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Analysis of Transport Mode Choice in Kathmandu Valley, Nepal: Lessons from Trondheim, Norway

By

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The undersigned certify they have read and recommended to the Institute of Engineering for acceptance of the thesis report entitled "**Analysis of Transport Mode Choice in Kathmandu Valley, Nepal: Lessons from Trondheim, Norway**" submitted by **Mr. Aashish Adhikari (076/MSUrP/001)** in partial fulfillment of the requirements for the degree of **Master of Science in Urban Planning**.

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DECLARATION

I hereby declare that the thesis entitled "**Analysis of Transport Mode Choice in Kathmandu Valley, Nepal: Lessons from Trondheim, Norway**", submitted to the Department of Architecture in partial fulfillment of the requirement for the degree of Master of Science in Urban Planning, is a record of an original work done under the guidance of Dr. Kirti Kusum Joshi, Institute of Engineering, Pulchowk Campus. This thesis contains only work completed by me except for the consulted material which has been duly referenced and acknowledged.

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ABSTRACT

Transportation Planning is essential as it is a basic foundation of society linked with mobility and several domains of environment and sustainability. An important aspect of urban transportation planning is travel demand analysis, particularly mode choice modeling which helps in understanding the decision-making process which is a need for creating suitable actions for achieving sustainable mobility by creating factors that can motivate individuals to avoid-shift and improve different modes of transportation. This paper uses both quantitative and qualitative methodologies for analyzing how different modes of transportation are used and their relationship with infrastructure which influences the particular mode choice along with studying the relationship between mode choice and land use attributes. A case study approach was taken from where different lessons were drawn. The results can show an analysis of different modes of transportation and their usage with the reason for particular mode selection along with mode shift parameters and the influence of infrastructure on particular mode choice. The research generates different conclusions and implications comparing different modes and can be used as a reference for further research on travel behavior and mode choice.

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076/MSUrP/001

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
BRT	Bus Rapid Transit
CBD	Central Business District
CBS	Central Bureau of Statistics
DCM	Discrete Choice Modeling
DoTM	Department of Transport Management
EC	European Commission
EV	Electric Vehicle
GPS	Global Positioning System
ICT	Information and Communication Technology
JICA	Japan International Cooperation Agency
KII	Key Informant Interview
MCDM	Multi-Criteria Decision Making
NMT	Non-Motorized Transportation
SDG	Sustainable Development Goals
PT	Public Transit
PMV	Personal Motor Vehicle
UN	United Nations
WHO	World Health Organization

LIST OF SYMBOLS

km	Kilometers
%	Percentage
Sq.km	Square Kilometers
^{0}	Degree
’	Minute
”	Seconds

CHAPTER 1: INTRODUCTION

1.1 Background

Transport is a basic foundation of society for the economy as well as fruitful functioning and for people to realize their freedom of movement (European Commission, 2011). Mobility is essential for this process and hence the transportation system lies at the core of Urban Life where people are hugely reliant upon the urban transportation facilities for the movement of people themselves or the movement of goods from one place to the other; generally referred to as Passenger Transport and Freight Transport. Moreover, According to United Nations et al. (2019), more than half of the world's population lives in urban areas as of 2018. Also, the urban population is increasing at a rapid pace and is expected to climb up to 68% in 2050. Hence, the need for transportation facilities will surge as the demand for infrastructure raises with the rise in the urban population.

Additionally, Cities all around the world are in quest for the implementation of a sustainable transport system. They are seeking to create a transportation system that is more efficient using the principles of urban planning as well as reduced reasons for congestion, air pollution, accidents, and emission of greenhouse gases (Gössling et al., 2016). More than ever, there are growing public health concerns and issues related to cities that prioritize automobiles. Since these issues have gotten worse in recent years and are predicted to get worse at an even faster rate in the future, a big overhaul in the transportation system is necessary(Gössling et al., 2016). Moreover, Road space or urban public space is a scarce resource and as the cities grow rapidly, the surge for urban transportation infrastructure also increases creating competition for that limited resource (Zheng & Geroliminis, 2013).

As such, Travel demand analysis and forecasting are done and are the most important aspect of urban transportation planning since it helps to estimate the demand for transportation facilities and services. Generally, Urban travel demand is estimated by creating models that can precisely reflect and simplify the problematic reality (Hidayati et al., 2018). A common modeling approach consists of four main stages and is often called "the four-step mode", namely Trip generation, Trip distribution, Modal Choice Models, and Trip Assignment (Ortúzar et al., 2011). These steps of modeling are iterative in nature and a particular sequence as depicted in the paper may not be followed as such with alterations in sequences like modal choice before trip distribution may be preferred (Ortúzar et al., 2011).

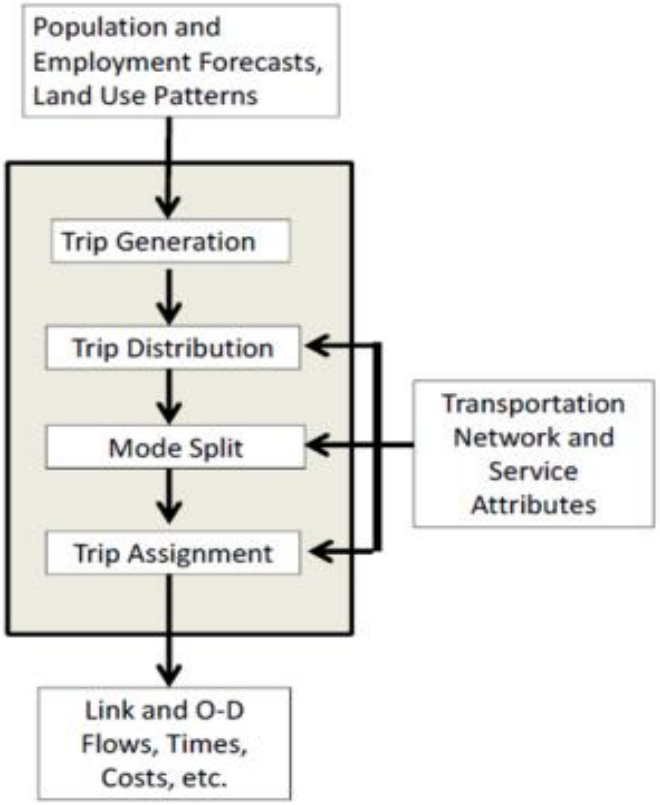

Figure 1.1 Conventional Four-Step Modeling Process (Source: (Meyer, 2016))

This paper was particularly interested in finding the mode split and performing the mode choice analysis; which is the third step or stage in the conventional four-step modeling process where the particular trip generated and distributed in previous steps are allocated to a particular mode of transportation. Mode of Transportation can be referred to as the various ways; particularly medium that a trip can be made from a point of origin to a point of destination and are used to predict the number of trips between the origin and destination pair (Meyer, 2016). Generally, modes and means of transportation can be used synonymously for urban travel; in urban travel available modes of transportation include airways, walking, bicycle, public transits, personal vehicle, Trains, and Trams along with Waterways.

Essentially, the distribution of different trips in different modes of transportation or modeling of mode choice is an integral step of the process in transportation planning since it has enormous policy implications on the use of road space more efficiently and ultimately implications for the general public and environment. Generally, different modes of transportation compete with one

another for the road space resource and thus urban public road spaces are a contested space as well as a scarce resource (Gössling et al., 2016). Moreover, the different modes of transportation have additional requirements or facilities such as parking, sidewalks, dedicated lanes, stops, and other many such infrastructures for the completely effective functioning of that particular mode of transportation in addition to the road space (Gössling et al., 2016). Hence, it is crucial to decide to invest in or to emphasize modes having desired long-term consequences in terms of road space management as well as infrastructural investment policies.

Additionally, different methodological tools have been developed for the assessment of modal choice, Discrete choice modeling (DCM) is largely used where the individuals or trip makers are provided with mutually exclusive travel alternatives where general assumptions of utility maximization principle are followed(Duleba et al., 2021). DCM being reliant on the utility maximization principle requires intensive data collection and observation along with difficulty in the measurement of utilities that are not immediately observable and measurable(Duleba et al., 2021). Moreover, several kinds of literature Banai-Kashani (1989), Duleba et al. (2021), Kumar et al. (2015), and Šinko et al. (2021) emphasized different forms of Multi-Criteria Decision Making(MCDM) Techniques for the modal choice modeling in different forms.

This research presents the comparison of different mode choices available to the trip maker and explains the reason behind the particular mode choice. This is to highlight the fact and behavior of urban transportation efficiency due to particular mode of transport as compared to others and to emphasize an Avoid-Shift-Improve framework from the unsustainable mode of transportation to a more sustainable mode of transportation and to find the driving or motivating factors that can create such a shift or change in travel behavior.

1.2 Study Area

The study area for the research was Kathmandu Valley, the capital city of Nepal. Kathmandu Valley is situated in Bagmati Province and being the capital is the center of developmental activities. It serves as the nation's principal administrative and political hub, a major entry point for tourists, and a key commercial area. Kathmandu Valley constitutes of 3 districts including Bhaktapur in the East and Lalitpur in the south. Kathmandu, Lalitpur, Bhaktapur, Kirtipur, and Madhyapur Thimi are the five municipal urban centers that make up the valley. The Bagmati river system drains the valley and geographically, the valley is located between 27°31′55″ and 27°48′56″ North latitude and 85°11′11″ and 85°31′52″ East longitude from 1,100 to 2,700 meters above sea level, the valley's height creates a complex terrain in a constrained geographic area. The total area of the valley

covers 899 sq. km. The total population of the valley is estimated more than 3 million with an average of more than 3300 people living per sq. km (CBS, 2021). The population of the valley is increasing at a rapid rate due to immigration from other parts of the country for better opportunities and prospects provided by the valley.

In addition to the population growth, there has been an increase in registered vehicles, including motorcycles, from 150,000 to 570,000 over the past ten years. This has caused traffic congestion in the city. Although the Nepali government is working to reduce traffic congestion by improving the road network and infrastructure still traffic infrastructure seems insufficient to withstand the traffic's growth rate(JICA, 2017). Moreover, air pollution is a major public health risk as the concentration of $PM_{2.5}$ is about five times higher than guidelines prescribed by World Health Organization(WHO) (WHO, 2018).

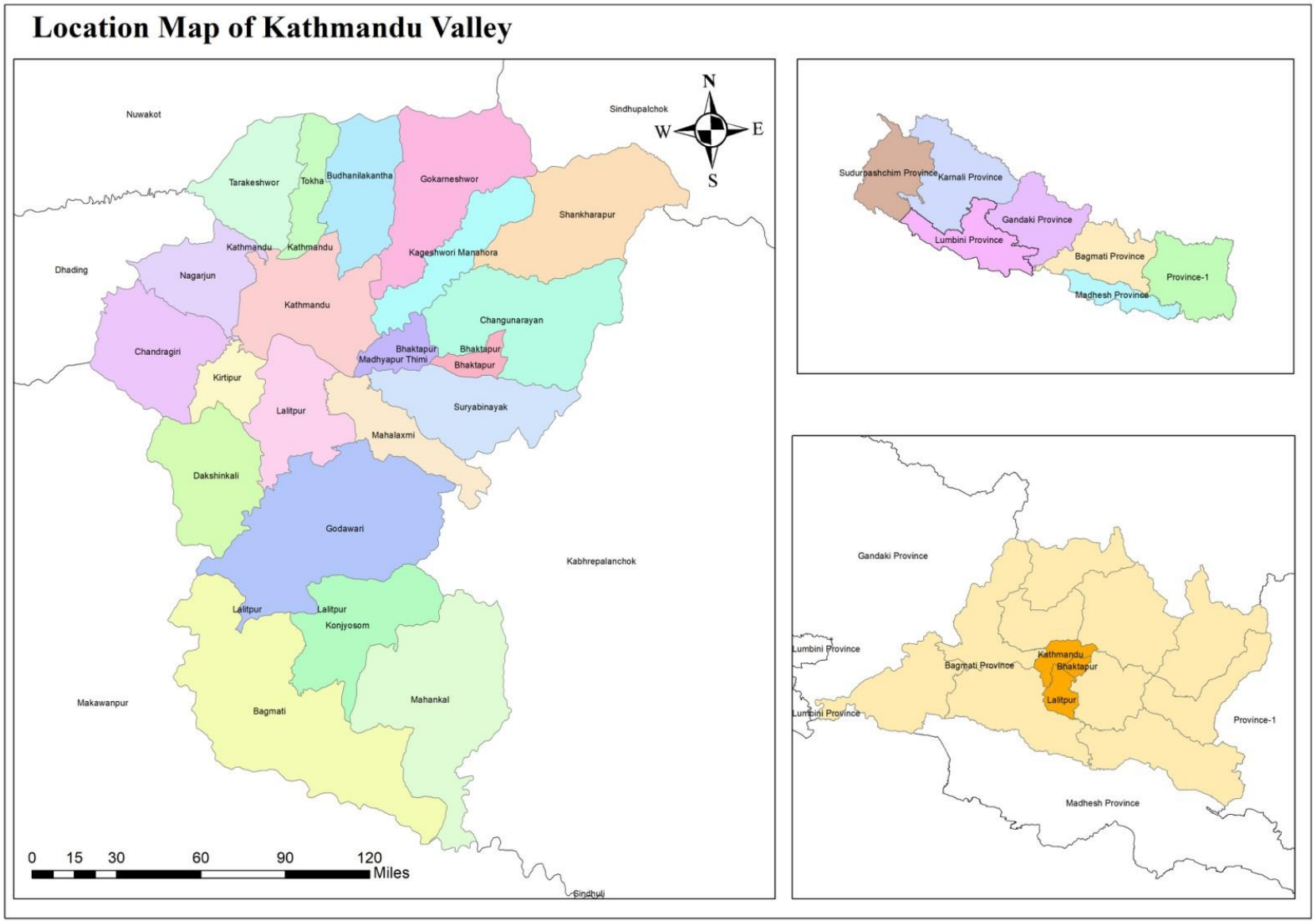

Figure 1.2Study Area Map

1.3 Need for Research

Mode choice is dependent upon various socio-economic behavior, the character of the trip maker, and infrastructural amenities available for the mode choice. Moreover, being an important step in four-step modeling is crucial to analyzing and forecasting current and future transportation demands (Ortúzar et al., 2011). Also, due to these factors, the urban transportation system is reliant on mode choice modeling which helps in understanding the decision-making process which is a need for creating suitable actions for achieving sustainable mobility(Duleba et al., 2022). As such, an assessment and analysis of the mode choice can state the differences in the usage pattern of different modes and also reveal the underlying reason behind the particular choice of mode. The factors that can motivate individuals to switch from one mode of transport to another mode also can be assessed which is a huge need since the auto-centric development, as well as deteriorating use of public transit, has been correlated to different sorts of urban transport-related problems and public health-related problem (Iamtrakul & Zhang, 2014). Hence, there is an emerging need for performing research to create an appropriate transportation policy to address the problem due to traffic in the urban realm.

1.4 Importance of Research

As this research is related to transportation mode choice and while operating and developing urban transport systems, increased attention shall be provided to the behavior of the commuters. Also, the mode choice has a substantial impact on traffic, emissions, and delays over time(Duleba et al., 2021). The research findings will help in assisting the policymakers, urban planners, and transportation planners in addressing the policy issues and the direction that the policy shall take to mitigate the problem at hand. More specifically, the research is important to explore the urban transport policy measures that need to be taken to direct the city towards sustainability in terms of urban mobility. Further, the research is also important to realize goals related to mobility which are in turn important for the Sustainable Development Goal (SDG) envisioned for 2030 relating to SDG goal Number 11 of Sustainable Cities and Communities along with other important SDGs.

1.5 Problem Statement

The core prerequisite of a sustainable city is the urban transportation planning system. The alarming increase in urbanization, as well as demand for urban transportation and auto-centered development, is causing a massive surge in demand for urban transportation infrastructure, leading to an increase in terms of frequency of urban travel and distance traveled (Thondoo et al., 2020).

As such, uncontrolled urbanization and automobile-based development strategies are the major causes of the phenomenon of urban sprawl and suburbanization which are in turn increasing commuting distance and reducing land-use efficiency and ultimately leading to the higher emission of harmful gases that pollute the overall environment of the city leading towards public health challenges as well as climate change as a whole (Iamtrakul & Zhang, 2014).

Moreover, the urban transport planning system is dependent upon the transport mode choice, so it can be considered a crucial stage of demand analysis. Mode choice affects the general efficiency within the urban mobility itself, focusing more on the transport modes like public transit, walking, and Non-motorized Transport (NMT) which in turn creates fundamentals for lowering traffic congestion and public health issues related to the transportation system (Ortúzar et al., 2011). Resource consumption, as well as the urban space requirements for the transport functions and mode, are dependent upon the mode choice available to the trip maker. Hence, it is crucial to develop and use models related to the mode of transportation and the reason behind the selection of the particular mode of transport itself.

Additionally, although various types of research are concerned with the mode choice modeling research towards the assessment and analysis of the different modes is rare and the literature also lacks the assessment of the reason behind the particular mode choice. As such, various pieces of literature ((Ortúzar et al., 2011); (Duleba et al., 2022)) imply the significance of model development and application decision that represents a travel attribute that influences individual mode selections. Hence, there is a research gap where mode choice and reason assessment has been performed.

The research is essential to academics, governments, and transportation agencies to learn the mode choice related to work-based trips and subsequently formulate urban transport policies. Also, the research findings can be specially used in finding the reasons for the difference in mode choice along with the reason which may be used for further academic and professional investigations and practices.

1.6 Research Purpose

The main objective of this research is to assess and compare the transport mode choice available to the trip maker and extract the criteria of the reason for the particular mode selection.

For that, the following objectives shall be met.

i. Analyze alternative mode choices available to the trip maker and study how a particular mode is used.

ii. Assess and Compare the Infrastructural Aspects influencing the particular Mode choice of the trip maker.

iii. Relate the mode choice and attributes of land use pattern of the city

1.7 Scope and Limitation

Urban Transport Planning is not only concerned with passenger transport but a major part of it contained within the freight transport as well as other trips related to logistics but the scope of this paper, in particular, was only concerned with passenger transport and the trips people make in respect to this urban travel.

