norm should be adjusted so that pedestrians and vehicles can coexist. They suggested that pedestrians should have the right of way, making Mandi a safer and more welcoming environment to visitors. In addition, the interviews suggested increasing the presence of footpaths, improving pathway and road conditions, and enacting a proper garbage collection system. Each of these solutions or ideally, the combination of these solutions, would limit obstacles to pedestrian travel, achieving a safer walking environment. One interviewee in particular, suggested that roads need divisions, having a barrier between sidewalks and the road itself, thereby physically separating vehicular travel from pedestrian travel. More specifically, interviewees also suggested implementing guardrails on highways and placing painted crosswalks in town for pedestrians, further establishing division between pedestrians and vehicles.

Another issue raised by the tourists is that so many roads have traffic traveling in both directions. Interviewees suggested assigning some roads to one-way traffic, specifically from Neher Chok to Kinatput. Also, putting in traffic lights at intersections as well as increasing the lane width of roads would also benefit the town, as suggested by interviewees. Like the feedback obtained from stakeholders above, some of the tourist interviewees also acknowledged that lack of parking facilities is a contributor to traffic congestion and suggested multi-level parking near Regent Palms.

Part 2: Analysis

4.4 Objective 1

As stated in our methodology, the main purpose of our quantitative data collection was to provide numerical support to the qualitative data collected through interviews. Through our assessment of parking lot capacity, collection and analysis of traffic flow rate data, and road dimensional analysis, we were able to quantitatively validate the severity of traffic congestion in Mandi.

The lack of parking facilities throughout the city was an issue brought up often during interviews carried out with stakeholders. To support the qualitative data we obtained, we numerically evaluated the capacity of each parking lot. These results are stated in the findings chapter above, but some analysis was required for interpretation. Mandi has a population of 42,685 ("Dp Mandi," 2012), and Mandi District has a total of 66,631 registered vehicles ("Registered Vehicles", 2011). Considering that Mandi City is the administrative and commercial center for the Mandi District, and that it experiences a lot of daily traffic, it is reasonable to conclude that the total number of parking spots, a meager 745 PCUs, is far from enough. In our observations we often found that these parking lots were stagnant during the day, suggesting that they are filled in the morning with people going to work, and have simply no room to accommodate any extra vehicles throughout the day.

A significant and important portion of quantitative data collection was the traffic flow rate study. Using the flow rate data collected at four different time slots, and at three different locations throughout the city, as well as the theoretical capacity obtained from the Indian Road Congress (IRC) we determined the Roadway Congestion Index (RCI). The capacity was based on the road width as well as the function of the road, whether it was a two-way or a one-way road. According to the IRC, a two-way two-lane road with road width between 7.5 and 10.5 meters, much like Skudi Bridge and the Suketu Bridge location, has the theoretical capacity of 750 PCU per hour (Dutta, 2012). The road width of our sample roads was even smaller than measured as pedestrians often walk on the road due to lack of sidewalks, and as such decrease the road width further. In addition, illegal roadside parking, which is widespread throughout the city, further decreases the road width by up to an additional 2 meters. Victoria Bridge is unique in that the vehicular traffic only ever flows in one direction across the bridge, regulated by a traffic light at either end. The bridge is less than half the width of the other locations, and

measures just 3 meters across throughout the entire length of the bridge. Moreover, the pedestrian traffic flow is in both directions, further impeding the smooth flow of traffic. As such, the theoretical capacity is half of the other locations, at a mere 375 PCU per hour.

The Roadway Congestion Index (RCI) was determined by a simple ratio between the actual capacity measured by the team and the theoretical capacity as defined by the IRC. To define the actual capacity of each location, the measurements from the busiest time-slot were used. The graph below provides a visual comparison of the theoretical and actual capacity as well as the RCI, in red, for each location (see figure 27).

