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Analyzing Willingness to Shift to Proposed Metro Rail System for Work Trips: A Case of New Baneshwor and Radhe Radhe

by

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ABSTRACT

With the increasing population in Kathmandu, there seem to be challenging mobility issues. Low occupancy and unregulated services of public vehicles have resulted in more private vehicles on the road. As such, in the last few decades, the number of new vehicles in the city has tripled, adding to the traffic volume and traffic congestion. Thus, the city needs efficient and reliable public transportation that would encourage walkable communities and transit-oriented development while lowering fuel consumption, reducing dependency on private vehicles, and reducing traffic congestion and pollution. Various studies on Mass Rapid Transit (MRT) are being conducted to solve these problems. This study examines the rarely studied yet crucial element—the perspective of potential users. Using the Stated Preference survey, the willingness to shift of 200 respondents in the proposed metro station location at New Baneshwor and Radhe Radhe was conducted through direct interviews. The results suggest that about two-thirds of the respondents were willing to shift to the metro. The study has discovered intriguing relationships between willingness to shift and factors including income, distance, mode of transportation, and origin and destination. Findings from the study revealed that the respondents willing to shift were mainly those with trip distance more than 2 km; high and medium-income groups; commuting by ride-sharing, private and public vehicle users; while those unwilling to shift were those commuting less than 2 km; low-income group; and those commuting on foot or cycle. Although there were significant differences in the settlement patterns of the two-study area, the responses were indifferent to spatial patterns. Hence the study concludes that there is a need for MRT in the city as the current public transport infrastructure has failed to meet the needs of the commuters.

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LIST OF ACRONYMS

BRT: Bus Rapid Transit

CBD: Central Business District

CBS: Central Bureau of Statistics

DOTM: Department of Transport Management

DUDBC: Department of Urban Development and Building Construction

GIS: Geographic Information System

LRT: Light Rail Transit

MRT: Mass Rapid Transit

NMT: Non-Motorized Transport

RP: Revealed Preference

SDG: Sustainable Development Goal

SP: Stated Preference

UN DESA: United Nations Department of Economic and Social Affairs

1 CHAPTER ONE: INTRODUCTION

1.1 Background

As the world becomes more urbanized, cities and metropolitan regions have the challenge of sustaining internal and external connectivity in the face of rapid population expansion and a high migration rate to urban areas. According to Ritchie & Roser (Ritchie & Roser, 2019), 68 percent of the world's population will reside in cities by 2050, up from 54 percent in 2016. The linkage between the many components and facets of urban development is one of the most significant aspects of sustaining livability, therefore, transportation is an essential guiding feature in the growth and growth pattern of any city and thus the nation.

Nepal is one of the top ten countries with the fastest rate of urbanization in the world (UN-DESA, 2018). The country's capital, Kathmandu - the administrative and commercial center, has seen tremendous urbanization over the last few decades. According to the census of 2021, Nepal's urban population is 1,92,91,031 people, accounting for 66.08 percent of the total population, while the rural population is 99,01,441 people, accounting for 33.12 percent (CBS Nepal, 2022). Although Nepal is projected to urbanize as one of the fastest countries in the coming decades, the fastest rates of urbanization over the period 2018-2050 are projected to be slower than those in the past, with an average rate of 2 percent per year (UN-DESA, 2018).

Urbanization is mainly dominated by a few cities with the Kathmandu Valley having an excessively high population density (JICA, 2019). In research on traffic improvement in Kathmandu Valley, the Japan International Cooperation Agency (JICA) projected the population rate to grow by 4.32 percent. According to this estimate, the valley's population in 2022 will be 3.84 million people. In the next five years, this population boom will probably result in a massive increase in travel demand and numerous transportation issues (Shahi & Bhattarai, 2021). The rapid growth of the population and their mobility needs is challenging and has resulted in significant traffic congestion and pollution. It is now vital to adopt efficient and effective measures to relieve traffic-congestion along with sustainable urban land use and development. Urban transportation problems include uncontrolled urban sprawl, monocentric urban architecture with heavy traffic

and a concentrated population in the city center, and an unstructured and ineffective public transportation system (JICA, 2019).

The average speed of vehicles in the core area in peak hour is only around 7 km/hr, hence the Kathmandu Valley is in severe need of a Mass Rapid Transit (MRT) system that can transport thousands of passengers every hour (Amatya, 2017). To address the various issues of the challenging mobility, the Government of Nepal (GON) has planned for various Railway and Metro networks across the country. According to Aman Chitrakar, the Senior Engineer at Department of Railways, along with Ministry of Physical Infrastructure and Transport has stated that the feasibility study of Kathmandu Metro Rail has been completed and its carrying capacity has set to be 25,000 to 60,000 (Chitrakar, n.d.).

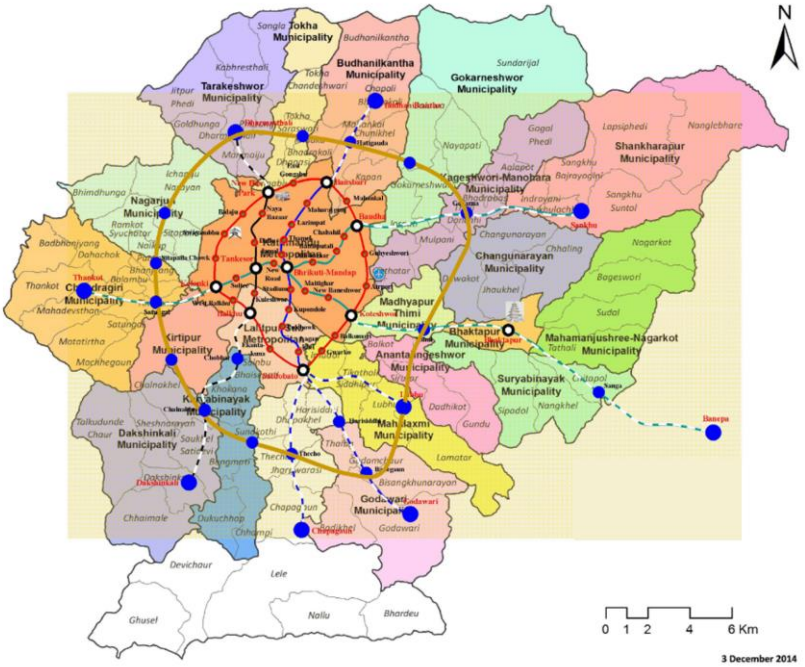

Figure 1.1: Kathmandu Metro Routes (Source: Amatya, 2017)

A metro system is Mass Rapid Transit (MRT) that moves a lot of commuters along a transit route at a high rate of frequency and capacity, which may be elevated or underground. It consists of modes of urban public transportation that only operate on designated fixed tracks, such as the metro, regional railways, light rail systems, and bus routes. It is significant because, when compared to road-based public transportation like buses, taxis, and other vehicles, it operates more efficiently and performs better. A secondary study of 'Kathmandu Metro Rail Vision 2040' by Dr.

Binod L. Amatya is referred for the Metro feasibility, routes lines and station location. Out of the various routes shown in Figure 1.2, the Kathmandu Line running along the east west direction is considered for this research.

Figure 1.2: Proposed Station in New Baneshwor and Radhe Radhe in the Kathmandu Line of the Proposed Metro Route (Source: Amatya, 2017)

The Kathmandu Line of the proposed Metro route connects the two districts of Kathmandu and Bhaktapur respectively. This route connects Banepa- Sanga- Bhaktapur- Sallaghari- Thimi- Koteshwor- Bhrikuti Mandap- Tankesor- Kalanki-New Satungal- Thankot. It is estimated to be 54 km running east to west and connecting with both the Arniko Highway and the Prithivi Highway. This corridor has a catchment area with high number of potential travelers. The choice of this corridor for our study is based on the fact that it passes through important urban centers with significant development. It consists of urban area, suburban area and peripheral area. Along this route two extreme condition of population density will be explored. Out of the various proposed stations along the route, this research will examine the New Baneshwor and Radhe Radhe area within its influence zone. A field study of New Baneshwor for core dense urban area and Radhe Radhe for peripheral area will be carried out to know the mobility pattern of work-based trips. For the purposes of this study, the region within 500 meters of the planned metro station will be referred to as the Transit Influence Area (TIA), as this distance may be readily traveled on foot in 5 to 10 minutes.

1.2 Need of the Research

Approximately 38.64% of trips in the Kathmandu Valley are done for work-related reasons, followed by 34.3% for school or college, 14.90% for business, 7.83% for personal visits, and 4.29% for shopping (Udas, 2012). This suggests that majority of the trips are made for work and educational purposes. Hence this research focuses on the work-based trips only.

A study by A. R. Bajracharya et al., (Bajracharya et al., 2020) found that private vehicles account for the most modal share for work trips in the Kathmandu valley with a share of about 69%, public transportation accounting for a share of about 17%, and non-motorized modes accounting for about 14%, as shown in Table 1.1. This implies that the city is highly dependent on private vehicles, which is due to the lack of efficient public transportation. There is a need to research on an efficient mode of public transportation, MRT, and explore the user's willingness to shift to an alternative mode of transportation.

Table 1.1: Modal Share in the Kathmandu Valley

Mode Category	**Travel Code**	**Modal Share**
Private	Car	20.8%
	Motorcycle	48.6%
Public Transport (PT)	Bus	11.1%
	Microbus	4.2%
	Tempo	1.6%
Non-Motorized Transport (NMT)	Walking	13.0%
	Bicycle	0.7%

Source: (Bajracharya et al., 2020)

Numerous scientific studies have looked into the relationship between land use and transportation. The literature to date indicates that the introduction of new transit routes affects urban form in both positive and negative ways. In regions close to stations or stop sites, these shifts in land use and intensity are particularly noticeable (Bocarejo et al., 2013). The consequences indicated above are dependent on the mode of transportation, according to studies on transit routes and land use. The link between property values and land usage in the context of rail transit is significant. In other words, research indicates that traditional bus transit systems have a limited ability to promote urban development, whereas the opening of a new metro line has significant, positive effects on local property values and urban growth (Cervero, Robert Kang, 2013; Lewis-Workman & Brod, 1997).

This is so that a city road's single lane can carry a smaller volume of people than the Metro. As most cities' populations are expanding or are projected to grow in the future.

As land use can affect people's habits, behavior, culture, identity, and ultimately mode choice, land use and transit planning are required and must be coordinated at the same time (Zuo et al., 2018). Over time, land use has substantially impacted traffic mobility (Sunoto et al., 2021). Hence for this, to know the publics' perceptions and their mobility pattern are very important.

Thus, this research attempts to explore willingness to shift to Metro and the settlement pattern of the present condition around the influence zone of the transits. The cases of New Baneshwor and Radhe Radhe area will be studied as urban and peripheral area respectively. Along with this, peoples' mobility pattern and their willingness to embrace new public transportation in the city will be examined. Being one of the initial investigations, this work will be used as a foundation for subsequent research. It can serve as a basis for the future planning of the MRTs in Nepal. The conclusions and data of this study can be utilized as references to carry out further researches.

1.3 Importance of the Research

In our context most of the land use plans and transportation plans are being carried out independently, so research such as this one is one step towards that integration. By studying the relationship between the mobility pattern and settlement pattern we can plan cities that are transit oriented. This study can contribute to the design of better cities with respect to mobility. The integration of long-distance mass transit and short-distance walking or bicycling is made possible by having a mixed-use development with all amenities adjacent to public transportation hubs. The Sustainable Development Goal (SDG) 11.2 stipulates that by 2030, all people should have access to secure, affordable, accessible, and sustainable transportation systems. The TOD is in line with this goal. It will also give special attention to the needs of those who are most at danger, such as women, children, people with disabilities, and the elderly. This will increase road safety, particularly through enhancing public transportation. Guidelines of the TOD can help to design smart sustainable cities. However, field observation and public perspective will help to understand our context and its ground realities. Studies as such should be done to help make policies towards a better city for the inhabitants. Government officials, decision-makers, practitioners, policy-makers, urban planners, transport planners, academics, and others will find the study's conclusions

relevant. The content of this report would add to a new knowledge and can be used as a reference for future work by organizations and institutes working on land use, urban mobility, transportation and transit-oriented development.

1.4 Problem Statement

Unmanaged transportation is one of the major issues with the existing system. The majority of the valley's public transportation network is often run and owned by private businesses. The bus schedule is largely unpredictable and arbitrary. The demand-driven transportation service travels along defined market routes.

Heavy traffic and inefficient service delivery are the results of the operators' competition to offer more services in the competitive lines (Prajapati et al., 2020). Due to increased traffic volume brought on by this rivalry, operators' profitability is decreased. In order to recoup their benefits, this causes the fare to rise, and ultimately, users must pay the price. In addition, there exists an unhealthy competition between public transports to pick up passengers. They stop in places other than the bus stops which leads to disturbances for fellow drivers and poses threat to the pedestrians which could cause long traffic jams or accidents. The public transportation is composed of vehicles that have low occupancy. The number of private vehicles on the road is steadily increasing as a result of the dearth of effective and dependable public transportation. As more people travel by car and two-wheeler, there are now substantial worries about traffic congestion, air pollution, and accidents (Advani & Tiwari, 2005). Due to the range of modes used, origins, and destinations, as well as the volume and type of traffic, urban transportation is extremely complex. According to research by the Metropolitan Traffic Police Division, if all of the valley's automobiles were made to stand in a queue, at 7.2 million feet, which would exceed the length of the Kathmandu Valley's highways, which is 4.5 million feet (Khatry, 2022). The road capacity is insufficient for the increasing numbers of vehicles due to which, the public open and sacred spaces have been encroached. In Nepal, there is a misconception that road widening solves traffic congestion. It can only bring temporary relief; however, as long as the number of vehicles continues to rise, road widening will be ineffective (Nepal National Report, 2016). Furthermore, the courtyards and footpath are being used for parking due to a lack of sufficient parking spaces.

The use of motor vehicles has been increasing as shown in Table 1.2. In 2074/75, Nepal had 32,21,042 vehicles, with 11,72,413 in Bagmati Province, accounting for 36.40 percent of the total and the highest in comparison to other provinces. With most of them running on the streets of Kathmandu Valley. Table 1.3 shows that new vehicles registrations have increased nearly three to four-fold in the last decades. This means that our cities are heavily reliant on motorized vehicles and much priority have been given to vehicular roads. Due to this there is limitation in non-motorized transportation such as walking and bicycling and its infrastructure. As a result, a shift from private vehicles to public transportation is required. Additionally, the necessity for public transit systems that allow for better mobility for the population.

Table 1.2: Total Vehicles in Nepal and Bagmati Province 2074/75

	Nepal	**Bagmati Province**
Number of Vehicles	32,21,042	11,72,413

Source: (DoTM, 2020)

Table 1.3: Total registered vehicles in Nepal and Bagmati Province

Year	**New Registered vehicles in Nepal**	**New Registered vehicles in Bagmati Province**
2054/55	24139	10667
2064/65	84740	42885
2074/75	437614	129557

Source: (DoTM, 2020)

To encourage such shift, there is a need for Transit Oriented Development (TOD) where all activities are in proximity to the transit. It is one of the most useful tools since it is based on the idea of compact growth near transit hubs. Transit systems are necessary in urbanized regions to physically accommodate high densities of varied activities, such as homes, businesses, offices, factories, parks, etc. while maintaining livable and appealing urban environments for people (Vuchic, 2004). According to Joshi and Kono (2009), it is vital to combine land use and transportation planning when designing development patterns that will decrease the amount of time or distance needed to commute. Transit-oriented development (TOD) must take place in the

transits in order to achieve the proper densification. Incorporating housing, commercial space, and urban amenities adjacent to public transportation hubs integrates long-distance mass transit with short-distance, neighborhood walking or using non-motorized transport modes (Nepal National Report, 2016). Several of today's transportation problems are blamed on inefficient development patterns (Johnson, 2003). However, choosing between public transportation and a more individualized mode is a personal option that is additionally influenced by governmental regulations and decisions made by metropolitan local bodies (Kumar, 2014). According to Cervero (2013), both the difficulties in coordinating land use and transportation are far more difficult in the developing world than they are in wealthier, industrialized nations. The potential benefits to the environment, underprivileged people, and long-term economic development are considerably larger if the two are well-coordinated (Cervero, 2013).

The Kathmandu Line of the proposed Metro, in order to improving the connectivity, through Banepa- Sanga- Bhaktapur- Sallaghari- Thimi- Koteshwor- Bhrikuti Mandap- Tankesor- Kalanki- New Satungal- Thankot links with both the Arniko Highway and the Nagdhunga highway. This corridor is dense and has an intense traffic flow with relatively high economic activities, resulting in more movement of people and vehicles to city center causing more traffic congestion, thus forming mono-centric concentration. This is due to the lack of an integrated approach towards transit and land use planning. Land use and transportation are dynamically connected. While the expansion of transportation systems improves accessibility levels, which in turn stimulates changes in land use patterns, changes in land use patterns can influence changes in travel demand patterns and cause changes in transportation systems (Pan & Zhang, 2008; Roukouni et al., 2012). In terms of land-use change, built form, accessibility, and land value, the transit region therefore has enormous potential to see a significant change in urban form.

