Pre-feasibility study

Pre-feasibility assessment for Mobility as a Service (MaaS) implementation in Kathmandu

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Executive Summary

Kathmandu is the capital and most populous city of Nepal and is inhabited by more than two million people. The rapid unplanned urbanisation and increase of wealth in Kathmandu have introduced several issues in Kathmandu´s transportation system, including the explosive increase in two-wheelers, low share of public transportation usage, traffic congestion, air pollution, and high traffic accident fatalities. In addition, most of the public transportation in Kathmandu is privately owned, resulting in competition between operators to generate more profit as well as a decentralised, unstructured, and unreliable public transportation system.

Mobility as a Service (MaaS) is an operating platform that enables multi-modal travel options. MaaS is the overarching operator, bringing together the existing transport options that already use intelligent transport systems (ITS). In the end, MaaS aims to incentivize private vehicle users into using shared or public transport as well as to encourage shared-transport users to employ public transport as their main mode of travel.

Considering Kathmandu´s context and complex urban transportation issues, this study aims to seek whether the MaaS system is viable and recommended for implementation within the local public transportation system, particularly within the frame of Kathmandu´s infrastructure, social, and technological setting.

To achieve this goal, this study analyses Kathmandu's transportation sector, particularly looking into the transportation supply and demand as well as the state of the Intelligent Transport System (ITS) in Kathmandu. In addition, it seeks best practices and examples from Whim, one of the prominent MaaS case studies. This study also provides an overview of opportunities and challenges pertaining to a possible MaaS system in Kathmandu. Lastly, a set of recommendations are synthesised within three key areas: ITS, legal framework, and business model.

Primarily, this study recommends three key elements in achieving MaaS Level 1 in Kathmandu: upgrading and implementing ITS elements, improving the business model through the provision of proper incentives, and establishing an accommodating regulatory framework.

Intelligent Transport System

The ITS needs to add decision support for commuters, making their trips easier and faster to select. Furthermore, the ITS needs to include a data collection element that can help improve resource management on behalf of the transport providers. The ITS data should also be shared by all public transport vehicles, which will enable more providers to emerge with platform solutions.

Business Model

An improved business model must provide economic incentives for transport operators, bus drivers, and bus conductors to adhere to regulations, time schedules, and routes. The model should maintain existing fares offering added value to the commuters without additional costs. The platform should help increase the number of commuters selecting public transport.

Legal, Rules, and Regulation

New regulations must incentivize transport operators, bus drivers, and operators to adhere to rules that contribute to a stable and well-functioning MaaS platform. Bus overcrowding should be disincentivized The regulations must ease data-sharing processes and enable improved profitability through market expansion.

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List of Abbreviations

DoTM	Department of Transport Management of Nepal
DTU	Technical University of Denmark
E-Ticket	Electronic Ticket
FNNTE	Federation of Nepalese National Transport Entrepreneurs
ITS	Intelligent Transport System
MaaS	Mobility as a Service
PT	Public Transportation
PAYG	Pay as You Go

1 Introduction

Kathmandu is the capital and most populous city of Nepal and is inhabited by more than two million people1. Kathmandu District, together with Lalitpur and Bhaktapur Districts, form the Kathmandu Valley (KV) region. Figure 1 shows the location of KV in a geographical context.

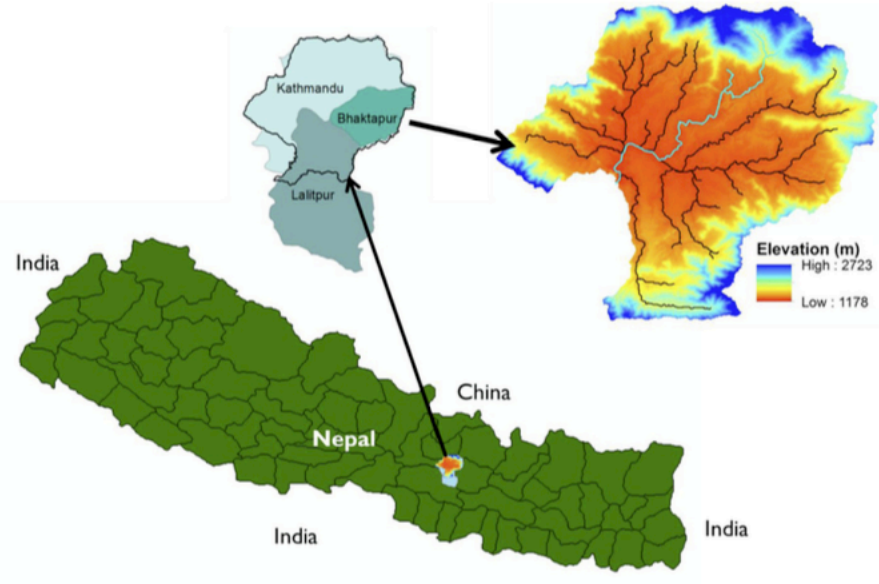

Figure 1 Location of Kathmandu Valley

Similar to other cities, Kathmandu also shows the signs of the megatrends that are significantly impacting urban transportation systems worldwide: hyper-urbanisation, climate change and emissions, demographic and societal change, and technological breakthroughs[2]. With a 412% built-up area increase in the last decades and 6.5% population growth per year, KV is one of the fastest-growing metropolitan areas in South Asia[3]. The road transportation sector in KV is estimated to emit around 6.5 million tCO_2 per year, with bus/minibus and two-wheelers as the predominant sources[4]. In addition, Kathmandu shows rapid growth in the smartphone market and internet penetration for the past few years. It is reported that more than 65% of Kathmandu´s population possessed a smartphone and the 3G/4G subscription was close to 100% of the population.

