Are ARTS the RopeWAY Forward;

Aerial Ropeway Transportation Systems (ARTS) as a Solution to Transportation Problems in Himachal Pradesh

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Abstract

As India urbanizes, a need for comprehensive transportation has become increasingly relevant, leading Himachal Pradesh (HP) to pursue Aerial Ropeway Transportation Systems (ARTS) to bridge growing gaps in existing transportation infrastructure strained by population and mountainous terrain. This project examines the feasibility of ARTS in HP as well as the role ARTS will play in India's future by interviewing communities impacted and professionals affiliated with transportation, ARTS, and city planning. Through analysis of stakeholders and impacts we analyze how multifaceted ARTS implementation is. Overall, ropeways will likely have a large role in India's future as urban ARTS are a feasible and impressive addition to HP's existing transportation infrastructure.

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Executive Summary

Introduction

As India is rapidly urbanizing, a need for comprehensive transportation has become increasingly relevant. Himachal Pradesh (HP) and other Northern States are looking into Aerial Ropeway Transportation Systems (ARTS) to bridge the growing gaps in existing infrastructure strained by growing population and mountainous, landslide-prone terrain. This project seeks to understand if ropeways are suitable transportation additions for Himachal Pradesh and furthermore, how ropeways play into India's future. Recently the Parvat Mala scheme has set aside 1.25 lakh crore (1.25 trillion rupees) over the next 5 years to implement ropeways in HP(Mukherjee & Ranhotra, 2024).

Three main research objectives were identified to understand the systems in place currently and the feasibility of ARTS. The objectives are to assess: (1) current and future traffic and transportation problems, (2) tourism expansion in Himachal Pradesh, and (3) potential impacts of ARTS implementation.

Methodology

The objectives of this project were met through informal interviews and field visits. Each of the individual's relationships with ropeways was known before the interview, so the questions were formatted accordingly. The initial questions were only used as an outline however as, given the informal nature of the interview, multiple questions could be answered by a single response, or follow up questions would be required to further explore a topic.

The three main groups that we were able to interview were the Mandi Police Department, the Ropeway and Rapid Transport System Development Corporation (RTDC), and a representative from the Smart City Initiative. We asked questions about the traffic in Mandi, existing and proposed ARTS and government investment into transportation in large cities from the three groups respectively.

The locations for our visits included a mix of offices, ropeway construction sites, and existing ropeways. In Shimla we got the chance to hear about the proposed 15km public transit ropeway and visit the existing Jakku ropeway that accesses the Jakku Temple. In Pandoh we got the chance to see the construction of the Baglamukhi Ropeway that will access the Shri Baglamukhi Temple. In Dharamshala we visited the Mcleodganj Ropeway and in Manali, the Solang Valley Ropeway. At each site we assessed purpose, throughput, ropeway demographics, cost and documented the ropeway through photography.

Results

We found there are three main categories of passenger ARTS in Himachal Pradesh, India: public transportation, secular tourism, and religious tourism.

Public transportation focused ropeways are functional infrastructure that integrate into the existing transportation network of roads, but routes, metro lines, etc. People use these systems in

daily life to commute to and from both essential and extraneous activities such as work, school, sporting events, and many others.

Secular tourism ART systems are the complete opposite of this. They are used as an attraction, or to bring tourists to an attraction that is meant to entertain the people participating, and in turn, creating income for the ropeway. Examples of these systems include ski lifts that bring people up a mountain and allow them to then ski back down to the bottom.

The third category is something that is not present in many other countries: religious tourism. Year round people travel to the numerous temples built everywhere, but during festivals the number of people who travel to the temples increases significantly. ART systems that are focused around such religious tourism facilitate people getting to the temple in a more convenient way. This can enable a larger portion of the population to both visit the temples and participate in festivals.

A takeaway from all of the ropeways we studied is the individuality of the conditions of the surrounding area. Each location suffers from universal problems, such as traffic volume and encroachment, but the individual problems each place has are the most interesting and display how multifaceted ARTS can be.

Each of these locations has problems that may be solvable with ropeways, but the main takeaway is there is no catch all solution because of the individualized issues each location has. Instead, each location that implements a ropeway has a unique reason for a ropeway and a unique way they implement it. This is especially evident in the large amount of work and effort that the people involved with deciding about ropeways have put into their jobs.

Analysis

This is by no means a simple project, and talking with the various professionals we interviewed made that even more apparent. To most clearly organize the data we collected, we determined an analysis of the relationship between stakeholders and the aspects of all three systems was required. This resulted in us determining that there are both universal constants of ropeways as well as problems and benefits that are unique to stakeholders or the types of systems built. In order for a successful system to be built a majority of the stakeholders need to be appeased. This does not mean that a majority of the categories of stakeholders needs to be appeased, as each group has a different weight and importance. In general however, the more people who are happy with the project, the more likely it is to succeed.

Stakeholders

While examining ARTS we found that implementation is extremely multifaceted and a convenient way to help illustrate this completely is to examine specific stakeholder values in the implementation of each previously identified type of ropeway. (To see this fully illustrated please see Table A.1 in the Appendix) Politicians, ropeways officials, commuters and residents will all have different opinions about different aspects of an ART.

Conditions for Implementation:

(1)Need for Improved Transportation

A lack of adequate existing transportation is imperative for an ARTS to succeed. When the current transportation solutions are at their limits, like in many cities in HP, other systems must be considered. HP roads are overcrowded with cars and buses and are unable to manage the throughput with the severe space limitation. Road expansion is impossible in some areas, and other high throughput transit such as rail or metro systems are equally infeasible. This leaves alternative transportation methods as the only option.

(2)Ability to Support Increased Tourism and Mobility

An ARTS that is supportive of tourism and the larger population is an indicator of a well planned system. Ropeways do not need to have one sole purpose as even transportation focused systems can be attractions for tourists, therefore planning accordingly is crucial for success. It is both unfair to locals and irresponsible to build a system that will cause a significant increase in tourism.

(3)Conducive Built and Natural Environments

Environment must be more conducive to ropeway systems over other methods of transit if implementation is to be successful. Ropeways are most efficient and effective in areas where traditional transportation falls short. These are typically mountainous areas with inadequate road and rail transportation due to rapid urbanization or poor city planning. In these instances, ropeways are often implemented successfully to deal with such adverse conditions. Additionally, in urban environments, the built environment must also be conducive to ropeway implementation and should have all other infrastructure properly connected to any ropeway stations.

(4)Funding

Ropeways are a far more expensive alternative to other forms of transportation. (Alshalalfah, Shalaby, Dale, & Othman 2012) When compared to the cost of both initial construction and ongoing operation of road based transportation, ARTS are still more expensive. Additionally, ARTS need far more oversight, requiring constant funding for upkeep, inspections and maintenance. With ARTS needing more funding for operation, cost analysis must be done to ensure that the funding is effectively used and the effect desired from the system is achieved.

(5)Community Support

Community support largely determines the successfulness of a system. Most ropeways are built with the community in mind, either transportationally or economically. Tourism is a large industry in many places, and a tourism focused system can significantly bolster the economy. Politicians and businesses need to support the ARTS too as they can cause legal barriers to ART implementation. Everyone in the community plays a role in making an ARTS successful.

Conclusion

Although all five of the previous requirements are important, they are not the only requirements, and understanding the stakeholders and how they will react to a specific system is

also important. This is well known by the RTDC however as they have worked on several ropeways. This means that future ropeways should be largely successful as systems that will not lend themselves to success will not be built. There is never a guarantee for something this complex that it will succeed, but given the financial investment RTDC will be doing everything in their power to make all future projects a success.

Future considerations for regulating bodies to take into account for ARTS implementation is the need for free land, analysis of where an ART system could be best implemented, and the population needs of the future. Understanding population growth and putting ropeways in select locations can be an excellent way to mitigate future traffic problems due to growing numbers of commuters.

Our two recommendations are to invest in an increase in legislation surrounding ARTS to continue to guarantee they are successful and to set aside/begin to acquire land in areas that will become urban in the next 50 years to accommodate necessary urban infrastructure, that may include ARTS.

Chapter One: Introduction

Transportation is a universal need; from large cities to small villages, everyone has to get around. Transportation allows people to go to work, purchase goods, and access services and systems inaccessible otherwise. Effective transportation systems are necessary for progress and a good transportation system is a cornerstone of an efficient economy and society.

Growth in world population comes with the expansion of urban centers. As urban areas expand, they are often limited by their existing infrastructure. The existing built environment forces city planners to either level large areas to make way for large public infrastructure projects, or work around the existing structures.

In Himachal Pradesh the issues associated with urban expansion are exacerbated by preexisting terrain challenges such as mountains, ravines and landslides. Many roads are carved into the sides of mountains and as a consequence are long and winding with risk of landslides. These roads are often inefficient and can pose a safety risk to travelers. Additionally, as Himachal Pradesh has increased in popularity as a tourist destination, urbanization associated with the expanding tourism industry is occuring. This influx of travel through communities stresses the current road infrastructure. To both decongest current transportation solutions, and mitigate the risks associated with current solutions, alternative transportation systems must be considered.

In this project we aim to determine if aerial ropeway transportation (ART) systems are an effective solution to help solve transportation issues in an urbanizing Himachal Pradesh. This was done by assessing current and future traffic and transportation problems, tourism expansion in Himachal Pradesh, and potential impacts of ropeway implementation. While these objectives will not result in a judgment of ropeway feasibility in any specific location in Himachal Pradesh, they will help by providing an assessment of the factors which must be considered when implementing systems in the state.

In Himachal Pradesh (HP), we conducted research to determine these questions. We conducted interviews with operators and builders, visited existing systems, talked to community members who may be affected by system implementation, and talked to those involved in the future of urban Himachal Pradesh. These various approaches were conducted to get a holistic view of ropeway needs, implementation, and impacts.

Previous research in the region has been focused on improving transportation access in more rural areas using smaller, more inexpensive systems that span smaller distances. Much of this research does not address larger, more urban focussed systems, especially in Himachal Pradesh. This project aims to fill the gap in research on the implementation of ART systems in the urban mountainous region of Himachal Pradesh. For this we have analyzed the factors which will go into ropeway construction as Himachal Pradesh urbanizes and modernizes. The goal of this research is to determine if ART systems are implementable in Himachal Pradesh and to establish a framework for decision making usable in similar mountainous regions of India.

Chapter Two: Background

2.1 What Are ART Systems

Aerial ropeway transportation (ART) systems are methods of transport that use a suspended rope or cable to move people and goods without having to directly interact with the ground. They are used in many applications throughout the world and have been for over a century (Hoffman & Zrnić 2012). Typically, most ART systems have been used for leisure purposes such as sightseeing and skiing, although these systems have been used for more practical measures as well.

2.1.1 Advantages of ART systems

The greatest advantage of ART systems is their ability to bypass terrain which is difficult to traverse by other means. Ropeways excel at "coping with, and even taking advantage of, hilly terrain" however that is not their only application (Joachim 2012, p.46). "Even on flat land, they can be used to overcome many other types of natural and man-made obstacles, such as rivers, lagoons and estuaries, harbors, railways, and motorways" (Joachim 2012, p.46). This allows ropeways to excel in specific circumstances where other transportation methods fall short. Additionally, in rocky, mountainous terrain the space necessary to build a ropeway between two key points is often less than building a road. (Raksha, 2019).

Ropeways are also mechanically efficient. This is due to the ropeway powerplant being a part of the station, meaning the ropeway does not need to move the weight of the engine. (Joachim, 2012). This, combined with mechanical systems being electrically powered, means mechanical systems can be environmentally friendly, provided the electricity is generated using a sustainable method. For gravity or human powered systems, power source is not an issue, as these are inherently green methods of propulsion.

2.1.2 Disadvantages of ART systems

ART systems have a maximum hauling capacity that is relatively low when compared to other transportation methods. Trucks and buses can carry more goods if a road is in place and can do so without any additional infrastructure. Trains are also much more efficient at carrying a large amount of people and can also be used to transport large amounts of goods and materials. Due to this, ropeways are ideal in low throughput situations because, "…due to technical limitations, aerial cable cars are not mass-transit systems and cannot transport significantly more than 3,000 passengers per hour."(Joachim, 2012 p.42)

Additionally, operating smaller aerial ropeways in the Himalayas during heavy winds or intense monsoons, which are common in the region, (Municipal Corporation, 2023) is less feasible compared to alternatives such as buses, trains, or personal transportation. (Hoffman & Liehl, 2005). To maintain safe operating practices, ropeway systems must be limited in operation during high winds or electrical storms (Alshalalfah, 2014). This could cause ART systems to be out of operation more often than other public transportation systems. With monsoon season afflicting Himachal Pradesh from July to August annually, (Municipal

Corporation, 2023) this could render an ART inoperable for significant time periods during these months each year.

2.2 Types of Aerial Ropeway System

There are many different types of ropeway systems which fill different operational requirements. The main categories of these systems are human powered systems, gravity systems, and mechanically powered systems.

2.2.1 Human-Powered Ropeways

Human-powered ART systems have been in use since 20,000 BCE (Hoffman & Zrnić 2012). In a human powered system, a rope is pulled across an obstacle or otherwise impassable terrain and a platform is hung beneath the cable. These are manually locomoted by a human operator, where the hanging gondola or platform is pulled across the rope suspending it as pictured in the top two images of the graphic below. It is also possible to make these systems powered by livestock as illustrated by the bottom name of the graphic below.