1.5 Research Objectives

The main aim of this research is to study the Metro as MRT and examine the willingness of the commuters to shift to metro for work-based trips in the proposed station location in New Baneshwor and Radhe Radhe. Further specific research objectives to assess the willingness to shift are:

• To assess the current travel behavior in commuting work trips.

• To study the settlement and mobility pattern around the station points.

1.6 Validity of the Research

This research is carried out to examine the settlement pattern of New Baneshwor and Radhe Radhe transits within the influence zone. Due to the lack of research, cities are being designed without integrating mobility and land use. It can be valuable in identifying the present situation, problems and potential. It is thus a vacant area of research in our context on how the introduction of a new mode of transportation can affect the people and the land use of the city.

The research studies the willingness of commuters to shift to metro in the area of two different settlement pattern and examine why people would opt for it or decide not to opt for it. Such research has rarely been done with a similar perspective to explain the phenomenon along the proposed Metro line. The result of the study would reflect the need for a metro in our context. The study guarantees a valid output addressing its objectives.

1.7 Scope and Limitations

The research studies the current travel behaviour and the willingness to shift to Metro from their current mode of transportation. For the feasibility of Metro routes and station location, it relies on secondary sources. However, the settlement pattern of the transits is made through field observations. Only the work-based mobility pattern is studied. The study will be limited to the two-station location, namely New Baneshwor and Radhe Radhe, in the Kathmandu Line route within the area of influence.

2 CHAPTER TWO: CONCEPTUAL FRAMEWORK AND METHODOLOGY

2.1 Ontology

A collection of philosophical and meta-theoretical assumptions about the nature of reality (ontology) and knowledge (epistemology), as well as the procedures for conducting scientific research (methodology), define the characteristics of scientific creations (research methods) (Egon G & Yvonna S, 1994; Slevitch, 2011). Ontology is the study of what is, or the essential character of reality. Ontology is the foundation of all study and the representation of social reality that serves as the foundation for theories. The epistemological and methodological positions follow ontology. The ontological position of this research lies within the interpretive paradigm in the reality that public transportation is unreliable, which has led to mobility challenges faced by the people. The reality is multifaceted because of the various population. The two studies in New Baneshwor and Radhe Radhe have different spatial scenarios with different mobility pattern, one being the dense settlement and the other an emerging settlement. Multiple people may experience the same system in different ways.

2.2 Epistemology

The requirements for knowledge production and the characteristics of scientific knowledge are covered by epistemology (Neuman, 2014). Epistemology is the possible way of gaining knowledge. In this research, some information is obtained through secondary sources, observation, field surveys and interviews with the stakeholders, which are then interpreted. The valid source of knowledge for this research is through interpretation of maps, documents and interaction with people. The land use can be observed through direct observation, field survey and aerial maps. Likewise, knowledge regarding the initial research of metro feasibility and station location will be obtained from secondary reports. The site observations and interaction with the people provide information on the work trips' current land use, travel behaviour and mobility patterns.

2.3 Methodology

The methodology is both a group of procedures or guidelines used to conduct a specific type of study (Somekh & Lewin, 2005). The methodology, which includes the scientific method,

ethnography, and action research, is the framework tied to a specific set of paradigmatic assumptions that will be applied to the research (Leary, 2017). A research plan known as a methodology transforms ontological and epistemological concepts into rules that specify how research should be carried out. The various research methods include qualitative research, correlational research, experimental research, simulation and modeling research, case study, and interpretive-historical research. Research methodology aims to determine the outcome of a particular issue or problem, often known as a research problem. In methods, researchers employ many criteria to address or search the specified study problem. The methods used by various sources to solve the problem vary. The word "methodology" refers to a process for conducting study or finding solutions to problems. In research methodology, the researcher constantly seeks to conduct a methodical, independent search for the answers to the provided topic.

2.4 Research Strategy

Several research studies relate to MRTs and metros, most of which focus only on technical issues. Currently, the transportation and land use plans are being carried out independently without any integration. Research gaps can be found in the context rather than the criterion of the research topic. This research will follow a Mixed Research strategy—using both qualitative and quantitative methods. Qualitative research is employed for observing the experience using an open research question. Qualitative research includes studying the mobility pattern and land use resulting from human choices, behaviours, and socio-cultural attributes that contribute to such decisions. Their current choice of mobility to commute to work will be made through the Revealed Preference survey. However, the hypothetical situation about their willingness to shift to Metro under given circumstances will be done through the Stated Preference survey. Quantitative research is employed in collecting data and analyzing it.

2.5 Paradigm

A systematic examination that collects, analyzes, and interprets data in an effort to comprehend, characterize, anticipate, or manage a psychological or educational event, or to empower people in such situations, is known as research (Mertens, 2015). Paradigms are sets of models or frameworks that reflect a worldview or set of beliefs about the nature of knowledge and existence (Cohen D, 2006). There are many paradigms, including constructivist, transformative, pragmatic,

deconstructivist, positivist, post-positivist, and interpretivist. The selection by rejection method is used to choose the study paradigm. A research endeavor is unique in its own way, and there are frequently several ways to do research.

The Positivist paradigm is a scientific research based on the rationalistic, empiricist philosophy (Donna M. Mertens, 2010). In an effort to achieve a goal and discover truth, positivists approached research in a very objective, regulated, rigid, and rigorous way (Plack, 2015).

Post positivist paradigm is based on most likely truth. Post positivist paradigm believes that reality can be known only imperfectly and probabilistically. It encourages the study of society as a value-free field in which it is possible to offer causal explanations.

The participants' perspectives of the situation being examined are frequently relied upon by the constructivist/interpretivist paradigm (Creswell & Creswell, 2018). It believes that there is no single reality or truth, and therefore, reality needs to be interpreted. The constructivist paradigm uses qualitative data gathering techniques or a mix of qualitative and quantitative techniques to gather information.

A pragmatic paradigm is one in which two research issues have two distinct paradigms. In terms of philosophy or reality, pragmatism has no commitments (Mackenzie & Knipe, 2006). The pragmatic paradigm prioritizes "the research challenge" and considers various methods of problem-solving when constructing its framework (Creswell & Creswell, 2018).

This research is mainly focused on evaluating the mobility pattern in the urban and peripheral area that lies in the selected route. It also studies the present land use pattern and identifies the important factors of the transit influence area. An interactive study will be done by interacting and carrying out a survey with a large number of people around that area about their mobility and willingness to shift to metro. The factors affecting people’s preferences are subjective and have multiple realities. In this context, this research demands the utilization of quantitative data in order to support and expand upon the qualitative data so that the social reality can be described in a holistic approach. The reality is primarily generated from within the society and is then interpreted through the researcher's lens. As such, the only valid source of knowledge in this research is the people’s opinion and observation of land use through field exploration, Geographic Information systems (GIS) and satellite images. The approach is subjective, where the researcher must dive deep, and

the truth is known by the context that has shaped it. Intrinsically, the research fits right within the interpretive and post-positivist paradigms. Thus, this research falls under the pragmatist paradigm.

2.6 Research Approach

Inductive reasoning, which is another term for the inductive technique, starts with observations, and theories are offered as a result of observations toward the end of the research process (Goddard & Melville, 2004). A deductive approach begins with a hypothesis and then tests a theory, whereas an inductive approach starts with a research question without any preconceived ideas, and the theory is derived from the data. This research will be based on Inductive logic as it will be based on the facts from observation which will finally lead to a conclusion. To arrive at the conclusions or develop theory, patterns, similarities, and regularities in experience are noticed (Business Research Methodology, n.d.).

1.1 Research Design

The research aims to explore existing problems and causes related to urban mobility and settlement patterns in the study area. Understanding the current mobility pattern and the people's willingness to shift to the metro is this research's main objective. As per research requirements, a researcher has selected an exploratory rather than a conclusive research design.

Exploratory research, as its name suggests, aims to study the research questions rather than offering comprehensive and conclusive solutions to current problems. This kind of research, carried out to ascertain the problem's nature, not only aids in our comprehension of the issue but also does not aim to offer conclusive proof.

Exploratory research design does not aim to provide conclusive answers to the research questions; instead, it only investigates the study issue in varied degrees of depth. It has been said that exploratory research is the preliminary study that lays the groundwork for more thorough investigation. It may even help with the choice of research design, sampling strategy, and data collection method. Exploratory studies frequently concentrate on brand-new topics for which little to no prior research has been done.

2.7 Research Frame

Research is framed in three stages in which mixed research is predominant. Stages of research are presented as follows:

- Stage I – Literature review
- Stage II – Pre-analysis of literature review, case study and Field observation and data collection
- Stage III – Analysis

2.7.1 Stage I

Researches were reviewed in this section in the case of Nepal for a better understanding of the development context. Reviews were done for the identification of development gaps in the research context.

2.7.2 Stage II

In the second stage of research, theories and models of MRTs, urban mobility and willingness to shift were reviewed, and some case studies related to the changes in land use due to the metro were done to compare the development of the research context. In this stage, field data was collected using observation, checklist, questionnaires, and interviews.

2.7.3 Stage III

In this stage, collected data from both secondary and primary data collection methods was analyzed to fulfil the objective of the research. Conclusions of the findings were drawn from the analysis. Recommendations were drawn for the study of results in this stage to conclude the investigation.

2.8 Research Method

A method is a systematic approach, set of steps, or set of instruments used in data collecting and analysis. In the Interpretivist paradigm, although qualitative methods predominate, quantitative methods can also be used (Mackenzie & Knipe, 2006). Although paradigms cannot be mixed but methods can be mixed in research. So, in this research, the mixed approach, i.e., qualitative and quantitative methods, is used to collect different data. Qualitative data are represented through words, pictures, and aerial maps and analyzed using thematic explorations. The data from the

qualitative research will be abstracted to seek meanings from it. The data are collected, unnecessary data are reduced, and then conclusions are drawn from it. A questionnaire survey along with revealed and stated preferences in the study area will be carried out to study their work-based mobility pattern and willingness to shift to the metro.

A quantitative approach was used in the study, with a questionnaire as a tool for data collection. The main focus was to collect data about the work-based travel pattern of the people and their willingness to shift to a Metro when commuting for their daily work trips. It focuses on employed people and the trip they generate and attract in New Baneshwor and Radhe Radhe.

The survey constitutes three parts –

Part I: 'Socio-Demographic Background' wherein socio-economic and demographic information were asked

Part II: 'Details of Travel Behavior (Existing Condition)' wherein details of mobility patters of daily work trip were asked (which includes travel mode, time, cost and comfort)

Part III: 'Details of an alternative hypothetical situation of Metro' wherein they were given a choice and parameters.

The data collection has been done through convenient surveying. Each individual was asked about their Revealed Preference (RP) and Stated Preference (SP) in person in the field, allocating a time duration of 20 minutes. Concerning this, options of two choices were given to the respondents. The choices are 'Alternative 1'- using their current mode of transportation and 'Alternative2'- shifting to Metro. To evaluate these, various parameters such as comfort, travel cost, travel time and frequency of Metro were stated alongside. The cost per kilometer, travel time and frequency has been taken reference from Delhi Metro Rail Corporation. The survey identified the ranking of the factors that would facilitate the public to shift to Metro. If the second alternative was selected, the questionnaire further asked how likely they were to change to Metro. This would help in identifying the type of shifters- effortless and difficult shifters.

The Stated Preference Survey form is shown in Table 2.1. The complete Survey Questionnaire has been placed in APPENDIX A: Survey Questionnaire.

Table 2.1: Stated Preference question form

Parameters	**Alternative 1**	**Alternative 2**
Transport choice	Your current Transport mode (Car, Bike, Public Vehicle, Cycle)	Metro
Time to reach to Transit/station from home		5-10 minutes
Travel Time (in-vehicle)		2 minutes per Km
Time to get from transit or to destination		5-10 minutes
Travel Cost		Rs.8 per Km
Comfort		Seats available/ Comfortable standing
Service frequency		Every 15 minutes
Additional Cost (Parking, maintenance)		No

Table 2.2: Travel fare (DelhiMetroRail, 2022)

Distance (Km)	**Fare (Nrs)**
0-2	16
2-5	32
5-12	48
12-21	64
21-32	80
Above 32	96

While a qualitative approach was used for the analysis of settlement pattern in the study area which was observed through site visits, interaction with the people, Google satellite images and maps. The uses were identified and data were illustrated in GIS.

2.8.1 Sample Size Determination

The term "sample size" in research refers to the number of respondents needed for a study to accurately reflect the population of the target location. The sample size, or total number of respondents included in a study, refers to how representative the sample is of the entire population. Subgroups of this number are routinely created depending on age, gender, and geographic factors. The selection of the appropriate sample size is important for statistical analysis. On the other hand, if the sample size is too small, it may not represent the population accurately to produce reliable results for the group under study. If it is too large, it would require a lot of time and cost to carry

out the research, even though higher sample sizes reduce margins of error and are more representative.

The parameters to determine the sample size are:

1. Confidence intervals- It calculates the level of certainty or uncertainty associated with a sampling technique and the degree of uncertainty associated with every given statistic.
2. Confidence level: This is the likelihood or degree of certainty that, given a random sample, the confidence interval would include the actual population parameter.
3. Standard deviation: This measurement of the data set's divergence from its mean is important for determining the sample size. It calculates the mean number as well as the variance among the responses. It is also possible to calculate the population standard deviation using the standard deviation of a sample.

Now, using Andrew Fisher's Formula to calculate the sample size:

$$\text{Sample Size} = \frac{(\text{Z score})^2 \times \text{Standard Deviation} \times (1 - \text{Standard Deviation})}{(\text{Confidence Interval})^2}$$

This equation is used to calculate the sample size for the study with a 90% confidence level corresponding to which the Z-score value using the confidence level table is 1.65. 50 percent of the population is presumed to be present, and a standard deviation of 0.5 is taken. Generally, a confidence interval (margin of error) of ± 5 to 10 % is taken; however, this study uses a confidence interval of ± 8.5%. The values are substituted in the formula:

$$\text{Sample Size} = \frac{1.65^2 \times 0.5 \times (1 - 0.5)}{(0.085)^2}$$

$$\text{Sample Size} = 94.20 \cong 95$$

Accordingly, 95 surveys or more are required to have a 90% confidence level and a real value that is within ±8.5% of the value of the survey. Consequently, 100 is chosen as the sample size.

2.8.2 Process of data collection

2.8.2.1 Field observation

Observation of infrastructure and services was done to better understand the context from the development standpoint. These observations helped researchers better comprehend the state of existing development.

2.8.2.2 Questionnaire Survey and Interviews

Questionnaires and interviews were conducted in the targeted locations mainly using non-probabilistic sampling techniques. Due to their simplicity and affordability, convenient and purposive sampling was used in qualitative research. These methods were also quite efficient in gathering public opinion. Two target groups were questioned, including individuals who commute to work by vehicle. In each research location, 100 samples were questioned. A total 200 questionnaire surveys were done.

Figure 2.1: Field Data Collection

3 CHAPTER THREE: LITERATURE REVIEW

Mobility is an integral part of human life; it is a defining characteristic of modern society. Understanding the connections between the use of urban land, transportation systems, and the activities of urban families and companies is the first step in addressing the systemic character of the urban transportation network. Transportation and urban form have definite connections. Land use patterns affect people's activities, such as where they work, reside, and enjoy their free time. The transportation system must handle movements between these various activity places, and transportation system advancements are expected to be adjusted accordingly. As a result, transportation developments influence location accessibility and, as a result, their appeal as a site for specific land use projects (Bertolini, 2012).

For example, land use developments are influenced by various factors such as land availability, local environmental characteristics, land use regulation, and regional economic dynamism. Individual qualities of homes and businesses, as well as the features of the larger socioeconomic backdrop, play a more significant effect in forming and adapting activity patterns than spatial considerations. The growth of transportation systems is impacted by the need for movement as well as mainly autonomous supply-side factors like technical innovation and mobility policy. When compared to changes in land use and transportation systems, which can take decades to complete, patterns of activity can be altered rather quickly (Bertolini, 2012).

The relationship between activity, accessibility, land use, and transportation are depicted in Figure 3.1 by the transport land use feedback cycle. Without necessitating a change in land use, accessibility changes can result in changes in activity patterns. On the other hand, changes in activity patterns can nevertheless influence changes in accessibility even in the absence of changes to the transportation system, such as those brought on by the consequences of congestion.