Several studies relate mode choice with transportation psychological factors and modal shift with travel habit and behavioral change, but this paper was limited in scope to view mode choice as a psychological phenomenon and attribute related variables in transport mode choice modeling.

CHAPTER 2: LITERATURE REVIEW

The research was an approach to compare different mode choices that were available within the urban transportation system for the trip maker for traveling from point A to point B and discuss the reasons that are affecting the choices of the particular mode of travel.

Here in this paper, the approach to literature review of scholarly sources on the topic has been discussed in several headings. Firstly, the relevant topics related to mode choice and the criteria of reason or the factors affecting mode choices were discussed. Then premises were setup for the study where modal shifts were studied; the premise created studied the relation of infrastructure to the mode choice and how infrastructure facilities can influence the decision-making for use of a particular mode of transportation.

2.1 Mode Choice

Modal Choice is the distribution of trips over the various available transportation modes available to the trip maker. They are used to predict the percentage of trips that are made using the mode of choice by the end-user (Meyer & Miller, 2001).

Schiller et al. (2010) classified the transportation modes or to be precise major in-town modes in order of importance for sustainable transportation as Walking, Bicycling, Public Transportation or transit (PT), and Personal Motor Vehicle (PMV). Here, the authors defined walking as the most sustainable which included walking assistance and other mobility assistance devices such as wheel chairs also bicycling as the second sustainable choice which included other variations like three-wheeled versions. The author defines public transit as consistent with buses, rails, shuttle services, and nonetheless taxis as well(Schiller et al., 2010). Finally, personal vehicles included all two-wheelers and automobiles used for personal purposes.

Moreover, Schiller et al. (2010) insist that urban travel is rather complex because they include not a particular mode of transportation for a particular journey from point A to point B, emphasizing that several modes of transportation may be used to reach a destination like use combination of modes which is defined by the authors as intermodal modes of travel. Further, another important concept authors highlight is the ability to choose among several modes of transportation for a trip, highlighting the importance of penetration or accessibility of different modes of travel.

2.2 Factors affecting Mode choice

The study of mode choice can be done by studying various factors that affect or interact with mode choice in particular. Hence, several authors like Ortúzar et al. (2011) and Schiller et al (2010) agree that the modal choice is dependent upon various attributes such as the characteristics of the trip maker, characteristics of the journey, and characteristics of the transport facility. However, besides infrastructure, travel and trip characteristics and functional characteristics, Schiller et al. (2010) reckon that land use, socio-economic distribution as well as environmental consideration play an important role in affecting mode choice, so as suggested by the authors these factors shall be studied altogether to study mode choice interactions with each other.

2.2.1 Characteristics of the trip maker

The characteristics of the trip maker include the household structure, income, car availability/ ownership, and other associated attributes that are linked with the trip maker in general (Ortúzar et al., 2011). Corpuz (2007), states through his research that accessibility or availability of a vehicle have a greater impact than the socio-economic attributes since choices are unavailable to the particular trip maker creating lower use due to lack of access. The research further classified socio-demographic characteristics between two groups and analyzed them accordingly, the group that had the tendency to use cars more often and the group that tended to use other means of transportation (Corpuz, 2007).

2.2.2 Characteristics of the journey

The characteristics of the journey can be explained using the trip purposes (work, shopping, recreation, etc.); which is generally sensed as different modes of transportation may be used to go to college and for making an important business trip. Corpuz (2007) also states that mode choice is dependent upon the trip purpose as the author found that car use was highest for work-related and public transport was mostly used for educational and commuting-based reasons.

Additionally, the character of the journey can also be influenced by the time of the day or seasonal variations; A example can be the use of cars instead of bicycles in the rainy and stormy weather, at a particular time of the particular season. Moreover, different articles such as (Corpuz, 2007; Ortúzar et al., 2011) define the time of the day as the distribution of travelers by different periods where mode choices are different. Corpuz (2007), stated that car usage was less attractive during peak office hours and when congestion is at peak and use of public transit is attractive to the users as a mode choice for the particular instance.

2.2.3 Characteristics of Transport Facility

Nonetheless, characteristics of the transport facility also determine the mode choice, Ortúzar et al. (2011) explain this relationship in terms of quantitative factors and qualitative factors.

The quantitative factors of transport facility influencing the mode choice are the components of travel time, monetary costs including tolls, fuels, operating cost, and reliability as well as regularity of service consistent within a particular mode of transportation (Ortúzar et al., 2011).

The qualitative factors that are associated are difficult to measure in practice which can be attributed to comfort and convenience, safety and security, and other similar features related to different modes of transportation themselves (Ortúzar et al., 2011).

Similarly, Walker (2012) states these factors simply with seven types of demands or factors affecting transit services as a mode choice:

1) It takes them where they want to go,
2) It takes them when they want to go,
3) It is a good use of their time,
4) It is a good use of their money,
5) It respects their safety and comfort,
6) They can trust it,
7) It gives them the freedom to change their plans,(Walker, 2012)

The author further analyses how transit serves them concerning stops/stations, connectivity, frequency, span, speed, fare, civility, reliability, simplicity, and presentation. A major finding is that based on desired mode and service provided, the users switch between the modes of transit that best suits the current situation. However, Walker (2012) argues that travel time is one of the most critical elements of a passenger's decision on whether to use the transit routinely.

Moreover, EN 13816: (2002), the European standard for transportation and public passenger transport defines the assessment of quality criteria of public transportation as being based on a large number of criteria about the customer view of the service provided, it has been stated in 8 headings as, Availability, Accessibility, Information, Time, Customer Care, Comfort, Security, and Environmental Impacts. The report emphasizes measuring and ensuring continuous improvements in transport quality and performance criteria. Similar research done by Ngoc et al. (2017) by separating consumer point of view and operator's point of view towards the variables described by European standards revealed that safety, security, and stop comfort was rated as the most important

criteria by motorcycle users while punctuality, frequency, bus comfort, cleanliness, and Accessibility were ranked most important criteria by bus users (Ngoc et al., 2017).

Also, the analysis of the factors affecting the mode choice may be particularly done in described headings but the land use phenomenon shall also be discussed along with environmental consideration. However, Corpuz (2007) states that environmental reasons are less significant in the choice of public transport but are an emerging area of interest for different research and car users are particularly interested in speed or time of travel as well as comfort and convenience with the flexibility of the trip making itself.

2.3 Mode Choice and Land Use Relationship

A review of various works of literature done by Gössling et al. (2016) indicates how cities have been shaped concerning the mode of transportation used by people historically. The paper emphasized the turn of 20th century US cities where major space allocation was to horse-drawn vehicles, pedestrians, and push card vendors while after the 1930s the street became much more accommodating to cars, which essentially created urban space management more reclined towards car-centric development which ultimately created an individualized transportation system giving rise to urban sprawl and other urban transport related problems(Gössling et al., 2016). Nonetheless, the paper contradicts that with the turn of the 21st-century concept of the 'New Urbanism' movement urban areas like Singapore, Copenhagen, Zurich, etc. have tried to create a sustainable mode choice decision via reconnecting the land use and transportation system as a part of the urban planning process. Hence, the Land use relationship and interaction between mode choice shall be studied as well(Gössling et al., 2016).

Also, by correctly integrating land use and transportation planning, cities may reduce their reliance on cars and the associated energy usage (Schiller et al., 2010). Urban policies that focus on modal shift and compaction are seen as crucial for reducing energy consumption in the transportation industry. Cities can become more compact or transit-oriented by encouraging the actors in the urban system to alter their behavior, such as relocating the sites of offices for businesses and households and enhancing transportation options for a wider range of travel needs (Schiller et al., 2010).

Additionally, Ortúzar et al. (2011) review several papers in their book highlighting the importance of land use and transportation interaction modeling, the authors suggest that the importance of transportation and land use can be described as transport strategies having implications on accessibility and can also create a disruption in transport patterns leading to impact on

transportation system itself. The author reckons that transportation system and land use models are almost inseparable and both modeling techniques shall be looked for while performing modeling for any of the system variables (Ortúzar et al., 2011).

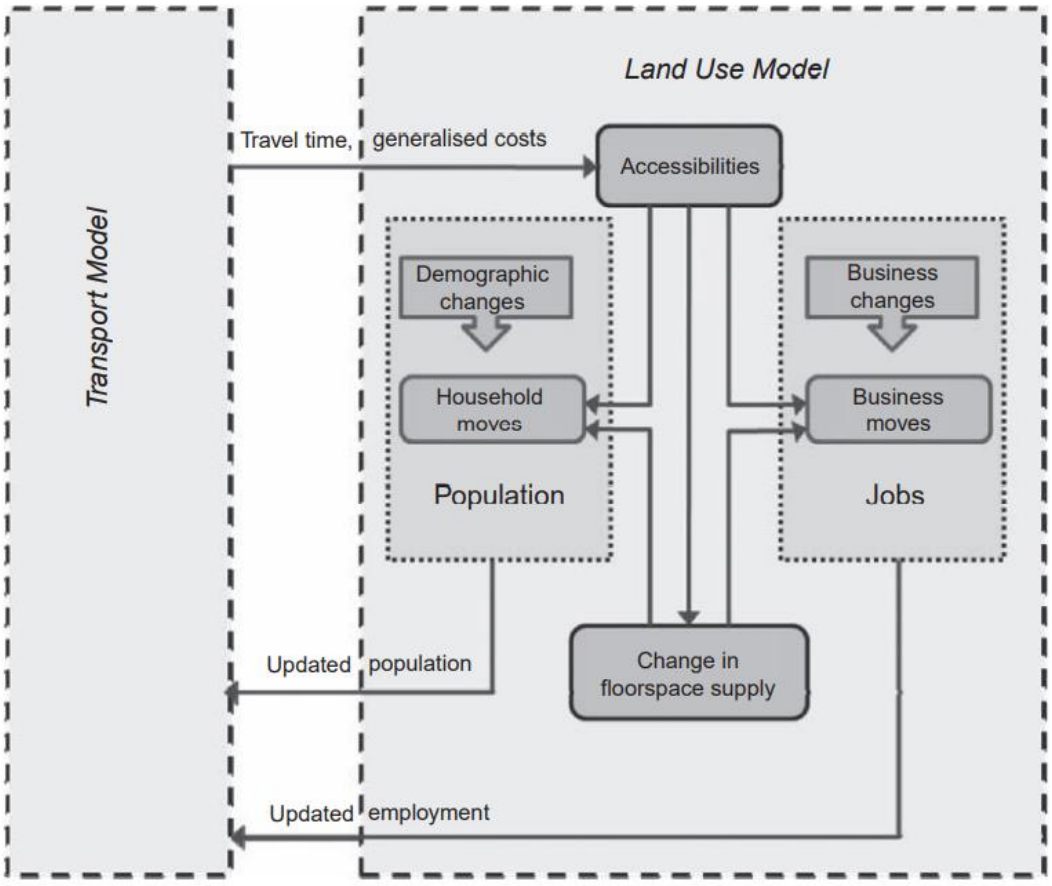

Figure 2.1 Mode Choice and Land Use Relationship (Source:(Ortúzar et al., 2011))

As depicted in Figure 2.1, Ortúzar et al. (2011) explained that the transport model has a significant impact on time travel as well as generalized costs which in turn affects the accessibility of the transportation facility which can create demographic as well as business changes as discussed by the authors. The land use models and accessibilities parameters create a change in floor space supply accompanied by household moves and business or employment moves which creates the requirement in changes regarding the transportation model and which in turn repeats the cycle and interrelated action in the relationship between the land use model and transportation model (Ortúzar et al., 2011).

Meurs & Haaijer (2001), tried to explain the relationship between spatial structure and planning of the residential environment. The paper tried to explain mobility and choice of mode of

transportation and their impacts on traffic management and significance on the planned environment. The authors demonstrated that mobility and the choice of transport modes are directly linked with the spatial environment and its extent of it. The combined impact of the residential environment's characteristics was by far the biggest when it came to excursions made for regular and other shopping (more than 30%). The impact on journeys made for social, recreational, educational, alone or with kids, and commuting purposes was less significant. However, the paper highlights that land use particularly has great importance on mobility (Meurs & Haaijer, 2001). Also, Tyrinopoulos and Antoniou (2013) reviewed different papers related to land use and spatial planning and the role related to factors affecting the mode choice. The authors reviewed similar papers where neighborhood and private vehicles were aggregated about mode choice. The paper highlights the importance of connectivity and accessibility as major factors that shall be considered for assessing the relationship between land use and mode choice.

Hence, for properly assessing the factors affecting the mode choice and in particular, factors related to land use, the interconnectedness of the land use or proximity of residence and proximity of working places or places for job creation shall be assessed. Shopping trips, as well as study trips, also have a significant impact on the mode choice reasons.

2.4 Mode Shift

As mentioned, different parameters related to journeys affect the decision of individuals to select a particular mode of transportation. This section explains how the influence of infrastructure or particularly new infrastructure facilities on shifting or choosing a new mode of transportation occurs as stated in this research.

2.4.1 Influence of Transport Infrastructure

Pritchard (2019), studied the influence of urban transport infrastructure on bicycle routes and mode choice where the author studied the effect of interventions, particularly about new infrastructures like the dedication of lanes, safety and comfort, and magnitude to create a modal shift or habit transformation towards bicycle travel. The travel behavior study was done in an environment where other casual influences beyond infrastructure such as travel costs, marketing, social norms, safety, convenience, and reliability were controlled. The study used an analytical framework where descriptive statistics, literature review, and geospatial tools were used to find the data related to modal shifts. The findings of the paper suggest that mode change is a function of intervention in infrastructure but also argue that the intervention shall be of a larger scale to be more evident and also added that the influence is evident after a long time frame(Pritchard, 2019).

Additionally, a similar team of Vasilev et al. (2018) studied the impact of redistribution of space from private motorized vehicles to sustainable modes of transport where the case of Trondheim, Norway was studied. The reallocation of a particular road stretch was done by creating a bypass tunnel and allocating it to bicyclists and pedestrian-friendly infrastructures with concrete barriers and painted horizontal lane markings. The travel questionnaire survey was performed by the authors where major findings included the average length of the project utilized by cyclists on common journeys doubled and suggested that the intervention was highly attractive to a bicyclist in the local area (Vasilev et al., 2018). Hence, the paper concluded that the infrastructure intervention like redistribution of spaces had a considerable impact on the travel behaviors of the users in terms of both frequency and choice of active transport modes, along with route and mode shift (Vasilev et al., 2018).

Contrastingly, Heinen et al. (2017) performed four-year quasi-experimental research where a cohort study was performed to investigate the intervention studies in the built environment as a motivating factor for modal shift from car travel towards active travel. The intervention that was studied consisted of an opening of a guided busway with a path for walking and cycling in 2011. An annual questionnaire between 2009 and 2012 was performed about the travel to work recorded. The findings were classified as different patterns of change found where the new intervention provided had mixed outcomes and enumerated as (1) no change, (2) a full modal shift, (3) a partial modal shift, (4) non-stable but patterned behavior, and (5) complicated or random patterns(Heinen et al., 2017). Although a minority of participants showed a full modal shift, some participants reported a partial mode shift while others showed no change at all. The paper concluded that large diversity of change can be observed as an influence of particular infrastructural interventions but it has to be noted that these travel behavior patterns were not specific and did not produce only full modal shifts(Heinen et al., 2017).

2.5 Past Studies and Research Gap

Nakarmi and Singh (2019) performed a similar study where they studied different transport facilities related to sustainable transportation in Kathmandu valley intending to determine sustainable infrastructure related to public transportation. The authors in the paper analyzed quantitative transport facilities such as road condition, condition of the bus, bus stops, footpaths, inclusion friendliness of the design as well as other qualitative analyses regarding the services of public transportation such as opinion surveys related to reliability, safety, and security as well as information flow. Further, the analysis of information and communication technology was also

performed. The findings of the paper found different variables of sustainable infrastructure related to public transportation namely, Bus stops, buses, roads, and Communication were put forth as the independent variables for smart infrastructure. Further, Dependent variables were analyzed to be reliability, safety, and security as well as accessibility (Nakarmi & Singh, 2019).

Similarly, Bajracharya & Shrestha (2020), conducted a case study in Kathmandu valley where energy consumption by transportation was measured in the base scenario year 2017. The analysis was performed where two scenarios were created one a hypothetical scenario and another survey was performed for the willingness to shift from a private mode of transport to a Bus rapid Transit System. According to the results, 55.6% of car owners and 72.2% of motorbike owners were willing to switch to public transportation if the service is adequate in terms of punctuality, comfort, and safety. The findings indicate that a 90% shift from private to BRTS can reduce annual transport energy consumption by 62 % on trips along the zones with access to the service, which may be difficult to achieve. However, as per the willingness to shift scenario, the reduction can be up to 44 % in energy consumption due to the urban transportation system (A. Bajracharya & Shrestha, 2020).

Nonetheless, Prajapati et al. (2020), performed research where public transport accessibility and its implications on Energy and the Environment was carried out in the case area of Kathmandu Valley. Accessibility in the paper was described as the physical access to the transit lines and geographical coverage reachable within a given travel time budget was analyzed by Geographic Information System. A GTFS data set was generated for the bus network creation where the bus stops, frequency of service, and service operation time based on the GTFS data were calculated. The finding showed that service optimization provides supply based on demand. It thus reduces unnecessary traffic volume reducing fuel consumption even without the need for massive investment. The scenario analysis showed that a reduction of 60% emissions can be obtained with a proper schedule combination in peak and off-peak hours (Prajapati et al., 2020).

2.6 Summary and Reflection

From the literature review, different reflection was done on how the specific objectives and lastly the main objective can be reached. The literature review was able to provide a strong theoretical foundation for the data collection, for which the following major and the specific criteria were sorted out. For the process of addressing the first objective, the analysis of different modes of travel shall be studied where the usage patterns along with the trends that different modes of transportation are following were the main requirement. The framework for data collection for the case shall be

to study the mode availability or ownership of different modes available to the trip maker. Secondly, for studying the infrastructural aspects of the modes of transportation, the framework also may be divided into two parts, first study of characteristics of transport facilities where the specific criteria may be grouped as the qualitative and quantitative framework. Quantitative data such as travel time and economic perspective can be gained by looking at the monetary cost related to different modes while reliability, as well as regularity of services, are one of the most important factors to be considered. Moreover, comfort, safety, and comfort may be assessed by assessing different qualitative indicators.