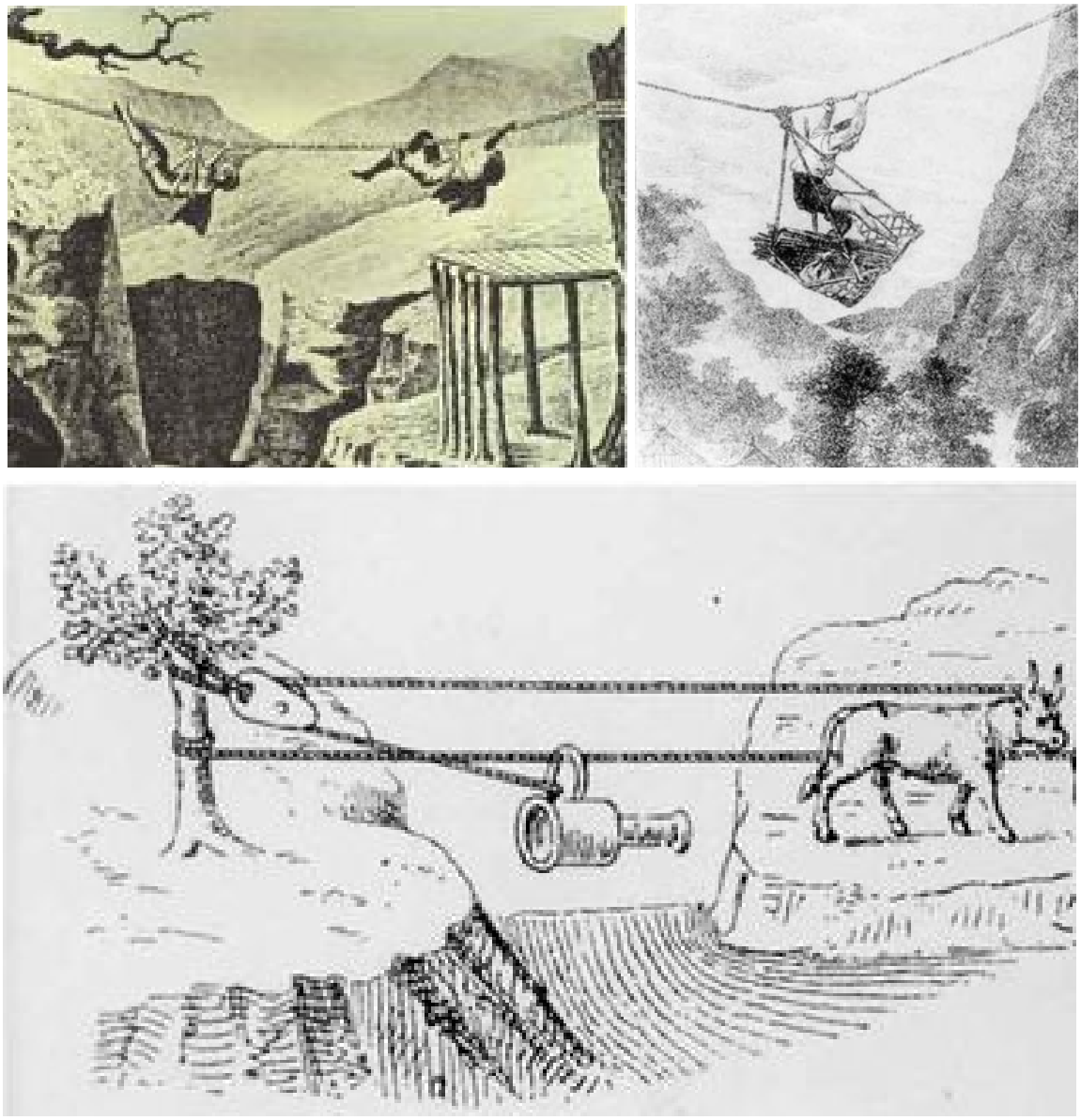


Figure 1: Examples of ancient ropeways
Various human/bovine-powered ancient ropeways (Brian Williams, 2022)

The benefits of implementing a human-powered ART come from the ability to cross challenging terrain with minimal infrastructure and all at low cost. In 2011, the cost to build a modern human-powered system was found to be around 14 thousand US dollars. (Sarita & Shradha 2011). This low cost allows these systems to be placed in areas where the cost for another higher volume transportation method could not be justified. However, with the low cost and low infrastructure requirements comes significant drawbacks to the system, primarily in the amount of people who can use it due to restrictions on capacity, limited to one platform at a time, and the type of people who can use it. A system reliant on one's own strength limits the accessibility of the system, with the operator needing to be able bodied and strong enough to pull

themselves and whatever cargo they are carrying across by themselves manually This also limits the length of the ropeway, with systems only being feasible up to 100m. (Sarita & Shradha 2011)

Human-powered ART systems are useful in a niche application where only limited transportation is necessary and the high cost of other transport cannot be justified. This makes it perfect for rural applications.

2.2.2 Gravity Ropeways

Gravity ropeways are another commonly used ART system. These systems look similar to human-powered systems with the locomotive effort being provided by gravity instead of a human. To do this, a cable is strung between two points where one point is adequately higher than the other. These systems typically transport tools and goods from a higher elevation to a lower elevation and can tolerate large and heavy payloads. For the speed to be regulated and for the gondola to stop, a brake system is necessary.

These systems are often limited to transport of goods due to safety constraints. A mass of cargo can be transported down from the upper to the lower station, and cargo of a lower mass can be brought up from the lower to the upper station using the weight of the cargo going down. For these systems, weight to be transported up can be roughly one third of the mass of the cargo going down to maintain an acceptable balance (Adhikari 2011). These systems are also relatively cheap and provide an alternative less prone to landslide closure than roads (Yadav & Khura 2015). In 2015 the Indian Society of Agricultural Engineers found that a system cost 30,00,000 INR for a 1500m system (Yadav & Khura 2015), significantly lower than the cost of a mountain roadway.

For gravity-powered systems to be truly effective, a location is needed where goods need to be transported one way from a relatively high altitude to a lower one. Despite this narrow scope, the system's advantages of low impact on the environment, low operating costs, and ability to traverse harsh terrain make it a very attractive transport solution.

2.2.3 Powered Systems

Mechanically-powered systems are by far the most developed and the most practical for urban applications due to their high passenger per hour per direction capabilities (pphpd) (Alshalalfah, Shalaby, Dale, & Othman 2012). These systems use mechanical means to drive gondolas with a high capacity across long, multi-towered routes (Neuman 1999). These systems are typically powered by a large electric motor with a backup diesel generator to deal with potential power system failures (Alshalalfah, Shalaby, Dale, & Othman 2012). This means that provided the power is generated sustainably, these systems will produce zero emissions under normal operation.

Initially developed for ski areas (Neuman 1999), these systems have found applications as transportation systems in many places throughout the world. There are two commonly utilized types of these systems seen around the globe. These two are the aerial tramway and the detachable gondola. Each system has different costs, capacities, speeds, and throughput capacities, all of which can be seen below in table 2.2.3.

2.2.3.1 Aerial Tramways

Aerial tramways, also called reversible ropeway or jig-back ropeway, use a stationary cable on which gondolas travel along, driven by another cable that is pulled from each end. This can be done with either one tram, with the driving cable being spooled at the end, or with two trams with the driving cable being run in a loop to each. This two-tram system is called a dual-haul aerial tramway. This type of system allows for multiple supporting cables and thus the gondolas and their loads can be very large. Only one gondola can go in each direction at once, resulting in passenger throughput values of up to ~2,000 passengers per hour per direction (pphpd) for the most capable systems. Due to there being only one car moving in each direction at a time, the gondolas can be stationary during loading and unloading. (Alshalalfah, Shalaby, Dale, & Othman 2012)

2.2.3.2 Detachable Gondolas:

Figure 2: Existing monocable detachable system end station in Manali.
One car (Left) in loading mode with doors open and one car (Right) accelerating out of the station onto the moving cable.

Detachable gondola systems are continuous systems that use smaller gondola vehicles spaced at regular intervals along a continuous cable (Alshalalfah, Shalaby, Dale, & Othman 2012). This allows for continuous loading and unloading at each end station as is pictured in the image above. At the end stations, the gondola is then detached from this line and slowed to a crawl to facilitate loading/unloading of the cars (Neuman 1999). Depending on the system, these

can transport up to 6,000 passengers per direction per hour (Alshalalfah, Shalaby, Dale, & Othman 2012). It is also possible to have mid-stations in these systems where passengers can unload/load in between the two end stations, allowing for more rail-like transport systems.

There are several types of these detachable gondola systems. The first to be developed were for ski areas. Called monocable detachable gondolas, the gondola is supported by a single cable which also drives the system. In these systems, the gondolas are relatively small and have low capacity. Later, when higher capacities and longer spans were desired, bi-cable and tri-cable detachable gondolas were developed. Similarly to aerial tramways, these systems feature additional large, stationary, cables which support the weight of the gondolas, with each system having one or two supporting cables respectively. Due to the extra cables, these systems can facilitate larger gondolas and thus higher throughput numbers. (Alshalalfah, Shalaby, Dale, & Othman 2012)

Table 1: Service Characteristics of Existing Powered ART Systems*

System	Occupants Per Car	Maximum Operating Speed		Approximate System Cost		Maximum Line Capacity
		(kph)	(mph)	Per km	Per mile	pphpd*
Aerial Tram	20-200	43.2	26.8	27-45 Million USD	43-72 Million USD	500-2,800
Dual Haul Aerial Tram	20-100	27	16.7	26-45 Million USD	42-72 Million USD	2,000
Monocable Detachable Gondola	4-15	21.6	13.4	9-18 Million USD	14-29 Million USD	3,600
Bicable Detachable Gondola	4-15	21.6	13.4	18-36 Million USD	29-58 Million USD	3,600
Tricable Detachable Gondola	4-35	30.6	19	27-45 Million USD	43-72 Million USD	6,000

***(Alshalalfah, Shalaby, Dale, & Othman 2012), All cost estimates adjusted for inflation, January 2024**
***pphpd - people per hour per direction, a measurement of system capacity**

2.3 Demographics of Himachal Pradesh

In Himachal Pradesh, the 2011 census recorded a population of 6,864,602 people, with a projected population of over 7.75 million by 2023 (Population Census 2011, 2023). Many of these people, especially those in urban areas, rely on public transport to make it to their destinations. “The bus remains the state mode of passenger transportation as the railway has a negligible presence in the state”(Saranta 2018, p.17). With buses being the primary method of public transit, there is room for other methods of transit to integrate and diversify transit networks.

2.4 Environmental Challenges of Himachal Pradesh

Himachal Pradesh is well known for its mountainous, landslide-prone terrain. Landslides are primarily caused by heavy rainfall during monsoon season but can also be attributed to a rocky soil composition, irregular climate, seismic activity, and topography (Singh, Gupta, & Shukla 2019). Small landslides occur frequently outside of monsoon season.

Figure 3: 2023 Pandoh landslide
Damage to the future Kiratpur-Manali national highway and the shoring installed to fix the damage to stabilize the highway & the Baglamukhi Ropeway base station in Pandoh.

Landslides have become more common in Himachal Pradesh as new and larger roads and highways are cut to compensate for increasing traffic. The cutting of the Kiratpur-Manali national highway, a four lane highway that would expedite travel through the province, has been under construction for 6 years. In the summer of 2023 during monsoon season, a large landslide occurred in Pandoh, right outside of Mandi, triggered largely due to unregulated cutting of the new Kiratpur-Manali national highway. Damage along one scratch of the highway is pictured above. 15 people were killed in this incident. Regardless of risks, the highway's construction was continued as the highway will allow traffic to bypass Mandi town, significantly alleviating traffic around the city.

Due to the damage roads cause to the terrain, ropeways may be a transportation solution that could bypass soil instability and cause fewer landslides while effectively traversing the mountainous terrain.

2.5 Transportation in Himachal Pradesh

In Himachal Pradesh, road transportation “is considered to be the lifeline of the people” (Saranta 2018, p.1). Without access to a train system, aside from the railway system between Kalka-Shimla and Pathankot-Joginder, roads are the only way for people to get from one place to another (Saranta 2018). South to North through traffic, encroachment, narrow roads, old bus stops, and lack of funding are the largest problems with the transportation in Mandi, the fourth largest city in Himachal Pradesh (Senior Superintendent of Mandi Police, Personal Communication, 2024).

India is known to have unsafe roads and Himachal Pradesh is no exception. Between narrow streets, mixed traffic patterns, encroachment around roads, and the newly constructed elevated roads, the region is challenging for drivers (Poddar 2022). For Mandi specifically, the majority of traffic comes from tourists passing from the south, through Mandi, to the north. Aside from unnecessary through traffic, road encroachment continues to play a major role in limiting traffic flow (Assistant Superintendent Mandi Police, Personal Communication, 2024). This heavy traffic, mountainous terrain, and unsafe road conditions contribute to Himachal Pradesh’s 11 deaths per 10,000 vehicles on the road, over 9 times higher than the 1.2-1.5 deaths per vehicle of developed countries (World Bank, 1996).

Privately owned vehicles are the growing preferred method of travel. In 1995 Mandi had only 250 privately owned cars registered. Today there are more than 5000 (Assistant Superintendent Mandi Police, Personal Communication, 2024). This rapid growth in the number of cars is another leading cause of traffic in the city. Many of the roads are impassable by cars, or unable to accommodate more than one car at a time. This leads to unavoidable car related traffic jams.

2.5.1 Improving Transportation in Himachal Pradesh

All public transit has drawbacks. As stated by Batta (2008, p.99) “The main external costs of transport use are congestion, accidents, and environmental costs". Additionally, these costs can include time, pollution, noise, public money, and others. For responsible transportation implementation, any form of transportation must attempt to minimize these drawbacks.

New transportation systems must be sustainable to continue to operate over the long term. Batta (2008) groups the needs of sustainability into three categories: economic, social, and environmental. An ideal solution will have to satisfy all three categories to be truly sustainable.