Challenges in Kathmandu Transportation System

The rapid unplanned urbanisation and increase of wealth in Kathmandu have introduced several issues in Kathmandu´s transportation system. The explosive increase in two-wheelers, which now accounts for 78% of nationwide new vehicle registrations annually[5], implies that the public transport system is deselected by the residents of Kathmandu in favour of individual means of transportation. This contributes further to other transportation issues in the region, including traffic jams, air pollution, and high traffic accident fatalities. In addition, most of the public transportation in

[1] Ministry of Foreign Affairs Nepal MOFA, 'Nepal Profile'.
[2] Kamargianni et al., 'Feasibility Study for "Mobility as a Service" Concept in London'.
[3] Ishtiaque, Shrestha, and Chhetri, 'Rapid Urban Growth in the Kathmandu Valley, Nepal'; Timsina et al., 'Trend of Urban Growth in Nepal with a Focus in Kathmandu Valley'.
[4] Ghimire and Shrestha, 'Estimating Vehicular Emission in Kathmandu Valley, Nepal'.
[5] Wagle, 'Motorcycle City'.

Kathmandu is privately owned, resulting in competition between operators to generate more profit as well as a decentralised, unstructured, and unreliable public transportation system.

Mobility as a Service

Mobility as a Service (MaaS) is an operating platform that enables multi-modal travel options. These modes of transport can be combined through a one-stop-shop ticketing system. This renders MaaS an overarching operator, bringing together the existing transport options that already use intelligent transport systems (ITS). Ultimately, MaaS aims to incentivize private vehicle users into using shared or public transport, as well as to encourage shared-transport users to employ public transport as their main mode of travel.

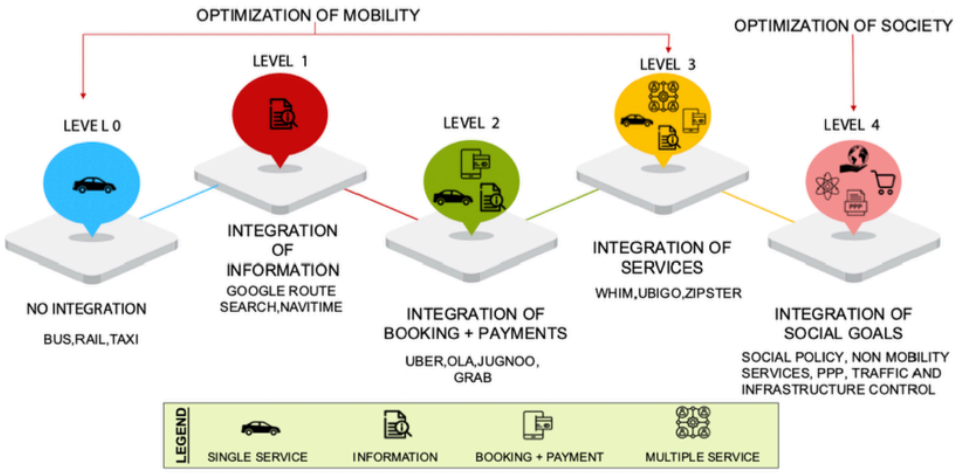

Figure 2 Level of MaaS

MaaS can be classified through levels, depending on the maturity of a system's integration with the available travel modes. Sochor et al. classify five levels of MaaS integration, assuring that no one level is explicitly better than the others, as this greatly depends on the user needs[6]. Figure 2 illustrates and summarizes the level of MaaS.

According to Kamargianni and Matyas, seven sub-components are necessary to facilitate a functional MaaS ecosystem for the users[7]. These seven sub-components of MaaS consist of: transport operators (including mobility service providers), data providers, technology and platform providers (technical back-end providers), information and communication technologies (ICT) infrastructure, insurance companies, regulatory organisations, and universities/research institutions. Together, they serve as the basis for assessing the opportunities and challenges that arise when conducting this study.

SOLUTIONSplus in Kathmandu

SOLUTIONSplus initiates collaboration between cities, industry, research, implementing organisations, and finance partners to kick-start the transition towards low-carbon urban mobility. The Kathmandu demonstration action in SOLUTIONSplus aims to contribute in creating an ecosystem of electric mobility to enhance public transport. It includes the conversion of a diesel bus into an e-bus, the remodelling of Safa tempos (e-3 wheelers) for passenger and cargo services, the new design of e-3 wheelers with a multi-use concept (passenger, cargo, and waste), the design of an e-shuttle van, and the conversion of a petrol-driven pickup truck into electric. Additionally, this pre-feasibility study looks into the potential use of vehicle integration services in public transport system, mainly through a Mobility as a Service (MaaS) implementation in Kathmandu.

[6] Sochor et al., 'A Topological Approach to Mobility as a Service'.
[7] Kamargianni and Matyas, 'The Business Ecosystem of Mobility-as-a-Service'.

This study was conducted in collaboration with the Technical University of Denmark (DTU), as a BSc thesis project[8].