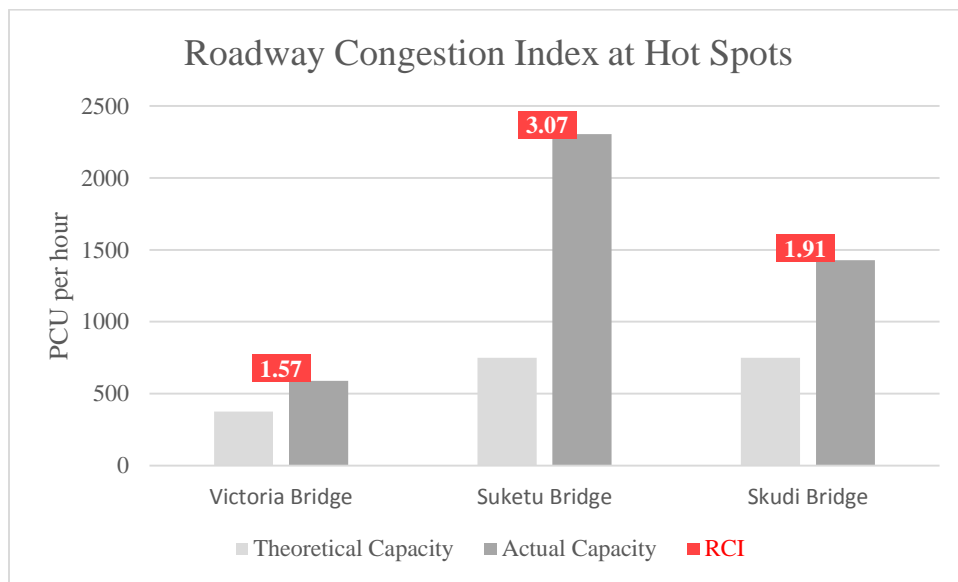


Figure 27: Comparison of actual and theoretical capacities with RCI

The Network-Weighted Average RCI was determined by dividing the road width at each location by the total road width of all three locations, and multiplying that by the Simple RCI for each location before summing all the Weighted Averages.

$$Network\ Weighted\ Average\ RCI = \sum Simple\ RCI\ for\ location \times \frac{Road\ Width\ for\ location}{\sum Road\ Widths}$$

The equation used is pictured above. The reasoning behind using the equation is that, first it gives weight to each of the locations based on the width of the roads, which reflects the tendency of wider roads to contribute more to traffic patterns throughout the network. Secondly, it effectively provides a single RCI for the entire network. The Network Weighted Average RCI for the center of Mandi city is 2.46. This means that the roads in the center of Mandi are nearly

2.5 times over capacity. This is the final quantitative data we need to positively conclude that traffic congestion is a prominent issue in the city. Along with the results of the interviews, these results provide a justification for action to alleviate traffic congestion in the city.

4.5 Objective 2 and 3

The amount of tourist activity and through-traffic in Mandi City is expected to increase due to the recent closing of the Kullu airport of Manali, as adventure enthusiasts are forced to use Mandi as a route to northern destinations. Virtually all transportation in Himachal Pradesh is by road and therefore, the number of vehicles on the roads will grow as a result of the airport closing. The recent establishment of the IIT campus in Mandi is also expected to attract a large incursion of population, as students, faculty, and visitors will travel to Mandi in large numbers. Given the expected spike in population, it can be assumed that Mandi's underlying issues related to traffic congestion, as indicated by the five stakeholder categories, will worsen during the years to come. These underlying issues include traffic accidents, noise pollution, inadequate and slow transportation, lack of parking facilities, and overall congestion in Mandi's popular locations.

The vast majority of interviewees, from each of the five stakeholder categories appeared eager to answer our questions regarding their interpretation of traffic congestion, perhaps due to the general understanding that traffic congestion will worsen in the future without any immediate traffic reform. Both the content of their feedback and their seemingly interested demeanor revealed that a dire need to alleviate traffic congestion, especially because congestion is expected to worsen, exists among residents. Indeed, a small minority of interviewees from all categories showed a lack of interest in our interview, due to an apprehension toward being interviewed or a lack of concern for traffic congestion. Perhaps, some of these interviewees are life-long residents of Mandi and are content continuing with the way in which traffic has always existed in Mandi (see figure 28).