A transportation system that is not economically viable will fail in the long term. Transport companies often have the goal of making money. Public transit systems however do not need to make money, but the government must be willing to pay for the resultant loss. If this is deemed necessary then the system can be economically sustainable nonetheless.

Social sustainability is also crucial for success. Public opinion can be shaped through education and advertising, however forcing a system on an unwilling population is not conducive to success. Depending on the project, having a small target customer base does not mean failure however. Many tourist ropeways operate with high enough margins that a low number of riders can still turn a profit. However with larger ART systems meant for public transit, high cost can often not be justified. Due to these systems being positioned in cities, in order to be competitive with cabs and buses a public transportation ART would need to be priced near that of other transportation. For customers to justify frequent use of the system, prices must be set so that a sufficient number of people can justify the price to either save time, or money.

Finally, environmental impact is very important in the long term sustainability of a system. Financial and social viability are heavily impacted by environmental stability. As Batta 2008) puts it: “pollution may appear to be an environmental concern but its impact on health and other economic activities also stimulates economic and social concerns.”

2.6 ART Potential

Pre-existing infrastructure has difficulties traversing the region and alternative transportation methods could help overcome these issues. For a new transportation system to succeed it should reduce local transportation time, increase engagement of locals in markets previously inaccessible, and improve the safety of transportation. Transportation that has a lower likelihood of being negatively affected by landslides in a landslide-prone environment improves the safety and quality of life of locals using the system. Transportation that can be placed at optimal locations above landslide-prone areas and whose implementation reduces the need for further roadway development which causes landslides provides better safety for local users and a higher quality of life. Farmers are able to participate in the economy more frequently and can increase their yearly income, workers are able to get to work quicker and more efficiently, and all people are able to access more areas of the city quicker to conduct business and visit places they would not have otherwise. An ART could greatly improve transportation for many people by diminishing commute times and the risks of other transportation methods.

Ropeways have been shown to work in hilly regions of other countries, with large elevation changes or difficulties with traditional transportation due to an unconducive built environment. Bolivia is a major example, with the Ropeway and Rapid Transport System Development Corporation (RTDC) in Himachal Pradesh taking inspiration and learnings from the ropeway located in La Paz. (RTDC, Personal Communication, 2024) As a majority of Himachal Pradesh is hilly and mountainous terrain, with successful implementation ropeways may be able to play a role in the state’s transportation.

2.7 ParvatMala Pariyojana

Recognising the potential of ropeways in Himachal Pradesh and other northern states because of the unique terrain of the Himalayas, the Indian government created the Parvatmala National Ropeways Development Programme in 2022. Hailing ARTS as an efficient and safe method of transportation the government set aside 1.25 lakh crore (1.25 trillion rupees) for the

next 5 years to construct new ropeways. The project proposes the funding of 8 ropeways, one of which is a proposed 15km ropeway in Shimla which will be the 2nd longest monocable detachable once it's built, only second to the La Paz-El Alto in Bolivia. (Ministry of Road Transport and Highways, 2021).

The government cites the benefits of the system as ability to overcome terrain difficulties like slopes, economic use of power, flexibility of what is being transported and low physical footprint/less impact on community. They mention successful ropeways across India that they wish to mimic which include the Girnar Ropeway in Gujarat and the Guwahati Passenger Ropeway in Assam pictured below. (Ministry of Road Transport and Highways, 2021)

Figure 4: The Guwahati Passenger Ropeway in Assam
(Damodar Ropeways & Infra Limited, 2021)

Chapter Three: Methodology

As Himachal Pradesh rapidly urbanizes, transportation must adapt to keep up with demand. Whether it is more roads, improved roads, an increase in available public transportation, or something else entirely, transportation needs to meet the demands of a people in order for them to thrive. One of these other options is Aerial Ropeway Systems and we intend to investigate the potential role they will play in the expansion of transportation in Himachal Pradesh. Potential implementations of ART systems will be investigated both in specific cities and across the region as a whole. To maintain a reasonable scope, seven locations across HP were chosen for the team to study in varying levels of detail, with the focus being on talking to professionals.

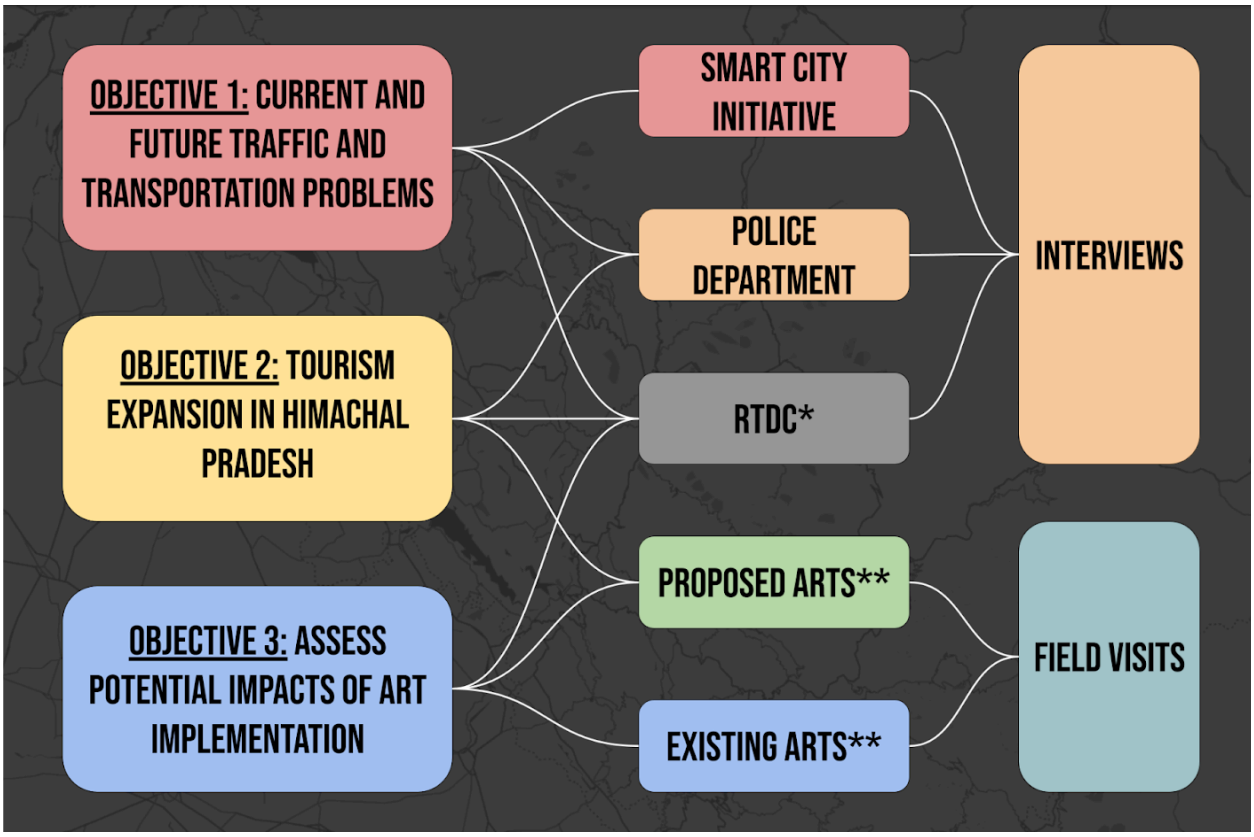


Figure 5: Methodology Graphic
***Ropeway and Rapid Transport System Development Corporation**
**** Aerial Ropeway Transportation Systems**

3.1 Objective 1: Current and Future Traffic and Transportation Problems

Transportation will play a pivotal role in the future of HP. To better understand what pivotal role it will play, we talked to various officials and professionals in the field.

Talking to the Senior Superintendent and Additional Superintendent of the Mandi Police Force, we inquired about the traffic situation of Mandi. Both were knowledgeable in the traffic

problems and proposed solutions for Mandi, HP and have an in-depth understanding of the problems with transportation there. With an understanding of the transportation issues and some potential solutions, we then focused on learning about ropeways, current and future. (Assistant & Senior Superintendent Mandi Police, Personal Communication, 2024)

The Ropeway and Rapid Transport System Development Corporation, or RTDC, is the governmental body in charge of ropeways. They work closely with other government branches to plan transportation for cities, and because of this, they have a wealth of knowledge not only on ropeways, but traffic and the area as a whole. The deputy general manager of the RTDC branch in Shimla has been heading the development of a fifteen kilometer ropeway, and was the perfect person to talk to for information on transportation focused ropeways.

Up until this point all of our contacts had been ropeway or traffic related, so to get a different perspective we wanted to talk to someone from the Smart City Project. The Smart City Project aims to create holistic infrastructure to achieve well being and sustainability across India. Additionally, a large part of planning cities is allocation of space and resources for transportation. This was perfect for our goal of a sustainable system and also general transportation information gathering, so thankfully we were able to talk to a Smart City Representative. His perspective is further removed from the actual planning and operation of specific transportation systems and is broader. This was useful to be able to put everything in context.

3.2 Objective 2: Tourism Expansion in Himachal Pradesh

It is important to not look at anything in a vacuum, and transportation is no exception. Just because a ropeway is designed with a specific demographic in mind, does not mean that will be the only demographic to use it. This will be the most obvious with a public transportation oriented ropeway as it could also be an attraction for tourists. Any impressive structure or piece of infrastructure can be an attraction, and regardless of if it is intentional or not, an ART system in an already tourist oriented city will be used by tourists.

To get the most accurate information about tourism in relation to ART systems, we centered our research on two separate locations: Shimla and Baglamukhi. Shimla was a focus because of the proposed ropeway and the impact it will have on an already tourism oriented city, and Baglamukhi was a focus because of the ART system that is already under construction to reach the temple there. In Shimla, the RTDC General Manager again was able to tell us about the predicted impacts on the city specifically because of the ropeway, and at the Baglamukhi temple both the Bagalmukhi Project Engineer and a Bagalamukhi Community Member, coming from different perspectives, were able to tell us about the potential impacts there. (RTDC, Personal Communication, 2024) (Bagalamukhi Community Member, Personal Communication, 2024)

The RTDC Engineer is overseeing the construction of the ropeway and is in charge of its success. In contrast, the Bagalmukhi Community Member is a local, active member of the Baglamukhi temple. Both individuals were knowledgeable and talking with them gave significant insight into how tourism and the ropeway are related.

The RTDC General manager was also aware of the tourism impacts the Shimla Ropeway would have and could give a slightly more removed perspective than either of the other two as ground has not yet broken on the Shimla project. (RTDC, Personal Communication, 2024)

Additionally, for ropeways that are more tourist oriented, they can be used by members of the community who find it convenient, however this has been observed to be less common than the opposite. Many of the people in the communities around tourist oriented ART systems were largely content with existing transportation before the construction of the ART and continue to use the original methods. This is not the case for every person, but through qualitative observation at the Jakhu, Dharamsala, and Manali ropeways we have verified this is largely the case.

3.3 Objective 3: Assess Potential Impacts of ART Implementation

It is difficult to fully predict the outcome that an ART system will have on an area. Regardless of how much planning goes into such a project, there will always be unintended consequences and/or benefits. Due to this, the best way to gauge possible impact is to talk to people from as many different backgrounds as possible. This was already achieved through many of our conducted interviews. We wanted to talk to people from different backgrounds to get a more holistic understanding of the problems faced in the area, as well as potential solutions. Having only one perspective may lead to bias and were therefore actively avoided. In doing this we reached a varied group of people through interviews, and were able to ask them about potential impacts as well.

From the RTDC members we wanted to know about the larger impacts, such as economical, environmental, and quality of life for community members. These are the areas that would have been the most heavily researched, and make the most sense to discuss with governmental members.

To see how a ropeway might impact an individual however, we talked with a member of the Bagalamukhi temple community. His unassociated perspective was unique from the other interviewed parties as he did not have a professional relationship with the ropeway. (Bagalamukhi Community Member, Personal Communication, 2024)

Additionally, a survey was conducted with commuters in Dharamshala on a route which could potentially benefit from ART connectivity in the city. This survey was done to gather the perspectives of the residents of a city which could potentially benefit from a ropeway transit system. The survey was taken on the route between the train station and the main bus stand. This route is one of the busiest in Dharamshala and could potentially benefit from a rapid transit solution. The survey assessed the commuters ideas about ropeway transportation, the price they would consider paying for travel, whether they think ropeway transportation would be a benefit, and the current problems of transportation in the city. This survey gave us good insight into the opinions and issues of many regular transportation users.

Chapter Four: Results

Through both research and physical observation we found there are three main categories of use case for passenger ART systems in Himachal Pradesh India: public transportation, secular tourism, and religious tourism. Public transportation focused ropeways are pieces of infrastructure that are supplemental or in place of the existing network of roads, bus routes, metro lines, etc. People take these systems to work and school, use them to see friends and family, and facilitate their daily lives. They are tools that allow people to get from one place to another. Secular tourism ART systems are the complete opposite of this. They are used as an attraction, or to bring tourists to an attraction that is meant to entertain the people participating, and make the company money. Ski lifts that bring people to the top of a mountain for them to ski back down are a perfect example of secular tourism ART systems. The only function is entertainment and profit.

The third category is something that is not present in many other countries: religious tourism. Historically, in Himachal Pradesh, temples were constructed as a display of power in addition to purely religious motivation (R. Sarkar, Personal Communication, 2024). This, along with the specific nature of each temple means there are thousands of temples throughout the mountains. These temples are all unique and desirable locations for people to visit to worship. This can be thought of as similar to a pilgrimage, but on a much smaller scale. This happens year round, but during festivals the number of people who travel to the temples increases significantly. This is especially the case during events which involve walking deities from one location to another. ART systems that are focused around such religious tourism facilitate people getting to the temple in a more convenient way. This can enable a larger portion of the population to both visit the temples and participate in festivals.