Study Objectives

Considering Kathmandu´s context and its complex urban transportation issues, this study aims to investigate whether a MaaS system is viable and recommended for implementation within the local public transportation system, particularly within the frame of Kathmandu´s infrastructure, social, and technological setting. The study further investigates Kathmandu´s MaaS readiness by seeking answers from leading experts among MaaS platform providers, data providers, transport operators, infrastructure planners, insurance companies, and regulatory organisations.

2 Analysis of Kathmandu´s Transportation Sector

This section explores how the transportation demand and supply are met, as well as the current state of implementation of ITS components in Kathmandu.

Transportation Demand in Kathmandu

Understanding the local user patterns, needs, and potential is crucial before implementing any MaaS system. This study utilizes data collected through surveys performed in Kathmandu by the Japan International Cooperation Agency (JICA) and The World Bank[9]. By analysing the data, the following key findings are synthesized:

- Commuters use buses as their main mode of public transport and reach their desired destination by a single bus trip.
- Commuters usually have to wait until a bus is full before leaving a station. Given that the majority of trips are short in both distance and time, this makes waiting for a bus less preferable compared to taking a quicker minibus or Safa Tempo.
- Implementation of bike sharing does not seem like a viable option since most commuters do not use this option for their daily commutes, notably due to the lack of bicycle lanes.
- Short travel time is one of the most important factors for commuters when selecting their mode of public transport. This implies that a MaaS solution can be competitive only if it results in travel times that are at least as fast as what the current system provides.
- Peak travel hours appear to be between 08:30-11:00 am and 05:00-07:00 pm. A MaaS solution needs to be able to identify the locations where travel demand is at its highest and meet this demand through the proper supply of PT vehicles.
- The lack of pedestrian walkways and bicycle lanes has reduced the number of trips taken by these means of transport in favour of two-wheelers.

Transportation Supply in Kathmandu

This section aims to seek whether the supply side of Kathmandu´s PT system can meet the demand both qualitatively and quantitatively. The key findings include:

- Dedicated bus lanes are unavailable, making the performance of bus-based PT a reflection of the city's traffic congestion.

[8] Ortving and Brodthagen, 'An Analysis of Kathmandu's Public Transport System and Viable Improvements through MAAS IT SolutiOns, A Pre-Feasibility Study'.
[9] JICA, 'Federal Democratic Repubic of Nepal: The Project on Urban Transport Improvement for Kathmandu Valley'; The World Bank, 'Gender and Public Transport: Kathmandu, Nepal'.

- Large buses cover a very small number of the routes, making paratransit service (e.g., micro-buses, Safa Tempos, or e-three wheelers) a necessity.
- Inconsistent and unreliable schedules, routes, and capacity availability characterize bus services. Bus drivers do not follow fixed schedules, as they often leave stations only after buses are full. In addition, the buses do not always adhere to the designated routes and diverge their travel routes. Overcrowding is a frequent condition, prohibiting commuters to use a bus due to capacity limitations. This makes MaaS implementation much more difficult as a commuter cannot always trust the information delivered by a MaaS platform.
- There is a lack of economic incentive for the driver to adhere to schedules and fixed prices. This is due to the bus operator attempting to maximize profit rather than delivering a service that is sustainable and efficient for the public.
- There are severe enforcement problems regarding bus and traffic regulations. This means that transport operators are much more inclined to divert from rules and regulations as the consequences of breaking these are most likely not penalised. If a fine is issued for breaking regulations, it is usually very low, thus, insufficient to act as a disincentive.
- There is a very large number of bus operators divided into organisations of varying sizes and structures. This might complicate the process of consolidation under a MaaS platform. Having FNNTE's approval could prove crucial for MaaS implementation success.

Intelligent Transport Systems (ITS) in Kathmandu

ITS is an umbrella term for the digitization of transportation services, for instance, E-Ticket sales and GPS systems. This section aims to identify to what extent the ITS components are implemented in Kathmandu as well as the availability of appropriate legislation enabling scalability. This section also provides an overview of existing bus tracking apps that are used in Nepal: MotorBhada, Letzgo, and Mero Sajha.

MotorBhada

MotorBhada is an app for public transport real-time tracking that was launched in 2017. The app uses GPS technology to allow PT companies and commuters to track PT vehicles. When the app was initiated, almost none of Kathmandu's transport data was digitally recorded. The company behind MotorBhada eventually gained around 70% of the available transport data. Due to the lack of response from the authorities regarding access to data collection, the development of MotorBhada was on hold since 2020.

LetzGo

LetzGo was launched by Ncell in collaboration with Ramlaxman Innovations in 2018. Instead of installing GPS on the buses, Ramlaxman uses drivers' phones as the GPS to locate the vehicles. This option could very well substitute the expensive and arduous task of GPS installation when implementing MaaS, as it is very flexible and easily scalable. Customers can use the app to check the real-time location of the buses through LetzGo and plan their journey accordingly. It is claimed that more than 600 buses were tracked during the initial phase. Limitations of LetzGo include the limited user size, OS availability, lack of updates, and limited features. It is reported that the number of downloads and frequency of use are lacking. The app is only available on Google Play and has not been updated since 2020. In addition, it does not integrate an E-Ticketing system on its platform and does not provide a schedule and journey planner for the users.

Mero Sajha

Mero Sajha is also powered by Ramlaxman Innovations and shares several features with LetzGo, but is only available for tracking Sajha Yatayat buses. The interface displays all Sajha vehicles in real-time on a 2-D map powered by Google Maps and provides information on the stops for the chosen vehicle. However, the app does not show travel times and does not provide a journey planner.