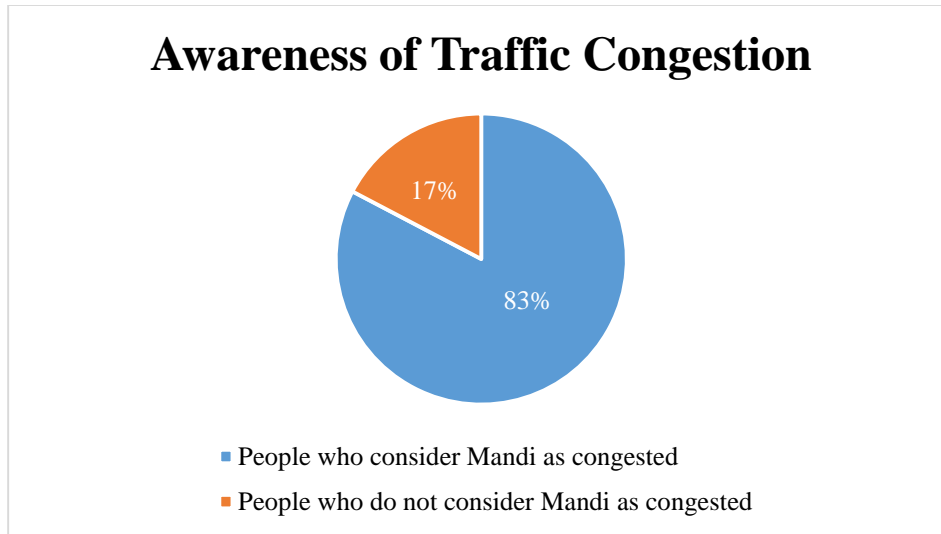


Figure 28: Percentage of interviewees aware of traffic congestion

Sharply contrasting from this nonchalance, many interviewees acknowledge the severity of traffic congestion. Among the several different suggestions we received, the most recurring suggestion we gained was the implementation of more available parking facilities, stating that lack of available parking space is the root cause for traffic congestion, not necessarily the amount of cars entering Mandi in a given day. As stated in Part 1, these suggestions ranged from constructing parking lots in empty spaces or perhaps outside of the city to demolishing existing structures to place parking facilities. For instance, it was suggested that multi-level parking facilities could be constructed in place of the current private parking facility (Regent Palms), in place of the Press Office, and in place of the Senior Secondary School. Although the establishment of a multi-level parking facility, at any of these locations, would greatly alleviate the presence of illegal parking, thereby creating more lane space for traffic flow, the political and financial support required to launch a project of this magnitude is less attainable. For example, the owner of the private parking facility at Regent Palms allegedly has plans of building a mall on that current space and city officials would be hesitant toward demolishing the Press Office due to its cultural and traditional charm. A great deal of political support for the establishment of a multi-level parking facility would be required to shift any of these perspectives. If Mandi adopted stricter fines, and fined vehicles for illegal parking, then perhaps a project of this magnitude could eventually be financed.

Because the implementation of a less expensive reform is more plausible and corresponds with the scope of our project, we have considered many short-term and relatively inexpensive

suggestions proposed by the stakeholders. For instance, the large presence of pot-holes and other road deformations were identified as major obstacles to safe and efficient driving, as vehicles tend to avoid these obstructions, further limiting the amount of space allocated for driving. Additionally, damage to roads and walking paths deter individuals from traveling by foot. These problems are intensified even further during rainy season as the poor drainage system causes water and garbage accumulation on roadsides. Perhaps this deterioration is not only a cause of traffic congestion, but also an effect of congestion, as the surface of the roadways endures immense amounts of wear and tear on a single day. Although improving the road quality is relatively feasible, this implementation will most likely fail to serve as a permanent solution as damage to roads will continue as traffic congestion continues.

Therefore, any implementations we enact must be both economically feasible while addressing traffic congestion at its source. For instance, it was suggested by a variety of stakeholders that alternative bus routes be established, given that the large presence of buses traveling through the city center contributes to much of the congestion. Increasing awareness of alternative bus routes would relieve Mandi from its current state of severe traffic, as vehicle owners wishing to travel to destinations north of Mandi will no longer be forced to navigate through the heart of Mandi. Also, policy-related reforms are relatively inexpensive in cost and carry the potential for instilling a sense of regulation and orderliness in traffic patterns. For instance, the addition of traffic lights, supplemented by a larger presence of police officers, would establish efficiency in terms of the general flow of traffic. Vehicles traveling in a particular direction will be forced to yield to those traveling in the perpendicular direction. This would minimize the constant stopping, persistent honking, and the general sense of chaos currently observed in several areas of Mandi. However, a change in the way in which travel is conducted in the city would take years to fully implement. The citizens of Mandi have grown accustomed to traveling through the city, without a large presence of traffic lights and police officers, and relying on honking for the communication of yielding, turning, and allowing other vehicles to pass. Likewise, suggestions such as designating roadways for one-way travel and restricting all vehicles from entering the center of Mandi (and enforcing a pedestrian-free zone) would be radical changes to the way in which the city and the citizens of Mandi operate. Therefore, inexpensive and relatively simple solutions aren't necessarily as feasible as they appear on the surface.

There were several suggestions proposed by the stakeholders, ranging from cost-effective solutions to expensive, yet potentially proficient solutions. For the purposes of this project, we identified cost-efficient solutions that can potentially serve as short-term implementations. Given that plausibility of implementation increases as cost decreases, we focused on enacting economically feasible projects. However, we also avoided rejection of expensive projects, given the large potential for effectiveness. Such projects were designated as potential long-term project ideas for the city of Mandi. Chapter 5 provides the hierarchy of recommendations on the basis of cost-efficiency.

Chapter 5: Recommendations and conclusions

Formed from our findings and analysis of our study on traffic congestion in Mandi City, we have developed a series of recommendations that we feel, if implemented, will help alleviate traffic congestion within the city. Following each recommendation, we have provided a proposed time-frame (1-year, 2-year, 5-year, or 10-year) in which we believe the recommendation can be implemented. Although our recommendations vary in feasibility, with regard to cost, we have included a detailed description of each recommendation, supplemented by a chart displaying a comparison of cost and effectiveness for each recommendation. Our findings and recommendations were presented to the District Commissioner of the Mandi District as well as displayed at an open house event, where anyone from the community was welcome to come and learn more about our project.

5.1 Recommendations

The following recommendations are divided into five categories: parking, urban planning, infrastructure, and policy reform. Under each category theme, individual recommendations are ordered on the basis of high impact; recommendations that are deemed highly effective, if implemented, precede those that are presumably less incremental. These criteria are independent of factors, such as cost and feasibility. The application of these factors in connection with effectiveness is later displayed in 5.2, where the relationship between cost and effectiveness are visually presented on a plot.

