Transport planning & design: The development of Sisaket

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1.0 Transport planning & design: the development of Sisaket

Urbanization is often accompanied by increased congestion throughout a city's transportation network, and municipalities must plan considerably to ensure that transportation systems successfully reduce excess traffic. Cities that face rapid population growth and motorization without having a reliable transportation network expansion process encounter traffic challenges that can obstruct economic growth or lead to economic instability.[1] Proactive city planning for the expansion of transportation networks can aid in a city's economic development, increasing its competitiveness within the region.[2]

Sisaket is a province in Northeast Thailand 550 km from Bangkok, and the city has a population of 41,145 people and area of 36.66 km^2. In 1997 the municipality of Sisaket began hosting many sporting events, including running races, bike races, boat races, volleyball championships, the Thailand ESports Championship, and the National Sport Competition, with support from the Sports Authority of Thailand. Consequently, Sisaket has the potential to continue growing in the tourism industry, however, its expected economic growth is being hindered by an unsupportive transportation network. As transportation systems are the route of access into a city for both consumers and sellers, Sisaket's lack of a cohesive network is significantly inhibiting its economic growth.[3] Between 2014 and 2018 the number of new personal vehicles registered in the province increased from 24,065 to 30,485, which is a growth of 26.56%.[4] With the expected continuation of motorization in coming years, the municipality of Sisaket must expand the city's transportation infrastructure and regulation techniques to keep up with such developments.

Thailand as a whole does not have a significant amount of public transportation, and with Sisaket falling in the bottom five provinces in terms of transportation and communication,[5] this is a major point of weakness. Prior transportation projects in Sisaket, such as city buses and modified pick-up trucks, have been unsuccessful due to inconsistent schedules, lack of communication with the public, and limited routes. Consequently, most people in Sisaket are heavily reliant on personal vehicles. Currently, other than the use of personal vehicles, people travel around the city via taxis and motorcycle taxis. Train and bus systems connect Sisaket to Bangkok, however this only provides transport from city to city without localized public transportation options.

With this in mind, we set out to suggest improvements to Sisaket's current transportation network to increase the city's economic competitiveness, sustainability, and quality of life. We first identified the current issues in Sisaket's transportation planning process through observation and interviews, then identified frequent routes taken by people in the city. Through focus groups, we gained information regarding travel routines among members of different communities of Sisaket. We also analyzed other cities' transportation planning processes and the success of their

transportation systems, as well as researched new systems that implement smart city principles. Our deliverables consist of a comparative analysis of potential new transport systems as well as recommendations for how to move forward with establishing them.

2.0 Transportation systems in case study cities

Developing regions tend to lack the necessary infrastructure to support a large transportation network, and this can impede the economic development of those cities. Lack of public transport contributes to increased traffic congestion, leading to lost productivity time, hindered economic growth, as well as increased greenhouse gas emissions.[1] In this chapter, we introduce the city of Sisaket, detail transportation planning strategies, and identify potential additions to different transportation systems that can improve a city's economy and the well-being of its inhabitants.

2.1 Overview of Sisaket

The municipality of Sisaket has a well developed road network, as seen in Figure 1. However, there is not a large variety of transport methods running through the city center, thus roads are primarily used by personal vehicles, taxis, and motorcycle taxis. Sisaket has a train and bus station that brings users to and from Bangkok, but no other modes of transport are used within the city.

Figure 1 *Sisaket City Map* Major transportation routes throughout the city of Sisaket, including highways and railways.[6]

In the past, the Sisaket municipality has made attempts at adopting different transportation systems, such as a city bus, a free university shuttle, and bike lanes. The city bus ran 40 years ago between markets, government buildings, and several educational institutions. The bus system was unsuccessful because there was no fixed schedule and it ran at low speeds, making the system inconvenient to its audience. Similarly, the university shuttle's route passed through popular destinations, such as markets and temples, and it experienced the same difficulties that the bus system did. The bike lanes that Sisaket implemented bore little usage, and commuters ended up using the lanes for parking as a result of poor regulation enforcement.

Sisaket city officials stated that the municipality is working to implement a new bus station for inter-province travel, but has no specific plans for new travel methods within Sisaket itself. The municipality of Sisaket is also aiming to develop the city into a smart city by 2037. These principles can be applied to their transportation development sector to implement new transportation options that are eco-friendly, cost-efficient, and use communication technology.

2.2 Transportation planning process

The transportation planning process is made up of six main steps: identifying the objective, considering existing and future conditions, conducting a needs assessment, developing transportation solutions, prioritizing which projects to pursue, and implementing the plan, as seen in Figure 2. At the end of our project we provided Sisaket with a comparative analysis in addition to supplementary research to aid in their transportation planning process. To do so we first investigated the city's needs then found how similar needs have been met in other regions. After we identified plausible transportation options and recommended a particular system, city planners need to collect more in-depth data to move forward with project development.

Figure 2 *Transportation Planning Process* [8]

2.3 Transportation systems

Public transportation is a broad term that encompassess all systems of transport available for use by the general public that operate on established routes.

Demand Responsive Transport (DRT) is a type of on-demand service that, instead of running on a schedule, provides service only when a user calls for a ride, which is most often used in private transportation systems.[7] This allows for flexibility in the system, making it more convenient and thereby enticing people from using their personal vehicles. Due to DRT systems innately providing direct travel paths, travel times can drastically decrease with little to no cost

for additional infrastructure. As well as providing a different method of transportation for day-to-day activities, DRT can also bridge gaps in a city's transportation network by helping people interchange between longer-route buses and trains to nearby towns.[9] Furthermore, DRT can increase the accessibility of a transport system through smart phone apps. Many companies, such as Uber, Lyft, and Grab, already use DRT to allow users to request a vehicle from their phone and have a driver pick them up. The use of smartphones alongside DRT can significantly increase use of a transportation system, which embodies how smart city principles aid city development success.