The following key findings summarize the state of ITS in Kathmandu:

- Most of the larger buses are equipped with GPS technology that enables the apps to track the location of the buses. However, there is no available information concerning the existence of GPS in smaller PT vehicles.
- The GPS is mostly used for tracking and informing users about bus routes. A journey planner or schedule is currently not available.
- Most of the GPS tracking apps in Kathmandu do not integrate E-Ticketing on their platform.
- DoTM seems to be positive towards GPS implementation in buses. DoTM planned to upgrade 100 PT vehicles on selected routes with free GPS. It is reported that their final goal is to provide ticket booking options although there is no mention of newly released apps[10].
- Previous attempts at implementing E-Ticketing have failed due to various reasons, notably due to the lack of trust from commuters, IT difficulties such as bad reception and machine lags, as well as disregard from the conductors.
- The E-Ticketing system is currently available for medium and long bus journeys, particularly due to DoTM's adoption of mandatory E-Ticketing during the Covid-19 pandemic through regulatory instruments. This legal approach could also be suitable for short-distance journeys.
- The population is used to a PAYG (Pay as You Go) system, making subscription-based tickets not viable in the initial stage. In addition, the PAYG system needs to be as fast as the cash payment system.

3 Case Study: Whim

Whim is a MaaS platform provider, which offers its services through a smartphone app in the Helsinki Region. The app is equipped with a journey planner that allows calculation of the most efficient routes, access to payment, and booking of tickets for a variety of transport services such as HSL (*Helsingin seudun liikenne* - Helsinki Region Transport), taxis, car-sharing and others.

Key takeaways from Whim Case Study include:

- Traffic analysis shows that the number of vehicles in Helsinki is much lower than in the rest of Finland. Whilst this is most likely not a direct result of the MaaS introduction, it can be argued that it is a direct result of having a very modern and effective PT system in place (HSL contributes to over 375 million trips per year). A lesson learned from this case study is that Kathmandu should first and foremost attempt to adopt a better PT system before introducing MaaS.
- As 95% of trips made with Whim are done through PT, this should signify the importance of having a strong PT network in place before committing to the implementation of MaaS. As such, Kathmandu needs to divert its commuters onto PT before attempting to implement a full-scale MaaS system with many different modes of transport.

[10] KC, 'GPS Tracking On Public Transport Started, Free Installation in the First Phase'.

- HSL shows huge success in -E-Ticketing, regardless of ticket type (PAYG or subscription-based). Kathmandu could implement a similar E-ticketing system; however, one should consider possible cultural differences including the degree to which commuters follow rules and payment structures in general. Therefore, further investigation into how an E-ticketing system should be implemented in Kathmandu is necessary.
- Helsinki's transport operators already had ITS in place before implementing Whim. This allowed for much quicker integration of operating services since the hardware was already in place. For Kathmandu to be able to implement MaaS, data-sharing hardware such as GPS would need to be installed in all vehicles used by the different transport operators.

4 Assessment of Opportunities and Challenges

This section explores the opportunities and challenges in implementing a MaaS system in Kathmandu. They are grouped into five of the seven sub-components mentioned in Section 1: data providers, transport operators, infrastructure, insurance companies, and regulatory organisations. The opportunities and challenges for the MaaS Platform Provider sub-component will be provided in the later chapters. Figure 3 summarizes the opportunities and challenges for MaaS implementation in Kathmandu.

Study Area	Opportunities	Challenges
Data Provider	• Some of the large buses are already equipped with GPS • Possibility to share real-time location/transport data • Possibility of shared-data format implementation • Implementation of Mobility Data Specification (MDS) element • E-Ticketing is available for medium and long-distance journey • Journey planning potential	• Unavailable GPS tracking for small public transport • Short distance travels only accept cash • Lack of data privacy regulation
Transport Operators	• ITS for GPS live-tracking are available for larger buses • Potential to integrate the vehicle location-sharing application into the MaaS platform	• GPS tracking in the larger bus segment is not integrated with e-ticketing • Smaller vehicles are not ready for ITS hardware upgrades and E-Ticketing • PT operators might be reluctant in sharing their GPS data due to the lack of incentives
Infrastructure	• Telephone coverage in Nepal fulfil the general needs for a MaaS system • Almost 100% of the population has access to 3G/4G access	• No actions were undertaken to ensure PT priority in Kathmandu • No incentive for micro-mobility
Insurance Companies	• Insurance for all PT customers is mandatory • Vehicles insurance is mandatory	
Regulatory Organisations		• Data privacy laws regarding sharing and storage cannot be identified • Regulation regarding ticket reselling cannot be identified

Figure 3 Summary of the Opportunities and Challenges for MaaS Implementation in Kathmandu

Opportunities

Data Provider

In general, there is some potential for real-time location data sharing for public transport in Kathmandu, but with several limitations. The analysis shows that some of the large buses are already equipped with GPS locators, which are installed in cooperation with DoTM. This enables the large buses to share real-time data within the current transportation system, which is integrated with the Mobility Data Specification (MDS). In addition, there have been several successful E-Ticketing implementations for medium- and long-distance trips although the readiness for the current payment solution to integrate with the MaaS platform is still unknown. Despite the unavailability of a journey planner for PT in Kathmandu, there are possibilities for journey planning potential particularly based on the case study of LetzGo and Mero Sajha apps.