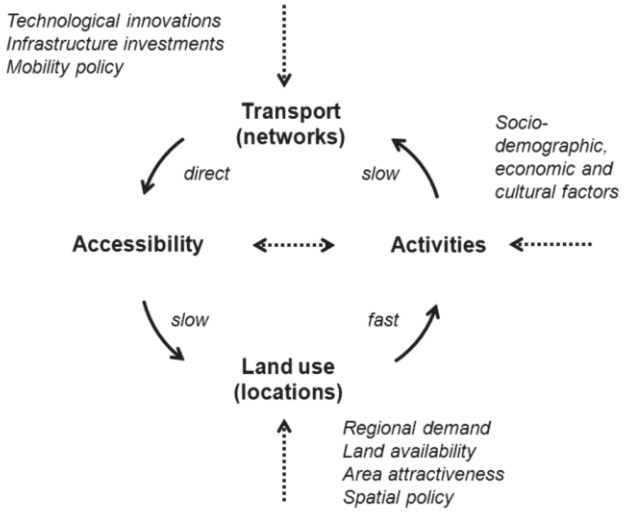

Figure 3.1: Transport land use feedback cycle (Bertolini, 2012)

3.1 Mass Rapid Transit

Mass Rapid Transit (MRT) refers to a term in which the metropolitan public transportation systems that can quickly convey huge numbers of passengers and can operate on both the road and rail. The term Mass Rapid Transit also known as "public transit" refers to a type of passenger transportation that runs on a set of fixed tracks, or exclusively uses the well-known possible path, on a set of predetermined routes, or along a set of lines, with a set of predetermined stops. Even yet, there are moments when trams and bus rapid transit share the road. It is made to transport lots of people between different locations inside of cities. Heavy rail transport, light rail transit, and bus rapid transit are some examples.

3.1.1 Heavy rail transit

A heavy rail transit system is defined as a transit system that operates in exclusive rights-of-way with high platform stops and trains of high-performance, electrically powered rail cars (TCRP, 1999).

3.1.2 Light Rail Transit

An urban electric railway system known as a light rail transit (LRT) system can run single cars or short trains along exclusive rights-of-way along ground level, aerial structures, in subways, or infrequently in streets, and can board and discharge people at track or car floor level (TCRP, 1999).

LRT systems include tramways, but a fundamental distinction is that trams frequently travel alongside other vehicles without having a dedicated right-of-way (GTZ, 2003).

3.1.3 Commuter rail systems

Commuter rail, usually referred to as suburban rail, is the field of passenger railroad operations that carries people between urban regions and their suburbs or inside urban areas. It is different from Metros and LRT in that it runs over tracks that are a part of the local train system, its passenger carriages are normally heavier, and the average trip lengths are typically longer (GTZ, 2003).

3.1.4 Bus Rapid Transit

Bus Rapid Transit is a customer-focused mode of transportation that integrates stations, vehicles, planning, and intelligent transport system components into a cohesive strategy with a distinct identity. Modernized bus technology, at-grade or grade-separated busways, and busway corridors are typical components of bus rapid transit systems (GTZ, 2003).

Table 3.1: Key Characteristics of MRT Systems

Characteristics	**Bus Rapid Transit (BRT)**	**Light Rail Transit (LRT)**	**Metro**	**Suburban Rail**
Segregation	At grade	At grade	Mostly elevated or underground	At grade
Space requirement	2-4 lanes from existing road	2-3 lanes from existing road	Little impact on existing road if elevated/underground	-
Impact on Traffic	Depends on policy & design	Depends on policy & design	Reduces congestion	Depends on frequency
Public Transit Integration	Problematic with paratransit	Often difficult	Excellent	Usually existing
Initial cost (US$ million/km)	0.5-15	13-50	15-30 at grade 30-75 elevated 60-180 underground	-

Implementation time	Short	Medium	Long	-
Interaction with land development	Good	Very good	Excellent	Variable
Fuel	Mainly Diesel/CNG/LPG	Electricity	Electricity	Electricity
Capacity (passenger/hr/direction)	10-35,000	12-30,000	60,000+	30,000
Speed (km/hr)	17-20	20-50	30-80	40-45+
Traffic Accident	Minor	Minor	No	Minor (at level crossing)
System image & passenger attraction	Good	Very Good	Excellent	Variable

Sources: (GTZ, 2005; Rahman, 2008; World Bank, 2002)

3.2 Taxonomy of Urban Mobilities

Mobility is tied to specific urban activities and land uses, each of which attracts and generates a range of motions. Variable recurrence, income, urban form, density, level of development, and technology are all closely related to this connection. Urban mobility is either mandated or optional when persons who create it are free to set their own schedules, such as leisure, when it is related to scheduled tasks like trips from house to work. The most popular types of urban mobility include:

Pendulum movements. These are mandatory movements between homes and places of employment. They are extremely recurring since they are predictable and occur on a regular basis, frequently on a daily basis, hence the name "pendulum" (Rodrigue, 2020).

Professional movements. These are motions related to professional, workplace activities that take up the majority of work hours, such as meetings, maintenance, repair, and customer service (Rodrigue, 2020).

Personal movements. These are voluntarily undertaken actions connected to the locations of commercial activities, such as shopping and leisure (Rodrigue, 2020).

Touristic movements. The presence of historical and recreational characteristics in cities is crucial. They usually occur seasonally or at particular times, and entail interactions between touristic landmarks (Rodrigue, 2020). Important urban mobility generators during their occurrence are major sporting events like the World Cup or the Olympics.

Distribution movements. These relate to freight distribution to meet consumer and production demands (Rodrigue, 2020). They typically connect to distribution centers, retail stores, and terminals for transportation. However, as internet sales increase, more deliveries to homes and freight movements are made to residential areas.

Urban mobility should take into account the origin, means of transportation, and final destination of its passengers:

Trip generation. In a city, people typically relocate to fulfil needs like access to jobs, leisure activities, or other services. Since it determines the travel required, a person's activity space is a crucial trip generation component (Rodrigue, 2020).

Modal split. For urban travel, this means a variety of modes of transportation, which is the result of a modal choice. This decision is influenced by several variables, including price, technology, accessibility, preference, travel distance, and money (Rodrigue, 2020). Walking, bicycling, using public transportation, driving, or even telecommuting will thus be utilized as an option or a restriction (lack of choice).

Trip assignment. Include the travel routes that will be taken when visiting the city. Most passenger excursions follow a predictable route (Rodrigue, 2020). For instance, commuters who drive cars often follow a defined route between their home and workplace. If there is traffic or a different activity (like shopping) is combined with this journey, a method known as trip chaining may alter this route (Rodrigue, 2020). The most crucial variables that affect trip assignment are transportation expenses, travel time, and traffic density.

Trip destination. Since each economic activity tends to be linked to a level of travel attraction, considerations based on activities are crucial (Rodrigue, 2020).

3.3 Transit Influence Area

The region where the passengers will walk to the station and use the facility is known as the influence zone of a transit station. Since the passengers will be prepared to go further distances and arrive at the station when the transit quality is good, the more prominent the catchment area will be (Calvo et al., 2016).

In order to encourage people to walk and take public transportation instead of using their own vehicles, transit-oriented development, or TOD, is any macro- or micro-scale development that is centered around a transit node. The primary goals of TOD are to:

- Lower the dependency on private vehicles and facilitate the use of public transport through design, policy initiatives and enforcement (MoUD India, 2017).
- Ease the transport access for people within walking distance – by densifying and improving connectivity (MoUD India, 2017).

Various studies established a "comfortable walking distance" (±10 minutes) from the transit stop for a majority of people in the United States, with the radius of influence area varying from 400–800 m (Calthorpe, 1992; Dittmar & Ohland, 2004; Flamm & Rivasplata, 2014).

According to Arasan et al. (Arasan et al., 1994), the permissible walking distance in the Indian context is 1.7 km, while the National TOD Policy of India has established the TOD influence area between 500 to 800 m (MoUD India, 2017). According to research on the Sustainable Urban Transport Index (SUTI), 85% of the population has easy access to public transportation in Kathmandu Valley, which is located just 500 meters from bus stops, (Khokali, 2017).

Topography, climate, intervening arterials or freeways, and other physical features influence reasonable walking distance. As a result, the size of a TOD will vary based on the surrounding elements (Calthorpe, 1992). Hence, this study will adopt 500m as the radius of influence for carrying out the research.

Table 3.2: Radius of Influence for different Context

Radius of Influence (meters)	**Context**	**Source**
600 m	San Diego, California	(Calthorpe, 1992)
800 m	New York, USA	Untermann and (Dittmar & Ohland, 2004)
400–800 m	Philadelphia and San Francisco, USA	(Flamm & Rivasplata, 2014)
1700 m	India	(Arasan et al., 1994)
500 m to 800 m	India	National TOD Policy of India (MoUD India, 2017)
500m	Nepal	Sustainable Urban Transport Index (SUTI) in Kathmandu Valley (Khokali, 2017)

3.4 Influencing Factors of Choice of Travel Mode

The mode of transportation used is influenced by a number of variables, from transportation-specific aspects (referred to as the numerous components of the transportation system) to individual-related variables, such as a person's ideas and habits. The literature classifies these elements as follows:

3.4.1 Hard and soft factors

According to some studies, the traits might be hard or soft, with hard features being simpler to define than soft ones. Hard criteria are frequently present in traditional utility-based models of transport mode selection. Complex challenges include things like wait times, travel times, and ticket prices. Comfort, service, and knowledge are examples of soft factors (Olsson, 2003). Soft elements, such as flexibility, ease of orienting, and so on, can be psychological.

Table 3.3: Influencing Factors

Hard factors	**Soft factors**	**Others**
Travel time	Comfort	Non-transport cost and taxes
Value of time	Service & Security	Limited time/ budgets
Travel cost	Information	Goods to be transported
Reliability	Flexibility	Workplace restrictions
Capacity		Daily Routine
		Weather
		Societal status/ trends

Source: (Fraszczyk et al., 2019)

3.4.2 Internal and external factors

Internal and external variables influence travel mode selection. Attitudes, socioeconomic and demographic characteristics, habits, and the perception of control are all internal factors. External influences include travel time and expense (Olsson, 2003).

3.4.3 Subjective and objective factors

Another approach is to categorize the elements into subjective and objective groups. Usually based on objective criteria, the factual components are easy to evaluate and quantify. The alternative's so-called hard standard factors, such travel time and fare, and soft standard aspects, like comfort and information, are taken into account as objective considerations (Olsson, 2003). The objective determinants include socioeconomic traits like age and gender as well as trip-related elements like purpose. Objective factors include things like the environment, topography, weather, and security. Subjective variables include assessments of the qualities, perspectives, and way of life of the alternative. These are more challenging to measure because they depend on the perception of the individual.

3.4.4 Classification of trip standard factors

According to Kottenhoff (Kottenhoff, 1999), the scheduling, comfort, service aspects, quality satisfaction and safety are the categories which divides the transport-related criteria that describe the travel standard for public transportation.

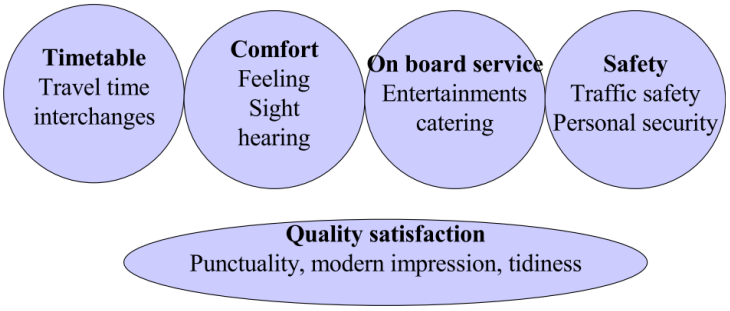

Figure 3.2: Classification of train-specific factors (Kottenhoff, 1999)

3.5 Relationship Between Land Use and Transportation

Social, cultural, and economic activities are organized into an activity system in urban areas. Some activities, like commuting, are regular because they are predictable and routinely occur. Unregular additional activities are created by a person's lifestyle (for instance, sports and leisure) or particular needs (e.g., healthcare). The majority of these activities are upon passenger movement.

Production, consumption, and distribution are all functions that most economical, social, or cultural activities entail. Urban land use is a highly diverse area, and the transportation network influences this variety. Core zones have arisen in the dispersion of urban activities due to institutional (universities), political (seats of government), economic (management and retail), or cultural reasons (religious institutions). The spatial accumulation in central regions and the land uses that go with it, such as retail, is high. Compared to residential and warehousing regions, peripheral areas have lower accumulation levels.

Urban form is primarily concerned with the patterns of nodes and links that make up the spatial structure of a city, whereas urban land use is concerned with the type and degree of spatial accumulation of activities. Whether they are economic, social, or cultural endeavors, the bulk of human activities involve a number of different tasks, such as production, consumption, and distribution. These activities take place inside an activity system, and land uses are created by spatially aggregating their locations (Bagley, 2003).

Therefore, the land usage will bear the behavioral impression of people, organizations, and businesses. An appropriate typology of land use, which might be formal or functional, is needed to portray this imprint.

- Formal representations of land use are descriptive and focus on the qualitative characteristics of space, form, pattern, and aspect.
- Functional land use representations are primarily socioeconomic descriptions of space that focus on the degree of spatial accumulation of economic activities including production, consumption, dwelling, and transportation.

Transport system. The modes and transportation infrastructure that support passenger movement. It typically conveys the degree of accessibility.

Spatial interactions. The characteristics, scope, points of origin, and final destinations of passenger urban movement. In addition to considering land use elements that are attracting and creating movements, they also take into account the characteristics of the transportation system.

Land use. The spatial activities and the mobility demand that go along with them. Land use and demographic and economic characteristics are frequently connected. Land use impacts are the alterations in land use that are brought about by accessibility improvements, either directly or indirectly. A fundamental idea in transportation is how transportation and land use are related.

The goal of urban transportation is to meet the transportation demands generated by a wide range of urban activities in diverse urban settings. Because the same processes can result in different outcomes, analyzing patterns and processes are crucial to comprehending urban entities. Transportation and land use are both a part of an open, dynamic system. Each, nevertheless, is continually changing as a result of shifts in technology, politics, the economy, demographics, and culture and morals. As a result, the linkages between land use and transportation continue to be reflected in the numerous decisions that people, organizations, and governments make.

3.6 MRT and City Form

Most MRT systems let city centers to expand farther, which is necessary for land use patterns and development that is transit-friendly. A mass transit system is integral to a large city's sustainable transportation system. It could significantly impact how the city develops in the future, resulting

in a transit-friendly city shape, especially in developing nations (GTZ, 2003). MRT eases city mobility for all commuters. It can determine the city in a planned and facilitated manner, thus making it habitable for all inhabitants.

3.7 Stated Preference and Revealed Preference

As the main sources of choice response, two sorts of data have evolved. The terms revealed preference (RP) and stated preference (SP) data are employed to describe this.

Revealed preference represents data collected in the actual scenario by asking decision makers about the actual choice they have made. If RP data is collected in the representative share of different modes. The limitations faced by decision-makers during the decision-making process are present in RP data, which increases the data's validity and dependability. However, there are restrictions on alternatives, characteristics, and attribute levels (Hensher et al., 2005).

Stated preference data represents the choice stated by decision-makers in a hypothetical situation presented to them. This can lead to situations where respondents may not consider constraints when making a choice. Therefore, the hypothetical alternatives should be as realistic as possible. With SP data, we can explore alternatives, attributes and attributes level and make predictions outside technological frontiers (Hensher et al., 2005).

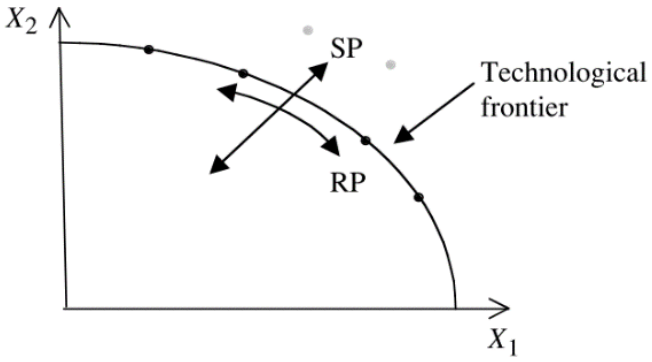

Figure 3.3: The technological frontier and the roles of RP and SP data (Source: Hensher et al., 2005)

Table 3.4: Differences between revealed preferences (RP) and stated preference (SP)

Revealed Preference (RP)	**Stated Preference (SP)**
Depicts the existing situation of the world	Describe the setting for hypothetical judgments.
Comprise the natural connections between qualities (technological constraints are fixed)	Relations that govern how qualities are controlled (permits utility functions with technologies)
As observables, only options that are in existence	Include present, proposed or generic choice alternatives
Excellent face validity and dependability	When responders commit to, comprehend, and complete tasks, it seems reliable.
One observation per respondent	Several observations for each respondent

Source: (Abdullah et al., 2011)

4 CHAPTER FOUR: CASE STUDIES

4.1 Cases of Willingness to Shift to Metro

Sohoni et al. (Sohoni et al., 2017) used RP and SP surveys were used to examine the mode transition behavior of commuters in Mumbai. About 80% of people who use public transportation and 60% of people who use private transportation were willing to shift to the suggested metro line.