Bus systems

Bus systems typically run between stops located at common points of interest and adhere to a strict time schedule.

Public transportation systems must be desirable to ride in order to significantly increase ridership. In Melbourne, Australia a study found that most people prioritize short wait times when taking the bus.[10] The longer people must wait to get on the bus, the more likely they are to choose taking a personal vehicle, thus an ideal bus system but balance the number of buses that are running with the demand of the city. Additionally, bus stops need to be located at common points of interest, as people will use a more convenient method of transportation if they have to walk too far to get to the nearest bus stops. Because long and irregular wait times are often a product of inefficient routing, these issues can be avoided with careful route planning during the transportation planning process.

When planning to implement a motorized transportation system, it is also important to consider its energy source, which will be influenced by budget limitations as well as specific city goals. Electric buses may be useful in Sisaket due to their small eco-footprint aiding smart city efforts. However, the cost of creating charging stations needs to be accounted for, raising the upfront investment in such a system.

Bike systems

Bike sharing systems consist of different stations where people can pick up and drop off bikes for a small fee, ride to another stop close to their destination, and then drop the bike off for other users. These systems help to create more diverse transportation networks, allowing for more choices and cheaper transportation alternatives in urban areas. However, bike sharing systems require ample planning to become convenient for users. Methods of implementing a successful bike sharing system depend on the local culture regarding biking, economy, road network, and relative safety of biking. When these factors are considered, cities can achieve successful bike traffic and reduce overall road congestion in urban areas.

Many cities have added bike lanes to their main roads as a safety precaution. Bike lanes promote accessibility and safety for cyclists and aim to encourage bike usage for regular daily activities. Bike lanes also increase the safety of motor vehicle occupants and pedestrians on the road.[12]

Because bikes do not typically require the use of a motor and thus do not emit greenhouse gasses or use up raw materials, they are inherently eco-friendly. Some bike share systems currently utilize power-assist bikes, which are still environmentally sustainable despite their small electric motor, while also appealing to a wider range of riders.[13]

Tuk tuks

Tuk tuks are three wheeled vehicles that are widely used in many East Asian countries, including Thailand, as seen in Figure 3. They operate similarly to taxis as they drive on-demand and can use DRT methods, which is sometimes paired with smartphone applications. They normally carry between two to six passengers and are useful in cities with tight streets due to being more maneuverable than a regular car. Recently, electrically powered tuk tuks have been developed, making them a desirable eco-friendly option for implementing in smart cities. As tuk tuks are a part of Thai culture, bringing them to Sisaket would be a culturally-appropriate change to the city. They also are fairly easy to implement due to not needing additional infrastructure to function.

Figure 3 *Tuk tuk vehicle in Thailand* [11]

Each of the previously-mentioned transportation systems come with their own set of advantages, thus we researched Sisaket's needs in order to recommend the next steps in selecting a system for the city. We have conducted interviews and discussions with the Sisaket transport

official, Sisaket community leaders, and private sector transportation services in order to further investigate which transportation systems would alleviate Sisaket's transport issues and help develop the city's economy.

3.0 Research process

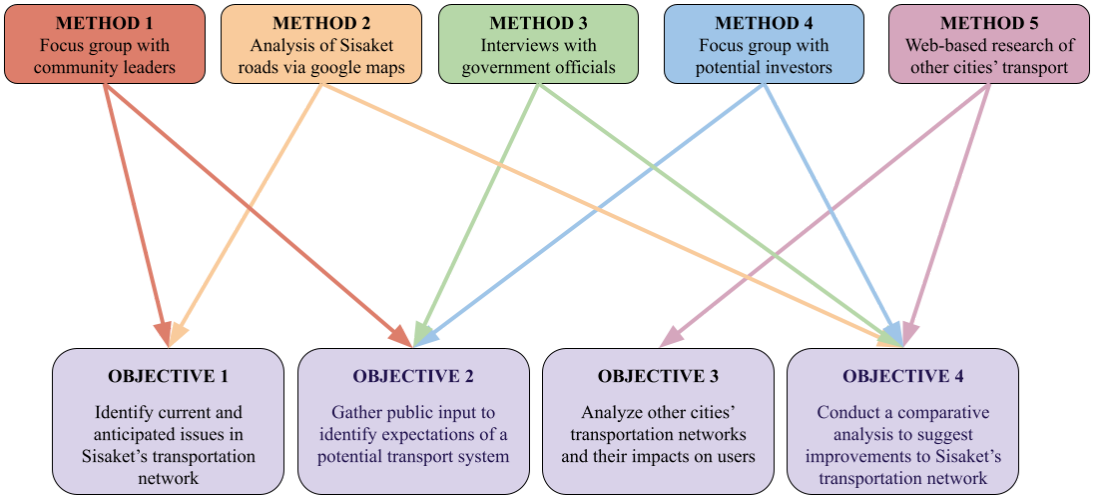

Figure 4 *Research activity flowchart*

Our main objective is to suggest improvements to Sisaket's city center's transportation system that the municipality can implement to reduce congestion and improve sustainability. We analyzed the approaches that other cities have used in implementing new transportation systems as well as assessed Sisaket's current needs to identify modes of transport that broaden transportation options within the city center.

Understanding how cities that are of a similar size and economic status to Sisaket have successfully reduced their traffic congestion was key to helping us develop guidelines for transportation planning in Sisaket. We also needed to understand Sisaket's physical, social, and economic environment as well as the city's growth projections for the future in order to begin developing a model for an improved transportation network. The following section details how we evaluated Sisaket's current transportation network, the way other cities have addressed similar scenarios, and why this information was critical to the project's completion.