The following sections break down the findings from our field visits by location. These locations are imaged on the topographical map included below. Given the vast differences in locations specifically for ropeway suitability, this was found to be the best way to divide the research. Additionally, the people we talked to were the most knowledgeable about their specific areas, so although some extrapolations can be made, they have been kept to a minimum without confirmation from other sources.

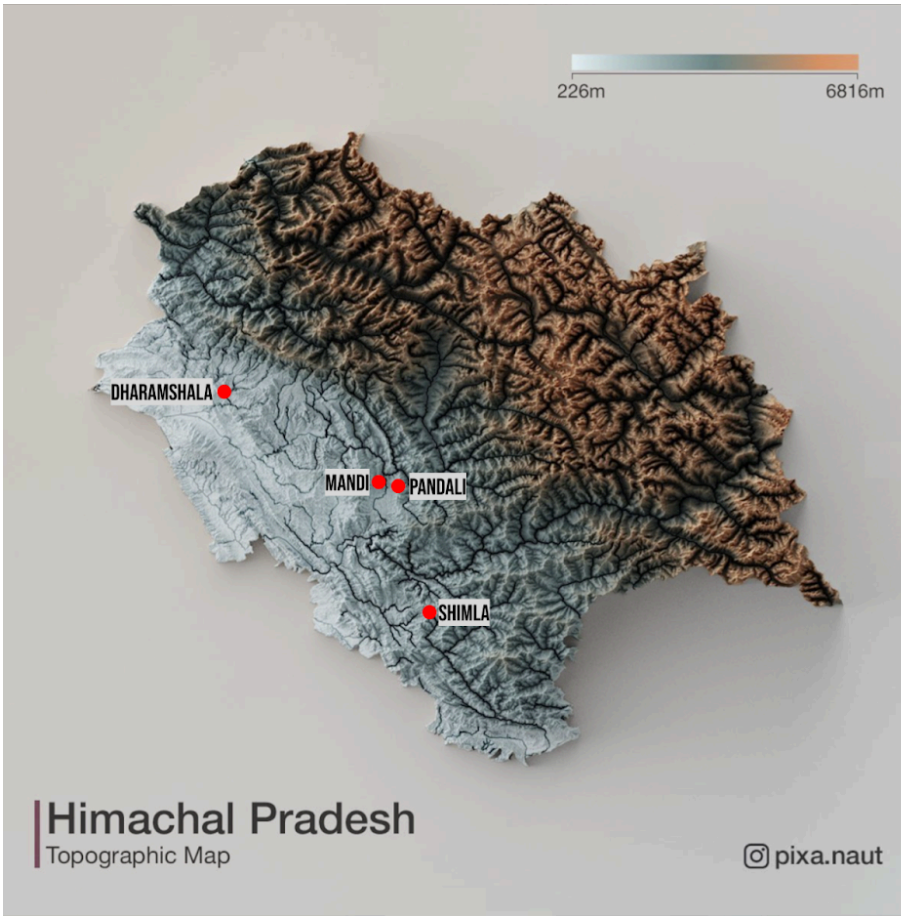


Figure 7: Topographical map of Himachal Pradesh
Notes of locations relevant to our project (PixaNaut, 2021)

4.1 Mandi: Existing Transportation Infrastructure

As the closest large city to IIT Mandi, Mandi made sense as the first case study. Many cities throughout Himachal Pradesh suffer from traffic congestion problems and foresee the problem to worsen as car ownership rates continue to increase. This has exacerbated city traffic, already hampered by nonlocal traffic of tourists passing through Mandi on the highway to Manali and other tourist cities. This is because Mandi is positioned directly along the 3 and 153 national highways. Smaller scale attempts of traffic direction from the Mandi police have yielded minimal results and the main intersection on Mandi's outskirts has consistently dealt with lengthy traffic jams of two or more hours. Many solutions have been considered, even/odd plate days, one way streets, and even the demolition of certain traffic impediments but none have been well received by locals as they would often require significant transportation lifestyle changes. The city has therefore decided to employ large-scale solutions and completely redirect highway traffic around the city with a mountain bypass tunnel, the entrance of which can be seen in the image below. The completion of the tunnel will alleviate 60% of intracity traffic by eliminating a majority of the highway traffic passing through the town. When inquiring about potential ART placement in the city the Superintendent of the Mandi Police department told us that it would be

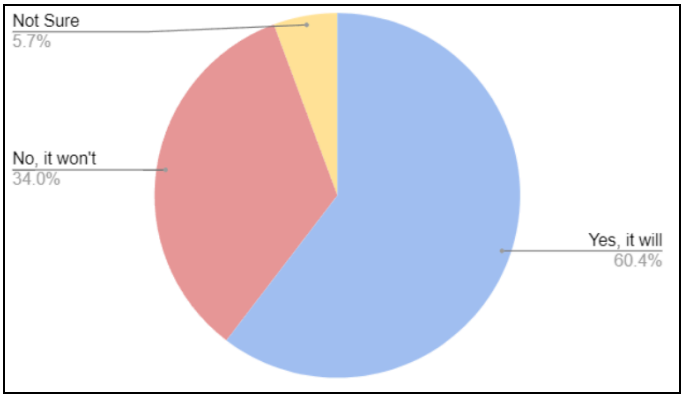
a challenge due to the city's current infrastructure and limited free space. Mandi has a very high urban density. This is to the point of market stalls encroaching onto the main roads in the city. This limited space would make the placement of ART stations difficult and not very feasible as a solution for traffic congestion in Mandi. (Senior Superintendent Mandi Police, Personal Communication, 2024)

Figure 8: Construction on the tunnel for the Kiratpur-Manali national highway
This will allow traffic to completely bypass Mandi town.

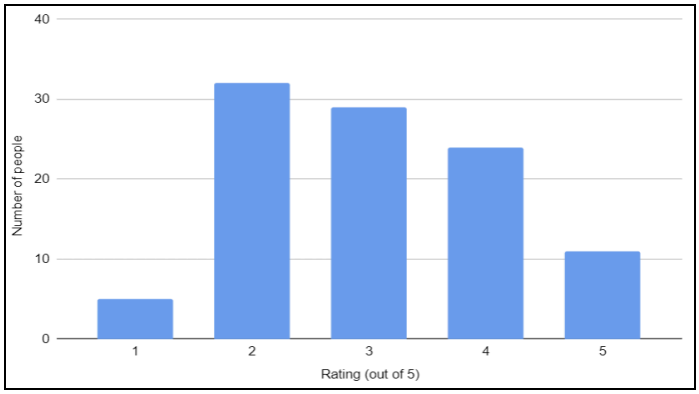
4.2 Dharamshala: Hypothetical Transportation Ropeway and Existing Secular Ropeway

4.2.1 Commuter Survey (Transportation)

Our corresponding Indian Institute of Technology (IIT) Mandi Interdisciplinary Socio-Technical Practicum (ISTP) group traveled to the city of Dharamshala to conduct an interest survey. With Dharamshala already having a ropeway focused on tourism, a portion of the population knew about ropeways and had feelings about the potential system. The ISTP group conducted surveys on the feasibility of transportation-focused ART in Dharamshala by asking commuters during rush hour along the busiest intersection in the city a series of questions. 107 commuters were interviewed with a computerized survey, the questions from which can be seen in the appendix. A summary of their data is included below.



Dharamshala Commuters Response of whether a ropeway would help their commute



Survey of Dharamshala City about people's satisfaction with the current transport options with 1 being dissatisfaction and 5 being total satisfaction.

Figure 9: Dharamshala Data

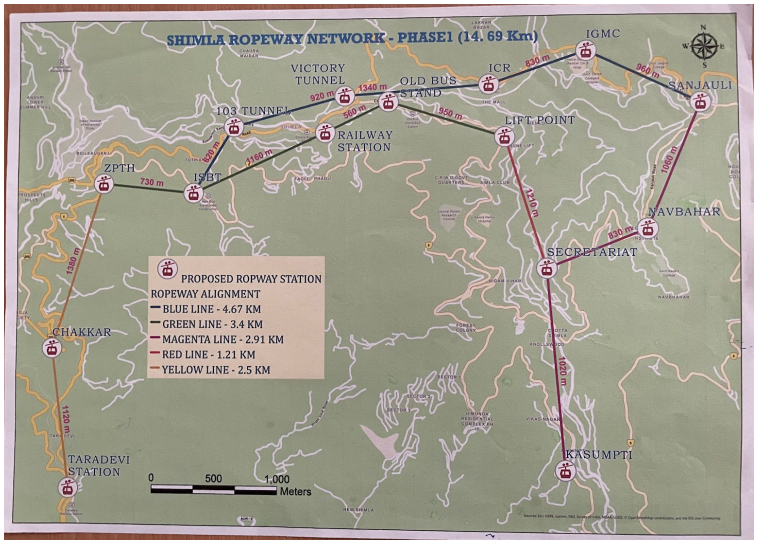
4.2.2 Dharmshala Skyway (Secular Tourism)

The existing ropeway in Dharamshala is largely tourism focused, and although it could be argued that it is transportation, neither the cost nor location of either station support that argument. The ropeway is a slow ride between a station positioned less than a ten minute walk from the Namgyal Monastery to the station positioned in the outskirts of Dharamsala. The ropeway does cover a significant elevation change, and may be the fastest way to get between the two stations, but it is unlikely the bottom station would be anyone's ultimate destination. It would only be a stop along a longer journey, possibly making it significantly out of the way of the ideal travel path.

4.3 Shimla: Proposed Transportation Ropeway and Existing Religious Ropeway

4.3.1 RTDC Interview (Transportation)

Shimla, another traffic-stricken city, has found a different solution to traffic issues. When visiting Shimla we had the opportunity to meet with the General Manager of the Ropeway and Rapid Transport System Development Corporation. Similar to Mandi, roads are often congested with large amounts of private vehicles and narrow roads. However, Shimla is in an uncommon geographical position. Shimla, positioned on the ridge of a mountain, creates a very uniquely steep and densely populated city that is physically taxing to manually navigate and takes a long time in a vehicle. They do have large amounts of government owned forest land throughout the city, leaving room for new infrastructure, like an ARTS. This has led the RTDC in Shimla to propose a 15km public transportation ropeway. The expected outcomes of this system are that traffic and travel times will be lowered and the economy bolstered. (RTDC, Personal Communication, 2024)



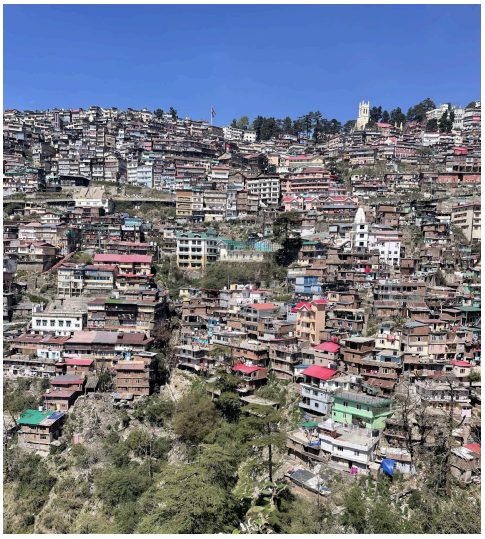


Figure 10: Map and picture of Shimla
(Left): Map of Phase One of 15km Shimla Ropeway Project (2024) (Right): Shimla's verticality (2024)

Braess's Paradox is a paradox whereby adding more lanes to a highway increases traffic. This occurs because the extra throughput draws people who would otherwise be using a different method of transport or not traveling at all, onto the roads. (Boyd, 2012) By removing some people from the roads, it is possible people who had preferred not to drive before will start driving. This could lead to the same level of traffic before and after the ropeway, however as the throughput is greater, it is still a net positive. This is only speculation however, as the RTDC General Manager predicts that traffic will lessen. (RTDC, Personal Communication, 2024)

For Shimla's economy, although taxis were not on board with the prospect of the ropeway due to potential future decrease in taxi usage, the ropeway will most likely bolster it. The RTDC General Manager predicts economic hubs to be formed around each of the ART stations as vendors will see the new location as a new ideal spot to set up their shops. (RTDC, Personal Communication, 2024)

Shimla intends to become a case study for the further implementation of these systems across India. According to the RTDC General Manager, if the Shimla 15 km ropeway is successful, this project will be a model for India to begin implementing ropeways elsewhere. Having an example of a domestic, successful public transport ART system would be a powerful motivator for cities to push for similar projects. (RTDC, Personal Communication, 2024)

With a success in Shimla and further legislation, the RTDC has continued plans for two more phases of system expansion. Ultimately, the goal of the RTDC and the transportation ministry is to have many cities in Himachal Pradesh and even India as a whole to have high speed ART systems. (RTDC, Personal Communication, 2024)

4.3.2 Jakku Ropeway (Religious Tourism)

In addition to the transportation ropeway plans, another type of ropeway already exists in Shimla to take tourists to the top of Jakku Hill. This ropeway leads to the Jakku Hanuman

Temple, a popular tourist location for both domestic and international tourists. With the temple being on top of a hill accessibility is otherwise limited. To walk, it takes about thirty minutes to reach the top from the bottom of the hill to the top*. (*Tested by a group of WPI students of slightly above average fitness and hiking enthusiasm) This hike can be avoided by utilizing the ropeway, taking visitors from Mall Road, a popular tourist strip filled with restaurants and shops, to the top of the hill with the upper station less than 200 meters away from the main temple. This ropeway is not only saving effort but time for visitors, reducing a the thirty minute walk* to a six minute ride costing 490 INR, with an average of a one minute loading time at the top and bottom of the ropeway. The mechanical system at the top of the Jakku Ropeway is pictured below.