Dahlan & Fraszczyk (Dahlan & Fraszczyk, 2019) divided the respondents in a study they performed in Jakarta, Indonesia, into two groups: those who lived within the new metro corridor and those who lived outside of the metro corridor. They discovered limited notable differences. Less people who owned private cars belonged to the metro corridor group than the other group, and they were more inclined to use the metro as a substitute for other forms of transportation.

In a different study by Dahlan & Fraszczyk (Dahlan & Fraszczyk, 2019), on a new metro line between Salaya and Bangkok, 90% of respondents—a sample of respondents who were potential users—declared a willingness to switch to metro. Younger respondents had a greater desire to change, whereas older respondents had a greater resistance to doing so, according to the data. It was also discovered that a stable timetable, good mode connectivity, and reduced trip times will all contribute to respondents' eventual shift to the metro.

In a 200 m radius of three prospective metro stations with various geographic locations and economic characteristics, Gavanas et al. (Gavanas et al., 2012) conducted a study in Thessaloniki, Greece. It was anticipated that 75% of commuters who had destinations in the city center would switch to the metro. For their daily work trips, 67% of respondents expect to switch from their existing means of transportation to the metro. Older commuters were hesitant to switch to a different method of transportation. 57% of commuters were anticipated to switch from private cars to the metro, but the majority of two-wheeler users in areas close to the city center are not anticipated to switch from motorcycles to the metro due to the motorcycle's low cost, flexibility, and door-to-door service.

The findings of various cases indicate numerous factors influencing the willingness to shift to the metro. The aforementioned situations involve elements like age, mode of transportation (private and public transportation), etc. Service dependability, connectivity, and time considerations were

important to the respondents when making their decision to commute by metro rather than using other modes in the future. These cases help us to draw a base and include these factors that could help us determine the most influencing factors in our context.

4.2 Nanjing City, China

Construction on Metro Line 1 began in 2001 and was completed in 2005. The major metropolis of Nanjing's core axis is traversed by Metro Line 1 with 21.72 kilometers. As Nanjing's first rail transit line, Metro Line 1 is crucial to the development of new inner-city services as well as the promotion of existing ones. The before and after cases of land use are shown in Figure 4.1 and Table 4.1.

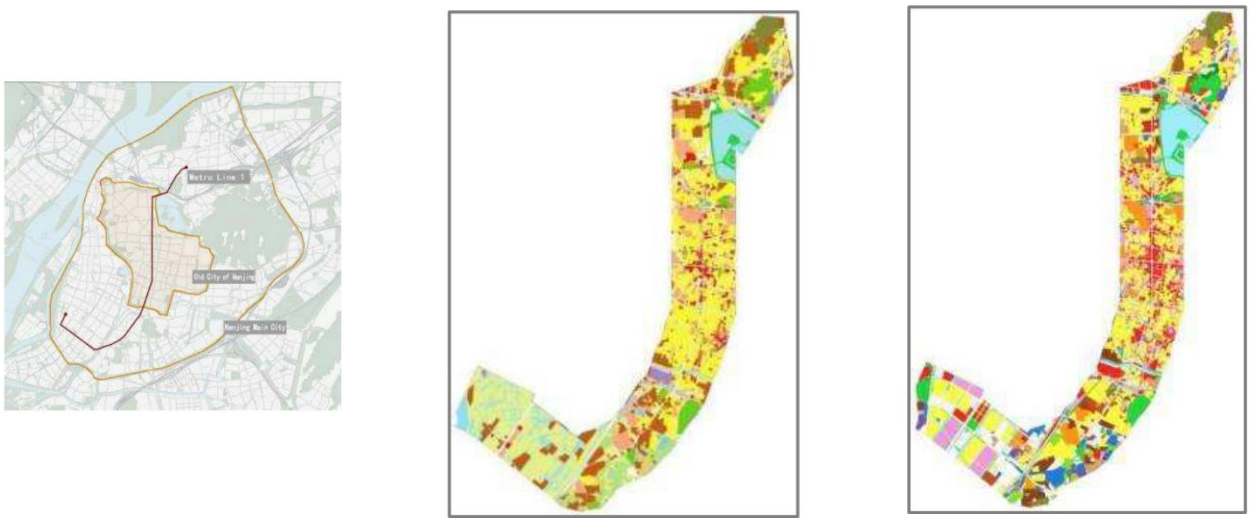

Figure 4.1: The location of Metro Line 1 in Nanjing City with Land use before (2000) and after (2007) rail transit construction (Rong, 2013)

Table 4.1: Change in Land use in 1 km before and after rail transit corridor

Type of Land use	**Proportion in 2000**	**Proportion in 2007**	**Inference**
Residential	31.62%	30.88%	Tendency of disperse, sprawl, and move to other locations
Public Facilities	14.75%	21.88%	Trend of centripetal aggregation
Industrial land	17.22%	9.98%	Few unchanged location, others centrifugal outward
External traffic	2.01%	1.31%	
Green land	10.55%	10.67%	No obvious changes

Waters and other land use	12.21%	17.19%	No obvious changes

Source: (Rong, 2013)

Gulou is situated in an area of the city with public amenities including Gulou Park. Along with the development of rail service, its commercial and office operations have expanded. With no discernible modifications to other categories of land, the building of rail transportation has replaced residential, industrial, and warehouse space in the area of Gulou Station with commercial service, medical, and sanitary land. Furthermore, the distribution of commercial and financial land tends to converge close to stations, whereas the distribution of residential land is generally steady in the area immediately surrounding the stations.

Figure 4.2: Changes of land use in the surrounding areas of Gulou Station (Left: Location; Center: 2000; Right: 2007) (Rong, 2013)

Figure 4.3: Changes of land use in the surrounding areas of Olympic Sports Center Station (Left: Location; Center: 2000; Right: 2007) (Rong, 2013)

The Olympic Sports Center (OSC) Station was situated at the south end of Line 1. In 2000, 85.83% of its land was non-constructive land. It progressively transformed into urban construction land usage as residential land and commercial sites following the successful completion of Metro.

There has been a considerable growth in property for public amenities. Additionally, the land utilized for public amenities and the surrounding residential neighborhoods adopted a circular ideal arrangement.

4.3 Chennai, India

Construction on the metro system started in 2009 after the agreement was concluded in 2007. Before and after the opening of the metro stations Ashok Nagar Station and Guindy Station in 2006 and 2018, the change in land usage was detected.

At the southwest corner of the city, along the Inner Ring Road, lies a residential neighborhood called Ashok Nagar. It was noted that residential land usage had decreased by 9%, from 80% to 71% and commercial land use had increased by 2%, from 2% to 4% in Ashok Nagar Station.

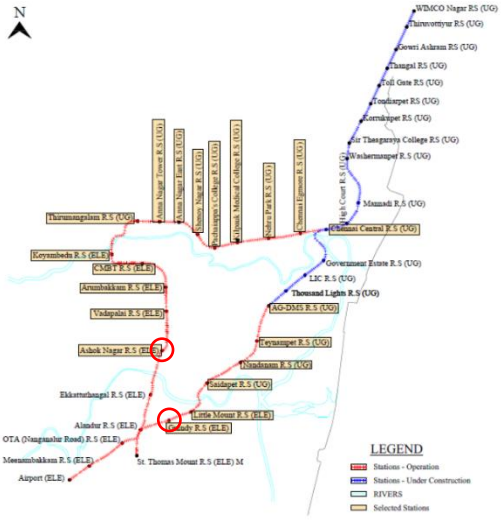

Figure 4.4: Chennai Metro Rail Corridor – 1st Phase (Karthigeyan & Chander, 2020)

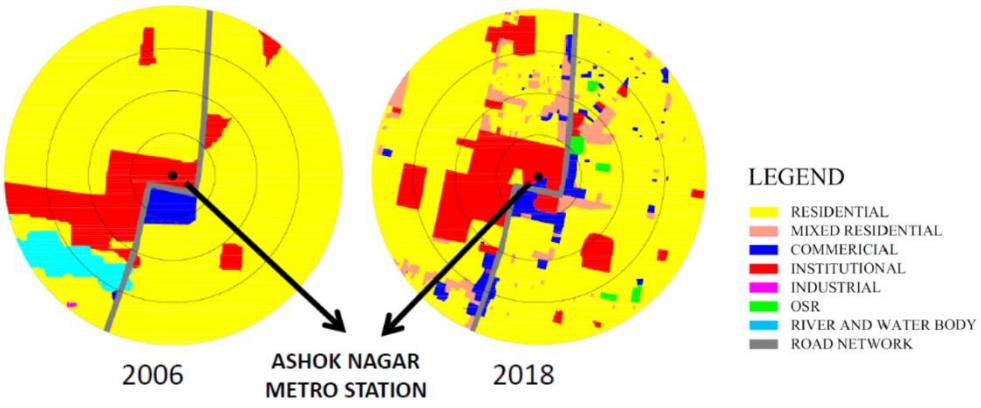

Figure 4.5: Influence zone land use 2006 and 2018 of Ashok Nagar Metro Station (Karthigeyan & Chander, 2020)

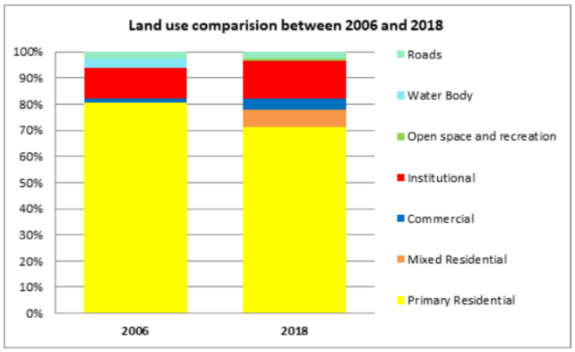

Figure 4.8: Land use comparison between 2006 and 2018 of Ashok Nagar Metro station (Karthigeyan & Chander, 2020)

The Guindy Metro Station is regarded as the hub between the CBD, which is located inside the city, and the airport, which is outside. Residential land use inside the influence zone in Guindy Metro station has decreased from 18% to 13%, and commercial land use has increased by 2%, from 2% to 4%.

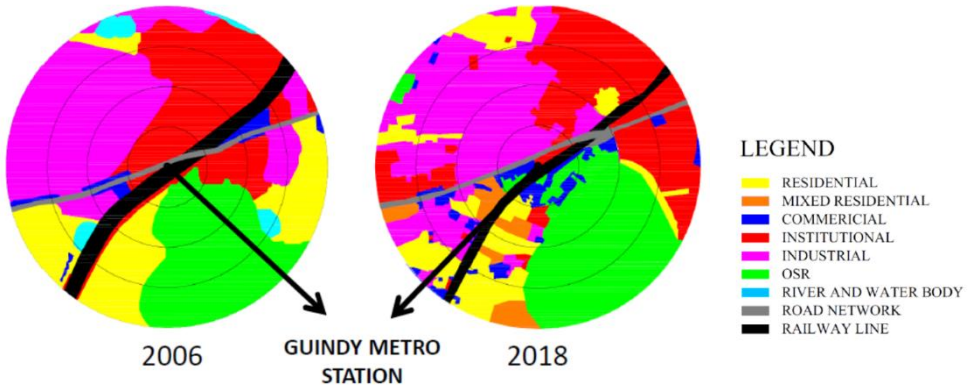

Figure 4.6: Influence zone land use 2006 and 2018 of Guindy Metro Station (Karthigeyan & Chander, 2020)

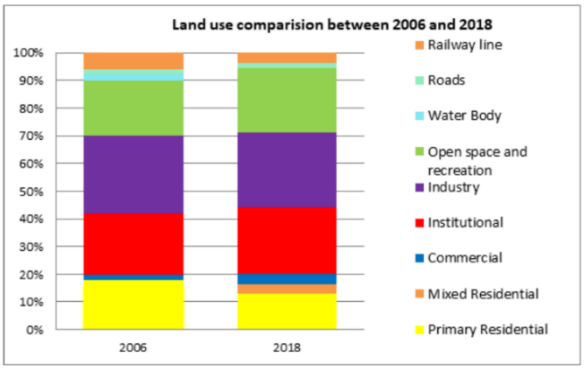

Figure 4.7: Land use comparison between 2006 and 2018 of Guindy Metro station (Karthigeyan & Chander, 2020)

4.4 Delhi, India

The study area includes three distinct kinds of metro stations with diverse activities. Lakshmi Nagar, Nirman Vihar, and Preet Vihar are the three metro stations in East Delhi. The total length of the stretch is 3 km, with only 1 km between the two metro stations with a minimum and maximum influence zone of 0.3 and 0.8 kilometers on either side of the metro corridor.

Figure 4.9: Laxmi Nagar, Nirman Vihar and Preet Vihar Station in East Delhi (Krishnan, 2015)

Laxmi Nagar features a residential area and commercial hub. Near to Lakshmi Nagar lies Nirman Vihar, a primarily business neighborhood with most government facilities. Preet Vihar is a posh neighbourhood area, and the region is well-known for its educational institutions.

Change in Land-Use Pattern

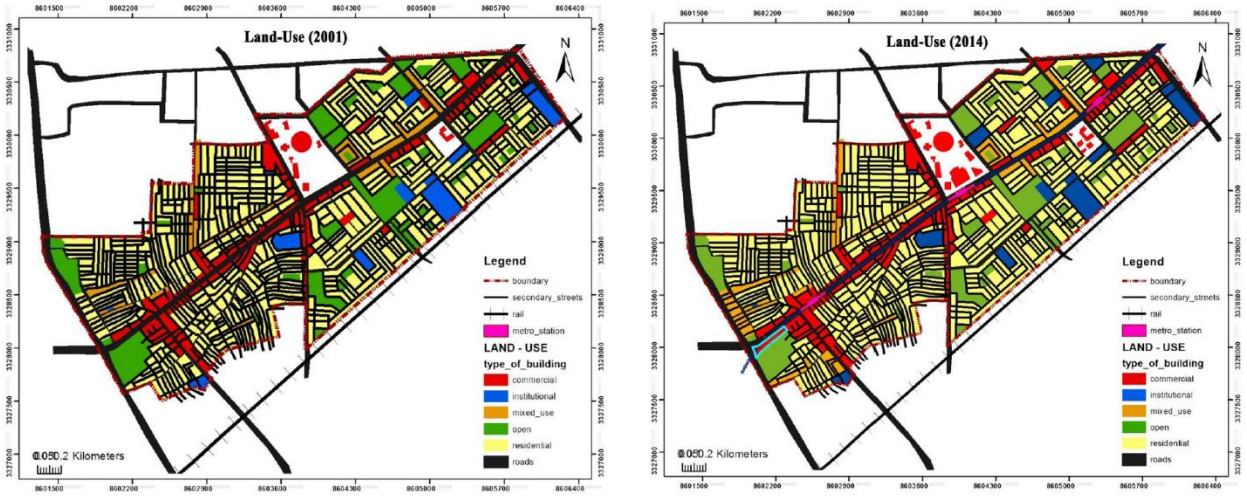

Figure 4.10: Land use in Laxmi Nagar, Nirman Vihar and Preet Vihar Station 2001 (Left) and 2014 (Right) (Krishnan, 2015)

From 2001 to 2014, it was found out that the residential area decreased by 6.11% from 66.43% to 60.32%, the commercial land use increased by 4% from 12.38% to 16.38%, the institutional land

use increased by 1.65% from 4.40% to 6.05%, the mixed use increased by 2.91% from 5.26% to 8.17% and the open area decreased by 4.37% from 13.75% to 9.38%.

Change in Built-Form

There had been a noticeable change in the built form of commercial areas. The maximum height for a business building had increased to 65 meters, up from the previous maximum height for commercial structures, which was 21 meters. However, the height of residential areas was observed to be the same at 9 meters (G+2) in 2001 and 2015.

Change in Land Value

The land value of the commercial and residential properties increased by 150%-200%, mainly due to the planned residential construction following the metro construction.

Accessibility

there were fewer motor vehicles on the highways with reduced travel time. The area's improved accessibility was indicated by the fact that although the population density increased, there were fewer automobiles on the roadways.

4.5 History of Mass Transit in Nepal

A trolley bus is a mass transit that is powered by electricity. It is an electric bus and receives its power from wires suspended from posts along the road. Werner von Siemens invented the first trolleybus in 1882 in Germany.