3.1 Analyzing transportation in other cities

Analyzing transportation networks in other cities can contextualize which methods of addressing traffic issues have been successful, or unsuccessful, and why. We analyzed many cities from both inside and outside Thailand, but will be addressing the following four in detail: Ubon Ratchathani, Thailand; Khon Kaen, Thailand; Vigan, Philippines; and Okasaki, Japan. We selected these cities based on them having both a similar population density to Sisaket and a robust transportation network. The city websites as well as previously written reports on the cities' transportation systems provided the details of our findings, which we used to understand each city's transportation planning process, current transportation network, and relative success. We also identified and analyzed Sisaket's transport network using methods described in the following sections. This collection of data allowed us to identify differences in the transportation systems between Sisaket and other cities, which gave us the opportunity to analyze areas of weakness in Sisaket's transportation network.

3.2 Identifying local conditions

In order to plan for Sisaket's transportation network, we must first understand where and when traffic occurs so that our suggested improvements target areas in which the city's traffic flow needs improvement. To do so we interviewed a transportation official from Sisaket to gather information on the current state of the city and its transportation system. We gathered data regarding traffic and transportation in the city along with the processes used to obtain this data.[20] We first gathered information on the current road conditions, which allowed us to consider the possibility of new transportation systems. We also found what the municipality currently has planned for the future of Sisaket's transportation network and what factors led to the creation of those plans.

Determining what attributes of a potential transport system our sponsor deems most important was also an important step in deciding the best system for Sisaket. We asked our sponsor to rate eight attributes of potential transportation systems based on what Sisaket hopes to gain from a new system, such as build cost, eco-friendliness, and networking capabilities.[20] The sponsor's feedback helped us analyze potential transportation systems they could implement in the city to solve Sisaket's current and projected transportation issues.

After gathering this information from our interviews, along with data gathered in our web-based research and focus groups, we were better able to suggest the next steps the municipality must take in developing their transportation system. Knowing Sisaket's current transportation conditions as well as what the city hopes to address allowed us to recommend improvements in the city's development.

3.3 Gathering public input

While gathering stakeholder data is an important part of our project, public input is also valuable to consider since residents and commuters will be the users of any implemented transportation system. To ensure the likelihood of Sisaket locals using a transportation system, its features must fit the preferences and needs of the community, which we obtained from community leaders during a focus group.

The questions we asked in our focus group were open-ended to provide an opportunity to obtain more in-depth information that we would not be able to process through survey-like methods. The focus group was made up of ten different elected representatives from the forty seven geographical sub-districts within Sisaket, which we chose because these ten communities have high population densities and high levels of traffic congestion. Conversing with this group served to help identify what the general public find to be the current transportation issues and what new systems they would prefer to be implemented. We were also able to identify common destinations within the municipality of Sisaket and what types of transportation they choose to use when traveling within the boundaries of the city.[20] It was important to gather this information to estimate the compatibility of different developmental strategies for new transportation systems.

3.4 Comparing various transport systems

A comparative analysis is a comprehensive approach of examining multiple alternative choices and rating each one independently based on chosen characteristics. Along with a rating for each attribute there is a correlating “weight” that is multiplied to the rating before summing the overall score.

We obtained the weight for each attribute by asking our sponsor to distribute 100 points amongst the attributes, assigning more points to those he deemed more important. The more points an attribute has the more heavily its rating affects the overall score. We then obtained the partial ratings for each transport system by asking our sponsor to rate each systems’ attributes based on how well its features, such as capacity and build cost, would benefit Sisaket. It is worth noting that the system being rated is not revealed to the respondent, thereby reducing bias toward systems that they may or may not be partial to.[20] Based on these weights and ratings we were able to calculate the overall ratings for each system.

3.5 Investigating the private sector

As municipalities often outsource transportation development to third party corporations, investigating potential companies and investors for Sisaket to work with was an important step in

our research. The benefit of outsourcing transportation management solutions to established companies is that they handle some of the work of developing and running the service.

We interviewed the business development team of a Thai-based private transportation company in order to learn more about how such services are run as well as what involvement from the municipality would look like.[20] They explained what responsibilities they, the municipality, and local partners would have and recommended how a trial run would function. With this knowledge we were able to formulate the next steps the municipality can take if they choose to move forward with outsourcing management to the private sector.

We also interviewed eight potential local investors that may be able to pay for the creation of a new transportation system in Sisaket, including the owners of the biggest local gas stations, the president of the Young Entrepreneur of Chamber of Commerce, the owner of the biggest motorcycle shop in the city, and the co-owner of the biggest mall in the city. As Sisaket is one of the poorest provinces in Thailand, attracting investors for big development projects is important to the municipality.

4.0 Discussion of findings

The following section delineates all the data we gathered throughout our project and how those findings influenced our concluding suggestions. We presented our research in a manner that allows the city to both learn from our work and continue to research what additions they should make to Sisaket's transportation network.

4.1 Other cities demonstrate effective features of transport systems

When we researched different methods of decreasing public reliance on personal vehicles and the subsequent issues this reliance causes it was important to understand previous approaches and their relative success. By learning from others' achievements and mistakes we can help Sisaket make decisions beneficial to their development in all facets, including time, money, and resources. With this in mind we researched different implementations of transport systems outside of Sisaket in order to learn what considerations must be taken when designing a network.