Parking

We recommend that a multi-level parking facility be established at the current transitional parking facility along NH-21 entering the city from the south. This lot, south of the interstate bus terminal is currently undeveloped and unmanaged, but has considerable available space. If the parking capacity of this location were to substantially increase, traffic congestion would remain outside of the center of the city, allowing many individuals to visit the center of Mandi City and carry out their shopping on foot. In the past, plans have been in place to create a parking lot over the river in this area. This would achieve the same goal: to create more parking space, right outside the city center, yet close enough to make the Indira Market within walking distance. *This recommendation could be implemented within a 5-year time-frame.*

We recommend that the Press Office be converted into a multi-level parking facility.

Because the Press Office is no longer in use, this property could be converted into a parking facility. However, this proposal may face opposition as it is regarded by some as a historical building. *This recommendation could be implemented within a 5-year time-frame.*

We recommend that taxi parking occur outside of the city. A great deal of the current illegal roadside parking is contributed by taxis. If a pre-paid taxi booth remained inside of the city, while parking allocated for taxis was placed outside of the city, then more parking spaces within the city would be available for vehicle owners. This parking could be located at the parking lot NH-21, for example. The implementation of a pre-paid taxi system would add a sense of organization within the city. *This recommendation could be implemented within a 2-year time-frame.*

We recommend that deteriorated sections of the Senior Secondary Boys School be converted into a parking facility. At the Senior Secondary Government Boys School, certain parts of the property have been deemed unsafe, and could be converted into parking facilities. In particular, the old wooden building could be converted into parking. This property currently offers some parking space. If converting this location into multi-level parking is unfeasible, perhaps increasing awareness of the existing parking space would satisfy the parking demand as indicated by many of the residents. *This recommendation could be implemented within a 2-year time-frame.*

We recommend that the area bordering the Indira Market be designated for temporary parking. This space is currently designated for the loading and unloading of auto rickshaws. Currently, the loading and unloading of goods from the auto rickshaws is mostly carried out in the morning and evening, and as a result, these auto rickshaws often do not move, but occupy precious space in the center of the city during the day. Although the area at the Indira Market is a relatively small space, replacing this loading area with a parking facility for shoppers would greatly reduce the amount of roadside parking. If vehicle owners were obliged to purchase a ticket or parking pass to use this space, then the city would greatly benefit. Because this parking facility would be so close in proximity to many of the shops, shoppers would be most likely willing to pay for parking. Since this space would be allocated for temporary use only, vehicle

owners could be charged for exceeding a time limit of perhaps 30 minutes. *This recommendation could be implemented within a 1-year time-frame.*

Urban planning

We recommend that a proactive urban planning strategy be put in place to allow future expansion of Mandi City. Given the expected increase in population in Mandi within the next 10 years, expansion of the city may become necessary. Representing a start to this proactive urban planning reform, the addition of a small shopping center outside of the city could draw much of the traffic from inside the center of the city to outside of the city. For instance, the area left of Bhiuli, on the way to the city, can be converted into a small economic development zone outside of the city. This area occupies the outermost area of the city that is on a level terrain. *This recommendation could be implemented within a 10-year time-frame.*

We recommend that Mandi City consider developing a pedestrian-only zone. If considerable parking facilities were to be established outside the center of the city, then it would be possible to designate a pedestrian-only zone, similar to Shimla's recent restriction of vehicular traffic within a portion of its city. If parking facilities were to be increased in both number and capacity, outside of the city or along the outskirts of the city, then the prohibition of vehicular traffic might be feasible. This zone could encompass the Indira market area. *This recommendation could be implemented within a 10-year time-frame.*

We recommend that Mandi City adopts a shuttle system. Currently, public transportation is not widely used, as auto rickshaws represent the only form of public transportation within the city. Residents, and especially visitors, would benefit from an alternative form of public transportation from outside of the city to the Indira market area. This shuttle would offer a higher amount of seating, in the form of a van or small bus. If the recommendation above were to be implemented, this shuttle system could be especially advantageous, as it would cater to the needs of those who are unable to walk the distance between the parking facility and Indira market. This shuttle could travel from outside of the city to Indira market multiple times per day, offering comfortable seating to accommodate those who cannot walk to and from Indira market. *This recommendation could be implemented within a 5-year time-frame.*

We recommend that roadways be widened through deconstruction. If urban planning projects outside of the city are deemed infeasible, perhaps the city would equally benefit from expansion projects within the interior of the city. Currently, shop owners have been encroaching onto government property. As a result, businesses are contributing to traffic congestion, as their presence on the streets is further narrowing driving lanes. This issue can be alleviated with stricter violations against encroachment. However, since this issue is already present, it may not be easily reversible. Therefore, the only option to effectively widen the roads to a width at which vehicles and pedestrians can travel safely through the city might be to reduce the amount of existing businesses along roadways and perhaps relocate some businesses to exterior sectors of the city, as suggested in the recommendation above. Although a largely unpopular approach, cities throughout India have been adopting this strategy, and it is most likely a matter of time before Mandi may have to resort to similar tactics. *This recommendation could be implemented within a 10-year time-frame.*