In 1975, twenty-two conventional trolley buses were launched in Kathmandu with a grant of Rs. 40 million from the Chinese government (Francon-Smith, 2018). With the aid and technical expertise, a 13 km long trolley bus system was established that connected Kathmandu with Thimi and Bhaktapur. It had left hand operating system. The 15-station trolley bus system that ran between Suryabinayak and Tripureswor was quite well-liked by the locals (Adhikari, 2017). Buses were added as their popularity grew, and the number of passengers increased from about 11,000 to 20,000 and had run for 16 hours straight (Adhikari, 2017). It had become the epitome of reliable government-based service. As profit increased, it expanded to other parts of the valley. Ten buses

with newer models were added in 1997. The route was operated by a branch of the Nepal Transportation Corporation called Nepal Trolley Bus Service (NTC).

Figure 4.11: Kathmandu-Bhaktapur trolley bus (Source: Edwards, 1975)

While the advent of democracy may have brought about significant developments in other areas, it was the beginning of the end for the trolley. The enveloping political system impacted every aspect of life, which resulted in riots. These riots significantly affected the trolley bus's ability to operate and bore the consequences. In addition, the Nepal Trolley Bus Service (NTBS) corporation was used by political influence as a job center to appease their political allies.

The company quickly went from being a lean operation with only what was necessary for the employees to become a bloated organization with roughly four times as much. Moreover, the drivers were responsible for collecting passenger fares, where there was considerable mismanagement in the earnings. The corporation had excessive staff and low productivity, decreasing its financial capacity, and inability to maintain and operate its system, ultimately leading to its collapse. The NTC was dissolved in 2001, and the trolley bus service was suspended because it had not made a profit since 1990 (Francon-Smith, 2018).

There were efforts to revive the corporation again in 2003, with a revitalization fund of 2 million rupees, under the management of Kathmandu, Bhaktapur, and Madhyapur Thimi municipalities. The line was shortened to 5 km between Tripureshwor and Koteswor in 2004 and operation was restarted along the full route (Kathmandu Trollybus Network, n.d.). In 2007, the removal of

wirework support poles and the closure of the entire system were threatened by a proposal to widen Arniko Highway, the primary trolleybus corridor (Kathmandu Trollybus Network, n.d.). The operation was irregular, and in 2008, the service was suspended. The 13 km long inter-urban transportation line was used for three decades. Due to the ongoing problems of theft of overhead wires and a lack of investment, the service was permanently shut in 2009.

4.6 Indicators from Case Studies and Literatures Review

From various literature and case studies, the indicators were inferred for conjecture:

4.6.1 Land use

The land use in that area will determine how the neighborhood around the metro station develops. The ratio of non-residential land use to other land uses is taken into account when examining the effects of land use on the transit system since non-residential areas draw more transportation trips than residential regions do. The case study suggests that with the new metro station, there have been changes in land use; there has been an increase in commercial and mixed-use, the transformation of the vacant land/ open space to build up and vice versa. The vacant/open areas are the ones that will have immediate change as a result of the impact of the metro station.

4.6.2 Proximity of Transport Network and Accessibility

Travel patterns are influenced by proximity to a transportation network, and large transportation networks had a noteworthy impact on the pattern of nearby development. With the improved infrastructure, the utility and worth of an area are enhanced through accessibility. This further improves the accessibility to the Central Business District (CBD) from all places and for all. Additionally, this increases the land cost and reduces transportation costs.

4.6.3 Social Infrastructure Facilities

The presence of social infrastructure amenities close to the station affects how the surrounding area develops. Social infrastructure institutions including schools, colleges, hospitals (including health centers), movie theaters, and retail centers were identified and included in order to assess the impact of social infrastructure on the pattern of growth in that area. These facilities tend to

increase in the area that is easily accessible through transportation and where there is the immense flow of people.

4.6.4 Land Value

With improved and planned infrastructure and facilities, it has become a more desirable and demanding location than before. Hence, property prices in the areas around metro stations are positively impacted.

4.6.5 Population Density

The total number of individuals living in a specific area is known as population density. This figure is often stated as people per square kilometer, per acre, etc. The population density around the station is likely to increase.

5 CHAPTER FIVE: STUDY AREA

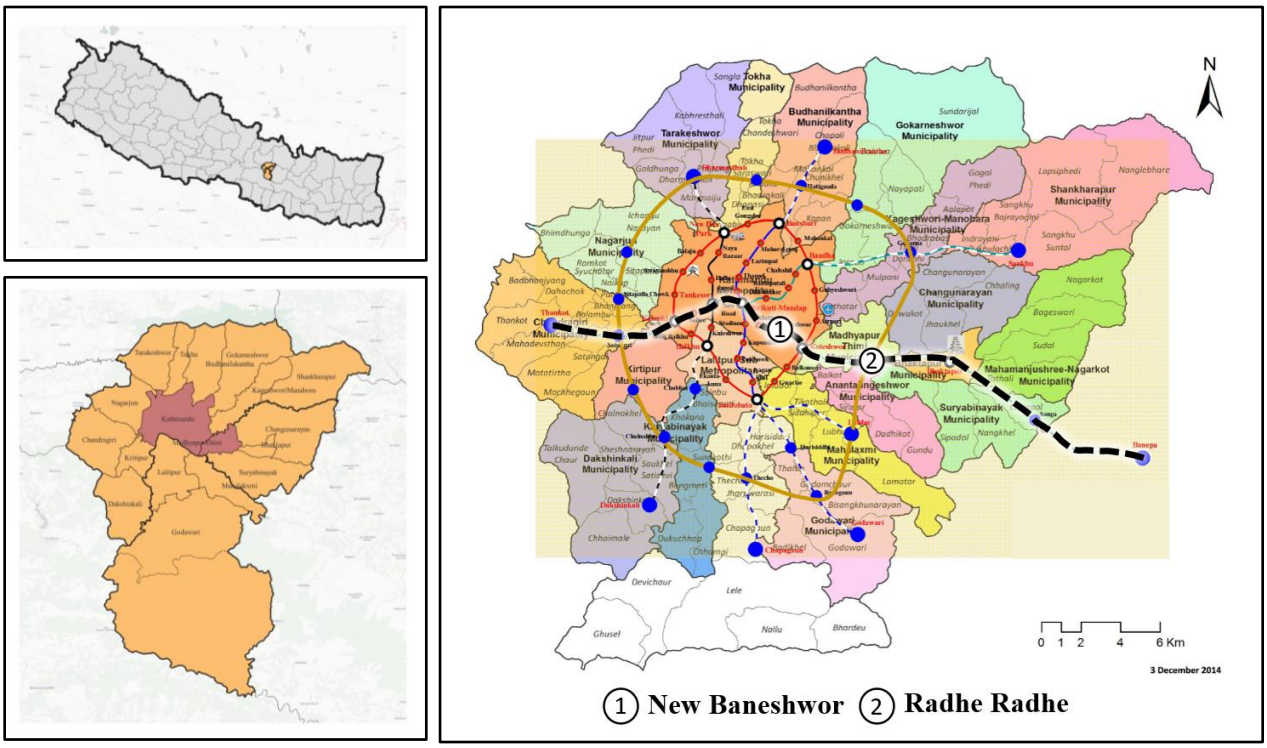

Figure 5.1: Index Map
Country map (Top Left); District map (Bottom Left); Route map with study station locaation (Left)

As shown in Figure 5.1, the two-study areas in Kathmandu Metropolitian city and Madhyapur Thimi municipality are investigated for this research. The study neighbourhood has been limited to a 500 m radius from the main road junction in New Baneshwor in the Kathmandu municipality and Radhe Radhe in the Madhyapur Thimi municipality. The transit's 500 m radius of influence is chosen considering 5 to 10 minutes of walking distance. New Baneshwor is one of the most densely populated, while Radhe Radhe is a less densely populated area, as shown in Figure 5.2, lying along the primary road in the Kathmandu Line Route of the proposed Metro System. New Baneshwor lies in the central hub, while Radhe Radhe is the new settlement in the periphery. These are certain illustrative of the overall condition of both the city and the emerging town.

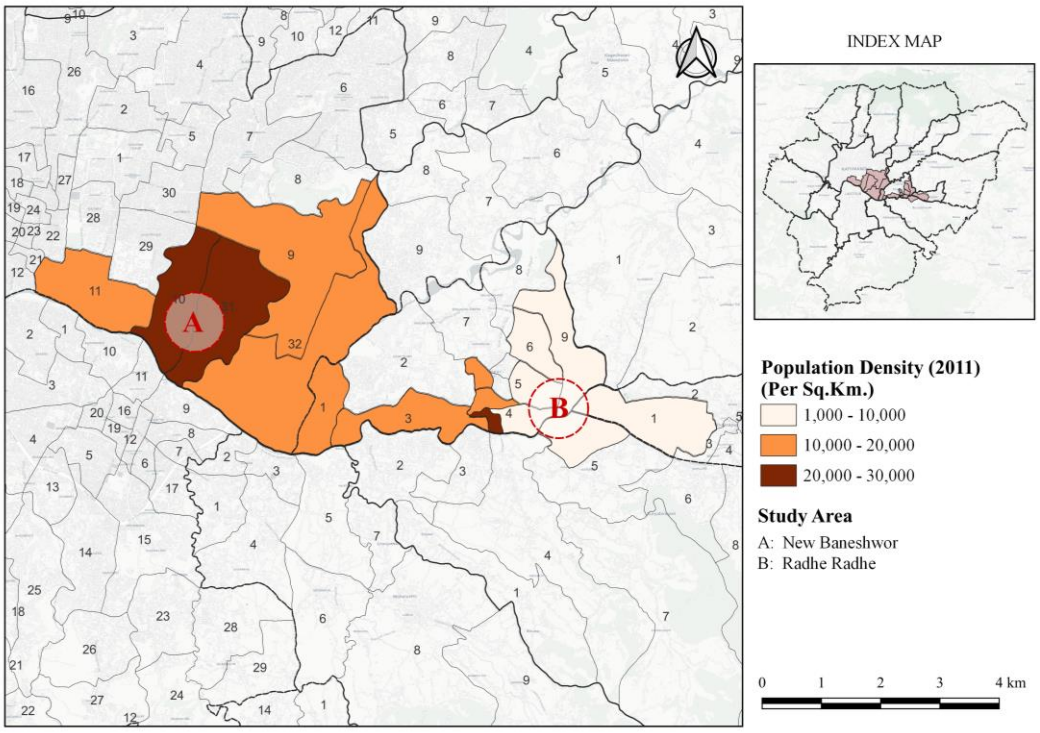

Figure 5.2: Wards lying in the Study area

5.1 New Baneshwor

The study area in New Baneshwor lies inwards no 10 and 31 of Kathmandu Metropolitan City with an average density of 26,813.08 people per sq.km of land, as shown in Figure 5.2 and Figure 5.4. Commercial, institutions and mixed uses mainly dominate the study area. Residential and hostels are in the periphery of the 500m study area. Moreover, New Baneshwor lies in the heart of the city, with all available facilities such as education, hospitals, hotel, commercial- banks, offices, restaurants, cafés, and shops; mixed-use- residences with shops or offices and residential hostels. Thus, this area is a center of attraction for various work trips, educational trips, shopping trips and leisure trips. It has a different mobility pattern with different trips. The amalgamation of numerous land use makes this neighbourhood interesting. Figure 5.4 shows the google image of the New Baneshwor in 2012 and 2022. However, very few changes have been observed in the built-up area over the last decade, mostly due to the saturation of developable land to build upon.

Figure 5.3: Field observation of New Baneshwor

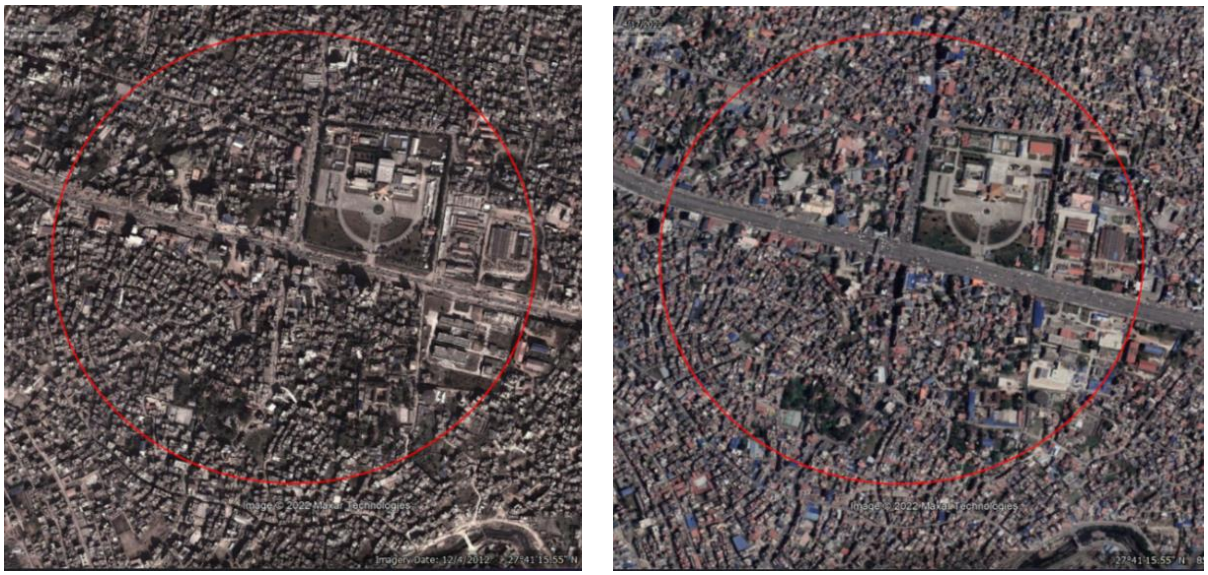

Figure 5.4: New Baneshwor in 2012(Left) and 2022(Right) (Google, 2022a)

5.2 Radhe Radhe

The study area in Radhe Radhe lies in ward no. 4,5,6,9 of Madhyapur Thimi municipality, ward no. 5 of Suryabinayak municipality and ward no. 1 of Bhaktapur, with the average density of these wards 5,500.14 people per sq.km of land, as shown in Figure 5.2 and Figure 5.4. The study area features a newly developing modern neighbourhood with a hierarchy of commercial, mixed-use and residential buildings developed along the road hierarchy. This area consists of mainly residential buildings. The Hanumante river flows across from the northeast to the south-west direction in the study area. The commercial growth has been driven around a supermarket on the northern side of the Araniko Highway, while its southern side seems to have agriculture and residential with few mixed uses. The agriculture fields are transforming into new construction sites for residential purposes. Figure 5.5 shows the google image of Radhe Radhe in 2012 and 2022. Over the last decade, this area has experienced rapid growth in the built-up area, primarily due to

the availability of agricultural and vacant lands on the city's outskirts that are being developed into new residential and mixed-use structures. It is in the process of densification.

Figure 5.5: Radhe Radhe in 2012 (Left) and 2022 (Right) (Google, 2022b)

Figure 5.6: Field observation in Radhe Radhe

6 CHAPTER SIX: RESULTS AND DISCUSSIONS

6.1 Descriptive Statistics

The survey began in June 2022, and data collection continued until July, 2022. Only employees and business people who commuted to or resided in New Baneshwor and Radhe Radhe area were the survey subjects. The total number of respondents was 200. Following the collection of the data, IBM SPSS 26 and Microsoft Excel were used to evaluate it. The data are presented below:

6.1.1 Socio-economic background

6.1.1.1 Gender

Among the 200 responders, 87 women and 113 men. We will use this information to understand the gender perspective.