The urban transport infrastructure like the condition of road infrastructure, vehicle characteristics, majorly the indication of the presence of priority lanes and dedicated lanes also shall be studied under the heading, while parking, terminal, hold positions along with stops may be studied for a better understanding of the topic.

Finally, different attributes of land use and mode choice such as journey length and mode choice interconnectedness as well as the accessibility parameters were added to remain within the framework for the accomplishment of the third objective related to connecting land use and mode choice.

This can be highlighted by the relevance shown by literature as shown in table 2.1.

Table 2.1 Framework for Data Collection

S.N	Major Criteria	Specific Criteria	References
1	Characteristics of Trip Maker		(Corpuz, 2007; Ortúzar et al., 2011)
		Mode Availability/ Ownership	
2	Characteristics of the transport facility		(Corpuz, 2007; EN 13816:2002, n.d.; Ngoc et al., 2017; Ortúzar et al., 2011; Walker, 2012)
	2.1 Quantitative Factors		
		Travel Time	
		Monetary Cost	
		Reliability and Regularity of Service	
	2.2 Qualitative Factors		
		Comfort	
		Safety and Security	
2	Characteristics of the Urban Transport Infrastructure		(Heinen et al., 2017; Pritchard, 2019; Vasilev et al., 2018)
		Road Infrastructure	
		Vehicle Characteristics	
		Dedication of Lanes	
		Parking/Terminals/Hold Positions	
		Stops	
3	Land Use Relation		(Gössling et al., 2016; Meurs & Haaijer, 2001; Ortúzar et al., 2011; Schiller et al., 2010; Tyrinopoulos & Antoniou, 2013)
		Journey Length and Mode Choice	
		Accessibility	

CHAPTER 3: RESEARCH METHODOLOGY

This section depicts the general principles and philosophy which underline how the investigation shall be carried out in the particular context of this research and how the validation of the knowledge generated be done. The research methodology follows from the epistemological position which is identified by defining the ontological assumption related to the research itself which is based on the paradigm under which the research falls. Finally, different methods and sources of data are discussed.

3.1 Research Paradigm

The paradigm was chosen through a process known as "selection by rejection". As a result, different paradigms were discussed, along with reasons why certain paradigms couldn't be used in this study. In positivism, the researcher's role is limited to data collection and objective interpretation, and it is based on complete understanding, experimentation, and observation (Howell, 2012). Because positivism is limited to dealing with a single reality and the natural world, paradigm shifts from positivism to post-positivism occur. The post-positivist paradigm developed from the positivist paradigm and is concerned with reality's subjectivity, moving away from the logical positivists' solely objective stance. Within the study process, the pragmatic paradigm means combining data collection techniques and data processing procedures(Howell, 2012).

The study examined different alternatives and criteria that could be assessed or defined to compare and contradict the modal choice of trip makers. Here the post-positivism in the paradigm could be seen since the criteria set were not objectively true for every research hence the concept of singular and hard and fast reality could be rejected as a whole. Also, the view of the different informants and respondents would be taken into account which certainly had different views towards different criteria put in front of them.; so, the research also could be seen to fall under the constructivism paradigm because people rated different factors differently based on their constructed realities.

The ontological claim of this research was that the mode choice modeling of transport choice and the reason behind the selection can be measured based upon different criteria which were extracted concerning the literature review.

The epistemological position of the research was that knowledge /information could be perceived from measurements of quantitative data regarding different criteria. The valid source of knowledge for this research could be generated through the measurement of parameters that affect the mode choice behavior of the trip maker.

3.2 Research Methodology

This research was majorly concerned with the mode choice in transportation and the reason behind the particular mode selection, the research problem was focused on describing the characteristics of the mode choice phenomenon and gaining more understanding of the reason behind people's choice of that particular mode of transportation over other available to the particular trip maker. Hence, the research problem demanded both qualitative data and quantitative data, meaning that the mode choice phenomenon could be better understood by quantitative data since it is an objective reality and can be measured objectively in nature. Contrastingly, the reason behind a particular mode selection was subjective and should be assessed qualitatively, interpreting the understanding into narrations and via case studies as well as participant observation.

The methodology for the research started with the literature review process from which a broad problem identified was and narrowed down to the scale of the research and hence the research problem was formulated. The research through various literature reviews devised a methodological flow where firstly analysis of travel alternatives available to the trip maker was done extensively which was then assessed in terms of different infrastructural criteria discovered through the literature review process where the research was able to find different major and specific criteria for the assessment and data collection. Different data collection techniques were applied, various methods were followed and several sources of data were used to reach the data analysis and findings phase of the research. The summarization of various steps involved is represented in chart 3.1 which shows that every step of the research was guided by past research and literature review.

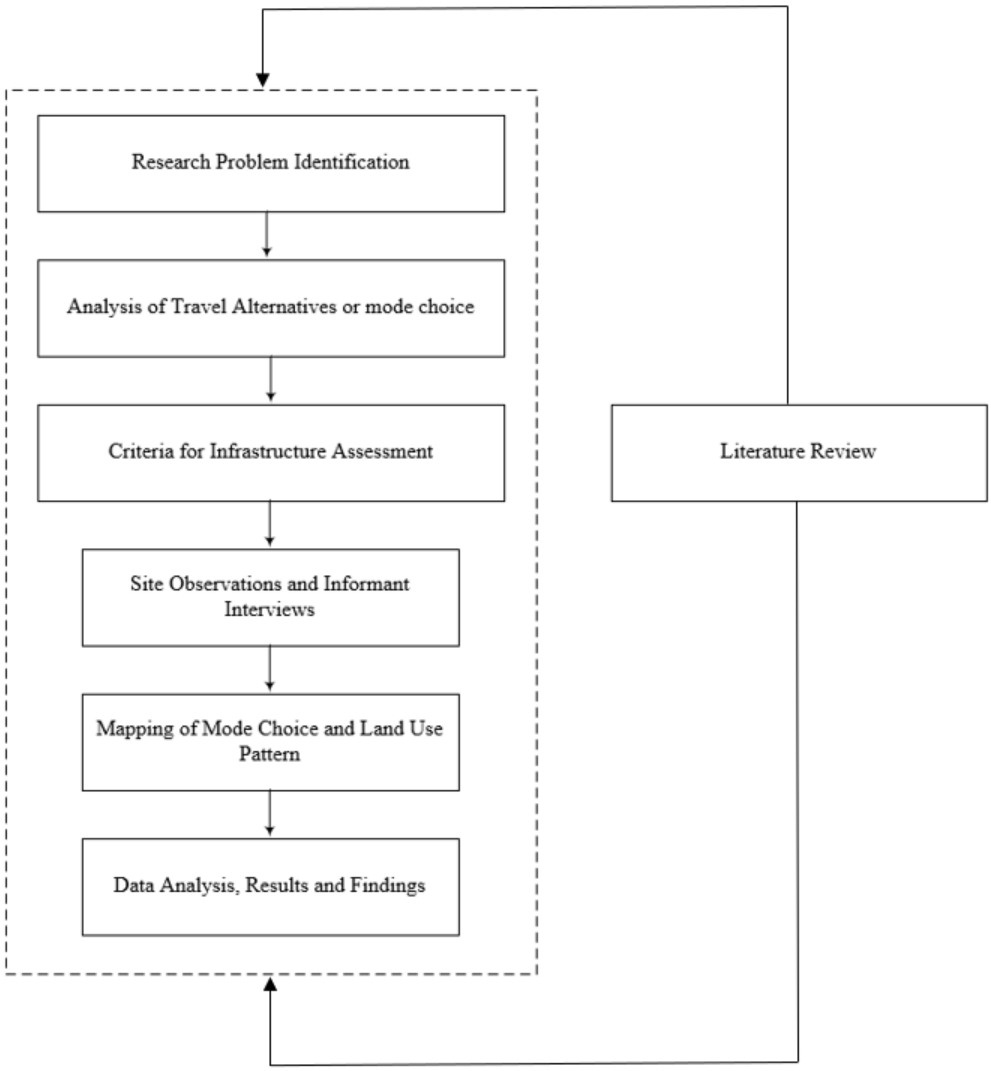

Figure 3.1 Methodological Flow Chart

3.2.1 Methods

Several methods including literature review, participant observation, and interviews along with case study were applied to accomplish the objectives set for the research.

3.2.1.1 Literature Review

The importance of literature review has been highlighted in chart 3.1 where from the research problem identification to the final stages of data analysis and discussion, past scholarly articles, books, and other literature relevant to the topics were searched and followed.

3.2.1.2 Participant Observation

Data collection in this research was mostly done through the technique of participant observation where different data collected like photographs, field problem analysis, and analysis of the actual problem can do through immersing into the setting while taking notes and/or recording the important findings (Kawulich, 2005). A checklist was prepared where different features related to the site, physical infrastructure, and other parameters related to research were extracted.

3.2.1.3 Interviews

Another method followed involved the process of taking interviews with the key people who have adequate information regarding the research parameters required by the author, which are qualitative and in-depth interviews with people in the community. Different such people were identified and semi-structured interviews with those key informants were taken, generally referred to as Key Informant Interviews (KII).

3.2.1.4 Case Study

A case study as a research method was used in this research where two cases particularly, Kathmandu and Trondheim were taken and comparison, contrasting, and/or supporting evidence were created for different criteria through which research findings and discussions were made.

3.2.2 Data Sources

The primary data for the research was extracted from the methods followed by the research but utmost care was given while extracting data from the secondary sources. The validity and reliability of the data source were clearly understood and the data were extracted accordingly. Wherever, possible government reports, highly indexed journal articles, and reputed books were considered the best ways to collect secondary data.

3.3 Research Setting

The research is based on two areas particularly, the study area of Kathmandu valley, Nepal, and the case area of Trondheim, Norway.

3.3.1 Case Study

The case study area for this research is taken as Trondheim, or administratively Trondheim municipality in Norway. The Trondheim municipality lies in Trøndelag county, 1000 km north of the capital city Oslo in Norway. The city has an area of urban settlement of 58.61 sq. km. and a population of 191,771 (Statistics Norway, 2021). The city is situated where River Nidelva flows through the middle of the city and meets Trondheim Fjord with various harbors.

The city of Trondheim does not have an intra-city railway network but is connected via railway networks for intercity travel. The city is facilitated by a strong public transportation network which includes both buses as well as tram facilities.

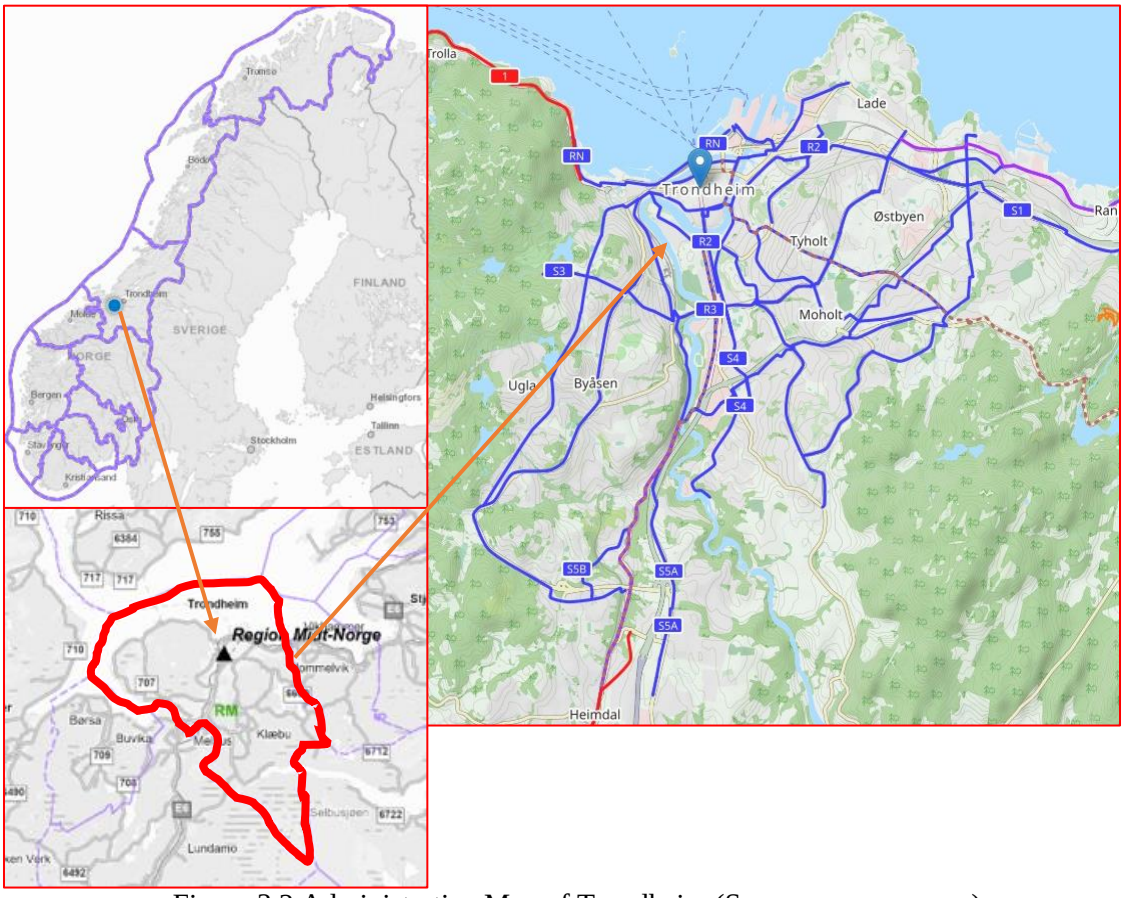

Figure 3.2 Administrative Map of Trondheim (Source: www.nve.no)

3.3.2 The basis for Drawing Lessons

The comparison of two cities with different contexts and different scenarios would provide different results and discussions but the need for comparison existed due to the followings scenarios as;

- The city of Trondheim recently signed an agreement with the state called a "zero growth target" in which the city secured more money from the state in return for passenger car traffic not increasing. Passenger transport must grow by using public transport, cycling, and walking. Greenhouse gases must be decreased, passenger car traffic must not increase and traffic in the metropolitan area must flow to protect the environment.
- The city of Trondheim does not have an intracity railway network but is serviced by the connectivity of public transportation same as Kathmandu valley
- The area of urban settlement in Trondheim is similar to Kathmandu's metropolitan city.

Hence, the validity of comparison exists along with learning lessons from Trondheim to strategies adopted for creating the desired stature.

CHAPTER 4: RESULTS AND FINDINGS

4.1 Characteristics of Transport System in Kathmandu Valley

Road transport is the major mode of transportation dominant in Nepal for both intercity as well as the intracity movement of people; while the majority of intracity traffic is still contributed by private vehicles(Prajapati et al., 2020). The Department of Transport Management (DoTM) keeps a record of all the vehicles registered in the country so the analysis is based on the data collected by the department itself.

Similar to the whole nation, Kathmandu valley has a dominant system of road transportation networks mostly shared by private motorcycles followed by four-wheelers private cars, jeeps, and vans. The share of total modes of transportation in Bagmati is depicted below. Though the data represents a cumulative number of vehicles registered in different years(DOTM, 2019), the data does not consider the number of vehicles removed from the road.

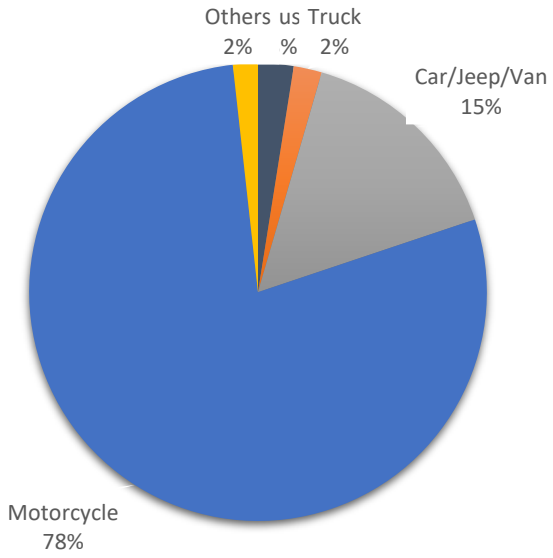

Figure 4.1Share of Transport Modes in Bagmati Zone 2016/17

The pie chart depicts the highest share of 78% in total samples of 1042855 to be represented by motorcycles. The public transport system of the valley is generally owned and operated by private companies, a total share of 3% can be seen to be contributed by Public Buses in the province. The DoTM did not have records for the number of other modes of transportation such as electric vehicles separately as well as for bicycles and other non-motorized vehicles. Nonetheless, the data is generated for the whole of the Bagmati Zone but a fair representation and share of Kathmandu valley was found present in the data

4.1.1 Modal Share/Usage in Kathmandu Valley

According to the data collection survey performed by the JICA in 2012, the total number of trips generated in the Kathmandu valley was approximately 34 million. The average number of trips made by one person in one day was found to be 1.409, meaning people nearly make 1 and a half trips daily in the Kathmandu valley(JICA, 2017).

Walking had the highest share among all modes of transportation in Kathmandu valley followed by the use of private transportation including motorcycle and car usage. While the comparison between the result seen in 1991 and 2011, the percentage of travel mode by walking decreased whereas motorcycle usage increased considerably (JICA, 2017). The table generated includes tempo, microbus, medium and large buses within the category of Bus whereas the category car includes passenger car and taxi.

Table 4.1 Comparison of Modal Share/Usage in Kathmandu Valley

Description	1991	2011
On Foot	53.1%	40.7%
Bicycle	6.6%	1.5%
Motorcycle	9.3%	26.00%
Car	3.8%	4.2%
Bus	27.2%	27.6%

The comparison shows that even though the population rise and growth of facilities related to public transportation are in place along with interventions and investment, the growth in the modal share of public transportation has no improvement. Car usage and motorcycle usage have increased very significantly and the lack of prioritization can be seen in the mode related to walking and bicycling.