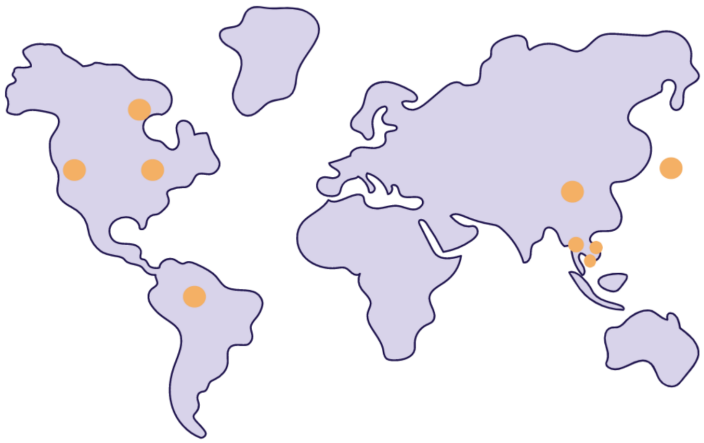

Figure 5 *Scope of different cities researched*

Mobile applications can integrate multiple transport systems to create a cohesive transport network

Okazaki, Japan utilizes multiple transport and management systems throughout the city to manage transport needs, including an extensive rail system, a bus system, and a mobile application that integrates the two.[14] These systems work seamlessly together to create an extensive transportation network that allows users to easily move around the city. The app is the defining feature that contributes to the network's success since many cities have both a bus and train system without incorporating an additional application to increase ride efficiency and encourage more usage. By allowing users to visualize the interconnection position of bus and rail systems as well as providing planning tools to help users identify optimal routes to their destinations, the mobile application seamlessly ties the systems together to build a cohesive transport network.

A city's physical and cultural restraints significantly influences local transport methods

Another important aspect to consider when planning to implement a transportation system is how well the city will adapt to the system. Vigan is a UNESCO World Heritage Site and is famous for its well-preserved Spanish Colonial town,[15] and since its historical preservation is its main tourist attraction the infrastructure required to implement a rail system would diminish its authenticity. As a result, jeepneys, seen in Figure 6, and motorcycle taxis are the most common transport methods available to the public. These transport systems are effective in the city due to their increased maneuverability in comparison to larger vehicles, like regular buses or car taxis.

Figure 6 *Jeepney in Vigan* [16]

Public satisfaction is crucial to generating usage in a transport system

When designing a system to address a city's transportation concerns, public input should influence decisions in order to maximize the new system's usage. Ubon Ratchathani significantly improved in Transportation & Communication because of their user-based approach in designing and implementing the new bus system.[5] The government began by conducting surveys to gather public feedback on present transportation systems, which found considerable discontent with the current network and a desire for a public transportation system. Following the collection of this information, the city was able to evaluate which method would best improve the city's transportation network while taking into account current conditions. Once the local government determined that a bus system would be the best addition to its transportation network, they then planned its routes and stops.

Schedule variability helps accommodate traffic congestion patterns

Khon Kaen, like Ubon Ratchathani, implemented a bus system to address their transport issues. According to Khon Kaen City Development Company Limited, the system aimed to provide transport services for inner city's citizens of different ages, gender, and occupation. To match demand the company increased the frequency of buses during rush hours as well as began operating 24 hours a day, and experiments were conducted before the first official operation in order to adjust the bus stops to meet the passengers' travel behavior. They identified this travel behavior via surveying locals on their travel time from their residence to the nearest planned bus stops, their access mode to the bus stops, and their travel cost to the bus stops. A defining feature

seen in the Khon Kaen bus system is the varying number of running buses to accommodate for rush hour when roads are typically more congested.[19]

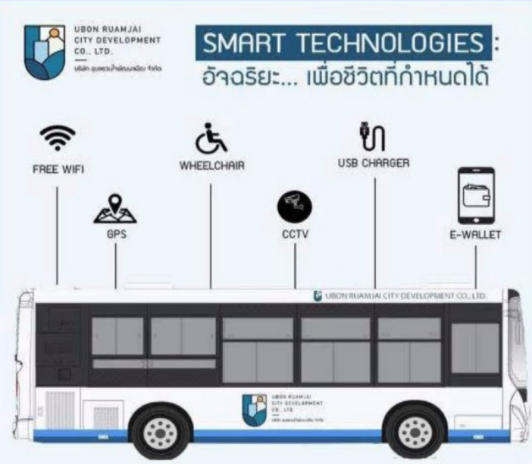

Figure 7 *Smart Buses in Ubon Ratchathani.*[17]

4.2 Roads surrounding educational institutes in Sisaket's city center bear heavy traffic congestion and may benefit from a new transportation system

Understanding the particular features Siaket's transportation network lacks was an important step toward making meaningful recommendations. It was imperative for us to identify high density areas and points of interest that could induce traffic congestion in the process of analyzing the current network.

Most of the traffic signals in Sisaket are located in the inner city at most intersections, as seen in Figure 8, due to the compactness of those roads. Figure 9 displays an outlined area inside the same region where the majority of the stop lights are, in which there are many educational institutes.