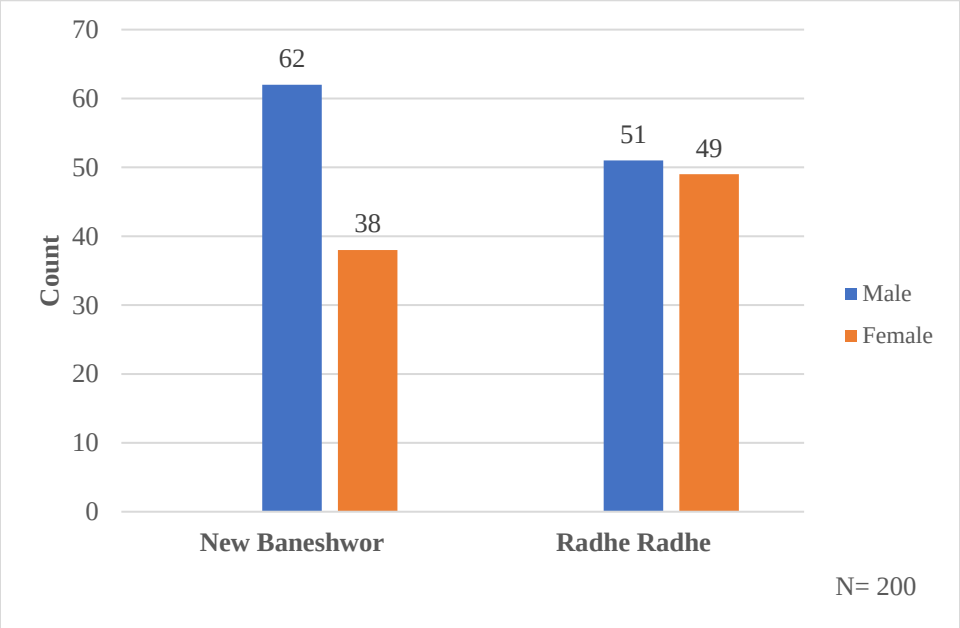

Chart 6.1: Respondent by Gender and Location

6.1.1.2 Age

Out of all respondents, 86 were from the age group 30-40. Seventy-one respondents were from the age group 20-30. The targeted diversity of working age groups and their current patterns to commute to work will be considered in forming indicators for shifting to Metro.

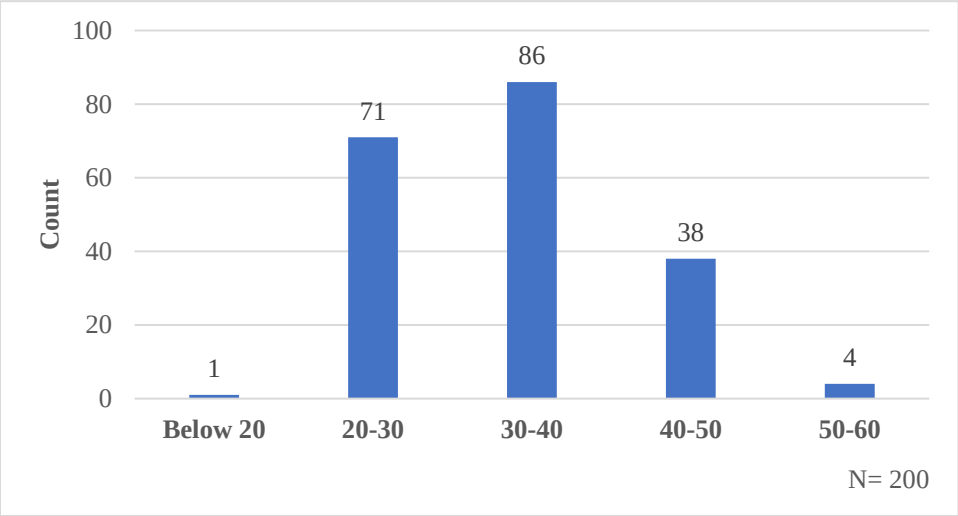

Chart 6.2: Respondent by Age

6.1.1.3 Education level

Education level was divided into five categories. 105 respondents completed their bachelors while 3 were primary/secondary school educated.

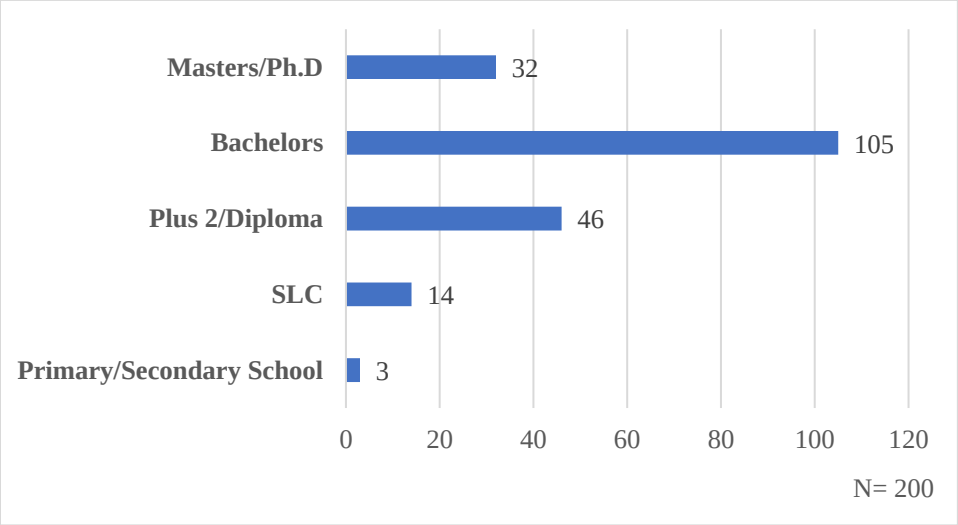

Chart 6.3: Respondents by Education level

6.1.1.4 Ethnicity

Data related to ethnicity was obtained to add diversity to responses. Most of the respondents were Brahmin.

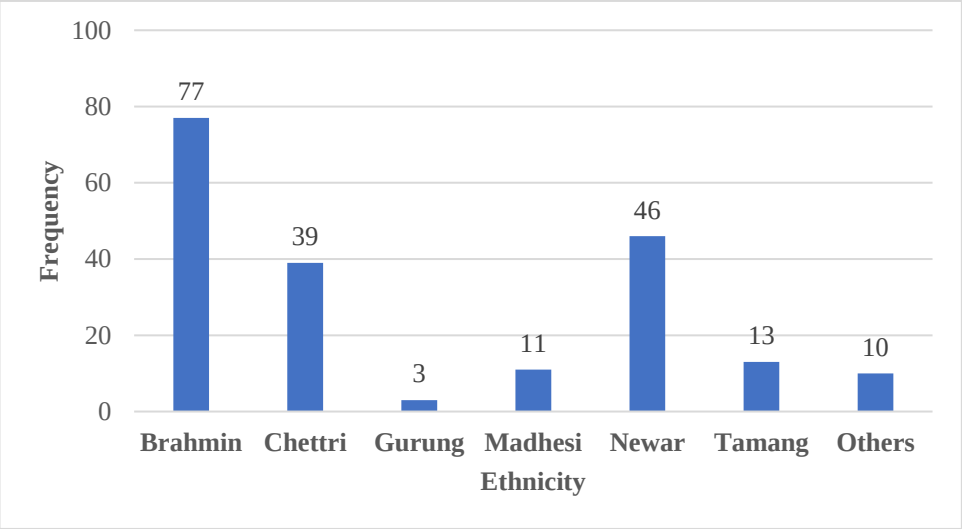

Chart 6.4: Respondents by Ethnicity

6.1.1.5 Profession

Most of the respondents were private employees.

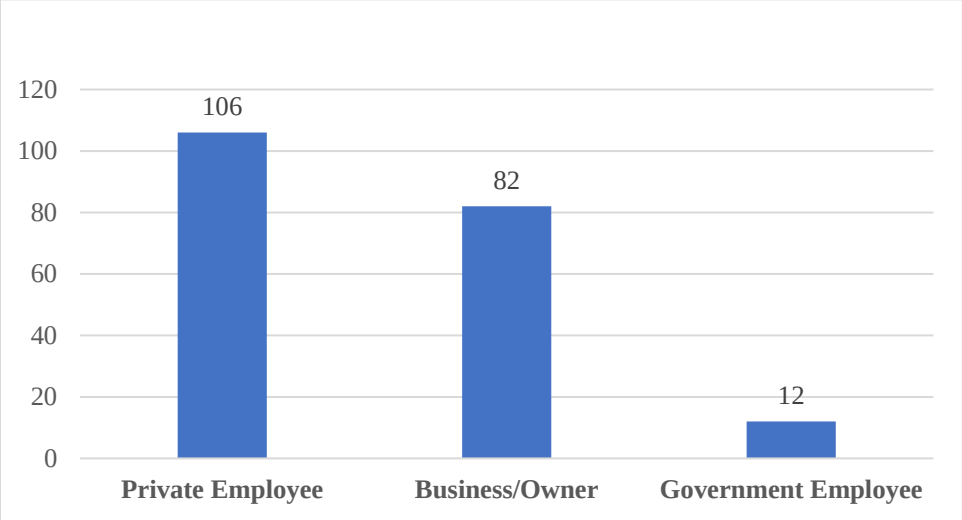

Chart 6.5: Respondent by Employment type

6.1.1.6 Income

Most respondents had a monthly income range of 20,000 to 40,000.

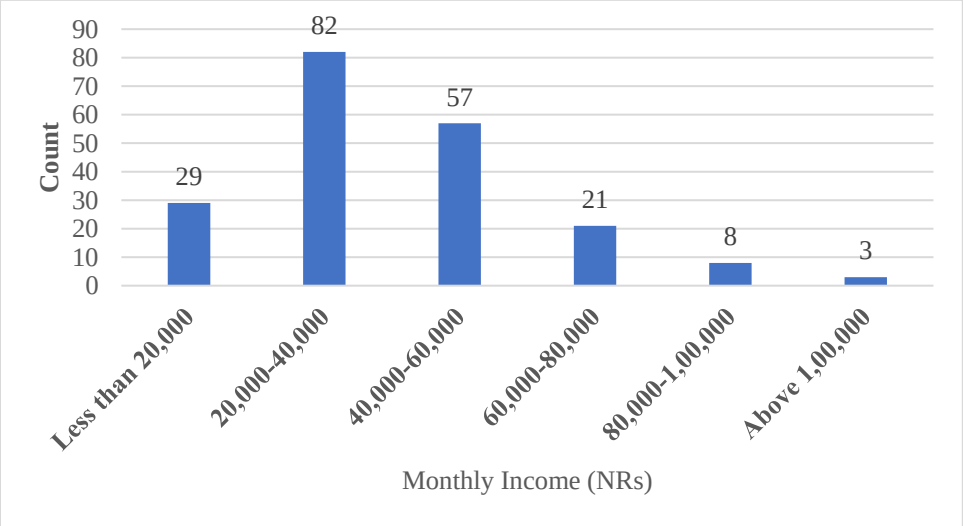

Chart 6.6: Respondent by Monthly Income

6.1.2 Travel Behavior

6.1.2.1 Primary Mode of Transport used to Travel to Work

Most respondents used private transport consisting of two-wheelers—bike and scooter and four-wheelers to travel to work. 159 out of 200, i.e., 79.5% of respondents used a private vehicle to commute to work, 15.5% (31) used public transport, 4% (8) walked/cycle, 1% (2) used ride-sharing as their primary mode of transport.

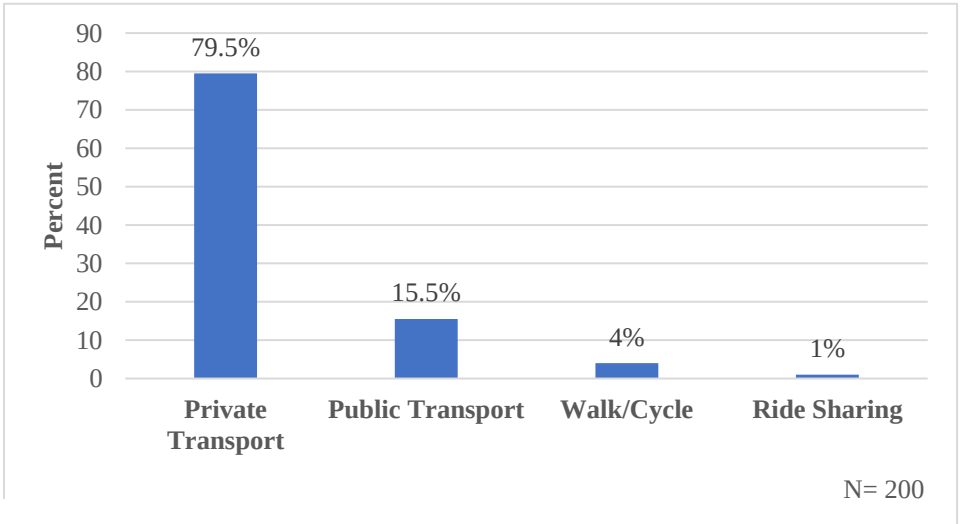

Chart 6.7: Respondents by Primary Mode of Transport used to Commute to Work

6.1.2.2 Household Vehicle Ownership

Out of all 200 respondents, 93% of respondents (186) households owned vehicles, while 7% of respondents (14) did not own any vehicle, including a bicycle.

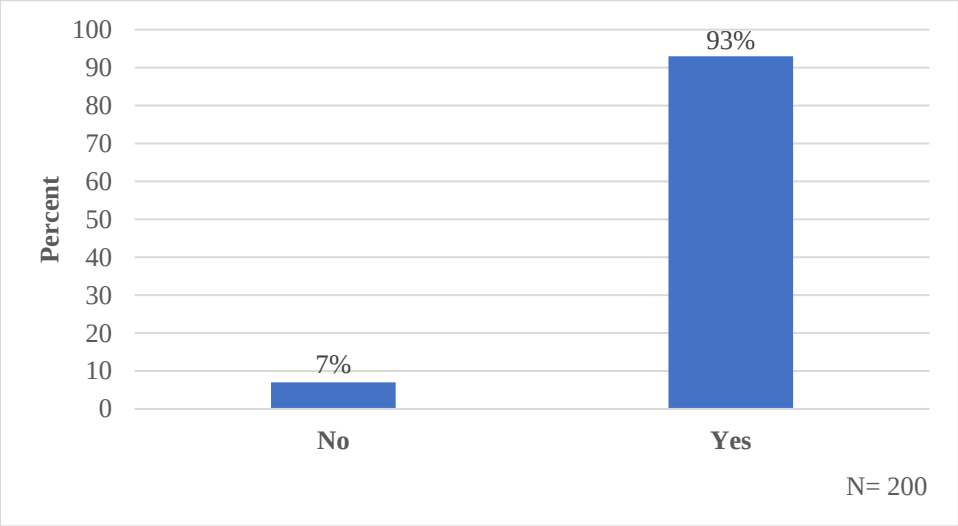

Chart 6.8: Respondent by Household Vehicle Ownership

6.1.2.3 Time is taken to reach the Bus stop, and the primary mode of Transport used to travel to work

Out of all respondents, 95 had access to the bus stop within 5 minutes of which 76 used a private vehicle, 14 used public vehicles, 4 were NMT users and 1 used ride-sharing modes to commute to work.

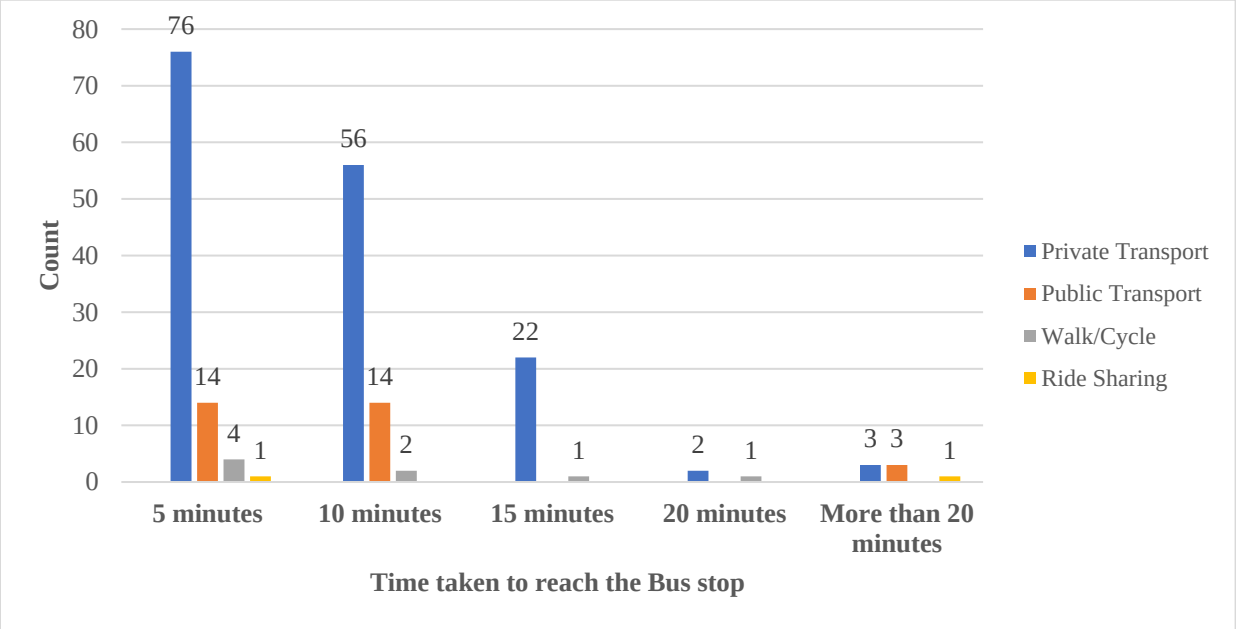

Chart 6.9: Respondent by time taken to reach the bus stop and the mode of transportation used

Table 6.1: Primary mode of transport used and the time taken to reach the bus stop

Time taken to reach the Bus stop	Primary Mode of Transport used to Travel to Work				Total
	Private Transport	Public Transport	Ride Sharing	Walk/ Cycle	
5 minutes	76	14	1	4	95
10 minutes	56	14	0	2	72
15 minutes	22	0	0	1	23
20 minutes	2	0	0	1	3
More than 20 minutes	3	3	1	0	7
Total	159	31	2	8	200

6.1.2.4 Comfort level of Current Transport

The comfort and satisfaction of commuters with their current mode of transportation were assessed using a 5-point Likert scale (1 = Strongly Dissatisfied to 5 = Strongly Satisfied). A 5-point Likert scale was employed to assess the commuters' degree of comfort and contentment with their present mode of transportation, with values ranging from 1 (strongly dissatisfied) to 5 (strongly satisfied). The current public transport user's satisfaction level was neutral and strongly satisfied (3 and above 3 in the Likert scale). While, for public transport, users' responses were neutral, dissatisfied and strongly dissatisfied (3 and below 3 on the Likert scale).