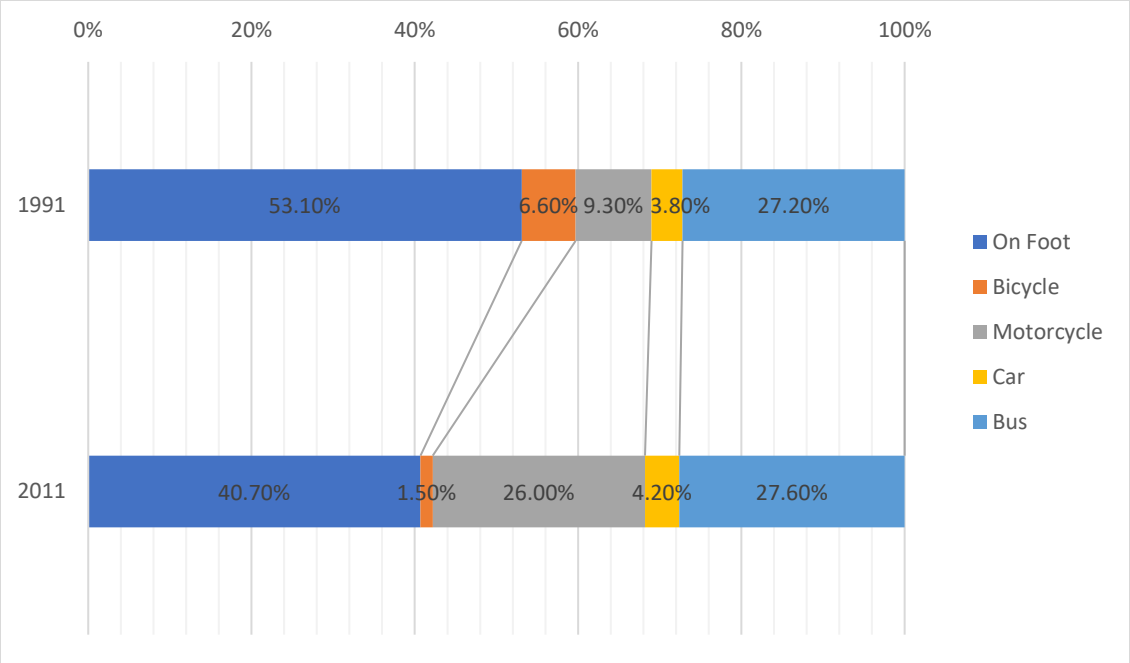

Figure 4.2 Modal Share 1991 and 2011 comparison in Kathmandu Valley

The chart clearly shows how the majority of trips were directed from other modes of transportation, particularly walking and cycling towards the use of private vehicles in form of motorcycle and car usage, although car usage has not increased so abruptly the use of motorcycles has increased with significant accounts, which may be attributed to tendency or desirability of people towards private transportation due to various reasons.

4.1.2 Modal Availability/Ownership in Kathmandu Valley

As discussed, the availability of mode for a particular trip and trip maker is also an important characteristic and criteria that shall be assessed to compare the mode choice models. To be precise, if the mode is unavailable to the user or the accessibility and availability are an issue then it is for sure that the trip maker cannot make the particular mode choice under the particular journey.

The data relating to ownership and availability can be taken into account by looking at the annual registration performed by the DoTM where analysis can be performed which can have implications towards the ownership increasing or decreasing pattern which can be further analyzed. The annual registration from the period 2010/11 to the year 2016/17 of the bus as public transportation and car and motorcycle has been tabulated as sourced from DoTM (DOTM, 2019).

Table 4.2 Annual Registration of Vehicles in Kathmandu Valley

Description	Bus	Car	Motorcycle
2010/11	675	5423	55092
2011/12	720	5561	44894
2012/13	1090	6334	54051
2013/14	1192	8397	52494
2014/15	2081	9945	55844
2015/16	3215	21647	64927
2016/17	3759	14542	94751

The data for the registration of buses includes the other forms of public transportation and other categories of buses like mini and micro-buses along with three-wheelers tempo. Public transportation ownership has increased linearly as shown on the chart while the increase in motorcycles seems to follow the exponential trend. Meanwhile, the increase in car ownership followed a trend of linear increase with a sharp increase in the year 2015/16.

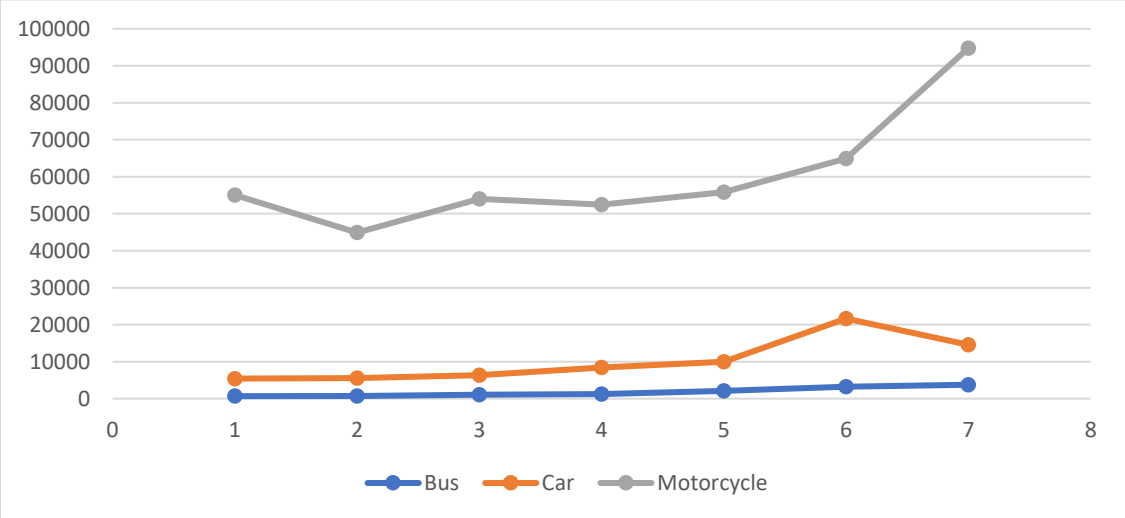

Figure 4.3 Pattern of Vehicle registration from 2010/11 to 2016/17 in Kathmandu Valley

Nonetheless, the data for mode availability and ownership must not be attributed to the vehicle registration since it does not provide the relation to population distribution and ownership of more than one category of vehicle as well as the addition of another category of vehicle or mode of transportation in use. Moreover, the data was generated for the whole Bagmati Zone of which a major share of vehicles are designed to be used in Kathmandu valley so it gives a representation of how the usage of a certain category of the vehicle has been increasing or the trend of the increasing mode of vehicles.

Hence, the availability of mode choice shall be looked at from a different perspective as well. According to the census of 2011, the household having facilities for motorcycles, bicycles, and other vehicles were quantified which is shown in the table below.

Table 4.3 Households with the facility of motorcycles, bicycles, and other vehicles in Kathmandu Valley (Source: Census 2011)

Description	Motorcycle	Cycle	Other Vehicles	Total Households
Census 2011	183935	70110	1964	613606

Here, motorcycle penetration can be seen in almost 30% of households while the availability of cycles can only be seen in nearly 11% of households. Although, the data also has its limitations where it did not represent or specify the users with multiple options of a cycle as well as motorcycle and other vehicles.

The rising popularity of two-wheelers due to their secure access to congested roads, adaptability in small spaces, efficient short-distance travel, and low capital costs made them well-liked in impoverished nations such as Nepal but demonstrates the poor performance of the transportation system(Prajapati et al., 2020). Only 10 public vehicles are available per 1000 people, based on registered vehicles.47 private vehicles per 1000 people (car, jeep, van), and 274 motorcycles per 1000 people in Kathmandu valley in 2017(DOTM, 2019). It demonstrates that the quantity of public transportation (buses) is hardly enough to satisfy the current travel demand(Prajapati et al., 2020).

4.1.3 Infrastructural Aspect of Different Modes of Transportation in Kathmandu Valley

As mentioned by various types of research infrastructural aspects influence different mode choices of people where different characteristics of transport facilities in both qualitative terms, as well as quantitative terms, were assessed to understand the mode choice of trip makers. Also, the influence of urban transport infrastructure was added to this section accordingly.

4.1.3.1 **Public Transit**

Kathmandu Valley has a public transportation system mostly owned and operated by private companies. There are no dedicated lanes or priority lanes that are exclusively designated for bus transport, consequently, they are highly affected by general traffic conditions. There is no set bus timetable, and it is generally random and unpredictable. The demand-oriented transportation service helps consumers, but the routes' operation is centered only in the well-established market(Prajapati et al., 2020). On the other hand, operators compete to operate more services on competing lines, resulting in heavy traffic congestion and inefficient service operation. Operator competition increases the number of operators in the same market, resulting in a complicated and unintelligible network(Prajapati et al., 2020).

JICA (2017), classified bus networks into three categories,

1. City Bus Service: Operating within the Ring Road, providing short distance service, nearly 5-10km
2. Commuter Bus Service: Operating for commuters between the area within the Ring Road and suburbs, for trips of 10-30 km
3. Long Distance Bus Service: Trips over 30 km, inter-regional

The majority of Bus services are serviced by four types of buses, namely tempo, microbus, minibus, and larger buses which have a total of 220 routes with varying capacity and variability in distance(JICA, 2017). The proportion of large buses to the number of bus routes was limited in comparison to the smaller variants of buses, which may be attributed to the lack of wider roads suitable for large bus operations, the lack of relatively bigger businesses, and small-sized single owners(JICA, 2017). Based on a survey conducted by JICA in 2011, the total number of buses was more than five thousand with 32,835 operations within Kathmandu valley.

On the other hand, Sajha Yatayat is a cooperative company with an investment in various municipalities of Kathmandu valley as well as from public investment. The company has a bus fleet working across both intracity as well as intercity levels, with 71 total buses. It was founded

with a vision of providing affordable, efficient, and safe transportation options. It has been trying to become more adaptive towards sustainability principles since its goal has been shifting towards electric transportation until 2025.

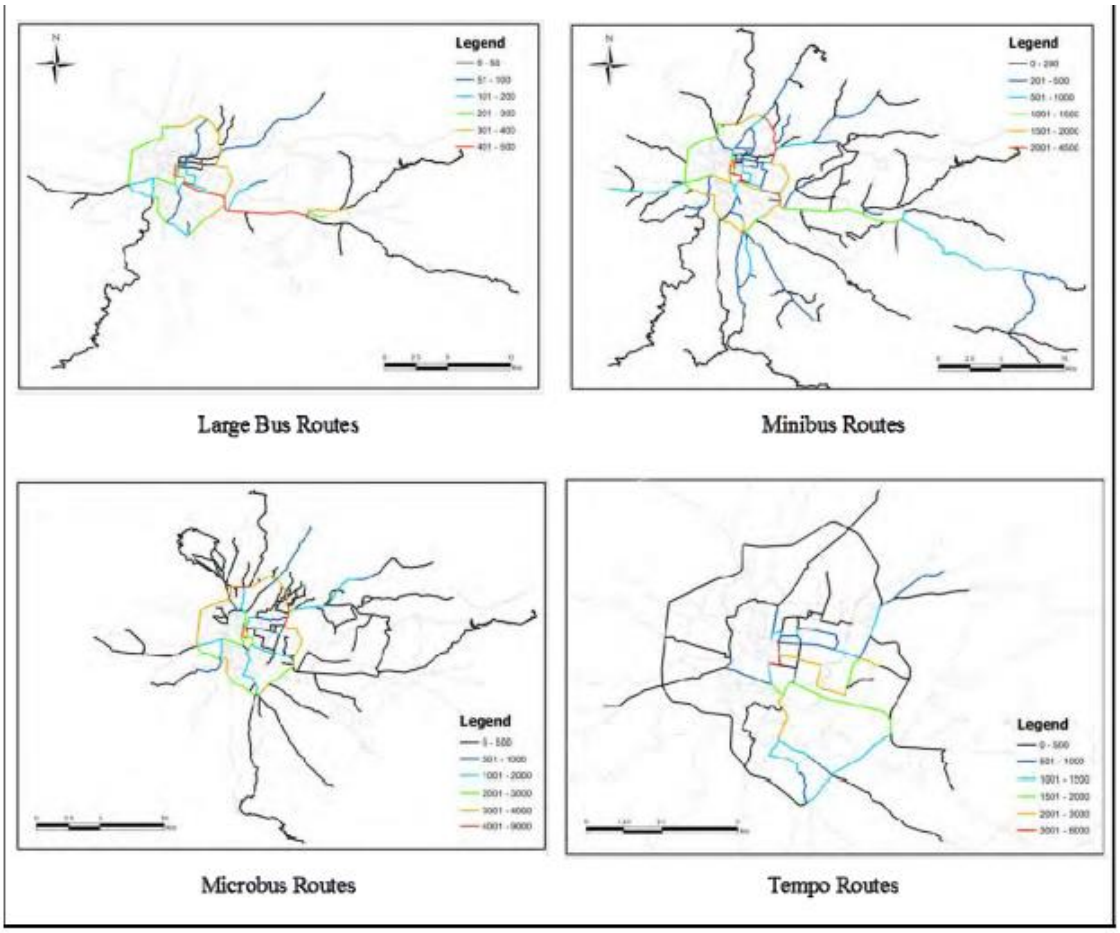

Figure 4.4 Bus routes of Kathmandu Valley (Source: (JICA,2017))

JICA (2017), collected the data for the routes and bus networks regarding various bus routes that were operational within the Kathmandu valley but a serious concern can be seen that these routes are operated by various private owners and their synchronization, as well as optimization, remains within the jurisdiction of local level as well as Department of Roads as envisioned by Provincial Transport Management Act, 2018. The act has overarching goals regarding the timetables and network layouts to be handed to the general public as well as other provisions for priority seating for females as well as the elderly. The monetary cost also is variable amongst various institutions but is governed by creating a minimum and maximum payable cost scheme by the Government of Nepal across the country. The intracity monetary cost has been attached in the Appendices of this research.

Regularity and Reliability were found to be dependent variables along with safety and security as well as accessibility through the research of Nakarmi & Singh (2019). The research on Kathmandu valley concerning road and public transportation, bus stop, and Bus Infrastructures as well as Information and Communication Technology highlighted the major findings as accessibility was not pedestrian friendly with numerous crossovers and bus stop heights were not standardized and inconvenient, while bus had recruited new buses with low floors but still, some company lacked that infrastructure and for information and communication the accessibility was not updated well and was limited with users having smartphones only with lack of display boards and other related real-time information systems (Nakarmi & Singh, 2019).

Regarding Reliability, the road infrastructure was found to be congested and the quality of the road degraded with a lot of potholes, bus stops had no proper information about the time, route, and availability of bus service. The buses were found not so reliable with limited routes and no information about operating hours and information updates(Nakarmi & Singh, 2019).

Similarly, the safety and comfort regarding road infrastructure were found unsafe footpaths with some surveillance systems on certain parts of the Kathmandu valley, traffic lights were found not all functional and especially during the busy schedules, the lights did not work. The bus stops had no proper lighting in them and the stoppages in particular bus stops had rushing ins and outs. The buses were connected with GPS systems, but the sense of security during late hours was challenging(Nakarmi & Singh, 2019).

4.1.3.2 Walking and Cycling

The walking infrastructure in Kathmandu valley was dominated by inconsistency in pavement and footpath design where varying widths of footpaths were present with different stone paved surfaces and other surfaces like classic stones and bricks in other parts of the town. The zebra crossings and overhead pedestrian bridge were present readily in the valley. The zebra crossings were consistent with traffic lights on most busy streets but were non-function during rush hours. The overhead bridge was consistent in making the crossings longer and the general perception of not using overhead bridges was seen evidently. The non-inclusivity in design was seen evident in overhead bridges and discontinuity in pedestrian pavements with obstructions and encroached streets were seen present in infrastructure related to walking.

The provision for dedicated cycle lanes was seen as a recent intervention in the valley, where major roads seem to include not completely dedicated without proper barriers and colored road design. The lanes were seen predominantly characterized by road side parking and obstructed by

construction as well as other materials like electric poles, plantation, etc. The dedicated lanes where other electric, as well as non-motorized transportation, can also be used, were provided by the city No bicycle infrastructure like mounting and parking location was seen in the valley. Moreover, different rikshaw and bicycles with provisions for carrying people with major sources of income were seen evident on the roads of Kathmandu valley.

4.1.3.3 Journey Length and Mode Choice

The journey length and mode choice phenomenon of the survey done in the year 2011 by JICA was discussed for Kathmandu valley. The people of Kathmandu have the highest tendency of walking as a mode choice for up to 4 km from where the mode choice shifted towards the motorcycle. The motorcycle was the dominant mode of transportation in Kathmandu valley and the use of public transportation was seen to increase when the distance was inaccessible on foot or after the 4 km mark.