Forgoing the expense of efficiency, many of the people in the communities around tourist oriented ART systems were largely content with existing transportation before the construction of the ART and continue to use the original methods. This is not the case for all community members, but through qualitative observation at the Jakhu ropeway and other tourism-centric ropeways in Dharamshala and Manali this has largely been the case.

Figure 11: Mechanical system at top of Jakku Ropeway

4.4 Pandoh-Baglamukhi: Ropeway Under Construction

The Indian government has invested significantly in ART systems as a tourist attraction. (RTDC, Personal Communication, 2024) An example of this we were able to observe is the Baglamukhi ropeway in Pandoh when we visited with a RTDC Engineer. This is in part due to the optics of new advanced forms of transportation, furthering the location's public perception as a tourist location bringing money and visitors.

Figure 12: Under construction base station of Baglamukhi Ropeway in Pandali (2024)

The Baglamukhi Ropeway, proposed and funded by the government of Himachal Pradesh, was created with the intention of promoting travel to the Baglamukhi Temple by expediting travel. With the current road only supporting one consistent lane making travel to the temple very slow, the Baglamukhi temple remains largely unvisited by tourists and people external to the area outside of certain religious holidays. The temple ropeway was proposed as an alternative to the lengthy roadway and is said to be able to carry 300 pphpd (people per hour per direction). This is anticipated to be mainly religious tourists.

As in the past, with the kings of India building temples to display wealth and power, ropeway projects can serve this additional purpose as well (R. Sarkar, Personal Conversation, 2024). With government officials wanting to remain popular with the people, they often aim to create large transportation projects with the hope of influencing tourism and creating more appealing locations for tourists. With the Baglamukhi temple this seems to be the case.

While talking to a Bagalamukhi Community Member, a Pandali local and involved member of the Baglamukhi temple, it became apparent that he and much of the temple community had a positive opinion of the ropeway. None of the major problems with the ropeway impacted much of the community in any way. Aside from the land that needed to be purchased from a local to build the one required tower, the ART system had little impact on the community. A Bagalamukhi Community Member was more excited by the possibility of more people getting to experience the temple than he was concerned about the cost to build or maintenance, or any of the major concerns for other parties. Even a major landslide which took place was seen as a positive. According to a Bagalamukhi Community Member, this landslide, which had occurred near the far station of the ropeway and had delayed construction, was a way of the deity

signaling support for the project as it created more space for parking on that side of the ropeway. (Bagalamukhi Community Member, Personal Communication, 2024)

With minimal, if any negatives for the locals and temple-goers, the temple has retained all of the benefits of the ropeway, while maintaining goodwill between the RTDC and local community. According to those involved with the RTDC, this project was a valuable experience in managing ropeway construction and has helped streamline their process for ropeway construction. The delays which the project experienced allowed the RTDC to assess their requirements and add several more, including building all infrastructure on public land to avoid lengthy processes for the purchase of land, and more in depth soil analysis to better avoid landslides.

4.5 Correlation to Traffic, Tourism and ART Impacts

While organizing our field visit results by location helps with the continuity of information, it does not explain any correlation to the three main objectives. The following are these results as they pertain to the research questions.

4.5.1 Current and Future Traffic and Transportation Problems

The majority of the traffic information, and information about the transportation problems faced by a city were gathered by the respective officials of each city that we talked to. Since we were unable to talk to someone knowledgeable from Dharamshala, and only interviewed people about a specific start and stop location, we were unable to gather any useful data for this section from there.

The main takeaway from all of the locations as a whole is the individuality of the situations. Each place suffers from universal problems, such as traffic volume and encroachment, but the special problems each place has are the most interesting. For Mandi the biggest problem is the amount of people who take the highway through Mandi with no intention of stopping there. This through traffic can be diverted with a highway that goes around the city however, alleviating the problem. This will lessen the strain on the road network and allow for other problems to be the main focus of efforts.

For Shimla the main problem is the verticality of the city. Many cities are built in valleys, and Shimla is instead built on the top and side of a hill, giving it significantly higher changes in elevation than Mandi. Mandi is almost completely flat compared to Shimla, and Dharamshala is even flatter. This means that for them the main bottleneck is not the physical distance between two locations, but instead the required path and elevation change.

Pandali does not suffer from the traffic problem that anywhere else studied has, but instead the distance is the biggest problem. This distance does not manifest itself into more cars on the road that cause congestion, but instead just adds travel time. There is simply not a better way to get from one side of the reservoir to the other without going around.

Each of these locations has problems that may be able to be solved with ropeways, but the main takeaway is not the solution to the problem and instead the variety. This data is useful in extrapolating situations in which ropeways could or could not be beneficial, but it does not

help to draw conclusions about the primary transportation issues in general. Each of the locations we have looked at have individualized issues that need to be addressed before any common issues should be looked at. This means that the future of traffic and transportation problems will only become apparent once the existing problems are addressed.

4.5.2 Tourism Expansion in Himachal Pradesh

The Himalayas are a large tourism destination for people from both within and outside of India. People from all over come to visit the mountains and the towns nestled within them. This is especially evident from the main traffic problem in Mandi: through traffic. Mandi is along the 3 and 154 national highways, through which many people are traveling to places further north. As cities continue to expand, and the tourism industry continues to thrive, tourism will only become a larger, more impactful part of the economy for many places. Two options for ropeways are to be the main attraction to draw in tourists, and the other is to use an existing attraction as the main reason for tourism and the ropeway only as the means to get to the attraction. All of the examples we have seen, aside from the secular tourism ropeway in Manali, have been from this later group. The Baglamukhi ropeway is a perfect example of this, where the temple is the main attraction, and the ropeway is just one of the ways to get there.

This ease of access is expected to increase the number of tourists for all predicted ropeways, which will help bolster the economy and make the place more desirable for tourists to visit in the first place. This positive feedback cycle is one of the intended benefits of adding any new attraction to an existing tourism location, and ropeways are no exception.

In Manali the planned ropeway, although not tourism focused, will also be used by tourists. The city is currently hard to navigate so tourists are unlikely to venture too far away from a central location like mall road. However, an ART system could lower the barrier to entry for public transportation and allow tourists to explore more of the city. This will help to decrease the density of tourists in hot spots, and bolster the economy throughout the city instead of just around the specific tourism focused areas. This ease of navigability can also be a draw for people thinking about visiting Shimla and can only help to increase the number of people who do decide to visit the city. Ultimately, tourism is expanding and the infrastructure being built in and around tourism locations will only help to increase it.

4.5.3 Assess Potential Impacts of ART Implementations

The impacts of ART implementations are both numerous and complex. Depending on the type of system the impact on various groups can radically change, and even within the same type of system different groups can be impacted in different ways. Not many of these interactions between both the systems and stakeholders were explicitly stated by any of the people we interviewed. Some are obvious, such as taxi drivers being opposed to the proposed tourism ropeway in Manali that would have been cheaper and more interesting than a cab ride, but most require analysis to acknowledge all of the given information.

Chapter Five: Analysis

5.1 Comparisons Between Stakeholder-ART System Relationships

ART systems are complex, multifaceted projects that involve input from many different parties to accommodate everyone. It is never possible to satisfy everyone with any project, but striving to appease the majority of stakeholders is important, and listening to and implementing changes to help minority stakeholder groups is even better. This shows that the ropeway company cares about the community as a whole and not just the main profit sources. To better understand how stakeholders interact with the three different types of ropeways the following sections will explain how some people interact with all three in the same way, and some interact with each type differently.

The bureaucracy of creating any new public infrastructure project is especially apparent the more parties are involved. Everyone wants something out of the system and is unwilling to concede on different points. This makes lobbying a universal constant of groups attempting to get what they want. Talking to politicians and convincing them to fight for an individual's desires is a strong tool that people use to great effect (Senior Superintendent Madni Police, Personal Communication, 2024). ART systems are no exception to this as construction approval is a significant hurdle in some locations.

Almost everyone in a given area will be negatively impacted by the construction of an ART system during the construction phase. The places that need them the most have narrow, winding roads which are not conducive to efficient traffic patterns, especially with construction equipment in the way. We have seen this firsthand many times when excavators are actively digging on the road we are trying to drive on. However, this is only a temporary drawback, and should not be the exclusive reason for not constructing an ART system. For some, such as shopkeepers, the construction and following existence of an ART system could render their businesses completely unnecessary. Most others, such as the police who will have to direct the resulting traffic, and the commuters who will have a longer commute, will only have short term effects.

Accessibility is critical to an ART system’s success. ART systems are not set up to be the most accessible systems in many situations. Unless the stations are immediately adjacent to where one needs to go, another form of transportation will likely be involved. Taxis and private vehicles can take the patron directly from where they are to where they need to go. No other transportation methods or extraneous stops are involved. Buses have set routes, and make stops along the entire length of those routes, but the bus network is often expansive. It is more than likely the bus network can come reasonably close to both locations of a journey, and can be used as a standalone system. The cheaper cost and reliability of the system is where the main accessibility compared to individual vehicles is.

ART systems can be more physically accessible than other transport systems, something that is largely unintegrated in India due to the rapid urbanization. Aside from this, the accessibility of ART systems is most apparent in the integration with other methods of transport.

They are not very accessible in the 4 established methods, however the speed and efficiency may make it worth some inconvenience. This speed and efficiency will also be the driving factor behind the slightly higher cost per distance compared to the bus network. It will always be cheaper than taxis, which can make them more accessible than taxis for many who are financially constrained.

Politics is notorious for conflict between parties, often taking opposing stances on every subject. This is no different in such important subjects as public infrastructure, tourism, and religion. This means that with party transitions comes funding reallocations and scope changes. ART systems can be controversial political pieces, and as such they too suffer from the problems with changing political parties. This can happen on any level of government, as politicians with the correct connections can get projects canceled or delayed. Additionally, many ropeways are seen as displays of wealth and power, so politicians too can be seen as important stakeholders.

The Shri Baglamukhi temple is an example of this political maneuvering. A bridge is currently in place that significantly reduces the walking distance compared to the driving distance, so expanding or replacing it with a driveable bridge could have been a significantly cheaper alternative to the ART system. This would not have had the same technological appeal that the ropeway does however, so it was one of the driving factors behind building the ropeway instead. Additionally, this temple is of a deity that has special importance for politicians, lawyers, doctors and businessmen. This was the reason why this specific temple was selected for such a project, as many people in the local government favor this temple. Had the party changed and this person was no longer in power it is possible that a different temple could become the location for such an impressive project. Although this specific example relates to religious tourism, it is also possible something similar could occur with any ropeway.

Governmental transportation officials from other departments and the police department are minimally impacted by all types of ART systems. Bus routes may need to be adjusted to reflect the new transportation options, but after an initial reconfiguration very little changes. There may not even be any changes that are needed depending on the level of integration. As for police, they will still have to direct traffic in congested areas, however the locations of congestion may change.

A difficult set of stakeholders to consider relating to ART projects are the people in charge of the other forms of transportation. While buses and taxis maintain the same consumer-base throughout construction, an additional competitor will inherently lower the number of people using other services. It is hard to accurately predict this decrease or if the ratio of clients for the bus and taxi networks will remain the same. This uncertainty, along with a general unwillingness to share the customer base is the main cause of the animosity between transportation groups.

Both government and privately run bus companies have similar relations to transportation focused ropeway systems. Fairs, efficiency, and comfort are already compared between public and private buses, so an ART system would only add competition. Generally, competition is good for consumers as it encourages growth and improvement, so the same can be assumed to be likely here. The tourism focused ART systems are less direct competitors with the bus networks

however, so this is of lesser concern to the bus companies. A small portion of bus patrons are tourists, regardless of their reason for tourism.

Conversely to buses, the main demographic of people who take taxis are tourists and some daily commuters. Taxis are usually the most expensive transportation option, so the primary patrons consist of those able to afford the high fair, and those who are willing to spend more money for a specific reason such as tourism. This lends itself to a smaller number of higher cost trips as opposed to the many lower cost trips buses make. It is for this reason that taxis are at the largest risk from tourism based ART systems. If integrated and priced appropriately, an ART system can heavily reduce the need for taxis. This is evident at the Jakku Ropeway where cab drivers stand near the entrance to the ropeway asking if people needed taxis to the top, and is why the taxi union in Manali pushed back so hard on the Rohtang Pass Ropeway. It would have significantly decreased the need for cabs, and endangered the livelihoods of many taxi drivers. Public transportation focused ropeways would also impact demand for taxis, but to a lesser extent than either of the tourism based systems, and is therefore could be less of a concern to drivers.

For the construction of a ropeway, there are two important parties involved: the RTDC and the ropeway company contracted to perform mechanical work. As the governmental body in charge of ropeways, the RTDC is in complete control of planning, constructing, and operating transportation focused ART systems. They are also in charge of ensuring the safety of all of the existing tourism focused ropeways, but since all of the tourist ropeways are privately owned, they have much less of a role in operation. Private ownership of ART systems is no longer allowed however, so as more tourism focused ART systems are built by the RTDC they will have a significantly more involved role with their operation. This allows them to ensure all ropeways maintain the desired levels of safety and do not reflect poorly on ropeways as a whole.