Infrastructure changes

We recommend that a pedestrian walkways be created. Currently, the presence of sewers along both sides of the roadways occupies a great deal of space that could be used as pedestrian walkways, separating pedestrian travel from vehicular travel. If these sewers were covered with cement, frequent drainage holes in the coverings will allow rainwater to drain underneath the paved coverings. In addition, a physical barrier in the form of a handrail or guard rail could be placed to separate pedestrians from vehicles. This would not only aid traffic patterns, but would also allow urban planners to establish sidewalks on top of the grates, increasing the factor of safety for pedestrians, and effectively decreasing the noise pollution caused by honking at pedestrians. *This recommendation could be implemented within a 5-year time-frame.*

We recommend a flyover bridge for pedestrians. If the recommendation above proves too restrictive for storm-water access, the congestion caused by competition of space between pedestrians and vehicles could also be somewhat alleviated by the implementation of a flyover pedestrian bridge. This structure would allow pedestrians to safely travel across highly congested junctions without hindering the flow of vehicular traffic. An area that would benefit from this structure is near the electronics store at the corner of Indira Market. A diagonal flyover would

allow individuals to walk over traffic, from the main roadways to the edge of the market. *This recommendation could be implemented within a 5-year time-frame.*

We recommend that the street shops outside of the Boys Government School be relocated to the center of the city. These small street side shops that currently occupy the sidewalk outside the Boys Government School are occupying precious pedestrian sidewalks, and as a result causing pedestrians to walk on the street. These business owners could benefit from relocation to a more central area such as the pedestrian area above Indira Market, which is big enough to accommodate both street carts and pedestrians. Proper waste management in their vicinity would help them keep their area cleaner and clear of spoiled goods, which was a complaint brought up by stakeholders when they were previously positioned at Indira Market. *This recommendation could be implemented within a 1-year time-frame.*

We recommend that the reconstruction of the bus stand continue. Structural improvements to the bus stand have been initiated. However, these construction efforts have been paused for reasons unknown. The continuation of construction could eventually incorporate a higher sense of organization, enhancing the popularity of public transportation. The addition of benches and public restrooms may further increase the appeal of public transportation by way of bus travel. *This recommendation could be implemented within a 1-year time-frame*

Policy reform

We recommend a more effective presence of law enforcement in Mandi. The higher presence of traffic police would establish a sense of order in the city. Currently, the city is littered with illegal parking; vehicle owners park in areas that are blatantly marked as “no parking” zones, knowing that they will most likely not face a penalty. If law enforcement officers were to adopt more strict and assertive practice such as penalizing those that park illegally, drive under-aged, and do not submit to one-way roads, then the level of chaos in roadways would most likely be reduced. Perhaps it would benefit police officers to partake in professional development training, to support their options for assertive and appropriate policing behaviors to alleviate congestion. *This recommendation could be implemented within a 1-year time-frame.*

We recommend that private parking facilities charge hourly. Currently, parking facilities tend to charge per entry at a flat rate. This system deters vehicle owners, who intend to park their

vehicles for a brief amount of time, from utilizing parking facilities. Instead, individuals resort to road side parking to avoid heavy parking fees. Vehicle owners, who desire to shop at Indira Market for only an hour, would be most likely willing to pay a small fee per hour, rather than paying a flat charge to enter the parking facility. Given the expected appreciation for this system, parking facility owners would presumably enjoy a larger profit compared to the revenue private parking facilities collect currently. In order to prevent parking facilities from reaching full capacity, parking facility owners could allocate 10% of available parking spots to short-term usage such as less than half an hour. Individuals that park their vehicles at the parking spots designated for temporary parking, for a period greater than 30 minutes, could be charged a higher cost. If this rule were to be adopted by parking facility owners, the spots allocated for short term use would need to be clearly marked as “30 minute parking only”. *This recommendation could be implemented within a 1-year time-frame.*

We recommend that alternative routes for bus travel be implemented outside of the city.

Currently, the city of Mandi experiences some through-traffic of buses. The amount of space occupied by the mere presence of buses is a significant contributor to traffic, as smaller vehicles simultaneously attempt to bypass the buses. If alternative bus routes were to be relocated to outside of the city, then much of the traffic congestion would be alleviated. Perhaps this alternative route could occur through Khaliyar. *We propose that this recommendation be implemented within a 5-year time-frame.*

We recommend that Jail Road and Tarna Road be made into one-way roads. Because Jail Road and Tarna Road run parallel, they could be made into one-way roads, each funneling traffic in a different direction. At their intersections in the city and again further outside, the roads could reconnect and become standard two-way roads. This connection would take place near the jail, where the two roads become close in proximity. *We propose that this recommendation be implemented within a 5-year time-frame.*