Table 4.4 Journey length and mode choice in Kathmandu valley

	On Foot	Bicycle	Motorcycle	On Car	Bus
< =1 km	71.80%	1.70%	14.90%	2.30%	9.30%
1-2 km	61.70%	1.70%	18.40%	3.10%	15.10%
2-3 km	53.40%	1.80%	23.50%	4.60%	16.80%
3-4 km	55.00%	1.30%	20.50%	3.40%	19.80%
4-5 km	32.90%	1.50%	29.50%	5.00%	31.10%
5-6 km	19.60%	1.70%	35.00%	7.50%	36.10%
6-7 km	19.00%	2.10%	33.70%	6.30%	38.90%
7-8 km	11.30%	1.40%	36.40%	6.60%	44.20%
8-9 km	15.30%	1.40%	31.40%	3.80%	48.20%
9-10 km	10.70%	0.80%	35.40%	5.20%	48.00%
>10 km	10.20%	1.20%	37.00%	4.80%	46.80%

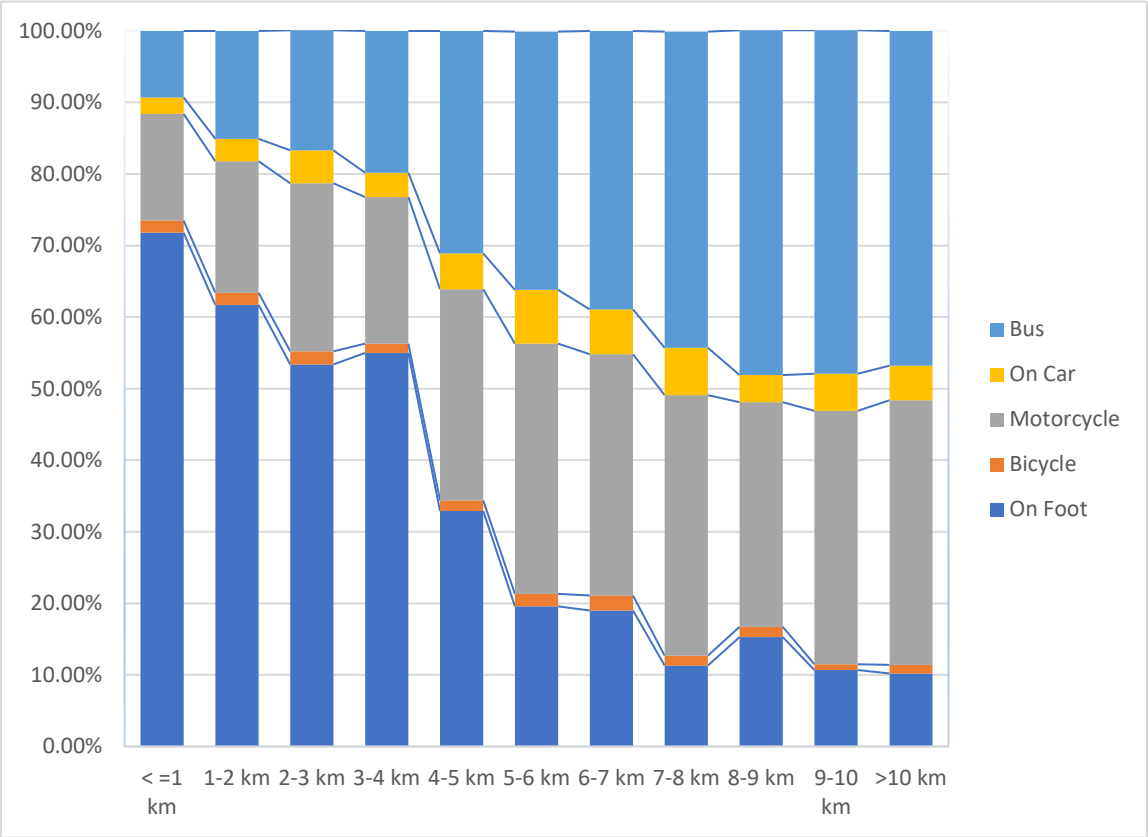

Figure 4.5 Bar diagram for journey length and mode choice in Kathmandu Valley

The chart illustrated although the popularity of motorcycle usage the pattern for use of public transportation was seen as impressive and consistent with growth potential.

4.1.3.4 General attributes of Land use in Kathmandu Valley

Bajracharya et al. (2020), in their paper, were able to link travel behavior and urban form for travels in Kathmandu valley. The analysis was able to provide the map as shown where the central business district (CBD) was highlighted along with the transportation network, and the distance from the CBD to the neighboring districts was highlighted on the map. The results were able to find that the current extent of mono-centricity needed to be transformed to polycentric form by the establishment of the suburban center which was the major issue found by the study conducted by JICA. The major issues in the urban structure or land use planning were highlighted as the Monocentric Concentration of CBD, High Population Density inside the ring road, Disorderly sprawling built, Monocentric radial road network, and Unorganized public transportation system.

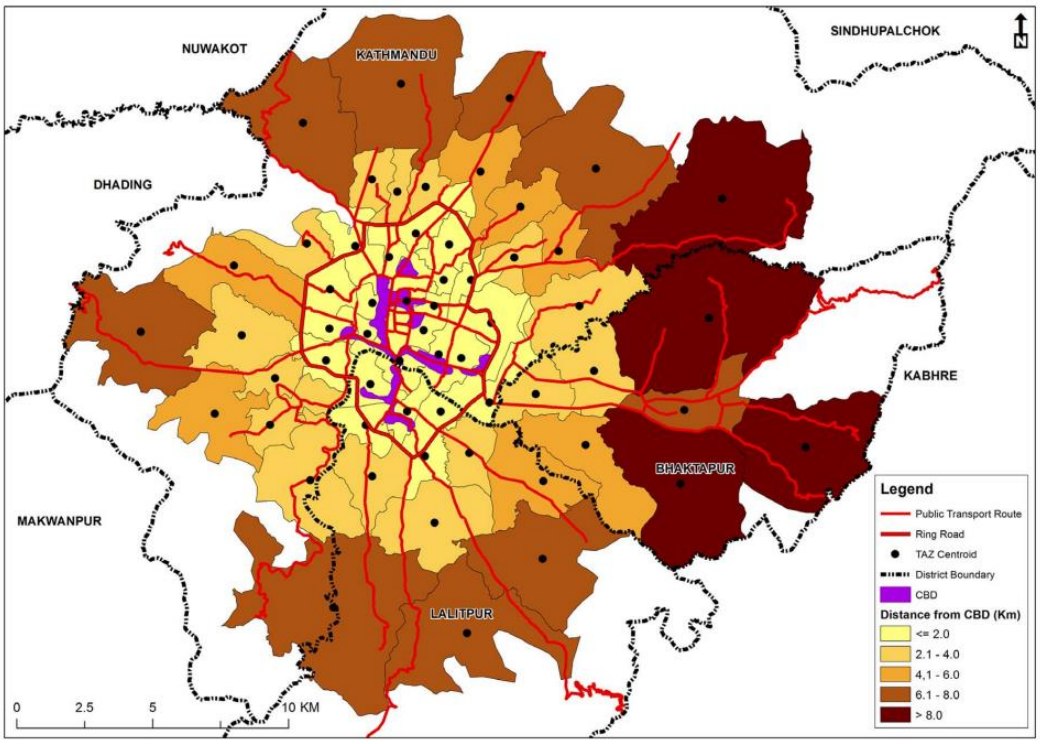

Figure 4.6 Distance from CBD to neighboring areas (Source:(Bajracharya et. al,2020))

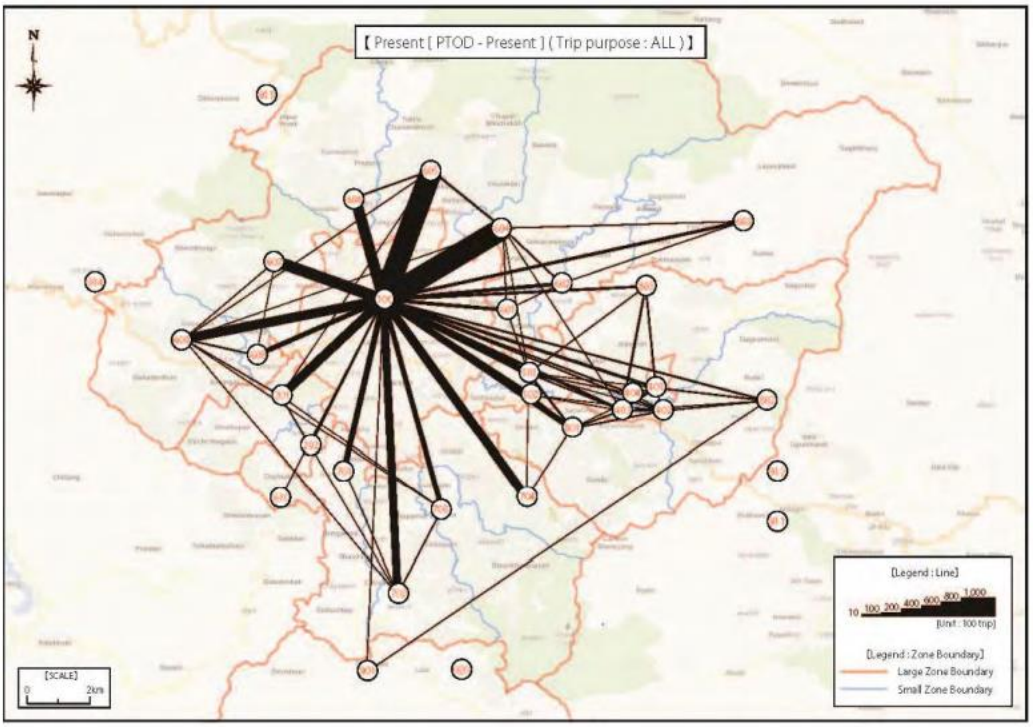

Figure 4.7 Trip Concentration and Desire Lines (Source:(JICA,2017))

Moreover, the study was able to show that NMT had shown to have a negligible influence on urban mobility because its percentage of trips is small. The results of correlation analysis with urban population density and distance to CBD showed that there were no significant relationships with NMT use. Hence, the use of the public transportation system and the accessibility, as well as other attributes related to public transportation, shall be able to contribute.

4.2 The character of the Transport System in Trondheim

The dataset for the analysis in this research has been referred from the Norwegian National Travel Survey (T.Nasjonal, 2020). The survey has over 60,000 respondents over the age of 13. A total of around 7000 responses were from those who listed Trondheim as their place of residence. The analysis compared travel behavior in these different cities, using the data on major travel modes (Walking, Bicycling, Car, and Public Transport) and different age groups (13-17, 18-24, 25-34, 35-44, 45-54, 55-64, 65-74, and 75+ years), along with the respondents' views on the access of public transport and how satisfactory the service was (T.Nasjonal, 2020).

The NTP 2022-33 has an overarching, long-term policy objective of "an efficient, environmentally friendly and safe transport system by 2050". For this, it has listed five policy objectives:

1) more value for money,
2) efficient use of new technologies,
3) contribute to Norway's fulfillment of its climate and environmental goals,
4) Vision Zero for road traffic fatalities and serious injuries,
5) make traveling easier, and increase the competitiveness of business and industry.

Norway has recently adopted a zero-growth policy where any growth in passenger transport shall be absorbed by public transport, cycling, and walking. Termed, Urban Growth Agreements (UGAs); are in place in Trondheim, which promotes the reallocation of road space to uses other than driving and parking private cars (OECD, 2021). UGAs are binding agreements summarizing infrastructure investments and packages of measures over ten years, for solutions that provide better accessibility and facilitate sustainable transport modes (OECD, 2021). The strategies being used in these cities to reduce or limit road traffic include densification and transformation of urban centers and improved conditions for walking and bicycling. Other strategies include better public transport services and restrictions on private car traffic (OECD, 2021).

4.2.1 Modal Share/ Usage in Trondheim

Residents of Trondheim (aged 13 and over) made almost one in three journeys on foot in 2020. Around seven percent are by bicycle and just over seven percent by public transport. Just over half of the journeys were made by car, either as a car driver (43%) or as a car passenger (9%).

Table 4.5 Year Wise Modal Share Data in Trondheim

Description	RVU 2009/10	RVU 2013/14	RVU 2018	RVU 2019	RVU 2020
On Foot	25.80%	27.00%	26.80%	25.70%	29.50%
Bicycle	6.80%	8.80%	10.20%	9.40%	7.40%
Collective	7.70%	10.30%	10.60%	11.90%	7.20%
On Car	45.60%	43.00%	40.60%	41.40%	42.90%
Car Passenger	10.80%	8.20%	9.30%	9.20%	8.70%
Others	3.20%	2.70%	2.40%	2.40%	4.30%

Since 2009/2010, residents of Trondheim have seen a trend towards more environmentally friendly travel. In 2020, however, the proportion of car drivers increased again, and the proportion of cyclists and public transport decreased. The proportion of trips on foot increased. The increase in the share of car drivers was due to a reduction in the total number of journeys in 2020, and a greater reduction in bicycle and public transport journeys than in car journeys.

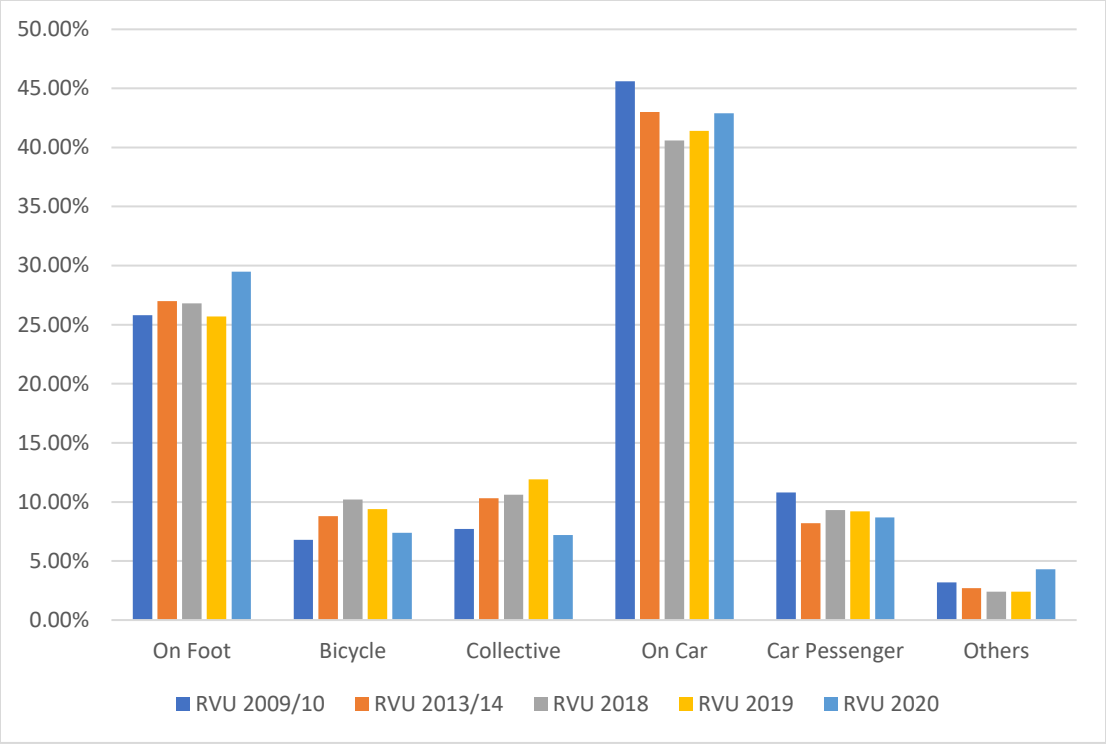

Figure 4.8 Year Wise Modal Share Bar Diagram in Trondheim

4.2.2 Mode Availability/ Ownership in Trondheim

4.2.2.1 Access to Public Transportation

In Trondheim, 21 percent of the respondents stated that they do not know the offer at their stop during the day between 9 am and 3 pm. This was at the same level as in 2019, but an increase compared to 2013/14 when 11 and 23 percent respectively stated that they did not know the offer at their stop. Out of those living in Trondheim who are aware of their public transport services, 69 percent stated that they have departures from the nearest stop (daytime) four times an hour or more often. This is an increase compared to previous surveys. In August 2019, a new route structure was introduced in Trondheim and the region. This may have contributed to the changes(T.Nasjonal, 2020).

Table 4.6Access to Pubilc Transportation in Trondheim

Number of Departures	RVU 2009/10	RVU 2013/14	RVU 2019	RVU 2020
4 times per hour	53%	65%	66%	69%
2-3 times per hour	37%	27%	26%	23%
1 time per hour	6%	6%	6%	6%
Every two hour	2%	1%	1%	1%
Less often	3%	1%	2%	2%
Total	100%	100%	100%	100%
N	4682	2742	3138	2412

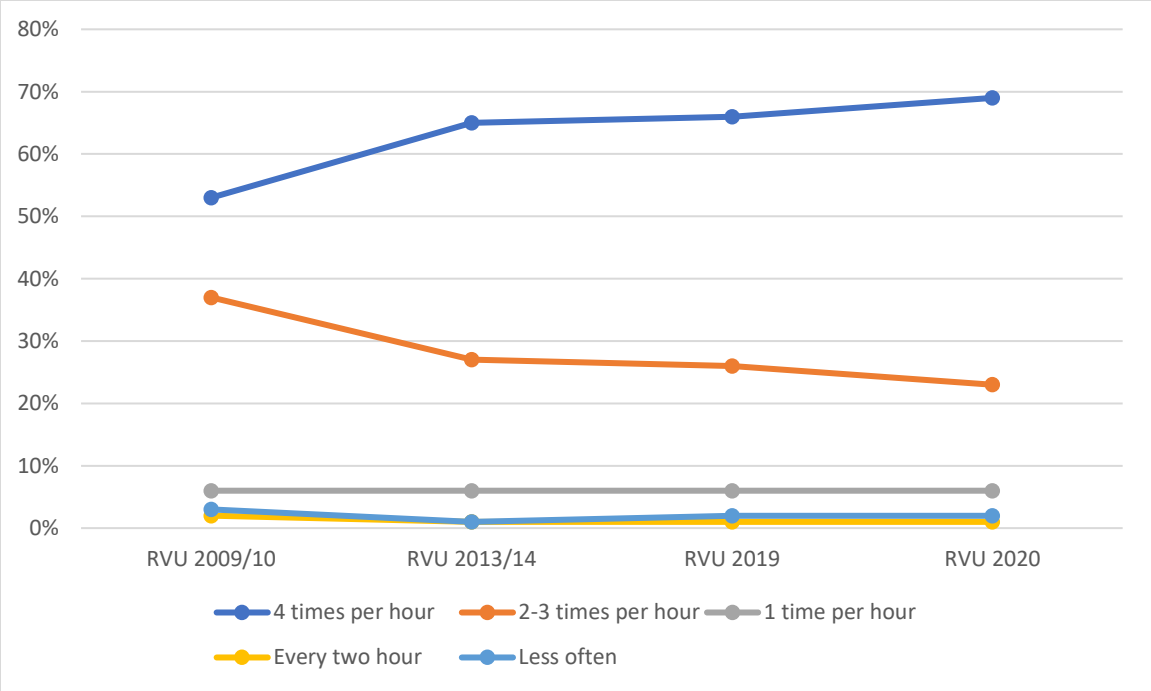

Figure 4.9 Frequency of Public Transportation (Access) in Trondheim

4.2.2.2 Access to Bicycle

Since the travel habits survey in 2013/14, the proportion of residents in Trondheim with access to a normal bicycle has decreased from 79 percent to 71 percent, while the proportion with access to an electric bicycle has increased from one percent to 13 percent. The proportion with access to motorbikes and mopeds/scooters has remained relatively stable.