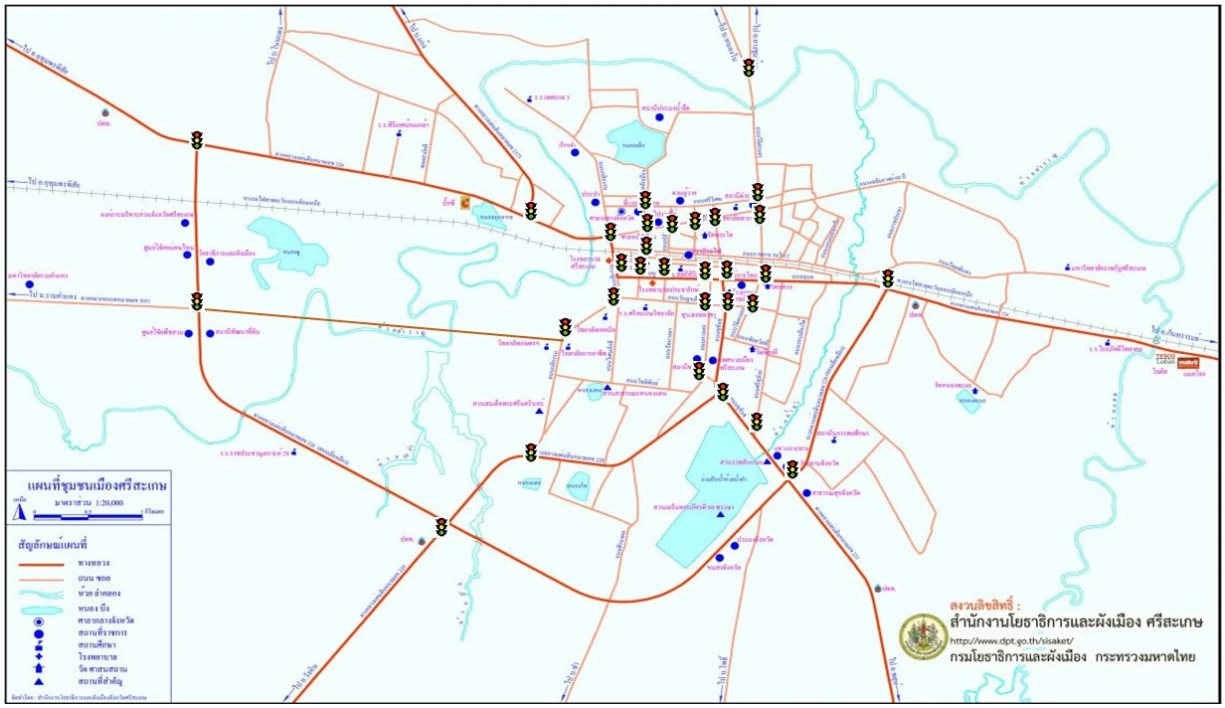

Figure 8 *Sisaket City Center Traffic Light Locations* [18]

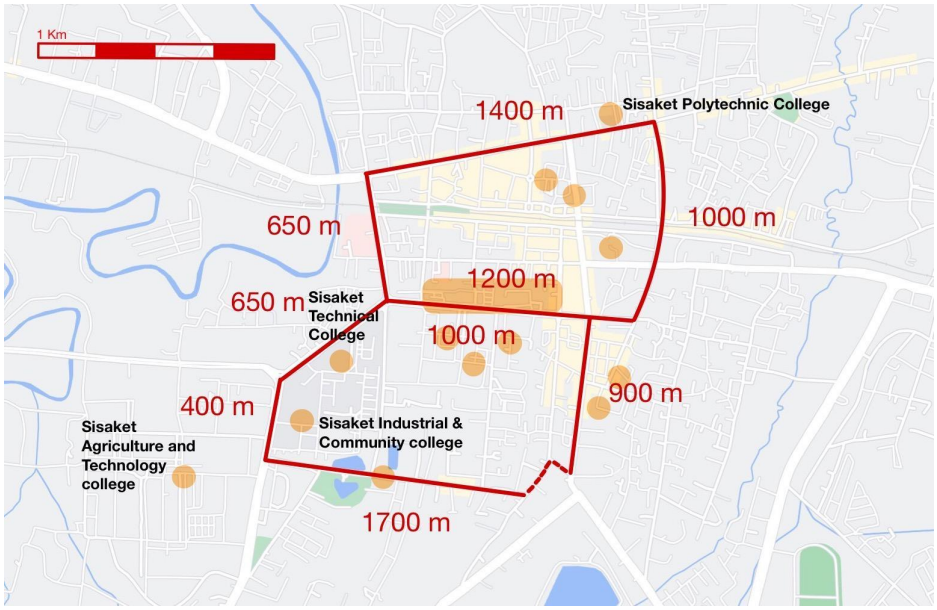

Figure 9 *Sisaket City Center* Orange highlighted areas are educational institutes.

Traffic flow information from Google Maps along with data gained from Figures 8 and 9 allowed us to develop a map of the congested roads surrounding popular destinations in Sisaket, as seen in Figure 10. The area outlined in these figures would greatly benefit from the addition of a transportation system to alleviate stress on the road network during rush hours.

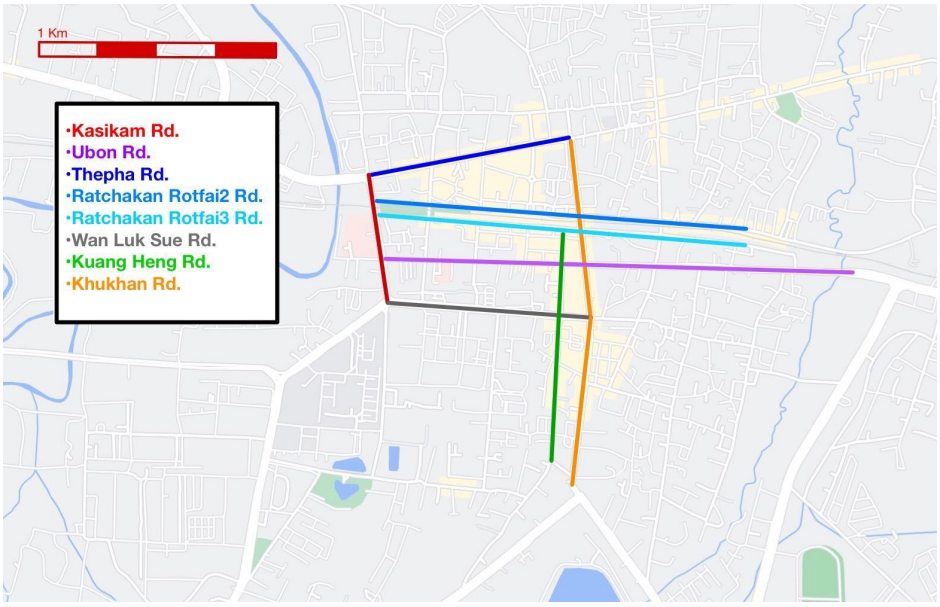

Figure 10 *Sisaket City Center High-Traffic Roads*

Due to the compactness of roads, dense population, and abundant popular destinations the roads in the region are prone to congestion. From this knowledge we can conclude that the implementation of a public transport system in the area could serve as an alternative to personal vehicle use and reduce the congestion over all.