Transport Operator

One of the key opportunities here is that some of the transport operators are already starting to implement ITS components on their fleets, particularly regarding large buses. Some of the large bus companies are using the ITS system for live GPS-tracking their buses, showing the potential of integrating the location-sharing features into the MaaS platform.

Infrastructure

Smartphone and internet services are quite accessible in Kathmandu, meeting the corresponding needs for a MaaS system. It is reported that 96% of the population in Nepal lives within signal coverage distance of a mobile tower[11]. Furthermore, government regulations enable the expansion of high-speed internet and the 3G/4G penetration combined reaches almost 100% of the population.

Insurance Companies

Both insurances for PT customers and vehicles are mandatory, enabling the support of a potential MaaS system in Kathmandu.

Regulatory Organizations

Currently, there are no identified opportunities for this study area.

Challenges

Data Provider

The main challenges concerning data providers more likely pertain to smaller vehicles and/or public transportation over shorter distances (<100 km). This is crucial since the predominant vehicles used for public transport services in Kathmandu are smaller vehicles. Currently, almost none of the smaller vehicles is equipped with GPS trackers. In addition, public transportation over shorter distances is exclusively made on cash payments. In the past, multiple attempts of implementing travel cards have reportedly failed due to various reasons including the unavailability of e-tickets in some buses, unreliable payment terminals, and lack of incentives for conductors. On the regulation side, the regulatory instrument for data privacy is currently lacking. Privacy and data protection laws are still in a very early development stage and Nepal currently does not have a unified data protection legislation.

Transport Operator

Several challenges come from the transport operators' side mostly related to the ITS elements and willingness to share data. While the larger buses are mostly equipped with GPS tracking, they are currently not integrated with the e-ticketing system. Meanwhile, smaller vehicles are not ready for ITS hardware upgrades and e-ticketing does not seem to be a viable solution. In addition, even if the GPS

[11] NepaliTelecom, 'Internet Users in Nepal Increases Rapidly, Penetration Reaches 63 Percent'.

were installed in all PT vehicles, it is unlikely that all transport operators would be willing to share the data due to lack of incentives.

Infrastructure
A key issue is the absence of actions that ensure PT priority in Kathmandu. For example, there are no priority lanes for buses – resulting in the buses being trapped in congestion. In addition, there are no incentives regarding the integration of micro-mobility in a Kathmandu MaaS.

Insurance Companies
Currently, there are no identified challenges for this study area.

Regulatory Organisations
Information about privacy laws regarding data sharing and storage, as well as regulation concerning ticket reselling currently cannot be identified.

5 Recommendations on MaaS Implementation in Kathmandu

In determining Kathmandu´s MaaS readiness and compatibility, this study recompiles the detected failures and challenges, isolates their causes, and suggests measures that may contribute to alleviating the said challenges. Appendix 1 provides a Cause-Effect Diagram structuring the analysis. The measures then inform a Catalogue of Objectives (refer to Appendix 2), which also indicates their corresponding priority (compulsory, recommended or simply desired). Lastly, Appendix 3 provides the risk analysis that serves as a cautionary element to the catalogue of objectives.

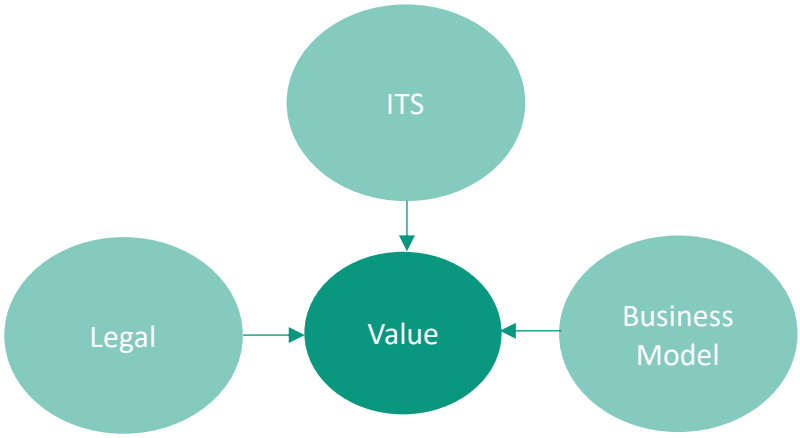

Figure 4 Key Objectives Area for MaaS Level 1

This study recommends that Kathmandu strive towards a Level 1 MaaS, focusing on the integration of centralised information, multi-modal travel planners, and assistance. For a MaaS system to be functional, it must add value to the transport ecosystem. In this simplest case, the transport ecosystem consists of the transport operators (i.e., bus operators), the government, and the commuters.

Primary Recommendations

This section provides primary recommendations that should be implemented in the initial steps of MaaS implementation in relation to the ITS, legal, and business model areas.

ITS Components
An upgrade of the current ITS in the public transportation system needs to be undertaken. The primary objective of the ITS is to add value to the commuter journey, for example by introducing a smartphone application that helps commuters with decision support through journey planning. It should be noted that reliable public transport cannot be achieved without the cooperation of the bus operators.

The key objectives that should be addressed include:

- All public transport vehicles must be fitted with GPS. This can be done through hardware installation or a smartphone application on the driver/conductor smartphone. Given that all PT vehicles need to participate in the MaaS platform, it is recommended to use the smartphone application as the solution. This is much easier to scale towards a very large and diversified vehicle fleet. The application provided by Ramlaxman Innovations, which is powered by Google Maps, could be a solution. This will limit the need for new software development.
- The MaaS platform needs to be reliable. This means that it should not be introduced until all drivers are following time schedules and routes. If the application is unreliable, it does not add value and commuters will disregard the application.
- Data sharing from GPS must be standardized such that third-party application providers can develop a MaaS application through standardized API.