Table 4.7Access to Bicycle in Trondheim

Description	RVU 2013/2014	RVU 2019	RVU 2020
Motorcycle	3.80%	4.50%	4.30%
Moped/scooter	7.50%	6.30%	6.70%
Electrical Bicycle	1.30%	11.00%	13.10%
Ordinary Bicycle	79.40%	72.50%	71.30%

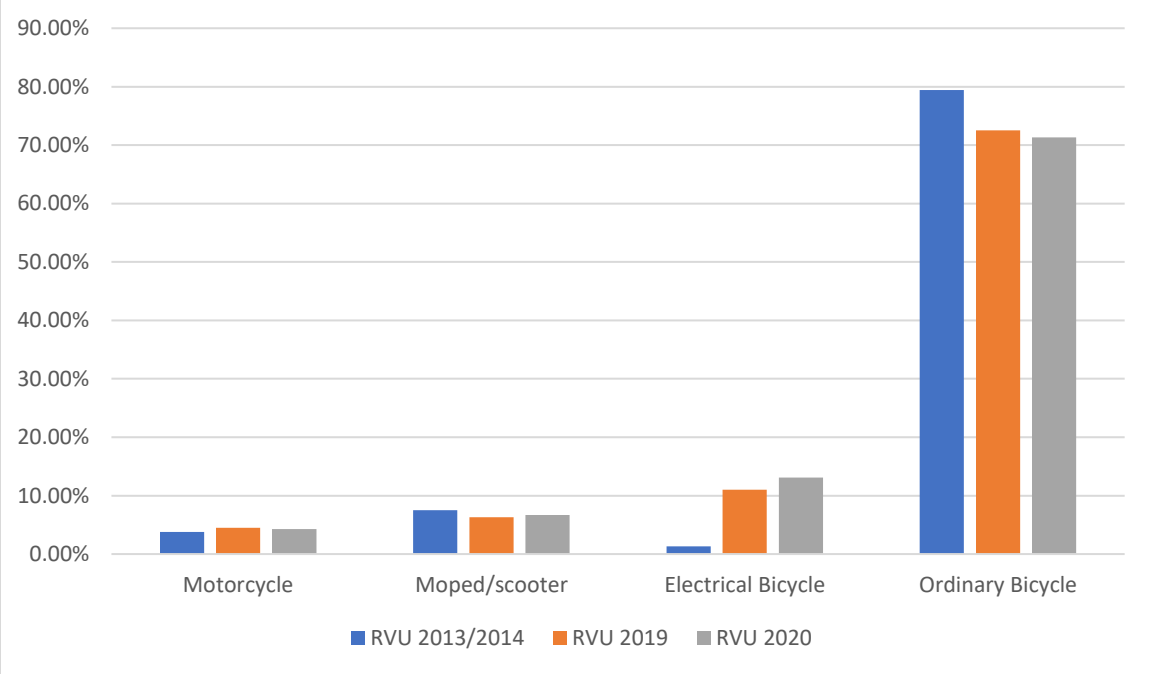

Figure 4.10 Access to Bicycle in Trondheim

4.2.2.3 Access to Private Car

In Trondheim, 81 percent of the adult population lived in a household that owns or disposes of a car. The remaining 19 percent stated that they do not have access to a car. In Trondheim, 52 percent of those who own/dispose of a car stated that they have access to one car, while 24 percent in the municipalities own two cars and close to 6 percent own/dispose of two or more cars.

Table 4.8 Access to Car/ Car Ownership in Trondheim

Number of Cars	RVU 2013/14	RVU 2018	RVU 2019	RVU 2020
No cars	14.80%	17.10%	18.50%	19.00%
1 car	55.80%	54.60%	53.10%	52.00%
2 cars	25.20%	24.00%	23.90%	24.00%
3 or more cars	4.20%	4.40%	4.50%	6.00%

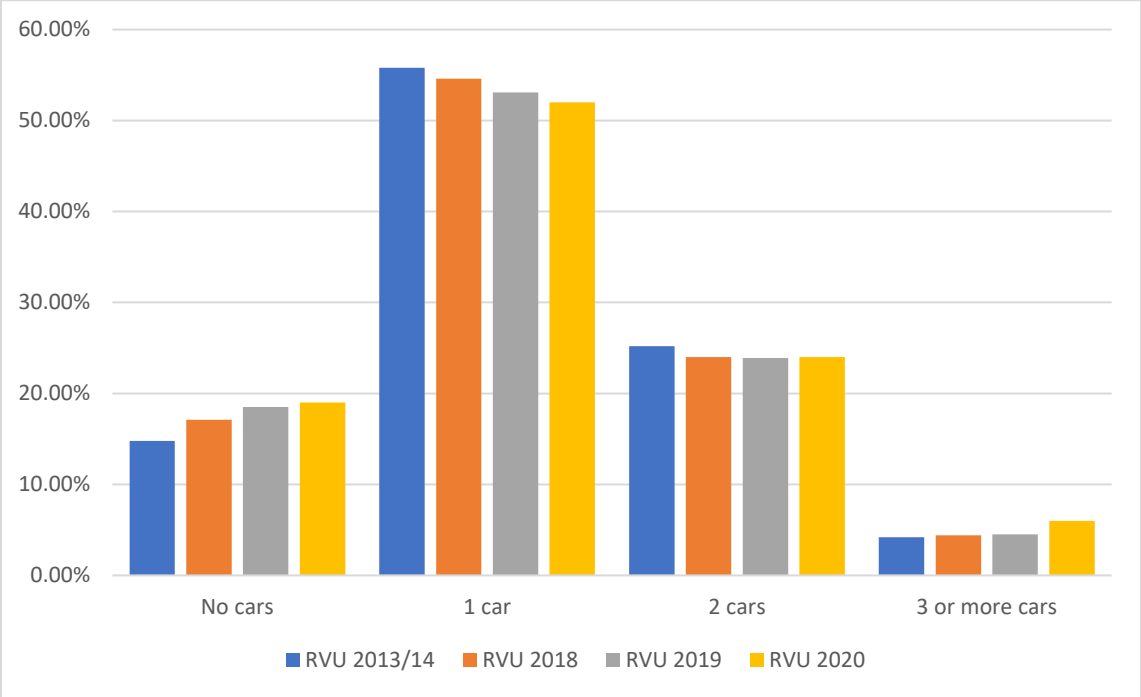

Figure 4.11 Access to Car/ Car Ownership in Trondheim

4.2.3 Infrastructural Aspects of Different Modes of Transportation in Trondheim

4.2.3.1 Public Transit

Public Transit and Intra city Travel and maintenance were found to be the core responsibility looked at from the county level in Norway. Trøndelag county is sorting out the required public transit-related goals and principles along with Trondheim municipality from a mobility company which is a joint stock company owned by the county itself namely, AtB. AtB plans, order, market, and develop public transport in the county. It was established on September 15, 2009, with a vision to offer future-oriented and sustainable mobility to the county. Tariffs are determined by the county

municipality as part of the budget treatment. AtB has three main sources of funding: Ticket revenues, grants from the Trøndelag County Council, and the Environmental Package (KII,2022).

Zoning and Monetary Cost

The public transportation system was divided into 13 zones within the whole county. Most of the regions of Trondheim municipality fall under zone A but also include other zones which are created based on the patterns of travel. Ticketing and pricing of journeys are based on the number of journeys that need to be traveled by the trip maker. The journey consists of the zone you travel from, the zone(s) you travel through and the zone you end your journey in. The ticketing can be performed in various ways like a 24-hour ticket, 7 days ticket,30 days ticket, 180 days ticket, or other similar categories, and the user can choose and pick the number of zones required for their travel purposes. An average single-zone ticket for an adult would cost around 890 Norwegian Krones. There is a provision for student and youth discounts while children and disability benefits are also provided with a subsidized ticket. An important fact that shall be noted was that the other modes of public transportation like trams and ferries are consistent within the same ticket when bought for a whole zone.

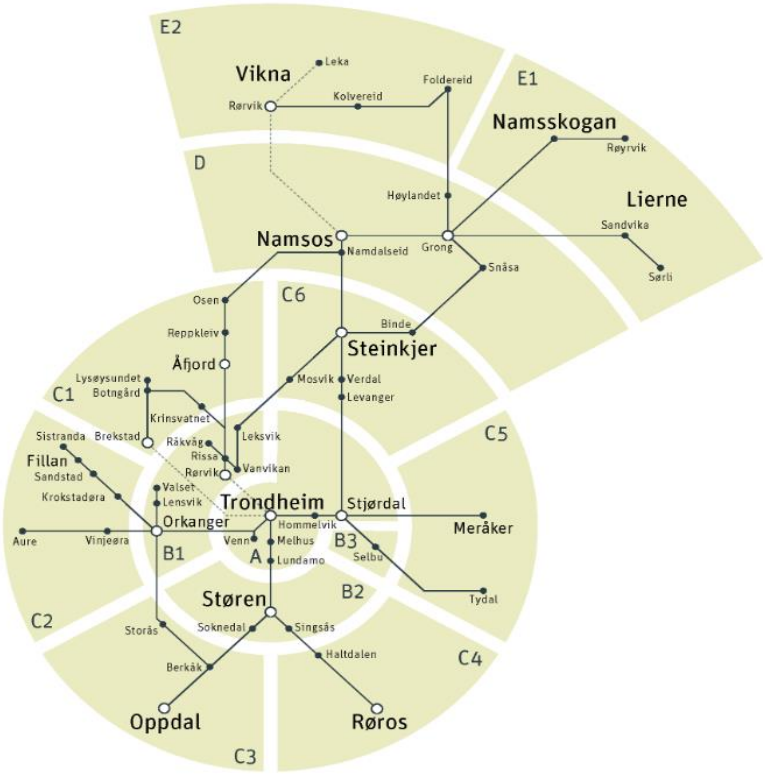

Figure 4.12 Zonation of Trøndelag County (Source: AtB)

Regularity and Reliability

The public transportation system in Trondheim followed a strict schedule and routes which were displayed and integrated with the Information and Communication Technology via mobile apps and digital networks with a real-time automatic update system. The timetables and arrivals, as well as departure boards, were placed at every bus stop. The travel guarantee scheme was available to the users where if the bus was delayed by certain timetables, necessary arrangements were made accordingly.

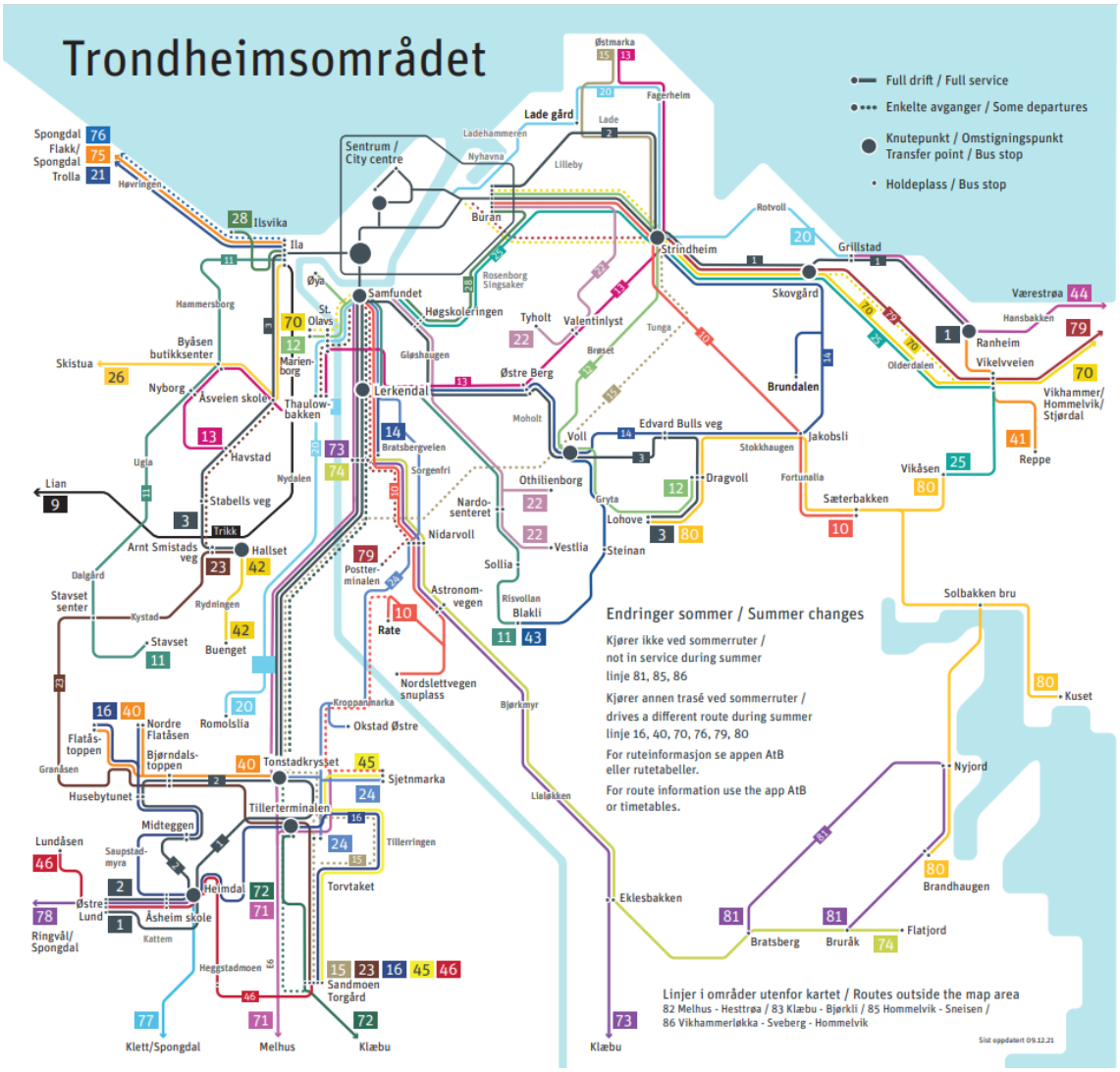

Figure 4.13 Network of Public Transportation Routes in Trondheim

Mobee was an app designed to integrate all the modes of transportation on the go where different modes of transportation and options are displayed from a real-time assistant that enabled the movement in Trondheim. It connected the mobility options nearby the location of the trip maker and also found the nearest stops where a provision to cross-app linkages as well as traveling and ticketing was possible.

Figure 4.14Typical Bus Stop in Trondheim

Comfort and Security

The real-time navigation and GPS included in the bus system itself contributes to the security while there was the presence of CCTV surveillance within the public transport. The Provision for HVAC, handrail for standing passenger comfort, and stop button for stopping at the next stop are certain attributes of the bus. Majorly comfort can be seen in wheelchair-friendly ramps and low floored buses where provisions of the suction system lower the floor space for the elderly and wheelchair and baby stroller. Also, the Intermodal transportation system which can include bicycles and electric scooters in the bus was present with more than 2 or 3 double panel doors for easiness. The capacity depiction and ICT capacity assessment were important attributes.

4.2.3.2 Walking and Cycling

There were dedicated projects for improving and finding out walking shortcuts in the city in collaboration with an institution called Milijopakken. The shortcuts were marked with different signages as depicted in the figure below. The institution was responsible for the upgradation as well as maintenance of the shortcuts as well. The features like provision for safe road crossing with lowered intersections and curbs for zebra crossing were essential for easiness. The inclusion of distinct tiles and beeping sounds in traffic lights was visually impaired-friendly. The elderly-friendly walking and inclusivity in walking were major features of walking as a mode of transportation.

Figure 4.15Walking Infrastructures in Trondheim

Figure 4.16Cycling Infrastructure in Trondheim

The provision for dedicated cycle lanes where other electric, as well as non-motorized transportation, can also be used was provided by the city. The design and solutions for user-

friendliness in cycling with cycle stand and parking were remarkable features. The Bike-sharing docks where the bikes could be rented for a specific period were available throughout the city. The Wheeling ramp, cycle counting system, and tramp bicycle lift were different infrastructures for bicycling and other related NMT.