4.3 Different transportation systems provide different sets of advantages and disadvantages to the city and riders

Whilst conducting our comparative analysis it was important for us to take into account Sisaket's physical and cultural characteristics. Therefore, we chose to focus on systems that have worked well in cities with similar attributes to Sisaket, both inside and outside of Thailand.

New transport systems could provide the most benefit to Sisaket in popular public locations; such as hospitals, schools and universities, fresh markets, bus and train terminals, government offices, and temples. These areas are optimal for implementing public transportation because there are naturally large gatherings of people. The addition of transport options to the

area would have a positive impact on future users and citizens by providing better accessibility to public transportation and reducing the necessity for personal vehicles.

Option A: Bus systems provide high capacity transport and opportunities for smart technology implementations

Based on other cities' transport methods, buses have been known to reduce congestion and increase productivity of a city. However, the feedback from the focus group suggests a bus system would not be used unless the bus is able to bring people closer to their homes. Hence, mini buses may be a more realistic option for Sisaket since the city does not need a high seating capacity and has some narrow streets.

If Sisaket were to implement a bus system, electric buses could be an option as the municipality is looking to implement eco-friendly forms of transportation. Although the upfront investment may be higher for electric vehicles, the money saved on upkeep and gas results in electric buses having a high return on investment (ROI).

Smart buses are another extension of bus systems that could be valuable to Sisaket's plans to expand smart city efforts. Smart buses provide a system that comes with other features, such as corresponding mobile applications, on-board wifi, and automated vehicle monitoring that improve user experience by increasing bus efficiency, safety, and interactiveness.

Option B: Bike Sharing reduces traffic congestion by encouraging self-motorized transport

As a non-motorized transportation option that moves people around in small areas, bikes are eco-friendly and low cost. Additional features could include bike lanes, parking sites, digital payment methods, and GPS tracking with the consideration of current infrastructure and public input. As we found from the community representative focus group, a bike sharing system has already been attempted in Sisaket many years ago and failed due to a lack of incentive to switch from a motorcycle to a bike. However, because it is relatively low cost to implement, a bike sharing system could be combined with other transport systems to better serve the city of Sisaket.

If a bike sharing system is implemented, it is important to establish set rules and regulations to keep the system safe for users and encourage new user ridership. Part of the reason the previous attempt at bike lanes failed in Sisaket was that people would use the lanes as parking spots, but with more strict enforcement of parking regulations the bike lanes may prove useful.

Option C: Tuk tuk systems provide a means of quick transport and fit Thai cultural norms

Sisaket's municipality can attract and allow tuk tuk drivers in the city center by implementing electric tuk tuk chargers and parking spots, but this initiative could vary considerably depending on how the government decides to implement tuk tuks. Whether the government decides to buy tuk tuks and employ drivers, work alongside an already established private company, or just encourage tuk tuk drivers to come to their city, a tuk tuk system would provide a flexible mode of transport for the city. An advantage of this system is that the government could have a small amount of involvement while still reducing congestion in the city and providing citizens with a means of public transport.

Option D: Tuk tuk systems that incorporate mobile application services demonstrate smart city practices

Implementing a tuk tuk system along with a mobile application could be another method of bringing public transportation into Sisaket. Tuk tuks by themselves provide fast and flexible transport in many cities throughout Thailand but do not have any smart-technology involvement. Currently most tuk tuks are run independently, so implementing a mobile application alongside them provides the opportunity for every driver to work together in a cohesive system. Mobile apps also allow for new use cases, such as ride sharing, mobile payment, and DRT services. This creates a user-friendly environment that aids the city in moving closer to its smart city goals.

4.4 Sisaket's community representatives prefer a tuk tuk transport system rather than buses or bike sharing

According to community leaders, most locals heavily favor using personal vehicles, specifically motorcycles, to travel around the city of Sisaket. They also informed us of Sisaket's tendency to temporarily borrow transportation systems when hosting sporting events due to the rapid entry and exit of city dwellers. Because there is a lack of available transportation methods for visitors of the city, the municipality brings in trams from nearby tourist attractions to transport visitors, as seen in Figure 11, who would otherwise be forced to use taxis.

Figure 11 *Tram from Wat Phrai Patthana Temple used during special events*

Regarding public transportation systems, many community representatives from the focus group brought up the difficulty of getting people to switch away from using their own personal vehicles. All ten representatives agreed they prefer to take a personal vehicle rather than walk home from the nearest bus stop, and only four out of the ten representatives agree that a bus system would be beneficial to Sisaket.

From the options we presented, the community heads displayed the most interest in a DRT ride-sharing tuk tuk service, where nine of the ten officials preferred it, as seen in Figure 12. None of the representatives thought a bike sharing system would be beneficial, which is a result of the recent failure of implementing bike lanes in Sisaket. We also used this data in our comparative analysis under an attribute “public want.”