Legal Components

In the legal context, it has been reported that travel time and overcrowding are the main concerns in travelling with public transport. To address this, incentives and disincentives should accompany the application of an ITS system. It should be noted that adopting regulatory measures alone is not sufficient to change the practices of public transport operators and drivers. Enforcement is of paramount importance along with a sustainable business model as indicated below.

The key objectives that should be addressed include:

- Drivers must not overcrowd buses. This leads to many commuters balking PT in favour of private transport. In addition, this practice is dangerous. Therefore, stronger enforcement in the form of substantial fines needs to be implemented, creating a considerable disincentive for drivers to deploy this practice. Of course, this measure needs to be accompanied by other actions ensuring the supply of sufficient capacity without intensifying the congestion problems (e.g., provision of financial incentives making the investment in larger and more sustainable buses more attractive, introduction of dedicated bus lanes where possible, etc.).
- Data sharing must become mandatory enabling the development of a MaaS platform. This data needs to be shared through standardized API for easy integration with smartphone applications and future payment solutions.

Business Model Components

The bus operator's business model is one of the most important aspects of improving the public transport system in Kathmandu. Previous attempts at improving the public transport system solely through IT solutions have already been attempted. Yet data indicates that no improvements have been made to the system. The study found that public transport drivers have no incentives to follow regulations, routes and time schedules. As they focus on profit maximisation, they tend to wait longer at the bus stops to fill the bus before leaving, resulting in longer transit times for buses. In turn, this leads to commuters opting for smaller and less efficient microbuses or private vehicles, particularly two-wheelers. It cannot be understated how important cooperation of all transport operators is in designing a more reliable public transportation system.

The key objectives that should be addressed include:

- Government and local authorities need to look at how the bus operators' and drivers' business models can be changed, such that they have an economic incentive to stick to a strict schedule as well as only stopping where the route permits. This is the first step that will allow a MaaS

platform to be introduced, by making reliable decision support available for commuters. Furthermore, this will decrease the travel time of the larger buses, which has been documented to be the single most important factor for commuters in Kathmandu.

- Government or transport authorities can help convince operators by providing GPS implementation free of charge. This will incentivise them to join a potential MaaS platform, as the platform is essentially expanding their business by increasing their market share.
- A new business model needs to be introduced in collaboration with the government, FNNTE and other transport authorities. All stakeholders need to be satisfied with the business model for it to be sustainable. How the model is going to look exactly is too early to state, but the benefits of incorporating a new sustainable business model must provide value for all parties.

Secondary Recommendations

This section provides secondary recommendations that should be implemented in the later stages of MaaS implementation after all the primary recommendations have been implemented.

E-Ticketing

To function properly, E-Ticketing must add value to the transport ecosystem. Cash payment is widely preferred in Kathmandu, forcing E-Ticket solutions to compete with cash payments. As mentioned in Section 4, multiple attempts to implement E-Ticketing in Kathmandu failed due to insufficient coverage, unreliable payment devices, and lack of incentives. In short, E-ticketing solutions failed to add value to the transport ecosystem.

This study recommends E-Ticketing to be implemented in a second stage. This means that the MaaS platform should have already been established and the commuters have been already used to the application before implementing the E-Ticketing system. By attempting to introduce E-Ticketing again before the MaaS platform is established, the risk of customers disregarding the platform due to ticketing complications might increase even if the journey planner is a success.

In this regard, a study conducted by Amatya et al. explores E-Ticketing and digitisation of records opportunities for Sajha Yatayat in Kathmandu[12]. The study tries to tackle the issue of revenue leakage from ticket distribution and transactions resulting from manual paper-based collection and recording systems. The proposed solution combines a digitised recording system that allows the transactions to be recorded in real-time along with people counting sensors, enabling Sajha Yatayat management to implement a dual tally system, which also allows the digital recording of tickets by the conductors. Once the passengers enter the bus, the conductor can provide the tickets immediately or go to the passenger seat to provide them with a ticket. In addition, sensors at the entrance and exit of the bus will be installed to provide the number of passengers travelling through the bus daily.

6 Conclusions

The implementation of MaaS in Kathmandu has one overarching goal: to increase the value in the transportation sector. Each of the components of Kathmandu's transport ecosystem needs to provide MaaS solutions in envisioning value.

Intelligent Transport System

The ITS needs to add decision support for commuters, making their trips easier and faster to select. Furthermore, the ITS needs to have a data collection element that can help improve resource

[12] Amatya et al., 'Sajha Yatayat: Digitization of Records'.

management for the transport providers. The ITS data should also be shared by all public transport vehicles, which will enable more providers to engage with platform solutions.

Business Model

An improvement of the business model must create economic incentives for transport operators, bus drivers, and bus conductors to adhere to regulations, time schedules, and routes. The model should also keep prices low for commuters to give them added value through the platform without extraneous costs. The platform should help increase the number of commuters selecting public transport.

Legal, Rules, and Regulation

New regulations must incentivize transport operators, bus drivers, and operators to adhere to rules that contribute to a stable and well-functioning MaaS platform. Furthermore, the regulations must incentivize bus drivers to not overcrowd their buses. Lastly, the regulations must ease data-sharing processes as well as ensure convenience for bus operators whilst helping them expand their market share.