We recommend that garbage disposal be transferred outside of pedestrian areas. Currently, waste materials, both in the form of loose trash and garbage dumpsters, occupy space and deter pedestrians from walking along the roadsides. If large-volume-capacity dumpsters were to be relocated to areas away from pedestrian movement, then pedestrians would be better able to

occupy roadsides, away from vehicular traffic. Not only would this pose a safer scenario for pedestrians, but it would also alleviate some of the competition for space among pedestrians and vehicles. For this recommendation to remain effective in the long-term, a garbage disposal system would need to remain intact. This system may require the hiring of garbage disposal officials to maintain the clearance of garbage. If garbage officials were to be hired by the government of Mandi for the purpose of transferring garbage from businesses and roadsides to larger dumpsters away from the interior of the city, then Mandi would appear cleaner from the perspective of visitors and offer a safer environment for travel. At the same time, waste disposal bins should be present and available for visitor use to alleviate littering. *This recommendation could be implemented within a 2-year time-frame.*

5.2 Recommendations by cost and effectiveness

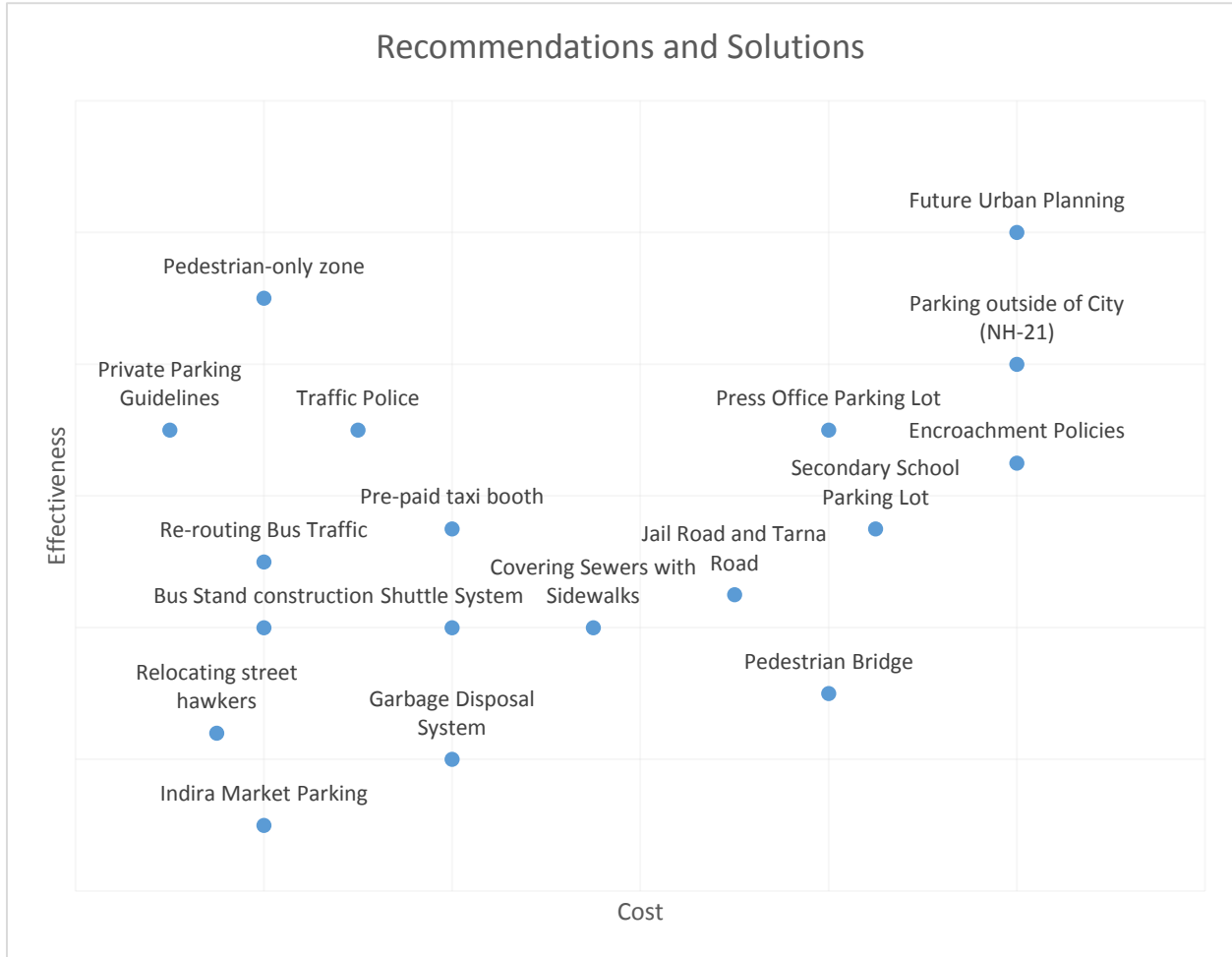


Figure 29: Visual representation of recommendations by cost and effectiveness

The following plot provides a visual representation of the relationship between cost and effectiveness for each individual recommendation detailed above. In addition, the chart offers a comparison of cost-effectiveness between recommendations. In other words, some ideas are deemed more cost-effective relative to others. Nevertheless, projects that are considered costly and less incremental are included among our recommendations and displayed in the plot for the purpose of providing a sense of relativity among recommendations that are deemed efficient with regard to cost and effectiveness.