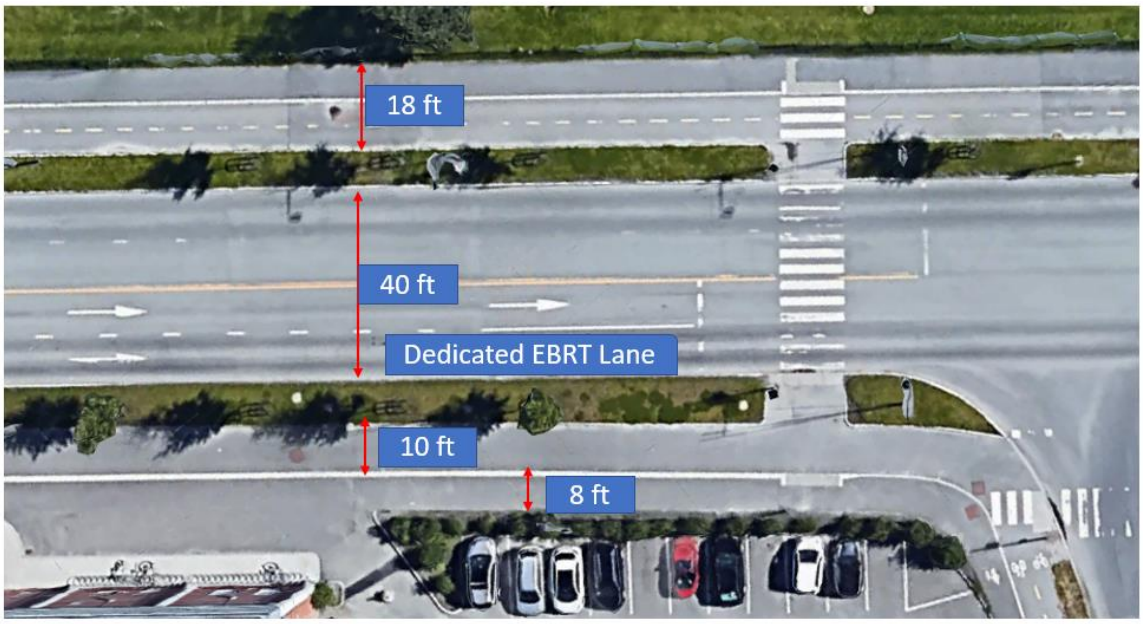

Figure 4.17Typical Road Section in Trondheim

The typical road section in Trondheim can be analyzed as the adequate distribution of road space resources as shown in the figure. The cycle lane of 10ft was seen able to create a positive and motivate the use of the bicycle as well as other non-motorized transportation systems. The road width of 40 ft was divided into 4 lanes where 2 dedicated lanes or priority lanes for electric vehicles including buses could be seen. The pedestrian lane was found sufficient with space allocated for greenery on both sides of the road.

Moreover, car transportation was found heavily taxed from initial taxation on customs and purchases to the road. Tolls and carbon taxation are incorporated as fossil fuel taxation. The parking charges were also found heavily charged along with minimal free parking inside the city center while electric vehicles were promoted as a sustainable means as compared to normal cars hence subsidies were provided in tolls as well as parking prices, the reason was found behind Norway's success in EVs.

4.2.3.3 Journey Length and Mode Choice in Trondheim

In the case of Trondheim, the shortest journeys were dominated on foot. On journeys of up to one kilometer, 70 percent of journeys were on foot in 2020. The largest share of public transport journeys was at 8-9 kilometers when 15 percent of journeys were by public transport. This was a change from previous surveys where shorter journeys have the highest proportion of public transport(T.Nasjonal, 2020). Compared to the previous year, the proportion of walking trips had increased in all travel length categories over one kilometer. The proportion of cycle trips and public transport journeys decreased in several categories of journey length.

Some journeys increase the average journey length. Therefore, the table below showed information on journeys that were less than 100 kilometers in addition to all journeys. For journeys in 2020 of less than 100 kilometers, the average journey for residents of Trondheim on foot was two kilometers, for bicycles just under four kilometers, for car drivers around nine kilometers, and public transport journeys 7.5 kilometers(T.Nasjonal, 2020)

.Table 4.9Journey length and mode choice for Trondheim

	On Foot	Bicycle	Collective	On Car	Car Passenger	Others
< =1 km	66.90%	8.10%	1.90%	18.20%	2.50%	2.40%
1-2 km	39.30%	13.30%	3.60%	35.30%	5.80%	2.90%
2-3 km	25.90%	12.60%	7.20%	41.60%	8.30%	4.50%
3-4 km	19.90%	11.00%	10.10%	44.30%	9.00%	5.70%
4-5 km	17.60%	5.90%	10.80%	50.30%	10.50%	4.90%
5-6 km	15.90%	7.00%	9.70%	53.20%	9.90%	4.30%
6-7 km	11.00%	12.40%	10.20%	50.50%	9.90%	6.00%
7-8 km	12.80%	7.30%	11.10%	54.30%	12.10%	2.40%
8-9 km	4.30%	1.20%	14.90%	60.90%	12.40%	6.20%
9-10 km	6.70%	1.80%	3.60%	71.20%	12.40%	4.10%
>10 km	1.80%	2.10%	7.30%	70.10%	14.30%	4.50%

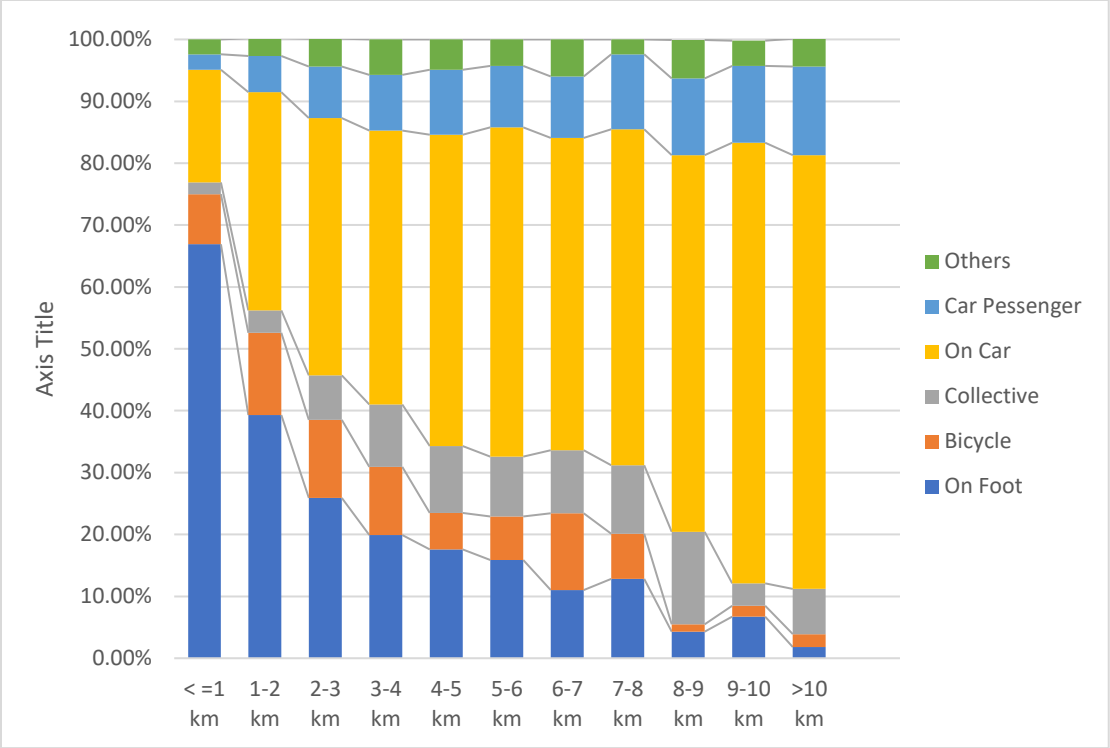

Figure 4.18 Journey Length and Mode Choice in Trondheim

4.2.3.4 General attributes of land use in Trondheim

The study of general attributes of land use in Trondheim was done by creating maps related to land use and mode choice interrelationship and analysis was done accordingly.

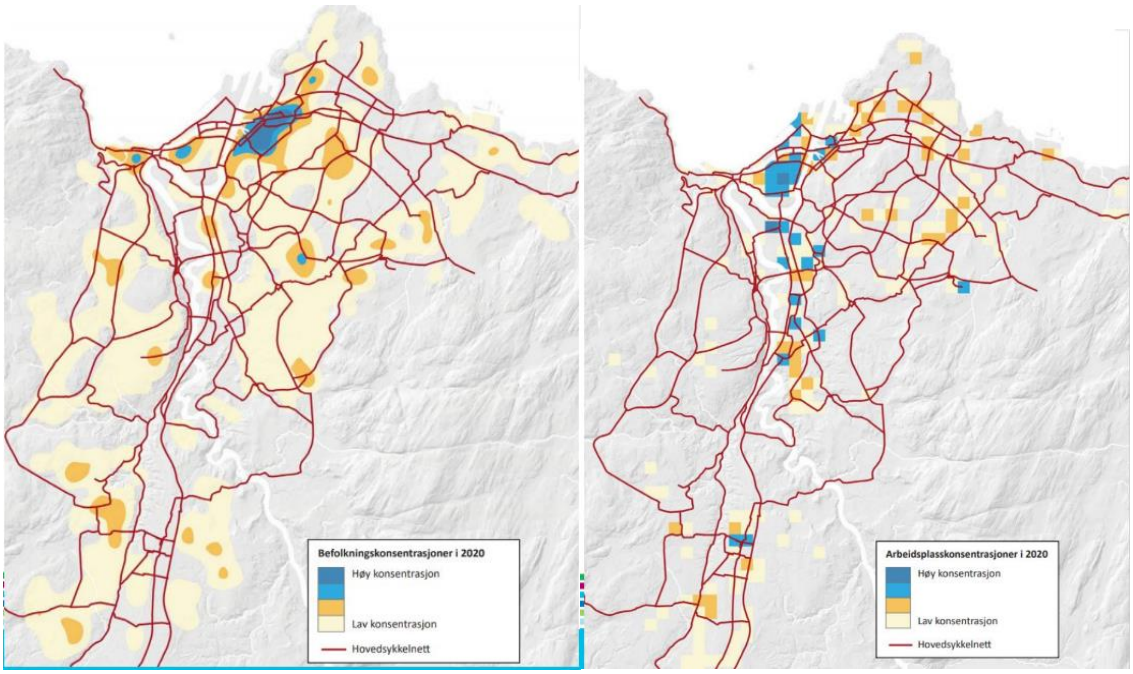

Figure 4.19 Settlement Concentration and Employment concentration map(Source: Milijopakken)

The two maps demonstrated here can illustrate the dependence of settlement density and work as well as CBD distance. The distance between these places of high concentration of settlements and CBD was found to be within the walkable range and the use of NMT also can be justified by this fact. Road Transportation systems, as well as public transportation, were also easily accessible making travel easier from the settlement area to CBD on public transportation easier.

Moreover, the placement of educational institutions was also found strategic reducing the use of the vehicle for getting to school meaning schools of children were located near the settlement area leading to limited vehicle use in rush hours, although students requiring to travel longer distances were found using public transportation for going to school, specialized buses for travel to school were rare.

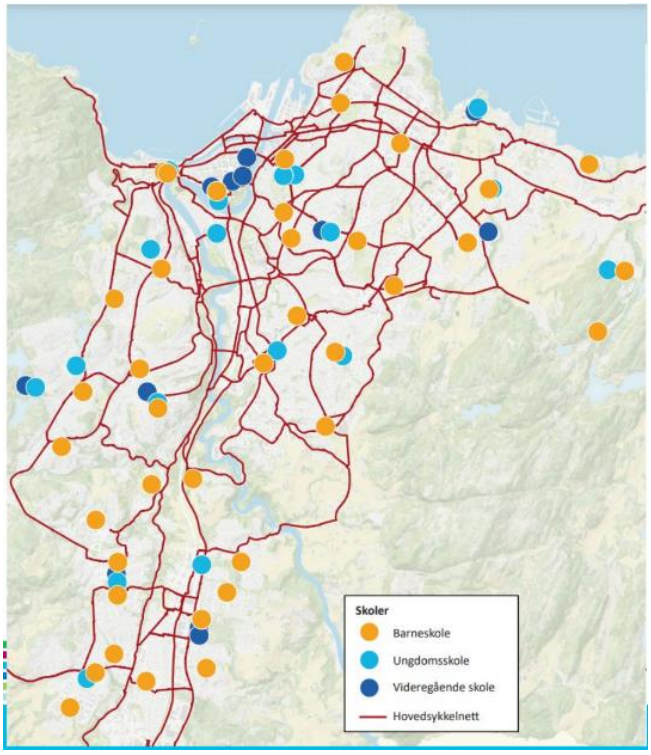

Figure 4.20 Education institutions in Trondheim

CHAPTER 5: DISCUSSION, CONCLUSION, AND IMPLICATIONS

Mode choice of a particular mode is dependent on the alternative modes available to the trip maker and the study of how a particular mode is being used by the trip maker. The study can be discussed with regards to the infrastructural level of service provided by the particular mode as well as the relationship of different mode choices along with the land use pattern of the city which were highlighted as the objectives of this research. The discussion part of this research was an approach to comparing and contradicting the study and the case area along with different results seen by the previous research. The discussion was broken concerning the research objective and is highlighted in different headings in this chapter.

5.1 Mode choice, availability, and usage of mode

To analyze the usage of a particular mode over time the depiction of the trips that have been made by using the particular mode of transportation, that is modal share can be found, and finding out the changes in modal share of total trips with time can be able to highlight how the popularity of different modes changed with time. Particularly, the first research objective formulated was interested in finding out the mode's availability and to study how variations in those mode usages have changed or patterns or trends those particular modes have followed which has been discussed in this section.

Comparing figure 4.2 of modal share in Kathmandu valley and modal share in Trondheim, the trend of usage of different modes of transportation may be discussed with one another. Figure 3.2 depicted that the usage of private vehicles in form of the motorcycle has gained the highest popularity with people compromising on travel on foot, which is in contrast to figure 4.8 where people of Trondheim are seen to have increased the trips made on foot and a trend of decreased travel by car while the increase in the use of collective means of transportation or buses. The trend in Kathmandu shows a similar usage of buses from 2011 to 1991 while the population and investments in public transportation have been increasing. Moreover, the residents of Trondheim were seen to be taking an interest in bicycling which has increased in recent times while the use of the bicycle in Kathmandu has degraded.

Nonetheless, the characteristics of transportation in Kathmandu valley as seen were dominant with privately owned motorcycles which share a total of more than three forth of registered vehicles in Bagmati province alone. The increase in travel by motorcycle in Kathmandu was particularly related to secured access to congested spaces and motorcycle's adjustability within limited spaces (Malla, 2014). Also, Malla (2014), found that the popularity of motorcycles was due to low capital

cost and efficient short-distance travel but reckons that this can be attributed to the inefficiency of the transportation system in Kathmandu valley. Also, Ghimire & Marsani (2019) stated the socio-economic related to the choice of two-wheelers over public vehicles. The authors found that gender, income, travel time, and travel cost had significant importance on the choice between these two modes of travel which was performed in Kathmandu by using multinominal regression analysis; while age, marital status, and occupation had no significant impact. The analysis further justified that people in Kathmandu were not sensitive to travel cost where travel time is of greater importance. Hence, the increase of motorcycle can be justified as a decision of increased income and an effort to reduce the travel time, with certain increase in travel cost.

On the contrary, the public transportation system in Trondheim was seen on a rise while car travel was seen with a trend of decline but with reversal due to rise in pandemic and change in bus routes done in 2019 as stated by travel and habit survey (T.Nasjonal, 2020). This result also can be seen in figure 4.11 where the car ownership/availability has been declining or fewer people were seen owning a car over time As discussed, the zero-growth policy and urban growth agreements were seen as contributing factors where investments were provided to the municipality of Trondheim for creating and motivating modal shift from the car and private transport to public transportation as well as investments directed towards cycling and walking were able to create a model for prioritized investments towards those particular modes(OECD, 2021).

Additionally, the cycling and walking scenarios in both the municipalities were following the reverse trend of one another which can be related to the infrastructure investment or influence of infrastructure but also can be attributed to institutions dedicated to creating and improving shortcuts and walking routes as in case of Milijopakken for walking in case of Trondheim. For the case of cycling for longer distances, Schiller et al.(2010) emphasized the intermodal transportation system. As with the case of accessibility and travel time reduction, as talked about in the case of Kathmandu, bicycles and particularly electric bicycles would be similar to motorcycles if the municipality was able to create intermodal public transportation where people traveling in bicycles could easily carry the cycles for longer distances in the public transport and use it for greater accessibility; although the required infrastructure and their influence were seen key in the process.

As such, it can be concluded that the popular mode of transportation was a motorcycle in the case of Kathmandu valley but the tendency or the percentage of using the bus as a mode of transportation was higher than the compared municipality which is declining with time, which was the concerning fact. Moreover, if the data was extrapolated to the present scenario, it can be predicted with

observations that the number of motorcycles as well as cars on roads has increased significantly creating the previously discussed undesirable effects.

5.2 Infrastructural aspects and mode choice decisions

Different kinds of literature were sorted out and criteria were extracted about the infrastructural aspect that can influence the modal choice as well as have an impact on modal shift or the factors that can persuade or motivate individuals to shift from one mode of transportation to another. The major factor or criteria that were discussed, were the characteristics of the transport facility and the characteristics of the urban transport infrastructure that enabled the use of the particular mode choice amongst others available to the trip maker.

As discussed by Walker (2012), there are seven parameters or factors that affect the transit service as a mode choice, and among those variables; the author laid particular emphasis on the travel time as the critical driver. The travel time factors in Kathmandu valley are shorter due to accessibility and efficient short-distance traveling modes like motorcycles hence the popularity of motorcycles as an efficient and convenient mode choice also can be justified by these factors(Malla, 2014). Travel time delays are evident mainly on public vehicles and car usage with the peak period congestion and infrastructure such as traffic lights and other related pedestrian crossing failure during the particular time of the day in morning and evening rush periods. Also, these delays and congestion along with infrastructural failure are responsible for the unreliable public transportation due to uncertainty caused during the clearing of huge traffic; leading to public transport not being able to reach particular destinations at the particular or designated time. Although, similar sorts of congestion problems; though not severe as Kathmandu were evident in Trondheim municipality the dedication of lanes was able to provide the swift passage and timely arrival of public transportation to the designated place at the designated time. However, Walker (2012), also reckons the personal preference factors that interplay where people tend to choose regarding the minimum travel time or endure longer travel time to avoid certain phases that the user dislikes like waiting, paying, walking, and changeover times.

Monetary cost, as discussed in the previous section as well, had a lower significance over the travel time, or in simpler terms, people were more lenient towards travel time reduction may it be related to increasing in monetary cost as discussed by Ghimire & Marsani (2019). In the case of Trondheim municipality, the sources of funding for the monetary cost were not only limited to ticket purchases but also funds from the county level and environmental package or urban growth agreements; meaning that the model of transportation was running on the subsidized model contributed by

county as well as state; in order not to increase the travel cost burden to the general public. But in the case of Kathmandu valley, the public transportation model is dependent on private companies driven by profit maximization of the private firms. Nakarmi & Singh (2019) did a primary survey regarding the concerns about public transportation in Kathmandu valley where the major concern was found as overcrowded vehicles which can be seen as an opportunity for the expansion of public transits and to capitalize and work on as the population requiring or opting for the public transportation as a mode choice. These facts suggest that even though an unsubsidized model of transportation exists in Kathmandu valley, people opting for public transportation at the same monetary cost are high where municipalities and responsible institutes can increase usage of public modes of transportation.