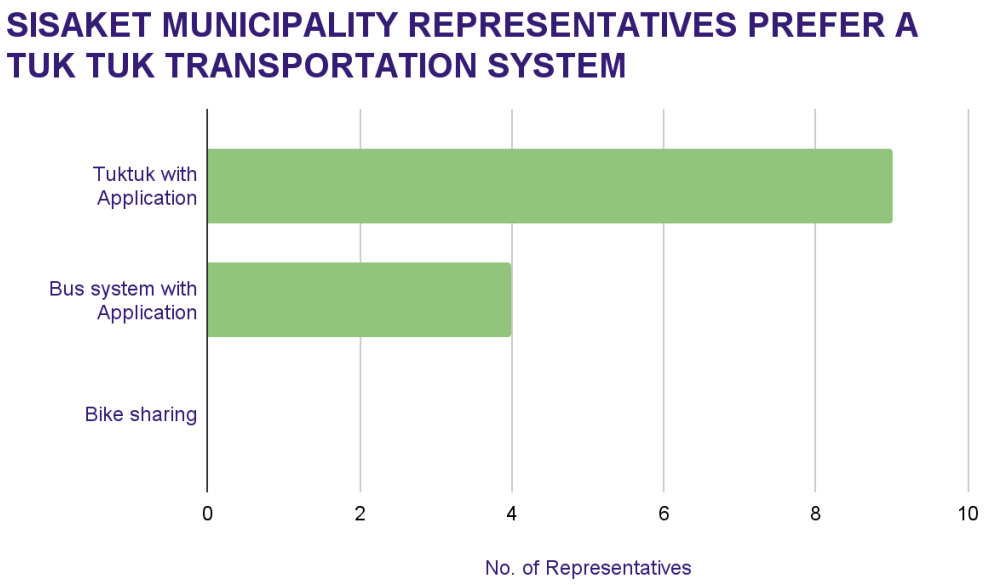

Figure 12 *Transportation Mode Preferences* This chart displays the number of representatives that preferred different modes of transportation, which was gathered in a focus group consisting of ten Sisaket municipality community representatives.

5.0 Analyses and recommendations

After conducting interviews, focus groups, and web-based research, we investigated how we could use our findings to make recommendations for a transport system that Sisaket could implement to alleviate traffic issues and progress toward their smart city goals.

5.1 Comparative analysis reveals a tuk tuk system is the most favorable transport method to introduce to Sisaket

As mentioned previously, we used a comparative analysis to decide on the transport system that best fits Sisaket's needs based on predetermined attributes. This allowed us to compare potential transport systems that we found to be successful in other cities and apply them to Sisaket's circumstances.

The first step in calculating the rating of each system was sending an evaluation form to the Sisaket Chamber of Commerce and our sponsor. Once they filled out the form and assigned the "weight" percentage to each attribute we found that they valued overall cost of the system as the most important attribute, as it was assigned ⅕ of the overall weight. This prioritization along

with the community leaders' preferences heavily influenced the final scores of each system since these were the highest weighted attributes.

Once we received our sponsor's responses and weights we multiplied each option's rating by its correlating weight. We then summed the resulting products for each system to calculate their overall scores. This creates a system where the allocated point difference between each choice can vary depending on the rating scale, which we set to be an integer range from 1 to 7, 1 being an extremely bad option and 7 being extremely good. The option with the highest total score revealed the system that best fits the needs of Sisaket, which we found to be a tuk tuk system with a mobile application, as seen in Table 1.

Weight	20	12	5	17	9	17	8	5	7	
Transport Type	**Cost**	**Build time**	**Capacity**	**ROI time**	**Complexity**	**Green**	**Jobs**	**Cost per use**	**Public want**	**Score**
Tuk tuks	4	5	5.5	3	4	6.5	4.5	5	6.3	470.1
Bus system	2.5	4.5	3.5	1.5	1	1	3.5	4	2.8	240.6
Bike sharing	6.5	6.5	1	5.5	3	6.5	1	1.5	0	459.5

Table 1 *Comparative analysis* Ratings are averages from sponsor and chamber of commerce

5.2 The municipality of Sisaket needs local investors to fund the implementation of a new transportation system

Unfortunately, Sisaket is a small city and cannot front large amounts of money for the development of their transportation network. However, with the help of local investors Sisaket may be able to begin implementing a transportation system, which will promote growth in the local economy. During our discussion, every investor agreed that the city should implement a public transportation system in the city center to improve the city's livelihood, boost the economy, and reduce the use of personal vehicles. They also all shared a common vision of Sisaket's future transportation network being combined with the use of technologies to assist resident and tourist travel.

As the investors we contacted are all born in Sisaket, they are familiar with the city's traffic infrastructure and local traveling behaviors. They anticipated that a DRT tuk tuk system would be the most popular transportation method due to locals prioritizing quick travel times over price and comfort. By implementing E-tuk tuks with a corresponding mobile app, an

improved transport network would positively impact the city's economy by attracting tourists, businesses, and new investors into town.

5.3 We recommend that Sisaket partners with MuvMi to bring E-tuk tuks to the city

There are many factors to consider when implementing a new transportation system in a city, but the main elements we focused on addressing in Sisaket were cost, ease of implementation, eco-friendliness, public support, and tech-driven operations. When comparing systems based on these attributes we came to the conclusion that an E-tuk tuk system is the best option for the municipality of Sisaket. Implementing this system would be a productive next step that Sisaket can take to address the city’s increase in motorization.

Currently MuvMi, an existing E-tuk tuk company based in Thailand, provides service in several areas throughout Bangkok, but one of the first trial locations was within and around Chulalongkorn University’s campus. MuvMi used this location to test the profitability of the system, which was later expanded. University trials provide many advantages to MuvMi, the biggest of which being the abundance of potential users. Thousands of students on and around campus need to travel between their apartments, academic buildings, other study spaces, and recreational activities in a timely manner. Fortunately, Sisaket has over twenty educational institutes within the city limits, the largest being Rajabhat University shown in Figure 13. This provides an opportunity for MuvMi to test the functionality of their system in Sisaket while also providing Sisaket with an effective means of public transport. This test will demonstrate to city officials how new transport systems can continue the development of Sisaket as a smart city.