5.3 Recommendations by time frame estimate

As noted under each recommendation, detailed in Chapter 5.1, individual recommendations are associated with a particular time-frame in which, we believe, that a certain recommendation can be accomplished. Because each recommendation varies in feasibility, as some projects require a higher level of financial and political support, our recommendations differ in time-frame required for execution. The graphic below in figure 30 lists the recommendations on the basis of estimated time necessary for implementation.

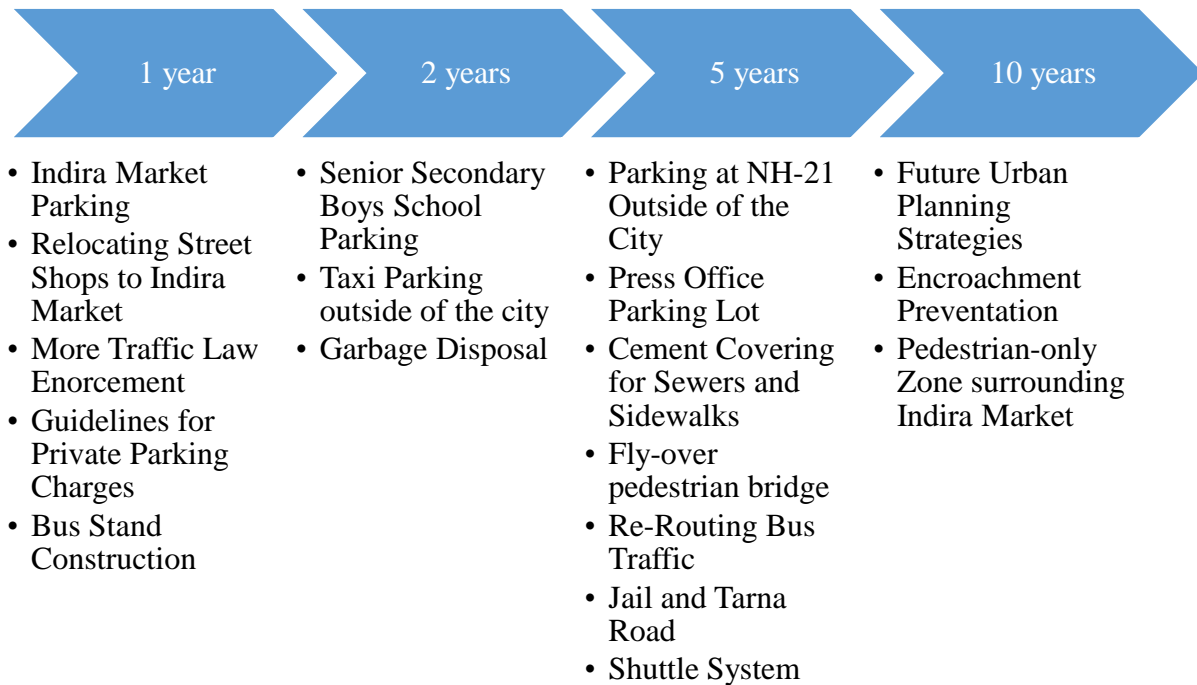


Figure 30: Visual representation of recommendations by time frame plan

5.3 Conclusion

Given the expected increase in population, traffic congestion in Mandi will presumably increase in severity during years to come. If this is the case, current effects of traffic congestion, including air and noise pollution, traffic-related accidents, and inefficient road travel, may place a harsh toll on the Mandi's residents. Our assessment and research on traffic congestion in Mandi has confirmed the existence of severe traffic congestion and its adverse effect on the city of Mandi. Through our discourse with store-owners, drivers, and pedestrians, we gained the impression that the residents of Mandi share an awareness of the severity of traffic congestion and are therefore receptive to potential traffic reformations. In fact, several stakeholders enthusiastically suggested detailed methods by which traffic congestion could potentially be alleviated, which were analyzed for feasibility and incorporated into a series of recommendations on the basis of projected time required for implementation.

The procedures we pursued to validate the severity of traffic congestion and ultimately formulate a collection of recommendations are applicable to any developing city around the world that suffers from traffic congestion and holds the potential for traffic alleviation. The infrastructures of developing cities across the world are struggling to support growing population sizes and resulting growth of number of vehicles. In recent years, individuals have taken advantage of the increasing affordability of vehicles, further attributing to the large vehicular presence among roadways. However, the roadways of many developing nations were simply not developed to withstand the large presence of personal cars, taxis, motorcycles, trucks, and other vehicles that have exponentially increased in number, throughout developing nations, in the last few decades. This phenomenon has caused catastrophic effect on India, seeing as India endures the highest number of road traffic accidents annually, as stated in Chapter 2. In particular, the city of Shimla, India, is plagued by narrow road widths and a large vehicular presence. In response to the resulting traffic congestion, Shimla enacted a pedestrian-only zone, a cost-effective method that ultimately transformed Shimla into a more pleasant destination for both its residents and visitors. Traffic congestion along with its adverse effects on individuals is not unique to India. Developing cities across the world, like Mandi, that suffer from narrow lane widths and lack of parking facilities would vastly benefit an approach similar to that of Shimla: an approach that takes advantage of existing space and reduces vehicular presence among roadways. Given the increasing popularity of personal vehicles and increasing worldwide

population, it is becoming crucial that cities that endure the adverse effects of traffic congestion, like Mandi, consider traffic congestion alleviation efforts such as those outlined in Chapter 5.