The largest group of people who care about a ropeway however, is the people who use it daily. The patrons who take it to work and around town are the ones most impacted. For ropeways without subsidies these people are responsible for keeping the ropeway in business, and for those with subsidies the patrons are the only source of income, so keeping them happy is essential. Additionally, people who don't use the ART care about the impact it has on their lives, but the riders care about every aspect of it. This is most true of transportation focused systems as the throughput will be significantly higher. Having a regular clientele incentivises companies to ensure users have a positive experience as the goal is to have as many repeat users as possible. Religious tourism focused ART systems have a similar necessity but to a lesser extent, and secular tourism ART systems only need to keep a high enough rating online that people want to ride it. The number of frequent repeat customers on the tourism systems are significantly lower than the transportation systems, so this should be accounted for when even thinking of "everyday riders."

Tourists can either be people local to a region taking an ART system as an accessibility aid to get to and from a religious sight, or people from elsewhere taking an ART as an atypical event, regardless of the purpose. This latter group is the majority, but also has no political power in the area that the ART system occupies. This only gives them the ability to vote with their

wallets, and not pay for a service they do not want. This can be a powerful incentive, but is not as helpful as the direct feedback other groups provide through lobbying and such.

For every ART type there are positives, negatives and a variety of stakeholders that must all be considered. Success, as defined for this project, is the participation of all involved parties, in the integration of any potential future ropeway. Only through the involvement of every stakeholder, can a majority be content, and the project be deemed successful in its implementation by all of those parties involved. At the end of the day, a company can build a ropeway and have many people riding it, but if everyone in the city hates it and refuses to ride it, it is not a success for many. With each ART type, there are differences and similarities. Some ropeways will need the same groups involved and others will require different methods and different things to consider. Tables A.1 and A.2 is a comprehensive list and format to follow when considering the type of ART to be implemented and which parties will need to be involved for the success of the project.

5.2 Analysis of ARTS Applicability

When researching ARTS, some final considerations were uniform to all types, while others had more specific considerations based on the usage demographics of the system. Combining all these, five general considerations were deemed imperative to success. Each category consists of things to keep in mind when implementing an ART. While this is not an all-encompassing set of considerations, this does encompass the largest considerations and can be used as a preliminary analysis when determining if ART implementation is feasible in an environment. Below is a figure which summarizes these findings.

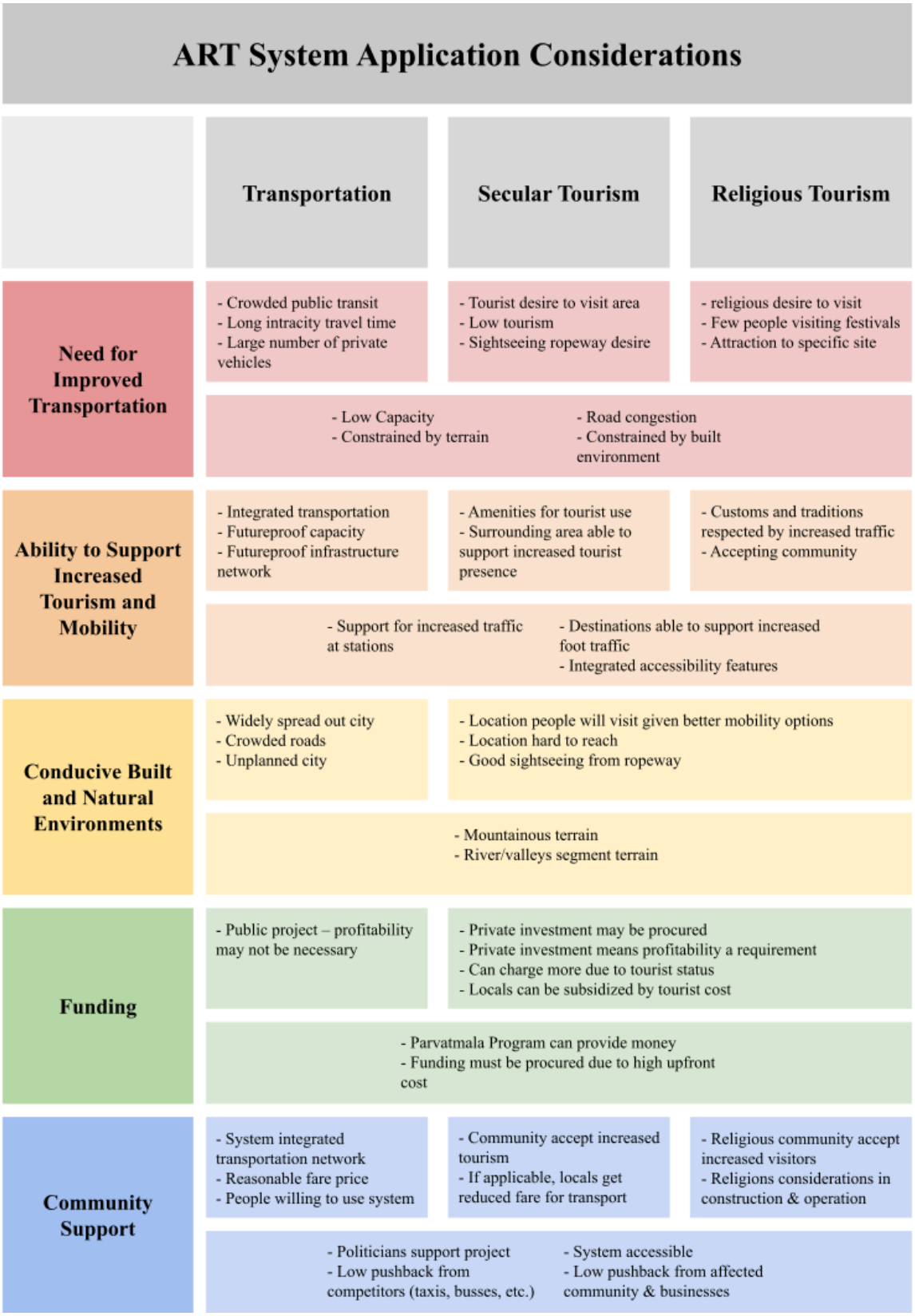


Figure 13: ART System Applicability Considerations

5.2.1 Need for Improved Transportation

The first necessary precondition for ropeway applicability is a need for more and better transportation. While rather self explanatory, this requirement is imperative for system success. For transportation focussed systems, if the current transportation of a city is adequate, an expansion of transportation may be unnecessary or may be done at low cost through other, smaller solutions. However, when the current transportation solutions are at their limits, other systems must be considered. The current transportation in many cities of Himachal Pradesh are becoming overstretched and crowded. This combined with all current transit being road based and thus limited by terrain means transportation is inefficient and slow. This inherent inefficiency means increasing the number of buses on the roads may not help reduce travel times unless roads and related infrastructure are expanded and made more direct and efficient. With road expansion being impossible in some areas, a different form of transportation may be needed to fill this gap.

For tourism focussed ropeways, the considerations are slightly different. Tourism focussed ropeways work best where an increase in mobility and transportation access will allow more people to visit a place they may not have otherwise. This means these systems work best when they have a destination in mind at the end of the system which is not easily accessible through other transportation. This is usually done with the purpose of increasing the number of people who visit this destination and thus increasing tourism revenue through both the ropeway and at the destination. The attraction can be either religious or secular, although religious sites often have more considerations to make.

5.2.2 Ability to Support Increased Tourism and Mobility

An ability for the area in which the system is built to support increased tourism and mobility is very important for a system to succeed. Transportation focussed ropeways are large infrastructure projects which connect a large area of a city, thus these systems allow for urban residents to be more mobile in the city. Moreover, the ropeways often also attract influxes of tourists as an additional attraction of a city. The areas connected by the system must have the ability to support this influx of people.

Most important to absorbing the influx, is integration into a wider transportation network. Without this, users will experience difficulties due to the lack of first and last mile connectivity. In the case of ropeways, first and last mile connectivity are systems which connect the ropeway stations out into the surrounding community. This is often done using bus systems and allows people to get from their home to the ropeway station without having to walk long distances.

Another important factor for these systems is that they be built for required capacities in the future. These systems will last decades and thus will often be required to support higher capacities in the future as population grows. For this it is important to keep population growth in mind when deciding on system implementation. This also applies to the integrated transportation network and surrounding commerce centers which can often expect to see increased traffic as a result of ropeway construction in the area.

For tourism focussed ropeways the considerations are slightly different. Often the most important aspect to consider for these systems is if the destination can support the increased traffic and increased demand caused by the influx of people. For secular systems the

considerations are often mostly practical ones regarding the infrastructure surrounding the system. For religious tourism focussed ropeways this becomes more complicated. Religious sites such as temples, which often have ropeways built to them to increase accessibility, have many set traditions and rules.. These traditions can sometimes limit how and who can go into the temple, which may cause issues due to the increase in people who may not know the traditions or rules (Baglamukhi Community Member, Personal Communication, 2024). It must be ensured that this increase in tourism does not cause issues for the religious community of the site. This can often be done by including the religious community in the planning and operations phases of the project in order to hear all possible challenges and deal with them appropriately.

5.2.3 Conducive Built and Natural Environments

For a system to make sense the environment must be conducive to ropeway systems over other methods of transit. Ropeways make the most sense in areas where traditional transportation often falls short. These are usually mountainous areas with inadequate road and rail transportation often due to cities being unplanned. In these instances, ropeways are often implemented successfully to deal with such adverse conditions.

This is especially important for transportation focussed ropeways as these systems have lower throughput values than most optimized systems of other types. As seen in table 2.2.3, even high end ropeways have lower capacities than optimized busses and rail networks. Additionally ropeways can be as or more expensive than these optimized networks even with lower throughput figures. This means ropeways work best in areas in which other transportation systems have significant problems which cannot be easily overcome. For example, Himachal Pradesh cities are constrained by their mountainous terrain and the layout of cities. The mountainous terrain often makes cities very spread out with sections of the city connected with long, winding roads which take a relatively long time to traverse. This simultaneously makes other systems such as buses and rail less efficient, while being a perfect application for ropeways which are good at connecting several centers together over longer distances. Additionally, the built environment plays a large part in this too. In northern India, cities are often built unplanned, as communities formed and built to their current needs with little future consideration. This means that the road networks are often overcrowded and underdeveloped with little possibility of large network overhaul. This leads to inefficiencies in road transportation but will not affect ropeway efficiency, making ropeways a potentially effective solution to this problem.

Additionally, with implementing ropeways, RTDC has found land acquisitions to be a significant problem that can cause multi year delays. This has led to favoring private and forest land that is already owned by the government as there is no acquisition required. A recent ruling by the government has only helped this by not requiring the government to purchase land along the entire path of the ropeway. (Er. Munish Sahni, Personal Communication, 2024) Now, only owning the land the towers are installed on is required which significantly increases the viable locations.

For tourism focussed ropeways the considerations are similar. However, unlike transportation systems, tourism ropeways are often an attraction in themselves and thus can be more flexible in application. Due to this ropeways are often placed in beautiful natural areas

which have pleasing views from the ropeway, as well as provide easier access to tourism sites typically in mountainous areas with attractions in high up and hard to reach places. Examples of this include the existing Dharamshala (Mcleodganj Car), Shimla (Jakku), and Manali (Solang) ropeways. In these situations, the ropeway being the fastest and most efficient transportation method are helpful, although less important due to their inherent tourism value.

5.2.4 Funding

Ropeways are expensive systems to build and operate. Compared to building roads in optimal conditions (primarily flat terrain), ropeways are far more expensive. Additionally, ropeways require constant inspections, upkeep, maintenance to maintain safe operation. For this, it is important to have adequate funding for these projects. Investment must be fully met immediately as an entire ART system must be built at once due to the nature of ropeways.

Currently funding is not an issue in India due to governmental efforts to expand infrastructure and develop cities quickly. The Indian transportation ministry has created the Parvatmala National Ropeway Development Program, allocating 1.25 lakh (10^5) crore (10^7) rupees to developing ropeways over the next 5 years. This very large amount of funds, comparable to ~1.5 billion USD, is being used to develop ropeways across India and provides adequate funding for many of these projects. The Indian government is committed to continuing infrastructure development especially in its rapidly developing regions such as Himachal Pradesh. Should this funding ever dry up or the Indian government become less focussed on infrastructural development, ropeway construction could become more difficult as funding may become harder to procure.

5.2.5 Community Support

For any ropeway to succeed community support is critical. The community ultimately determines whether the system will be a success. If the community does not use the ropeway or benefit from the tourism the ropeway generates, the system will ultimately fail. For transportation focussed ropeways this is especially crucial as the members of the community will be the customers and will thus determine the systems success. For any system this also means the support of businesses and local politicians. If there is a lack of support or even opposition this could lead to political issues or legal challenges. Getting and maintaining community support for a transportation ropeway project is largely about accessibility and perceived usefulness. For a system to be useful to the community it must be inexpensive enough for a large base of users to utilize, must have stations in areas useful to most people, must have supporting bus and road networks, and must be conveniently accessible from large areas of the community. These factors are largely influenced by the planning stage of the project and thus it is very important that the ropeway be planned with support and input from the affected community.

For tourism ropeways many of these factors are similar. The community must be involved in planning the ropeway as it will affect the tourism industry of the area it is placed in. This can affect many people, especially businesses either positively or negatively. Businesses such as taxi companies/unions are often very against ropeway construction as it means they will have more competition in transportation to sites and tourist destinations. Other businesses can be

positively affected especially if the ropeway attracts more tourists to the area. All these factors must be taken into account when the ropeway is being considered and the community must be consulted.

For religious tourism ropeways it is especially important for the religious community to be involved. Because many religious sites have important customs and traditions, ropeways can often interfere with many of these both due to the people they bring to the area and their physical presence. For a favorable outcome to be reached such as in the case of the Baglamukhi ropeway, members of the religious community must be consulted and negotiations must be done to ensure a desired outcome.