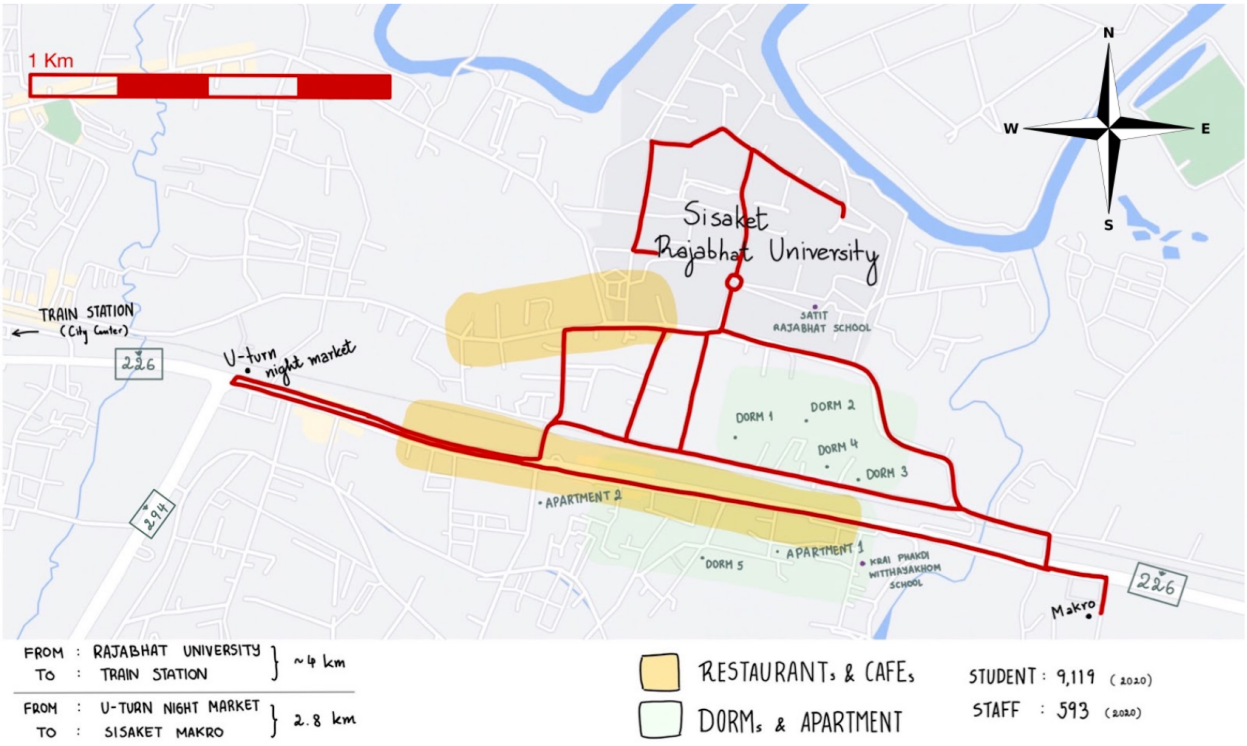

Figure 13 *Rajabhat University in Sisaket*

If implementation within the area of the university proves to be profitable, it would then make sense to expand the network to the city center, specifically the area shown in Figure 10. MuvMi recommended starting with ten tuk tuks for the 3 km^2 area and locating the chargers near areas of operation with high potential-customer traffic.

A benefit of working with MuvMi is that they are flexible with how their system is implemented and operated. They have established the option to include other transport vehicles in their application as well as allow the local city to handle daily operations, as local support is more likely to address the many nuances of problems within the city. MuvMi recommends they themselves help with implementing their E-tuk tuk system by providing the vehicles, training local drivers, and managing their mobile application services. This would require the municipality of Sisaket to regulate the tuk tuk licenses as well as assist in finding space for charging stations and parking spots for the MuvMi vehicles. The Sisaket municipality's current laws and regulations limit their ability to invest in the private sectors as their involvement would be considered running a business. As such, with the help of local partners investing in these regional operations and managing day-to-day customer support, MuvMi has the potential to become a widely-used transportation system in Sisaket's city center.

As our research was limited by our available time and resources, it is important for the municipality to use similar approaches to continue researching the most suitable next steps. The municipality may do so on a larger scale and learn more about the impacts such a system would have on their city.

5.4 Continued research is essential to the development of Sisaket's transport network

As the city continues to develop, the municipality must continue research into the long term success of changes in the transportation network. Road expansion quick-fixes, like increasing the number of lanes on a road, are only temporary improvements for traffic-congested roads as wider roads encourage more motorization and create a continuous cycle of adding lanes. The root issue of excessive personal vehicle usage will continue to cause complications in the transportation network if the correct steps to address public transportation are not taken. When implementing a new transport system, the city must verify that the system not only addresses the current issues in the city but also allows room for expanding and evolving as the city continues to develop.

Accordingly, establishing MuvMi's E-tuk tuks and application in Sisaket is the first step that the municipality can take in developing the city's transportation network. However, the municipality should continue to research what other transportation systems could be implemented in the city center. All new systems should be technologically driven in order to keep up with their smart city goals, and will ideally create a cohesive transport network that provides seamless travel within the city center.

Sisaket has the opportunity to increase its economic competitiveness via the implementation of a new transport system, which would be the first step in developing a larger network of connected transport systems. By continuing our research the municipality can find the most suitable system to implement and continue developing Sisaket's city center.

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[20]Refer to supplementary materials for full list