7 Limitations of the Pre-Feasibility Study

One of the main limitations of this study is regarding the data and information used for the analysis. It was not always possible to verify the accuracy of collected information and online information on Kathmandu is not on par with information available for the western part of the world, forcing at times the use of information derived from newspaper articles and websites. Furthermore, the validity of the data collected from published scientific articles can also be contested, since a majority of the available data concerns the period when the transport syndicate system was deployed. Therefore, further data needs to be collected regarding the current transport sector state to assess how well the PT system in Kathmandu could implement a MaaS system, and how the abolishment of the syndicate might affect this.

Another limitation is that the authors are not local experts in Kathmandu. Therefore, the entire study has been based on the information that has been available online. This will undoubtedly mean that there are aspects of the transport ecosystem that has not been addressed in the study. Future feasibility studies need to be aware that this limitation.

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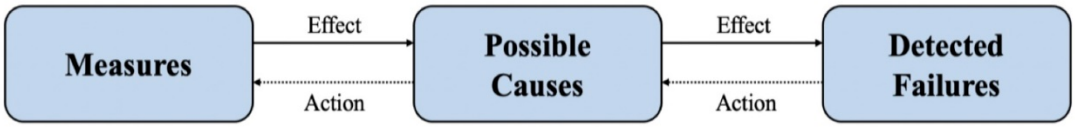
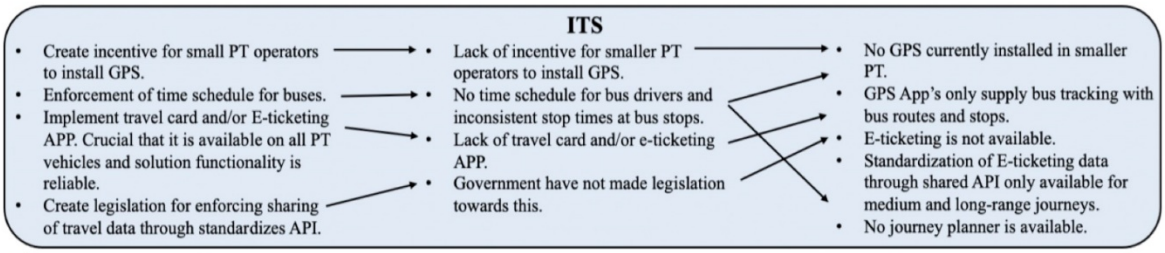
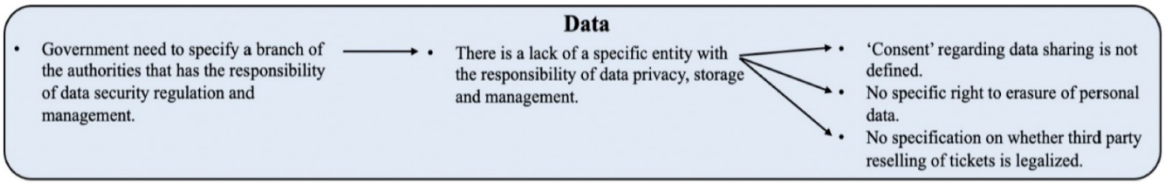
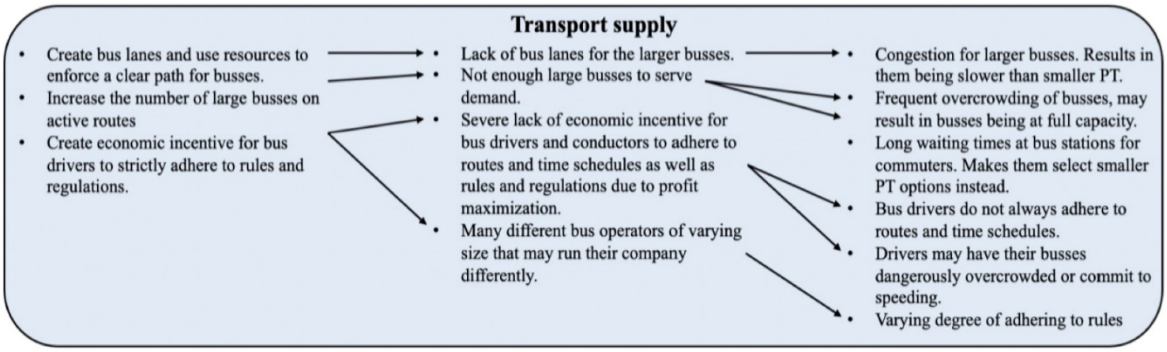
Appendices