Chapter Six: Conclusion/Recommendations

This investigation has shown this issue is far more multifaceted than originally assumed. Not only are transportation, tourism and ropeways tied together, they are intrinsically attached to numerous other factors. This paper has discussed many of these factors relevant to the objectives of this paper however there are many other factors and facets to this problem which were outside the scope of this relatively short investigation. Many people in Himachal Pradesh will be both positively and negatively affected in many ways by the installation of ART systems, but there is enough will, finding, need, and knowledge in place to make these systems a reality and the processes are already in place to create and maintain them effectively. There are two major recommendations regarding the future of Aerial Ropeway Transportation systems in the region which we believe will aid in integration of ART systems into Himachal Pradesh and India as a whole.

The first recommendation is not to force ART systems as solutions when faced with transportation issues and excitement over innovation while not carefully considering other long term solutions.As we have examined, these systems work in very specific situations and require certain conditions to work optimally. In projects where the public good is in question, we should be careful not to force suboptimal solutions when there are better options for the sake of innovation and progress.

In our research we have seen ropeways placed in environments where they were not needed and when a simpler and cheaper alternative such as an improved bus network would have yielded better results. (Maria, 2014). Currently, the Himachal Pradesh RTDC has researched and examined feasibility and impacts of the Shimala 15km Urban Ropeway. This process has made us confident in its future success as a public transportation system and as technology that will help set India apart on the global stage.

With this said, should the Shimla ropeway succeed, and barriers to ART construction lower as a result, the conditions for successful ART implementation should be kept in mind before spreading this solution to other cities to ensure these systems are successful. With a successful Shimla ropeway, stakeholders may begin to view ropeways much more positively and ropeway solutions may be pushed through the planning and development phases with insufficient research and questioning. An example of this phenomenon has occurred in Cazucá Colombia. After successful implementation of ropeways in other areas of Colombia and South America, a system was promised and pushed through without much consideration for why or if there were better solutions to the problems of the community. The system would ultimately fail and leave the community worse off as a result (Maria, 2014). It has been observed that many of the conditions which may result in ropeways being pushed through without adequate preparation or consideration exist in India, such as a proclivity for advanced solutions and grand technological solutions to problems. This combined potentially lowering the barrier of ART construction may ultimately lead to systems which do not ultimately meet the needs of a certain community. To avoid situations such as this one, it must be ensured that care is always taken when planning systems and all necessary preconditions must be met. Planning should include all stakeholders

and should examine other solutions to determine what would be best for the long term health and growth of communities.

The second recommendation is to invest in communities as they invest over the next several decades. For example, we briefly examined Mandi as a city to support an urban ART as a part of our corresponding ISTP groups project and it was quickly eliminated as a site because, in addition to meeting very few of our requirements, it did not have the built or natural environment to support an ART. The city is too densely built and does not cover a wide enough geographic area. If a community is anticipated to grow into the near future and this can be identified now, local governments can begin to set aside and acquire land for future infrastructure. The federal government can begin funding these communities by including them in projects like the Smart City Initiative (Smart City Representative, Personal Communication, 2024)) or similar programs intended to assist in infrastructure development. These government supports can help create a foundation for public infrastructure that will be necessary in the future. These future solutions may include ART systems but may not. It is important to embrace a variety of solutions to create comprehensive solutions to future transportation problems.

Ultimately, some communities are suited to ART systems and could greatly benefit,and some communities are not, and should not invest in ropeways but instead in other solutions. For an ART to benefit a community it must have a need for better transportation, the ability to support an increase in tourism, the perfect environment (with enough government owned land for construction, otherwise difficult to traverse terrain, ect), the funding, the planning and the support of the majority of the local community. If all of these conditions align, an ART might be the perfect state of the art transportation addition to Himachal Pradesh's infrastructure.

This said, the 15km line in Shimla will test whether the city, the biggest city in the region to meet all of our requirements, will provide the needed transportation improvements and improve the lives of its inhabitants. The examination of this line and its construction will provide good insight and experience into how to build these systems and should be kept in mind in the future once it is completed. This is, however, outside the scope and timeline of this project.

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Appendices

Tables A.1 and A.2: Relationships Between ART Systems and Stakeholders

Relationship Between Ropeways & Involved Parties

Ropeway Relations During Phases

People & Parties Impacted

		Transportation Focused Ropeway			Secular Tourism Focused Ropeway			Religious Tourism Focused Ropeway		
		Planning	Construction	Operating*	Planning	Construction	Operating	Planning	Construction	Operating
Private Companies	Construction Company	Bidding	Partial Control	N/A	Bidding	Partial Control	N/A	Bidding	Partial Control	N/A
	Ropeway System Companies	Creates bidding, Plans ropeway parts	Oversight, Ropeway installation	Partial control, Maintenance, Training	Creates bidding, Can be primary planners or just mechanical planner	Oversight, Ropeway installation	Partial to full control, Maintenance, Training	Creates bidding, Can be primary planners or just mechanical planner	Oversight, Ropeway installation	Partial to full control, Maintenance, Training
	Private Bus Companies	Lobbying, Functional Transportation Baseline	Route may be affected, Retain commuters during construction	Heavy competition for commuters	Lobbying against ART motivated by concern about competition	Route may be affected, Retain tourists during construction	Minimal competition for tourists	Lobbying against ART motivated by concern about competition	Route may be affected, Retain tourists during construction	Minimal competition for tourists
	Taxi Drivers	Lobbying, Functional Transportation Baseline	Route may be affected, Retain commuters during construction	Moderate competition for commuters	Lobbying, Functional Transportation Baseline	Route may be affected, Retain tourists during construction	Heavy competition for tourists	Lobbying, Functional Transportation Baseline	Route may be affected, Retain tourists during construction	Moderate competition for tourists
Government	Government Run Buses	Lobbying, Functional Transportation Baseline	Route may be affected, Retain commuters during construction	Heavy competition for commuters	Lobbying	Route may be affected, Retain tourists during construction	Minimal competition for tourists	Lobbying	Route may be affected, Retain tourists during construction	Minimal competition for tourists
	Local Politicians	Vocalizing other's concerns, Party transition can halt or delay	Party transition can halt or delay	Can make people's usage of ART political	Vocalizing other's concerns, Can be swayed by tourism opinions, Party transition can halt or delay	Party transition can halt or delay	Can make people's usage of ART political, Can be swayed by tourism opinions	Vocalizing other's concerns, Can be religiously motivated, Party transition can halt or delay	Party transition can halt or delay	Can make people's usage of ART political, Can be religiously motivated
	National Politicians	Safety & accessibility regulations, Can make political	Potential delay/cancelation if political party switches	Can make political	Safety & accessibility regulations, Can make political, Can be swayed by tourism opinions	Potential delay/cancelation if political party switches	Can make usage political	Safety & accessibility regulations, Can make political, Can be swayed by religions opinions	Potential delay/cancelation if political party switches	Can make usage political
	Federal Government	Funding, Green initiative, Can make political	Funding dependant on over/under-budget	Subsides, Can make political, Partial oversight	Funding, Green initiative, Can make political, Can be swayed by tourism opinions	Funding dependant on over/under-budget	Subsides, Can make political, Partial oversight	Funding, Green initiative, Can make political, Can be swayed by religious opinions	Funding dependant on over/under-budget	Subsides, Can make political, Partial oversight
	Ropeway Officials	Plans everything	Heavy oversight	Control, Oversight	Can be primary planners	Oversight	Partial control, Oversight	Can be primary planners	Oversight	Partial control, Oversight
	Other Transportation Officials	Traffic analysis, Transportation baseline, Lobbying, Planning detours for construction	N/A	Impact assessment, Potential departmental downsizing	Traffic analysis, Transportation baseline, Lobbying, Planning detours for construction	N/A	N/A	Traffic analysis, Transportation baseline, Lobbying, Planning detours for construction	N/A	N/A
	Police	Creating traffic control plans in conjunction with ropeway planning organization	Directing resultant traffic	Manage altered traffic, Potentially receive complaints about ART	Creating traffic control plans in conjunction with ropeway planning organization	Directing resultant traffic	Manage altered traffic	Creating traffic control plans in conjunction with ropeway planning organization	Directing resultant traffic	Manage altered traffic
Transportation Users	Primarily ART	Voice opinions at public forums, Lobbying	Group does not exist yet	Primary revenue for ART system	Voice opinions at public forums, Lobbying	Group does not exist yet	See Religious/Secular Tourists columns	Voice opinions at public forums, Lobbying	Group does not exist yet	See Religious/Secular Tourists columns
	Primarily Bus	Voice opinions at public forums, Lobbying	Travel may be impacted by construction traffic	Possibly less traffic, Less bus users	Voice opinions at public forums, Lobbying	Travel may be impacted by construction traffic	Largely unimpacted	Voice opinions at public forums, Lobbying	Travel may be impacted by construction traffic	Largely unimpacted
	Primarily Personal Vehicle	Voice opinions at public forums, Lobbying	Travel may be impacted by construction traffic	Possibly less traffic, less personal vehicles on road	Voice opinions at public forums, Lobbying	Travel may be impacted by construction traffic	Largely unimpacted	Voice opinions at public forums, Lobbying	Travel may be impacted by construction traffic	Largely unimpacted
	Primarily Mixed Transit	Voice opinions at public forums, Lobbying	Travel may be impacted by construction traffic	More options, Transportation choices can sway decisions	Voice opinions at public forums, Lobbying	Travel may be impacted by construction traffic	Technically more options, Largely unimpacted	Voice opinions at public forums, Lobbying	Travel may be impacted by construction traffic	More transportation options, Largely unimpacted
	Religious Tourists	N/A	Travel may be impacted by construction traffic	Another transportation option	N/A	Travel may be impacted by construction traffic	Another transportation option	Locals voice opinions at public forums, Lobbying	Noise concerns & construction unsightliness at religious site	Primary revenue for ART system
	Secular Tourists	N/A	Travel may be impacted by construction traffic	Another transportation option	N/A	Travel may be impacted by construction traffic	Primary revenue for ART system	N/A	Travel may be impacted by construction traffic	Can still be attraction for secular tourists
Community Members	Primarily Non Transportation Users	Voice Opinions at Public Forums, Lobbying	May be impacted by construction traffic	Foot paths may change, may use transportation more frequently	Voice Opinions at Public Forums, Lobbying	May be impacted by construction traffic	Foot paths may be different, may use transportation more frequently	Voice Opinions at Public Forums, Lobbying	May be impacted by construction traffic	Foot paths may be different, may use transportation more frequently
	Stationary Businesses	Voice Opinions at Public Forums, Lobbying	May be impacted by construction traffic	Changed traffic can significantly impact business	Voice Opinions at Public Forums, Lobbying	May Be Impacted by Construction Traffic	Changed traffic can significantly impact business	Voice Opinions at Public Forums, Lobbying	May Be Impacted by Construction Traffic	Changed traffic can significantly impact business
	Mobile Businesses	Voice Opinions at Public Forums, Lobbying	May be impacted by construction traffic	Changed optimal shop locations	Voice Opinions at Public Forums, Lobbying	May Be Impacted by Construction Traffic	Changed optimal shop locations	Voice Opinions at Public Forums, Lobbying	May Be Impacted by Construction Traffic	Changed optimal shop locations

*Table 2.0 addresses the transportation focused ropeway's operating concerns of impacted parties in more depth