With ample time and consideration, we are confident that the implementation of our recommendations is conceivable and if enacted, would immensely benefit both residents and visitors of Mandi. Our research revealed that traffic congestion is not an issue to be taken lightly and that there are many dimensions involved in changing a practice that has been a standard for countless years. Our recommendations are only a start to improvements that are possible with time, dedication, proper financing, and continued community engagement.

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Appendix A: Interview questions

Below is our set of interview questions. In order to diversify our study, we approached individuals on the streets, in parking lots, or any other location of convenience, ensuring that our sampling population included pedestrians, car owners, business people (e.g.: shopkeepers), transit travelers (e.g.: tourists), and public transport vehicle drivers.

General Section:

1. Do you live in Mandi? (answer redirects to corresponding *Specific Section*)
2. What is your occupation? (answer redirects to corresponding *Specific Section*)
3. Do you utilize public transportation or auto rickshaws? If so, how often?
4. Do you own a vehicle?
5. If so, what kind (four wheeler, two wheeler, fruit/vegetable cart.)?
6. Where do you park your vehicle while you are in the city?
7. Where do other people park while in the city?
8. Do you think that there is traffic congestion in Mandi?
9. Can you help us spot a few places with high traffic congestion on the map?
10. What do you do when you face such congestion? (take another route? - which?; cancel schedule? etc..)
11. Do you suggest any solution that can help mitigate these traffic problems (in the places mentioned by you in the previous question)?
12. Are there parts of this city that you would NOT want changed? If so, what are they?

Specific Section: Based on the category of the participant chose the appropriate section from below.

Cab/auto rickshaw drivers

1. Problems faced while driving on the street (vehicle, crowd, animals, road quality etc.) if any?
2. Do you think you have adequate space for temporary parking, pickup and drop off points? If yes, are you satisfied?
3. If no, why? (possible choices - parking area charges, parking area space, distance of parking lot from destination, not interested to park, other: specify)
4. Do you think there are also indirect reasons for the traffic congestion? (Few re-fuelling spots, few servicing spots, unrestricted flow of different types of vehicles, other: specify)

5. Can you suggest some solution(s) to help solve the problems you said you face while driving?

Pedestrians

1. Do you face any problem at home because of the traffic? If yes, possible choices - noise, air/trash pollution, roads close to residence, other - please specify.
2. Do you face any problem during short distance travel by foot? If yes, what kind? (possible choices - congested road, proper foot-walks, not interested to walk, other)
3. Do you want to suggest any solution for the above?

Tourists

1. Where do you come from?
2. What is the purpose of your visit? (Possible Choices - Vacation, Official Work, others - specify)
3. Do you see any difference in the traffic condition here with the traffic conditions at your place? (How do you find it?)
4. Do you think Mandi's roadways are particularly congested? (Yes/ No)
5. If so, does traffic congestion negatively impact your stay in Mandi?
6. Would your stay be more enjoyable with less traffic congestion? (Yes/ No)
7. Do you think it's necessary that infrastructural change be implemented? (Yes/ No)
8. What do you think about access to public transportation (buses, taxis, auto rickshaws) system here?
9. If you think there are points of improvement, can you describe them briefly? (moderate if required so that the participant doesn't start telling a story)

Store-owners

1. Do you think Mandi has congested roadways? (Yes/ No)
2. If so, how does traffic congestion affect your business?
3. What kind of shop/distribution you own/run?
4. Do you think traffic congestion brings you customers? (Yes/ No)
5. If so, is congestion of pedestrians or vehicles more beneficial to your company? (Yes/ No)
6. Does your shop/distribution deal with large quantity of goods? (Yes/ No)

7. Do you own any kind of vehicle used for transportation of the goods? (Yes/ No)
8. Do you deal with the loading/unloading of goods or a third-party does that for you? (Yes/ No)
9. How do you manage loading/unloading of goods? (if applicable)
10. What problems do you face with loading/unloading of goods that you think are related to traffic congestion?
11. What time do you load/unload? (Get a Time Estimate)
12. Where do you load/unload? (Location in Mandi)

Vehicle owners

1. Type of vehicle you own? (car - type, motorcycle, scooter, bicycle, horse-cart, food-cart)
2. Was your choice of vehicle influenced by existing parking/road conditions? (Yes/ No)
3. Do you use parking space frequently? (Yes/ No)
4. What kind of parking problems you face, if any?
5. Are you charged on parking? If yes, what are the charges (per hour)?
6. Can you suggest some possible solutions to improve the traffic problems you are facing?