Additionally, Reliability and regularity factors of buses were not found so reliable with limited routes and lack of information regarding operating hours, routes, and real-time information flow in Kathmandu valley. Walker (2012) pg.37 states "Real-time information is also transformative", here the author also adds that "walking, waiting and connecting" are made worse by uncertainty, thus if uncertainty factors were eliminated through the use of mobile phone-based information sources, the only thing the trip maker would care about was travel time. The real-time information and ICT integration can be seen as hugely efficient in the case of Trondheim where AtB has created a web-based as well as mobile-based solution where route information and ticketing options are readily available to the trip maker. Similarly, Sajha yatayat has also opted for the app-based solution where the inclusion of GPS-based real-time information flow was found helpful but the information seemed incomplete without the times and schedules being displayed on the app itself, but the approach and intent for information flow were seen as compared to other private operators. Similarly, the comfort, safety as well as security factors of sajha yatayat in Kathmandu valley were found good in comparison to other privately owned transportation, meanwhile, inclusion and inclusivity should be focused on and sorted out.

On the other hand, Urban Transport infrastructure has a greater influence on people as described by various kinds of literature. The major infrastructure for the case of public transits in Trondheim was the dedication of bus rapid transit lanes or priority lanes for electric vehicles and public transportation which has influenced reliability and regularity of service as well as reduced travel time delays. Moreover, infrastructures like crossovers and underpasses created a dichotomy in highway traffic and high-speed traffic with urban traffic which created an atmosphere of reduced congestion and waiting on signals. The major lessons from Trondheim shall be to direct the investment toward the infrastructures that create the desired change or shift from one mode of

transportation to the intended mode. Moreover, the designs of intersections, roundabouts, and islands have a great influence on mode choice which are interlinked with other attributes of urban travel. Meanwhile, special attention shall be given to the magnitude and scale of the intervention. (Pritchard, 2019)

5.3 Mode choice and land use attributes

The research was also focused on finding the relevance of mode choice decisions of people and relating the fact with different attributes of land use patterns of the city. The specific criteria from the literature were discussed as the relationship between the length of the journey of a particular trip and the mode choice behavior of people connected to that journey length which was able to reveal the choice people made for the specific length of travel. Moreover, the research was able to analyze different maps generated from secondary sources related to the mode choice and land use attributes and discuss different parameters about land use and mode choice behavior of people.

The relation between mode choice and journey length of Kathmandu valley was illustrated in figure 4.5 and of Trondheim was illustrated in figure 4.18. Both charts illustrated the dominance of journeys on foot for shorter journeys but gradually the shift occurrence was noticed from walking as a mode choice to private modes of transportation, particularly car on the case of Trondheim and motorcycles in Kathmandu valley; which discussed were also the most popular and used modes of transportation in terms of modal share on both the cities. Similar findings were discussed previously Corpuz (2007), also mentioned that private mode users are primarily concerned with the speed as well as comfort and convenience associated with making the trips travel time shorter and attaining flexibility in the trip making. Similarly, as discussed in the previous section as well, the usage of motorcycles was found associated with these facts in Kathmandu valley as described by various authors (Ghimire & Marsani, 2019; Malla, 2014).

Likewise, the share of the bicycle in Trondheim was seen as dominant up to a mark of more than 10 percent of total travel distance but the share of bicycle travel was found very insignificant in the case of Kathmandu valley. This could be discussed with previous references as a lack of bicycling infrastructure and a lack of prioritized investment for the particular mode. Moreover, in Kathmandu valley, as discussed, the mode usage or modal share has been declining in use. This can also be attributed to the land use patterns of the city amongst different built environments and bikeability related to cycling. Figures 4.4 and 4.9 depict the clear contradiction where different urban centers and sub-centers seem to be formed in the Trondheim municipality near the residential zones while the problem of mono-centricity and dependence on CBD was seen higher in the case of Kathmandu.

Contrastingly, the use of public transportation as a mode choice and its popularity with increasing journey length could be seen more evident in the case of Kathmandu valley where more than 40 percent of travel was made by public transportation for journeys more than 5km. This could be justified by the line diagram shown, where the people dependent on the CBD of the valley make the commuter trips from the neighboring districts and municipalities only possible with private modes of transportation or public transportation only, through which the declining popularity of cycle as a mode choice also may be justified.

The land use attributes suggest that the placement of settlements or residential areas near CBD as a concept of the compact is crucial to adopt to lesser use of automobiles and promoting the use of walking and bicycling as a mode choice. The public transportation system in Trondheim was found to be linking the land use and CBD districts, where residential or settlement areas were found connected to the CBD by a strong public transportation network. The frequency of the bus also was evident to be the function of the settlement density and land use in general. Meanwhile, the public transportation system in Kathmandu being privatized and profit-oriented is based on demand while the places with higher settlement density are served well but places of low density are compelled to use private means of transportation due to low level of service and lack of accessibility.

5.4 Conclusion and Implications

The general conclusions are summarized in this heading where key research findings are mentioned concerning research aims. This section was able to review the limitations as well as provide different implications of research both in the case of Kathmandu valley and the theoretical framework generated in the initial portion of the research. Based on the literature reviews and other methods followed by the research, the research was able to generate different results and different discussions were made accordingly. The research aimed to assess the transport mode choice in Kathmandu valley that were available to the trip maker and extract the reasons behind the particular mode selection. The case study as a research methodology was adopted along with both quantitative and qualitative analysis where the framework for modal shifts from one mode to another mode was discussed. The field visit and case study of Trondheim, Norway were used as an example to draw lessons from the positive and good practices that have been done in the municipality.

Both in the case of Trondheim and Kathmandu, private modes of transportation were most preferred by the people which may be related to criteria of reasons or specific criteria defined in the literature review as travel time reduction, accessibility, and other factors like independence of reliability and regularity, comfort, safety and within the control of the trip maker themselves. However, the use

of motorcycles in the case of Kathmandu valley was also attributed to economic feasibility as reduced monetary cost for the trip maker. Nonetheless, as described in the literature, private modes of transportation are attributed to problems defined as unsustainable and shall be created a shift from other sustainable modes of transportation. Likewise, the aspect of reducing modal share and availability of private transport in the case of Trondheim was seen which could be compared to increased economic accessibility or monetary value by the use of tolls, higher parking costs, and other taxation systems, also in conjunction with increasing investment creating lucrative environment or motivations for people to be shifted towards on other modes of transportation particularly public transportation, walking, and cycling.

Moreover, Public transportation as a modal share can be seen depleting for making trips in Kathmandu valley but when attributed to journey length and mode choice characteristics of the valley the use of public transportation can be seen dominant for more than 6 km journey. The criteria for reason for this can be explained with the land use relation where people from distant regions of the valley were found making trips to CBD because of the monocentric urban structure due to which people from distant regions are compelled to make trips to or near CBD. Also, the fact that private modal availability of Kathmandu valley was found to be around 30%, clarifying that only 30 people in 100 and additionally living in distant regions are heavily reliant on public transportation The mode shift attributes towards public transits was found majorly attributed to travel time, reliability and regularity of service. As lessons are drawn from Trondheim, the integration of apps for real-time information flow and reducing uncertainty, and prioritized investments towards public transits like the dedication of lanes for improved travel times along with other major interventions will be able to create and motivate as well as cater and create demands for public transportation in Kathmandu valley.

Nonetheless, Walking was found as a dominant mode of transportation for lesser distances but the modal share in the case of Kathmandu valley was seen reducing extremely at expense of motorcycle use which can be majorly attributed to land use and infrastructure condition of Kathmandu valley which were found very poor. Similarly, cycling as a mode choice has significantly decreased a mode choice in Kathmandu, although the usage and criteria for reason for selection of modes such as travel time reduction, use in congested space, and monetary cost between motorcycle as well as the cycle were found highly resembling. The journey length and mode choice depicted that motorcycle was the dominant mode of transportation in Kathmandu valley for around 5 km of the journey from which public transportation dominated, while the lessons drawn from Trondheim depicted that the journey within that mark to be dominated by bicycle in case of Trondheim. This

suggests, the shift from motorcycle to bicycle shall be motivated and investment shall be directed towards making roads more bikeable and creating priority lanes and dedicated lanes shall be addressed along with the land use linkages creation between settlement area and CBD and other land use functions like a compact city.

Nonetheless, the implications suggest infrastructural aspects play an important role in shaping how different modes of transportation are used. Thus, the investment in infrastructure shall be prioritized and directed towards the desired results. Mode shift to environmentally friendly modes of transportation requires not only infrastructural investments but also hybrid solutions like incentives, campaigns, and marketing of competing mode choices, but the shift is a function of the magnitude of intervention and time. Initiatives like recent attention drawn towards cycling as a mode choice will be able to create the desired changes expected in this paper. But again, the research relied heavily on secondary data and literature and the data availability was a major part of the assessment The implications for further study may be stated as the use of more advanced techniques in data collection which may reveal deeper insight into the topic. Moreover, the land use and mode choice topic shall be assessed further to reach more meaningful conclusions. Nonetheless, this paper may be used as a stepping stone for creating other such studies.

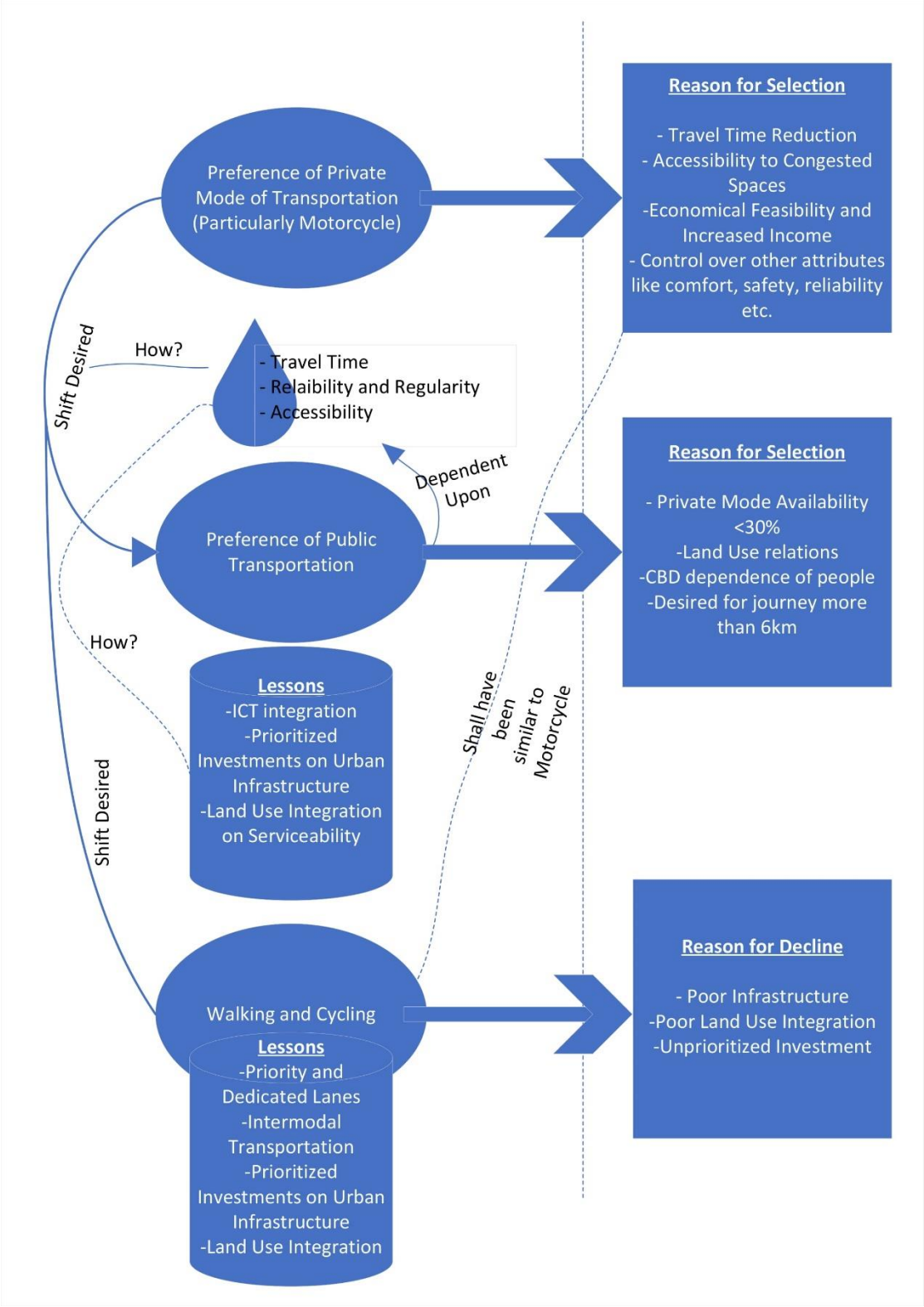

Figure 5.1 Conclusion and Summary

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ANNEXES

Annex A: Key Informant Interview

Annex B: Site Photographs

Annex A: Key Informant Interview

Semi structure for KII

1. Urban Mobility by NMT
2. Walking as mode choice
3. Public Transportation Status

Interview with Mr. Dr. Ray Pritchards, Mr. Eirik Skjelsvik, Mr. Rubaid Naksar, and Mrs. Kelly Riedesel

Photo A. 1, Interview with Dr. Ray Pritchards

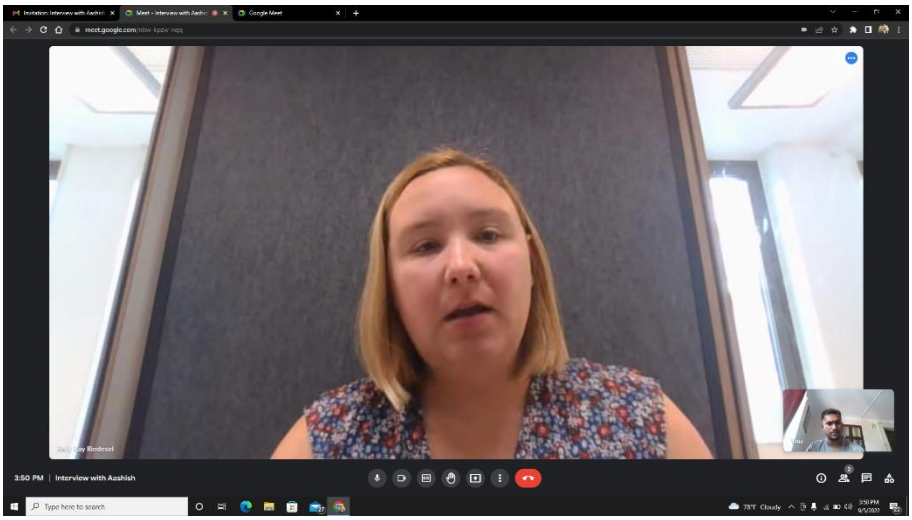

Photo A.2 Interview with Mrs.KellyRiedsel

Annex B: Site Photographs

Photo B. 1:Bicycle Infrastructure in Trondheim

Photo B. 2 Cycle Counting System and Wheeling Ramp and Tramp Bicycle Lift in Trondheim

Photo B -3 Typical Buses in Trondheim

Photo B. 4 Infrastructure related to Public Transportation in Trondheim

Photo B.5 Marketing pamphlets of App Mobee in Trondheim

Photo B.6 Typical Road Infrastructure in Kathmandu

Photo B.7 Urban Transport Infrastructure in Kathmandu

Annex C: LOG BOOK

S.N	Date	Meeting	Major Comments	Remarks/ Page No.
1	12 June	Dr. Kirti Kusum Joshi	Secondary Data Collection, Reformulation of Objectives, Balancing Mobility/ Accessibility	23
2	18 June	Dr. Kirti Kusum Joshi	Perception of Walking, Door to Door Connectivity, Land Use and Transportation relationship	12
3	22 June	Dr. Martina Keitsch	Travel Habits in Trondheim, Motivation/Persuasion relationship, Highlight Relation with SDG	38,6
4	28 June	Dr. Peter Andreas Gotsch	Research Objective formulation and linkages to overall research	7
4	7 July	Dr. Martina Keitsch	Add graphics in presentation, Roles of Tables, figures and Charts	All
5	14 July	Dr. Martina Keitsch	Organization of Literature Review Section, Research Design and Methodology	9
6	19 July	Dr. Kirti Kusum Joshi	Data Collection Techniques, Framework for Data Collection	16
7	26 July	Dr. Martina Keitsch	Concept of Infrastructure before law, Economic Infrastructure, Recommendation section review	All
8	3 August	Dr. Hans Narve Skotte	Linkages between Chapters, Literature review and Theoretical Background	9
9	12 August	Dr. Hans Narve Skotte	Title Restatement	I
10	3 Sept	Dr. Kirti Kusum Joshi	Comments on Slides, Importance of Research restate, research setting, report hierarchy and organization	All
11	15 Sept	Dr. Kirti Kusum Joshi	Restatement of Title, Report Reorganization	All
12	25 Sept	Ar. Yek Raj Adhikari	Hierarchy of Bus System Introduction	30,31,42
			Distance of School and Settlement	49
			Explanation on Zero Growth Policy	36
			Rewrite Abstract	V
13	25 Sept	Er. Kishore K. Jha	Profit Orientation vs Market Orientation	52,53
			Secondary Data Orientation	8
			Municipality Management	52
14	25 Sept	Dr. Ajay Chandra Lal	Dichotomy in use	14
			Dynamics of Public Transport	52,53
			Monocentric and Land Use of Kathmandu	34,54
15	25 Sept	Dr. Kirti Kusum Joshi	Car as “status symbol”	8
			Cumulative Data instead of Annual	25,29
			Policy Orientation and Hybrid Solutions	55,56