Relationship Between Transportation Focused Ropeways & Involved Parties p.1

People & Parties Impacted			Operating Considerations								
			Cost	Maintenance	Accessibility (physical, economical, etc.)	Efficiency (time v distance)	Safety	Integration into existing infrastructure/ Physicality/ Aesthetics	Community Impact	Longevity	Sustainability/ Environmental Impact
	Private Companies	Construction Company	Bid initially, Largely unimpacted	May have ongoing maintenance contract	Required to be constructed to codes	N/A	Company perception can impact ropeway perception	Required to build around existing infrastructure	Ropeway perception can impact company perception	Physical longevity impacts company image	N/A
		Ropeway System Companies	Bid initially, Large factor in who gets contract, Profit concerned	In charge of Maintenance, Training workers, Company Reputation	Catering to Elderly/Disabled	Company Reputation	European Standards	Cannot be an eyesore	Technological grandstanding, Foreign companies less impacted	Forward thinking capacity, Maintenance	"Green project"
		Private Bus Companies	Ticket prices largely regulates competition but bus will likely be cheaper	Will be required to work extra during downtime	May be cheaper, Circumstantially more accessible	Lower efficiency at cheaper cost is still valued by many	More hazardous, More room for human error, May have higher perceived safety by some	Can allow for or prevent more efficient mixed transport	ART success dictates bus public image, competition positively impacts quality	Routes, schedules, rates & quantity of buses may all change	Individuals may value sustainability
		Taxi Drivers	Fare largely regulates competition but ART will likely be cheaper	Will be required to work extra during downtime	Can be more accessible, More direct location to location	Faster speed, less transportation swaps at higher cost is still valued	More hazardous, More room for human error, May have higher perceived safety by some	Can allow or prevent more efficient mixed transport, new ideal cab stand locations	ART success somewhat dictates taxi public image, competition positively impacts quality	Ideal cab stand locations may change, less cabs may be needed, cheaper cab rates to compete	Individuals may value sustainability
	Government	Government Run Buses	Ticket prices largely regulates competition but bus will likely be cheaper	May serve ART users during maintenance	May be cheaper, Circumstantially more accessible	Lower efficiency at cheaper cost is still valued by many	More hazardous, More room for human error, May have higher perceived safety by some	Can allow for or prevent more efficient mixed transport	ART success dictates bus public image, competition positively impacts quality	Routes, schedules, rates & quantity of buses may all change	Gov't prioritizes electric powered systems as green project
		Local Politicians	Parvat Mala funding, Politize spending	Potentially opposed it if it disrupts community	Public perception reflects on politicians	Public perception reflects on politicians	Public perception reflects on politicians	Public perception reflects on politicians, Intradepartmental communications important	Public perception reflects on politicians, Can sway public opinions, Providing a public service	Positive outcomes can reflect positively on party forever	Way to appease federal government, Community may be indifferent
		National Politicians	Parvat Mala funding, Politize spending	Disasters reflect poorly, sets precedence	Greater accessibility, greater appeal, Can be campaign points	Compared to other countries, Can be a global leader, First country with this many ARTS	Compared to other countries, Can be a global leader, First country with this many ARTS	Compared to other countries, Can be a global leader, First country with this many ARTS	Positive impact required given the number of ARTS planned	Compared to other countries, Can be a global leader, First country with this many ARTS	Green initiatives, Important to some people, No environmental assessment required
		Federal Government	Parvat Mala funding, Politize spending	Disasters reflect poorly, sets precedence	Greater accessibility, greater appeal	Incentivized to compete with private transportation	Lacking proper legislation, Uses European standards instead of domestic ones	Requirement for number of ARTS being installed	Positive impact required given the number of ARTS planned	Currently limitless budget, future funding may be a major concern	Green initiatives, Important to some people, No environmental assessment required
		Ropeway Officials	Oversee the budget, Have to choose ropeway company, Profitability	Disasters reflect poorly, sets precedence, Allocates funding	Greater accessibility, greater appeal	Traffic reduction and mitigation assessment	Oversee maintenance, Human life, reputation and livelihood at stake	Compared to other countries, Can be a global leader, First country with this many ARTS, Limited by existing infrastructure	Large, positive impact desired; Trying to be global leader; Trying to satisfy as many people as possible	Planning for the near and distant future	Green initiatives, Environmental assessment required to ensure safety, Satisfy governmental regulations
		Other Transportation Officials	Ticket prices largely determines competition, Less universal infrastructural investments	Requires different workers, Different funding pools, Can strain other transportation systems	Could fill in lacking gaps in accessibility	Can be competitors, Can be positioned to offer different benefits	Perception of ART safety will largely impact utilization, Other officials can help or hurt this	Existing routes may need reworked, passenger distribution may shift	Could cause other departments to downsize	ARTS are monofunctional infrastructure, could pull resources away from multifunctional infrastructure	Unable to expand in green ways, can limit future governmental funding depending on the direction India goes
		Police	N/A	Directing resultant traffic	N/A	N/A	Controlling traffic in immediate area, Need to respond to issues	Need to respond to issues	May have to manage/direct ART complaints, need to control protests (if applicable)	Less traffic reduces strain on police force	N/A

Relationship Between Transportation Focused Ropeways & Involved Parties

People & Parties Impacted			Operating Considerations								
			Cost	Maintenance	Accessibility (physical, economical, etc.)	Efficiency (time v distance)	Safety	Integration into existing infrastructure/ Physicality/ Aesthetics	Community Impact	Longevity	Sustainability/ Environmental Impact
	Transportation Users	Primarily ART	Integration to daily budget, If more expensive needs justification	Heavily impacted by delays	Can be driving reason for use	Can be driving reason for use	Required, Perception of safety equally as important	Desirable to better integrate multimodal transportation	Fulfills need, provides additional transport option	Need to maintain relevance to hold a large enough clientele base	Likely not a major concern for most people
		Primarily Bus	Ticket price likely cheaper than ART, Can be driving reason for use	Moderately impacted by delays causing additional traffic	Cheaper, Situationally more accessible, larger route coverage	Can be driving reason for use; Can be similar to ART; Better for short, specific routes	ARTS safety perception can be driving reason for use	Routes, Schedules, Rates. Quantity of buses, may all change	Relative perception can change drastically	ART maintenance should not block roads, Can lessen strain on bus network	No electric bus infrastructure exists, ARTS are only feasible green transportation
		Primarily Personal Vehicle	Ticket price can impact if ART become an additional, infrequent transport option	Moderately impacted by delays causing additional traffic	Larger barrier to entry, situationally more or less accessible, requires parking	Likely lower efficiency, Other benefits outweigh lower efficiency	ARTS safety perception can be driving reason for use	Largely unimpacted	N/A	ART maintenance should not block roads, Can lessen strain on roads	N/A
		Primarily Mixed Transit	Can be determining factor in ART usage	Less impacted than Primary ART users, similar impact to road users	Can be driving factor for mixed usage	Can be driving factor for mixed usage	Perception of safety can be determining factor in ART usage	Can be determining factor in ART usage	Can move away from single transportation usage to mixed	More options can result in better transportation experience overall	N/A
		Religious Tourists	Willing to pay higher ticket prices the less frequently visited	Slightly impacted by delays causing additional traffic	Potentially impacted by accessibility options thus choosing better option than ART	Can be a factor in type of transportation used	Perception of safety can be determining factor in ART usage	Likely far from final destination, multiple transportation methods required	Potential for increased tourism with additional accessibility	Largely unimpacted, other transportation still required	Quiet, clean transportation near temples is desirable
		Secular Tourists	Willing to pay higher ticket prices the less frequently visited, may pay regardless of price	Slightly impacted by delays causing additional traffic	Additional option aside from taxis	Can be a factor in type of transportation used	Perception of safety can be determining factor in ART usage	Optional, May seek out to ride for fun	Potential for increased tourism with additional accessibility, additional activity	Can bolster tourism economy, Does not have to be intentional tourism attraction to do so	Quiet, clean transportation near attractions is desirable
	Community Members	Primarily Non Transportation Users	Can change some from non transportation users to ART users	Can disrupt walking paths	Can still lack properly accessible options	N/A	ARTS safety perception can be driving reason for non usage use	Desire for the ropeway to not be an eyesore, Can be the reason for usage/nonusage	Perception of ART can be reason for usage/nonusage	May be more inclined to use as time goes on	N/A
		Stationary Businesses	N/A	Maintenance may affect the location and impact business	Accessibility options may require additional space and impact business	N/A	Accidents would reduce traffic near ART, Can impact businesses in immediate area	Distance from ART station may positively or negatively impact business	N/A	Distance from ART station may impact business long-term	N/A
		Mobile Businesses	N/A	Maintenance may affect the location and force business to move	Accessibility options may require additional space and force business to move	N/A	Accidents would reduce traffic near ART, Can impact businesses in immediate area	May require moving to station locations if increased traffic	N/A	Distance from ART station may impact ideal location of business	N/A

Figure A.1: Complex Relationships of ART systems in Himachal Pradesh

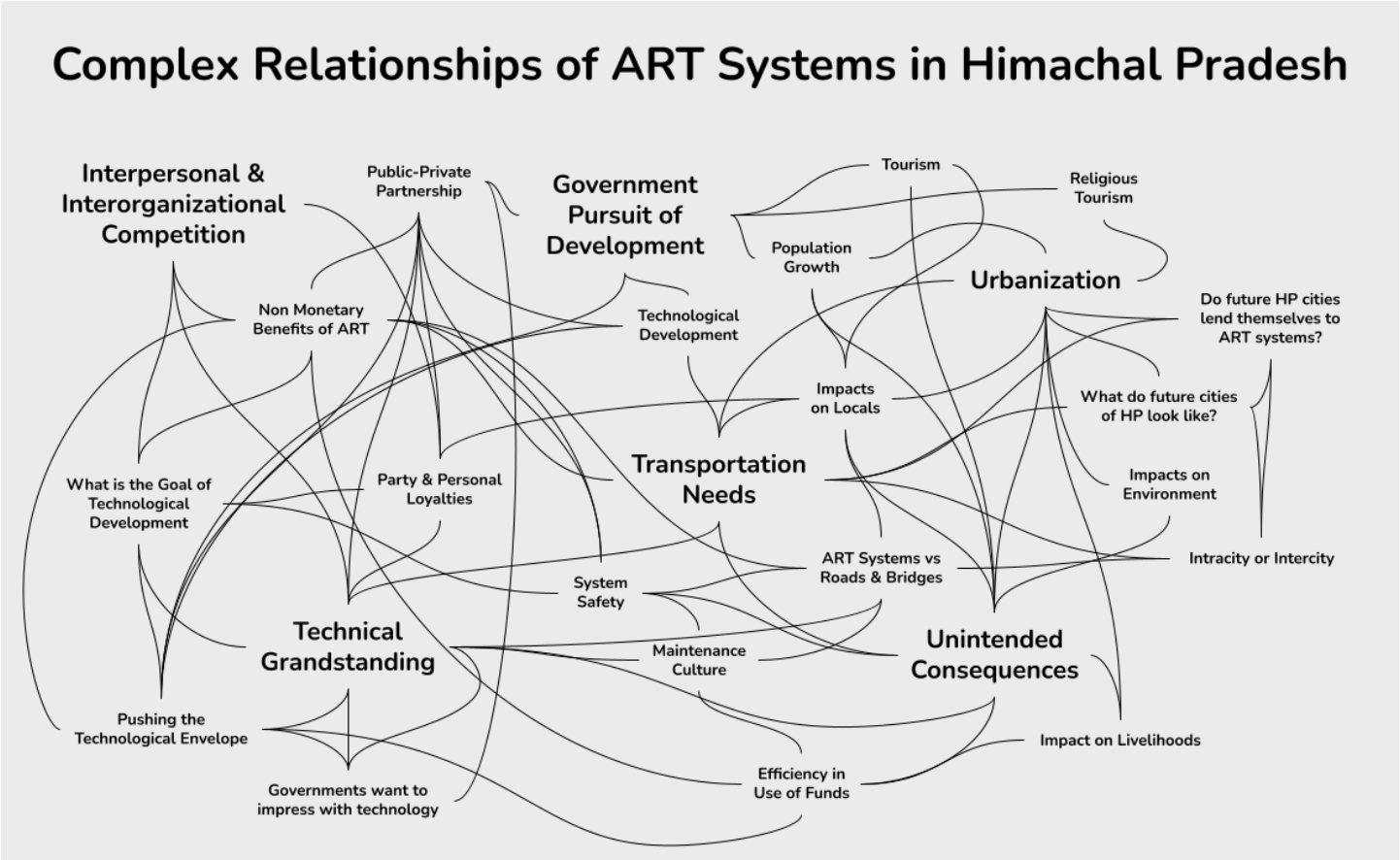

Figure A.1: A web showing some of the complex relationships between ART system components and considerations.

Baglamukhi Ropeway - Pandali/Pandoh - Images

Under construction Baglamukhi top station

Under construction Baglamukhi bottom station

The partially completed top station with initial mechanical system installation underway

Shri Baglamukhi Temple in Pandoh

Midway tower

Jakhu Ropeway - Shimla - Images

Base station of Jakku ropeway from ground

Mechanical system of Jakku ropeway top station

Top station of Jakku ropeway

Mcleodganj Ropeway - Dharamshala - Images

View from gondola of Mcleodganj Ropeway

Solang Valley Ropeway - Manali - Images

Base Station of Solang Valley Ropeway

Top Station of Solang Valley Ropeway

Interview Questions

Below are questions asked in interviews conducted with users:

Are there any gondolas in the area?

- YES) What is your daily interaction with it?
    - SOME) Can you tell me about your interaction with it?
    - NONE) What do people use it for? Does anyone you know use it?
    - OTHER) Can you tell me more about that?
- NO) Have you been on one before anywhere else?
    - YES) Why did you go on it?
    - NO) Why have you never ridden a gondola?
        - Opportunity)
        - Safety - perceived or actual)
        - other)
- WHAT?)
    - Explain what the gondola is and have pictures of multiple types of ropeways ready to show.

Do you like the system? Do you feel comfortable using the system?

- YES)
    - What is your favorite thing about the system?
    - How often do you use the system?
- NO)
    - Why do you not like it?
    - Is there something about the system that could be improved?
- OTHER) (probably no feelings one way or another)
    - How do you prefer to travel? How varied are travel times? Are there any locations you think could benefit from a gondola?

Below are questions asked to operators:

- What did the system cost to build?
- What does the system cost to operate?
- What is the capacity of the system?
- Do you find there is adequate demand for the system?
- Why do people use the ropeway?
- How long has the system been in use?

● Is there a projected service life?
● How often is maintenance done?
● What would cause a system to need to be offline? How long are these delays?

Below are questions asked to Government:

● What safety regulations are in place for building one of these systems?
● Can you walk us through a general pathway for building one?
● Has the government considered a gondola system before?
● Is the government involved in the implementation of the ART system on the IIT campus?
● Has the government talked to any companies about the possibilities of gondola transportation before
● Has the government done any studies into the feasibility of gondola systems

Below are questions asked to ART companies:

What are some of the systems you have built in the area? Can you tell me a bit about them?
● Can you provide us with any statistics on these systems?
● How much do they cost to build?
● How much do they cost to run, what are the day-to-day operational costs?
● How much do they cost to maintain?
● What are the primary terrain limitations your system overcomes? Are there any terrain challenges your system cannot overcome?
● How long do you expect the system you mentioned to remain operational? Would the system be viable with expensive maintenance or would a replacement ART be more cost efficient? What's the average lifespan of a system like that?
● Who owns the systems you have built?
● How reliable are the systems? Do they often go down for maintenance? How often?
● How often is maintenance required/done? What is typically done in maintenance?
● How long do your systems take to build? Is it relatively similar for all systems? What unique challenges have you encountered that have caused construction to be extended?
● System throughput
● What is the average capacity of your systems per hour?
● Do you focus primarily on large scale systems or have you also made smaller systems? What types of systems do you offer? Monocable? Bicable? Tricable?

Team Photo

ARTS team at the Taj Mahal (Left to Right: Owen, Dan, Zabelle, Joe)
Photo credits: Val Corrente