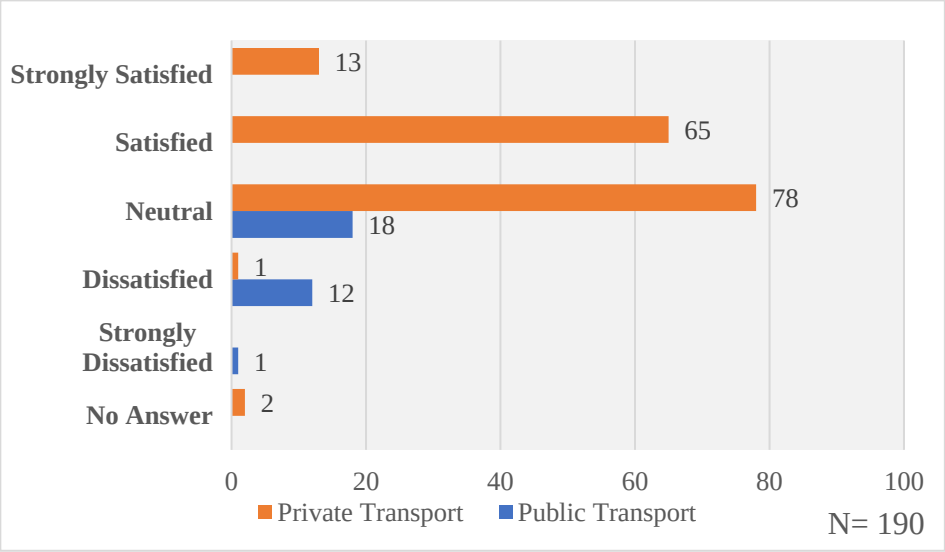

Chart 6.10: Comfort level of Current Transportation

As Chart 6.10 illustrates, among the public and private vehicle users (N= 190), out of 159 private consumers, 78 reported being content with their current means of transportation, and the remaining half were neutral about it. On the other hand, 18 out of 31 public transportation users were neutral in satisfaction with their travel mode, and the remaining 13 were dissatisfied to some degree.

6.1.2.5 Reason for not using public transportation for Private Vehicle owners

The private transport user not using the public transport of all the factors was mainly the time factor. 58% of respondents (116) stated comparatively more travel time, 8% (16) stated crowded, 2.5% (5) less frequency of bus service, 3.5% (7) respondents said uncomfortable seating and 6.5% (13) stated others which included habit, travel sickness, continence, poor service and no regulation.

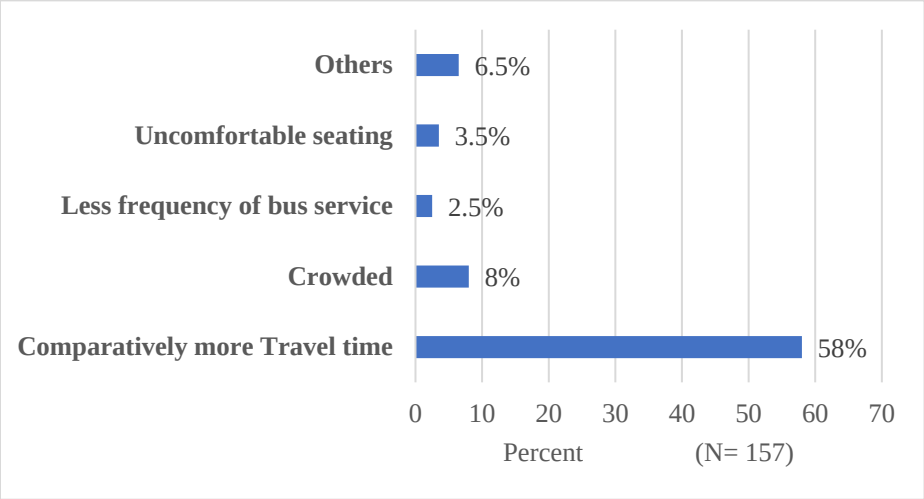

Chart 6.11: Reason for not using the public transportation

6.1.2.6 One-way Distance from home to work

Out of all respondents, 80 travelled 2 to 5 km to their workplace, while respondents commuting a distance of more than 15 km were the least.

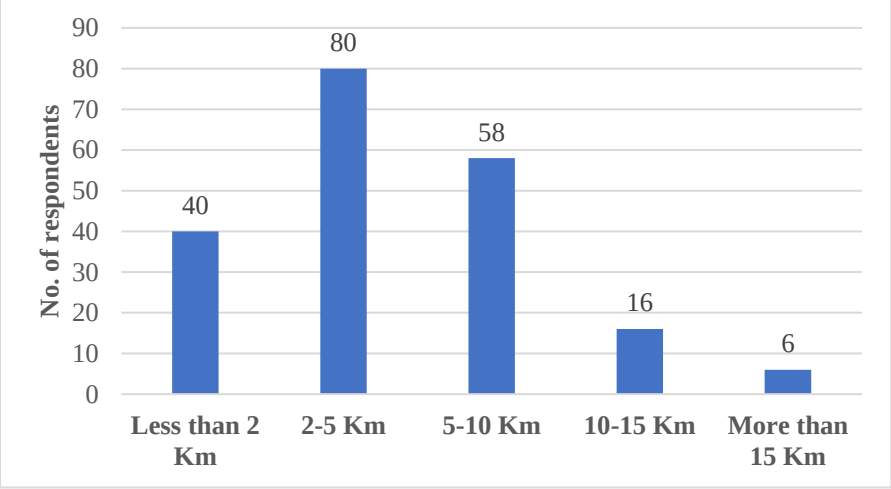

Chart 6.12: Respondents by commuting distance to their work one way

6.1.2.7 One-way Travel time from home to work

For most respondents, the time taken to commute one way to work from home was 15 to 30 minutes.

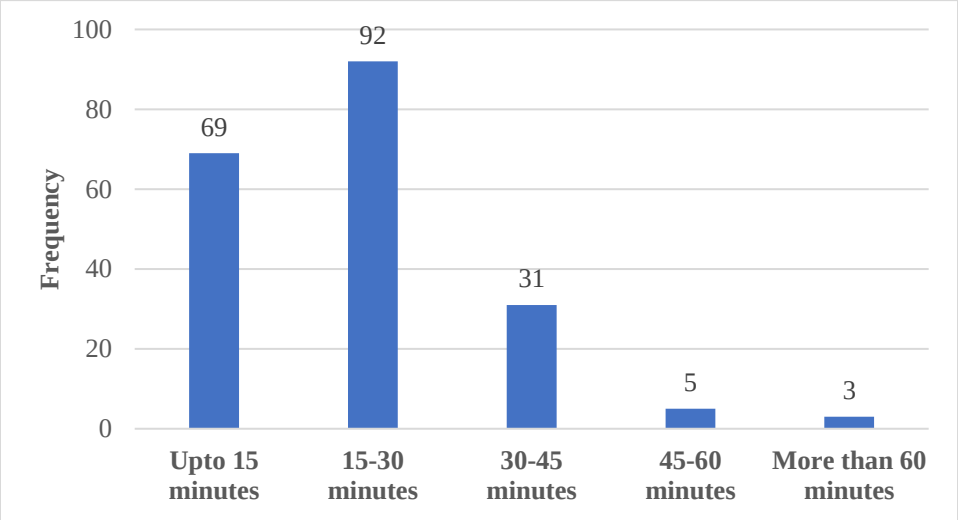

Chart 6.13: Respondents by time taken to travel from home to work one way

6.1.2.8 Primary Mode of Transport used to Travel to Work and Travel Cost per trip (one way)

Most of the respondents used a private vehicle to commute to work. The cost per trip to work for most of the respondents using a private vehicle cost in-between Rs.30 to Rs.60. In contrast, that for the public vehicle user costs less than Rs.30. The respondents with zero travel cost included the government vehicle users and users commuting by walk and cycle. The travel cost has been defined as the ticket fare for public vehicles and fuel cost for Private vehicles. It includes the cost an individual is bearing. For some government employees, the travel cost is borne by the government; hence, their travel cost is zero. The maintenance and depreciation costs have not been included; only the running costs have been considered.

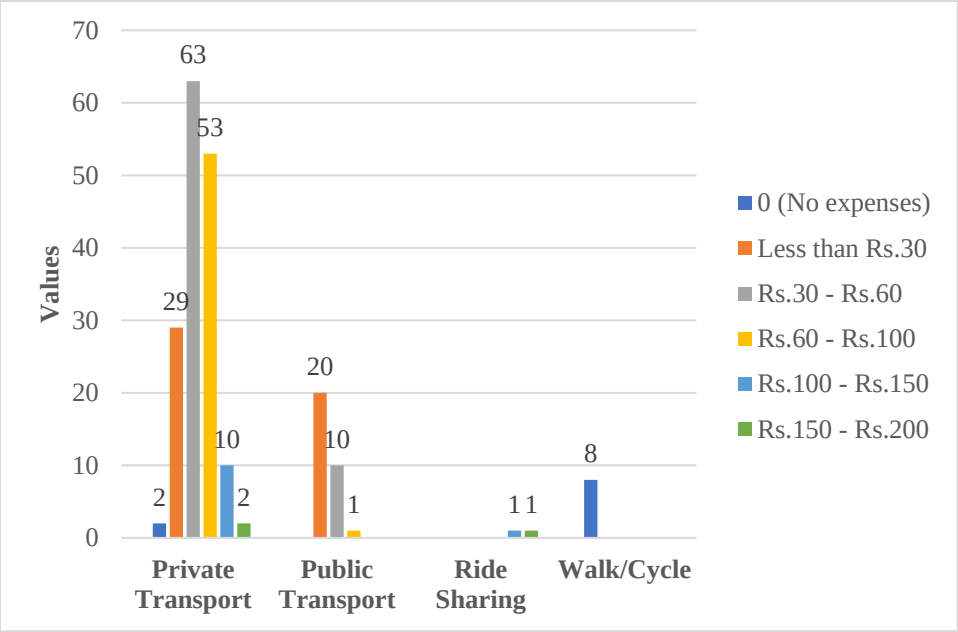

Chart 6.14: Respondent by travel cost per trip

6.1.2.9 Do you know what a Metro Rail is?

69.5% of the respondents knew what a Metro is, while 30.5% did not know about Metro.

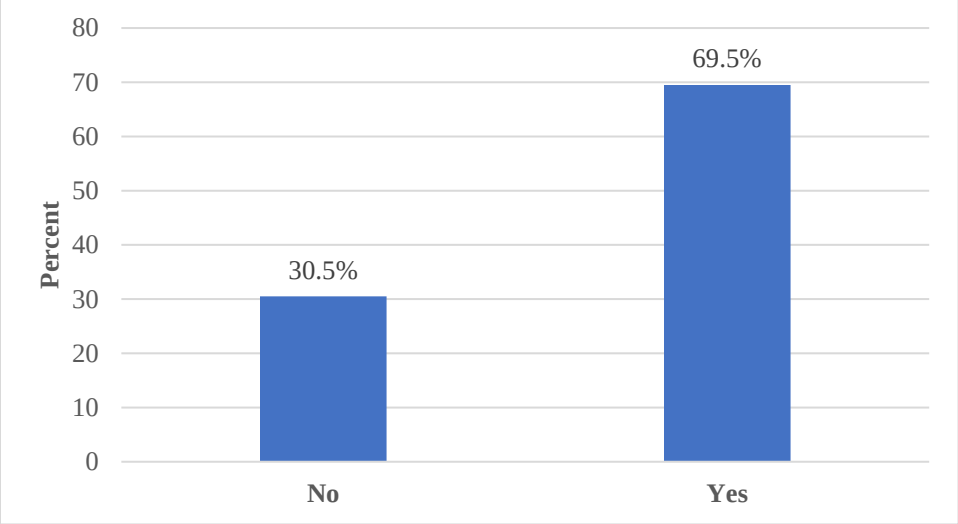

Chart 6.15: Respondents by their knowledge of Metro

6.1.2.10 In which Country have you used Metro?

Out of 69.5% of the respondents who knew about metro, most of them has traveled in metro in India in Delhi. 32.5% of the total respondents have travelled in metro, and 22.5% of the total respondents have travelled in Delhi Metro.

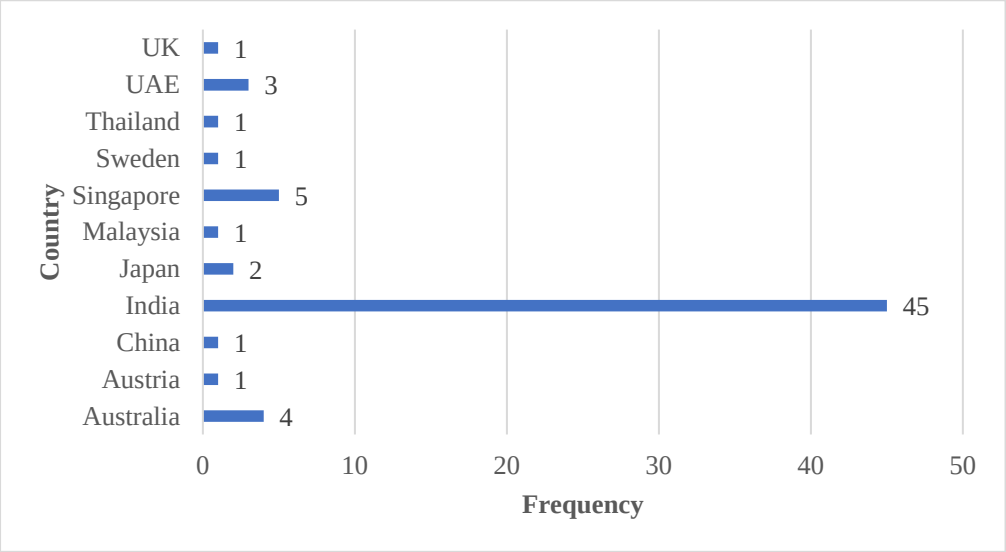

Chart 6.16: Respondents by the country where they used Metro

6.1.3 Willingness to Shift

As the Stated Preference survey was conducted, it was found that 68% of the respondents were willing to shift to the metro while 32% were unwilling to shift. 136 respondents opted for Alternative 2, the metro, while 64 opted for Alternative 1, their current means of transport.

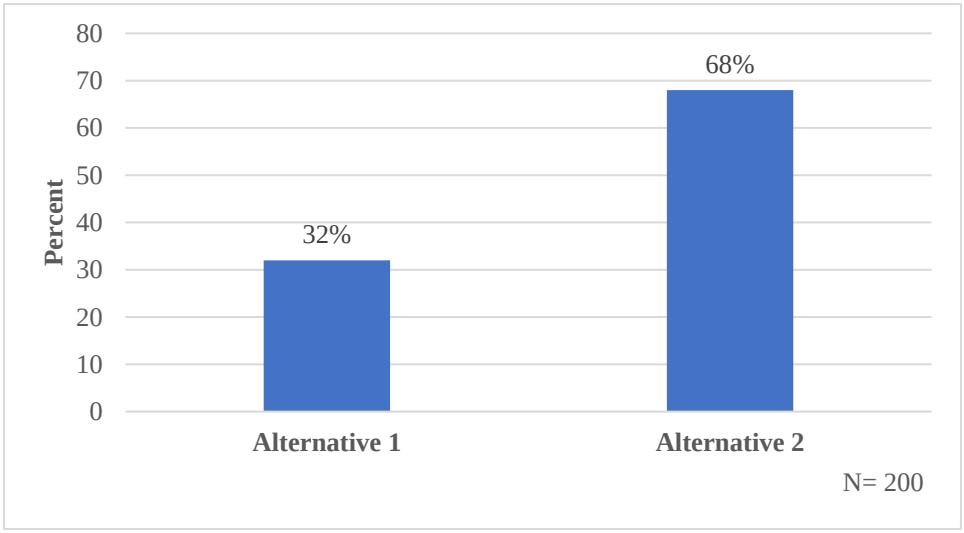

Figure 6.1: Respondent by Stated Preference Survey

The 68% of the respondent who were willing to shift had various degree of likeliness to shift. Those willing to shift 100%, 75%-50% and 25% were classified as easy shifters, moderate shifters and difficult shifters, respectively. The study found that 46% were easy shifters, 44% were medium shifters, and 10% were difficult shifters of those willing to shift.