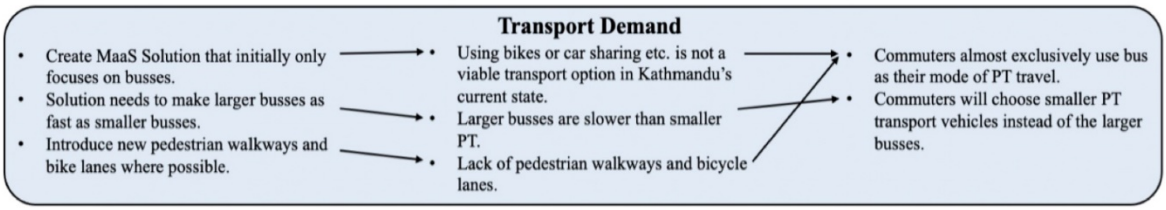
Appendix 1 Cause-Effect Diagram











Appendix 2 Catalog of Objectives

Objective	Remark	Rating
GPS Solutions need to be shareable through standard API.	For a journey planner to be able to integrate all operators, they need to send their locations through a standard shareable API.	(C)
E-Ticketing needs to be shareable through standard API.	This allows for integration into one MaaS platform compatible with standardized data.	(C)
Create an economic incentive for bus drivers of all vehicle types to adhere to regulations.	Can be achieved by looking at bus operators' business models.	(C)
Create legislation enforcing travel data sharing.	Travel data should come in a standardized API format for easy compatibility with MaaS platform solutions.	(C)
Create incentives for small public transport operators to install GPS solutions and share data.	The solution to this could be either a hardware GPS instalment or a smartphone APP solution. The second is the recommended option.	(C)
Enforce time schedules for buses.	This makes a static journey planning available until a real-time journey planner is developed.	(C)
Develop an E-ticketing solution.	The solution can be both a travel card or APP. The solution must be very stable and efficient. Needs to be on par with cash payments.	(R)
Government establishing data responsible entity.	One entity governing all data security, privacy, sharing, and regulation needs to be developed.	(R)
Establish bus lanes.	Establish these in locations where larger busses are caught in congestion.	(R)
Increase the number of large buses.	The number of large buses needs to be able to meet demand. Research the specific average demand and locations.	(R)
ITS solution should only look at buses initially.	This means looking at all types of buses in the public transport fleet.	(R)
Larger buses must spend less time at bus stops.	Larger buses need to be faster, so they can compete with smaller public transport vehicles on speed parameters.	(R)
The solution needs to be PAYG.	PAYG needs to be available through cash and possibly also E-ticketing. Subscription-based is not mandatory to implement from the start.	(R)
Reselling of tickets needs to be viable.	MaaS platforms need to be able to resell tickets. Otherwise, they are limited to booking which reduces platform efficiency.	(R)
The solution incorporates all public transport operators.	Including FNNTE and having them onboard with the solution may very well be the key.	(R)
Introduce pedestrian walkways and bike lanes.	Introduce these in specific locations where many accidents are prone.	(D)
The solution should meet peak-hour demand.	Measure high-demand bus stops and specific demand times and adjust fleet availability accordingly.	(D)
(C) Compulsory (R) Recommended (D) Desired		

Appendix 3 Risk Assessment

Risk	Description	Likelihood	Consequence	Remarks
Failure to implement GPS	Bus operators will not agree to GPS implementation in vehicles.	Small	High	GPS hardware implementation should be free of charge (incurred by government) in order to incentivize all operators to join. Alternative to hardware solution could be smart phone application. Gain FNNTE acceptance for implementation is key.
Failure to legislate mandatory data sharing	Currently no legislation enforces data sharing through a standard API regarding GPS locations and/or time schedules.	Medium	High	Without data regarding vehicle locations and travel times/schedules an ITS cannot contain a journey planner. Authorities should look to the Finnish regulation for inspiration regarding this piece of legislation.
Missing economic incentive	Bus operators and drivers need economic incentives to adhere to all rules and regulations	Medium	High	Without economic incentives to follow regulations an ITS will likely fail due to unreliable services provided by the public transport operators. Therefore, the implementation of an ITS need to analyse how drivers and operators will economically benefit from this implementation.
No Incentive for small vehicle operators to join an ITS	The bulk of the public transport fleet is made up of smaller vehicles. They need to have an incentive to join a potential ITS.	Medium	High	An ITS solution must ensure that the small vehicle operators see economic incentives to join and contribute to the ITS.
Failure to enforce time schedules	Without time schedules, the travel times will continue to behave randomly resulting in ITS journey planners being unreliable.	Medium	High	The commuters will quickly loose faith in a potential MaaS platform if the vehicle time schedules behave erratically. The solution must ensure incentives for the bus drivers and conductors to always adhere to time schedules.
No increase in the number of busses	Overcrowding is a consequence of a lack of supply. More busses can alleviate overcrowding.	Medium	Small	Consequence is small, since this is how the system currently operates. Therefore, commuters will not react negatively to a lack of overcrowding. However, this system should be addressed to improve commuters' views.
Failure to establish bus lanes	Busses are caught in congestion. Bus lanes can mitigate this problem.	Medium	Medium	It is essential that public transport becomes as fast as private transport. This will make public transport a true cheaper alternative. Travel speed is the number one factor of commuters and must be addressed accordingly.
Busses spend to much time at bus stops	Currently busses on occasion spend to much time at bus stops (particularly larger busses). This makes travel time slow and schedules unreliable.	Medium	Medium	As travel speed has been known to be a priority factor, this risk must be addressed. An ITS solution needs to enforce drivers to stay on schedule and this can be done through creating incentives for drivers to adhere to schedules rather than waiting at bus stops and focusing on profit maximization.
Solution does not allow for cash payments	As cash payments is the preferred method of payment an ITS should allow for this method.	Small	Medium	As seen with the inception of the travel card and other E-ticketing solutions, they can fail. The ITS should not be reliant upon E-ticketing alone as this could cause system failure if commuters gain negative view of the platform.
Solution does not include all public transport operators	If the solution does not include all operators, a ITS platform becomes unreliable.	Medium	High	The MaaS platform needs to be trustworthy and show all potential travel option for commuters to trust the platform. Therefore, incentives to have all operators join is essential.