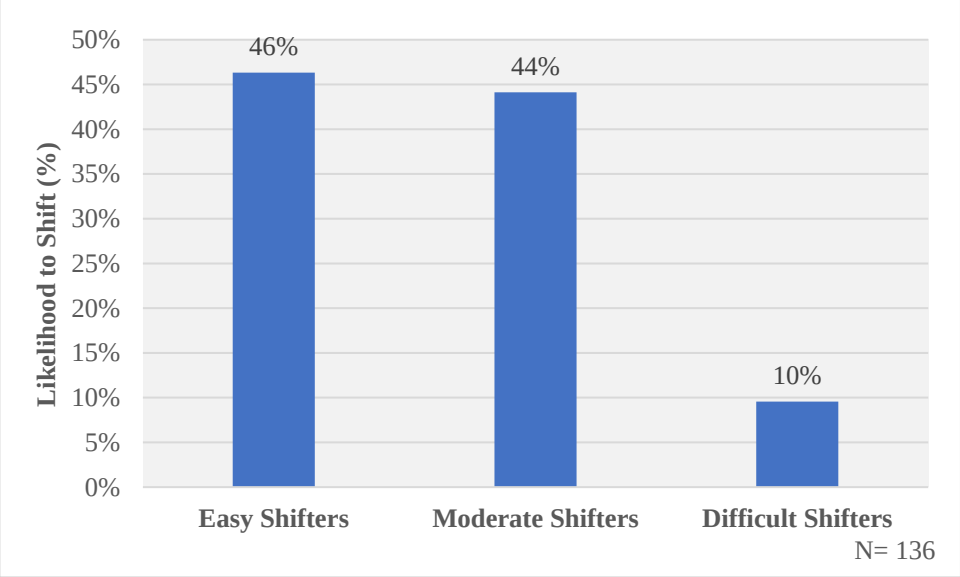

Chart 6.17: Degree of Willingness to Shift of those who were willing to shift

New Baneshwor had 70%, and Radhe Radhe had 66% willingness to shift. While those not willing to shift were mainly because they were not willing to walk to and from the station, and the comparative travel cost and travel time were almost similar to their current travel pattern. It could also be as they belonged to a low-income group, living nearby and commuting by walking/cycling.

6.1.3.1 Willingness to shift as per the Income Group of the respondents

The income range was classified into three categories: low income with monthly earnings upto Rs.20,000, medium income with monthly earnings ranging from Rs.20,000 to Rs.60,000 and high income with monthly earnings above Rs.60,001.

It was found that 55.2% of the respondents in the low-income group, 67.6% in the medium-income group and 81.3% in the high-income group were willing to shift. In comparison, 44.8% of the low-income group, 32.4% of the medium-income group and 18.8% of the high-income group were unwilling to shift from their current transport mode to the metro. Overall, 68% of the respondents were willing to shift, while 32% were not willing to shift.

It was interesting to find out that 44.8% of the low-income group people were not willing to shift; it was mainly because they were living in rented spaces nearby within 2 km distance from their work location. The majority of high-income and middle-income groups (81.3% and 67.6%, respectively) were willing to shift, which could be because of unsustainable soaring fuel prices, the high price of electric vehicles, the traffic chaos during peak hours, and unmanaged public transport services. The additional time and energy required to reach the station from the origin and from station to destination could have been one of the reasons for those not willing to shift. The convenience of private vehicles and the location of current bus stops at a closer distance from the commuter's origin/destination of the trip compared to the site of the proposed metro station could be another reason for the unwillingness among the public to shift to metro.

The data on willingness to shift as per the income group of New Baneshwor and Radhe Radhe respondents is provided in Table 6.2 below.

Table 6.2: Willingness to shift as per the income group of the respondents in New Baneshwor and Radhe Radhe

Location	**Income Group**		**Willingness to Shift**				**Total**
			No	**%**	**Yes**	**%**	
New Baneshwor		Low Income	3	42.9%	4	57.1%	7
		Medium Income	23	31.1%	51	68.9%	74
		High Income	4	21.1%	15	78.9%	19
	Total		30	30.0%	70	70.0%	100
Radhe Radhe		Low Income	10	45.5%	12	54.5%	22
		Medium Income	22	33.8%	43	66.2%	65
		High Income	2	15.4%	11	84.6%	13
	Total		34	34.0%	66	66.0%	100
Total		Low Income	13	44.8%	16	55.2%	29
		Medium Income	45	32.4%	94	67.6%	139
		High Income	6	18.8%	26	81.3%	32
	Total		64	32.0%	136	68.0%	200

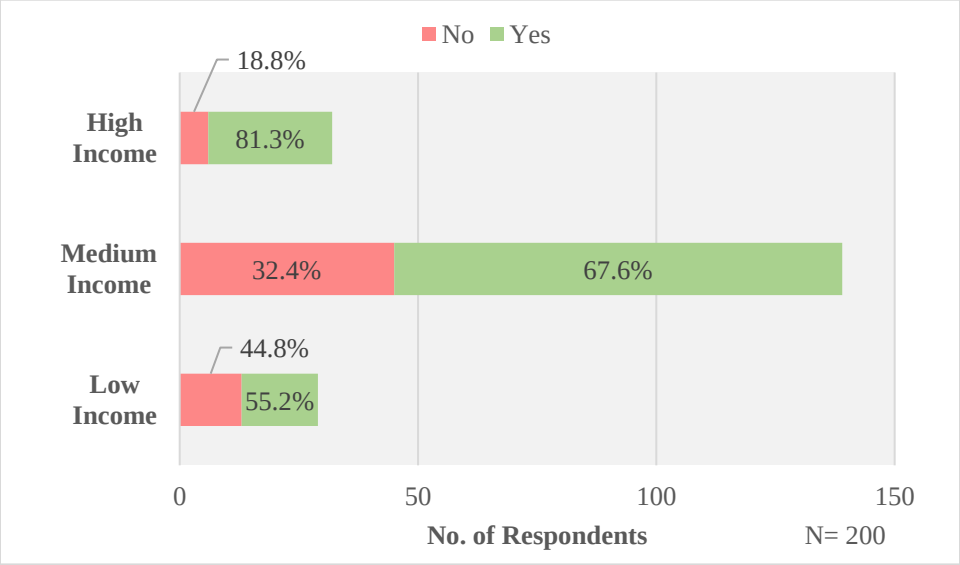

Chart 6.18: Respondents by willingness to shift as per the income group

6.1.3.2 Willingness to shift as per the Primary mode of transportation used to commute to work

It was found that 66% of the respondents used private transport, 87.1% used public transport, and 25% used walk/cycle and were willing to shift. In comparison, 34% of the respondents using private transport, 12.9% used public transport, and 75% used to walk/cycle and were unwilling to shift from their current transport mode to the metro. Overall, 68% of the respondents were willing to shift, while 32% were not willing to shift. The primary mode of transport and willingness was significant ($p < 0.05$).

100% of those commuting to work by ride-sharing were willing to shift as it would be cost-effective. 75% of those commuting to work by walking or cycling were unwilling to shift; it could be because they were commuting short walkable distances and belonged to low-income groups living nearby. 87.1% of those commuting to work by public transport were willing to shift; it could be because they were travelling medium to long distances, and the alternative metro was fulfilling the need for reliable and efficient public transportation. Two-thirds of private transport users were willing to shift as it was time and cost-effective and had the advantage of not having to ride or drive alone.

The data on willingness to shift as per the mode of transportation used to commute to work of New Baneshwor and Radhe Radhe respondents is provided in Table 6.3 below.

Table 6.3: Willingness to shift as per the mode of transportation used to commute to work of the respondents

Location	**Primary Mode of Transport used to commute to work**		**Willingness to Shift**				**Total**
			No	**%**	**Yes**	**%**	
New Baneshwor		Private Transport	28	35.9%	50	64.1%	78
		Public Transport	2	11.1%	16	88.9%	18
		Ride Sharing	0	0.0%	2	100.0%	2
		Walk/Cycle	0	0.0%	2	100.0%	2
	Total		30	30.0%	70	70.0%	100
Radhe Radhe		Private Transport	26	32.1%	55	67.9%	81
		Public Transport	2	15.4%	11	84.6%	13
		Walk/Cycle	6	100.0%	0	0.0%	6
	Total		34	34.0%	66	66.0%	100
Total		Private Transport	54	34.0%	105	66.0%	159
		Public Transport	4	12.9%	27	87.1%	31
		Ride Sharing	0	0.0%	2	100.0%	2
		Walk/Cycle	6	75.0%	2	25.0%	8
	Total		64	32.0%	136	68.0%	200

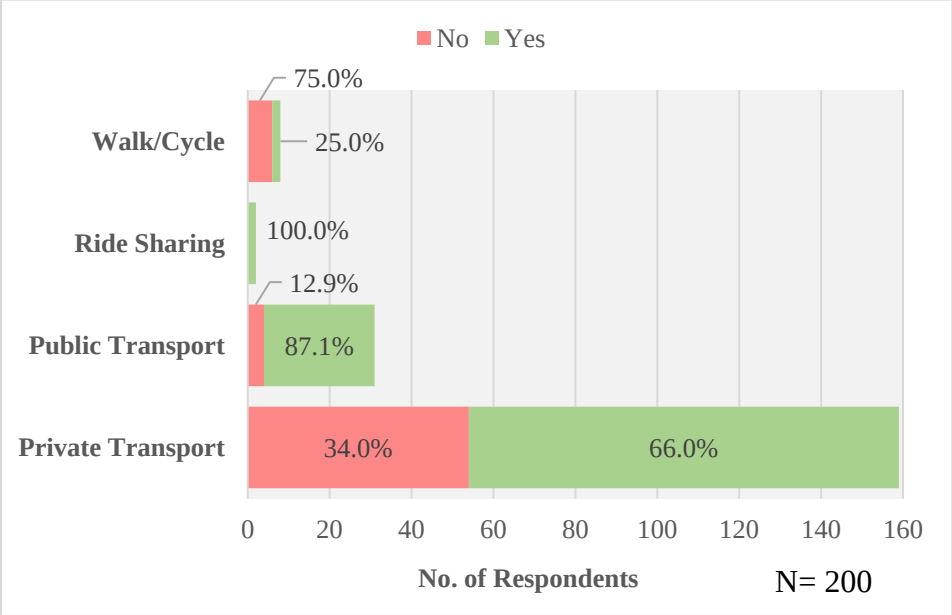

Chart 6.19:Respondents by willingness to shift as per the mode of transportation used to commute to work

Table 6.4: Chi-square Test

	Asymptotic Significance (2-sided)
Pearson Chi-Square	.004

6.1.3.3 Willingness to shift as per the one-way Commute Distance of the respondents

The travel distance for one way was divided into three categories: short distance travelling up to 2 km, medium distance ranging from 2 to 10 km and long-distance travelling more than 10 km.

It was found that 22.5% of the respondents travelling a short distance, 79.7% travelling medium distance and 73.3% travelling long distance were willing to shift. In comparison, 77.5% of the respondents travelling a short distance, 20.3% travelling medium distance and 22.7% travelling long distance were unwilling to shift from their current transport mode to the metro. Overall, 68% of the respondents were willing to shift, while 32% were not willing to shift. Distance and willingness to shift were significant ($p < 0.05$).

Most of those commuting medium to long distances were willing to shift as it would benefit them in terms of cost, time, and comfort. In contrast, more than three-fourths of those commuting short

distances up to 2 km were unwilling to shift as they were living nearby, and for them, it would take more time and cost to reach the station.

The data on willingness to shift as per the commute distance to work of New Baneshwor and Radhe Radhe respondents is provided in Table 6.5 below.

Table 6.5: Willingness to shift as per the trip distance of the respondents of New Baneshwor and Radhe Radhe

Location	**Travel Distance (one way)**		**Willingness to Shift**				**Total**
			No	**%**	**Yes**	**%**	
New Baneshwor		Short Distance (0-2 Km)	17	73.9%	6	26.1%	23
		Medium Distance (2-10 Km)	12	16.4%	61	83.6%	73
		Long Distance (>10 Km)	1	25.0%	3	75.0%	4
	Total		30	30.0%	70	70.0%	100
Radhe Radhe		Short Distance (0-2 Km)	14	82.4%	3	17.6%	17
		Medium Distance (2-10 Km)	16	24.6%	49	75.4%	65
		Long Distance (>10 Km)	4	22.2%	14	77.8%	18
	Total		34	34.0%	66	66.0%	100
Total		Short Distance (0-2 Km)	31	77.5%	9	22.5%	40
		Medium Distance (2-10 Km)	28	20.3%	110	79.7%	138
		Long Distance (>10 Km)	5	22.7%	17	77.3%	22
	Total		64	32.0%	136	68.0%	200

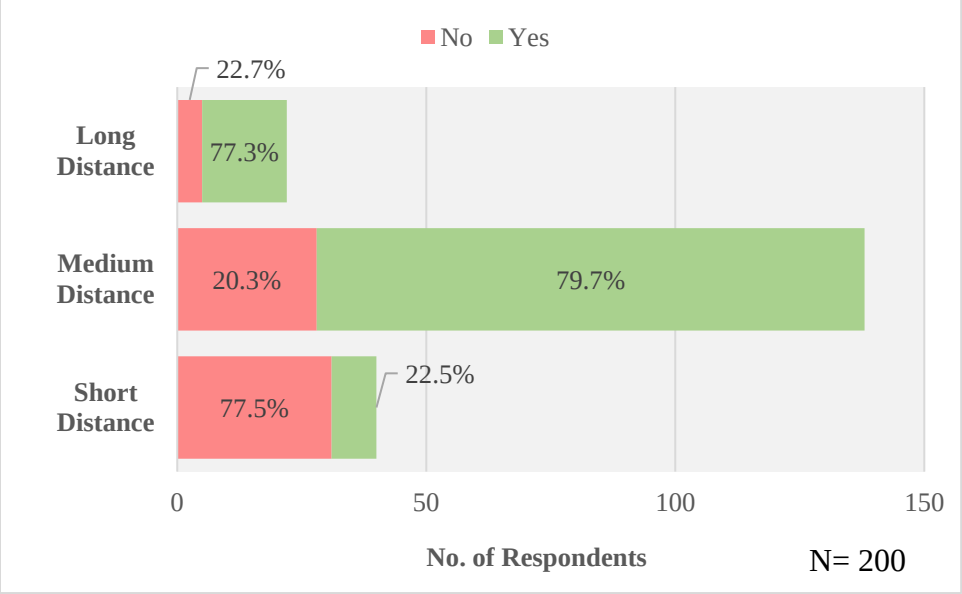

Chart 6.20: Respondents by willingness to shift as per the trip distance

Table 6.6: Chi-square Test

	Asymptotic Significance (2-sided)
Pearson Chi-Square	0.000

6.1.3.4 Willingness to shift as per the Origin and Destination of the respondents

Of all the respondents (N= 200), the study areas were a point of origin for 42% and a point of destination for 58%. Of those, 73.8% of individuals who had the study area as their point of origin and 63.8% of those who had it as their destination was willing to shift, as illustrated in Chart 6.21. About two-thirds of trips originating and ending in New Baneshwor (n= 100) were willing to shift. On the other hand, three-fourths of trips originating and only half of the trips ending in Radhe Radhe (n= 100) were willing to shift. This could result from Radhe Radhe being a location of trip production as opposed to the case of New Baneshwor being a location of the trip attraction.

Table 6.7: Willingness to shift as per the trip generation of the respondents

Location	***Trip Generation***		***Shift***				***Total***
			No	***%***	***Yes***	***%***	
New Baneshwor		Origin	9	34.6%	17	65.4%	26
		Destination	21	28.4%	53	71.6%	74
	Total		30	30.0%	70	70.0%	100
Radhe Radhe		Origin	13	22.4%	45	77.6%	58
		Destination	21	50.0%	21	50.0%	42
	Total		34	34.0%	66	66.0%	100
Total		Origin	22	26.2%	62	73.8%	84
		Destination	42	36.2%	74	63.8%	116
	Total		64	32.0%	136	68.0%	200

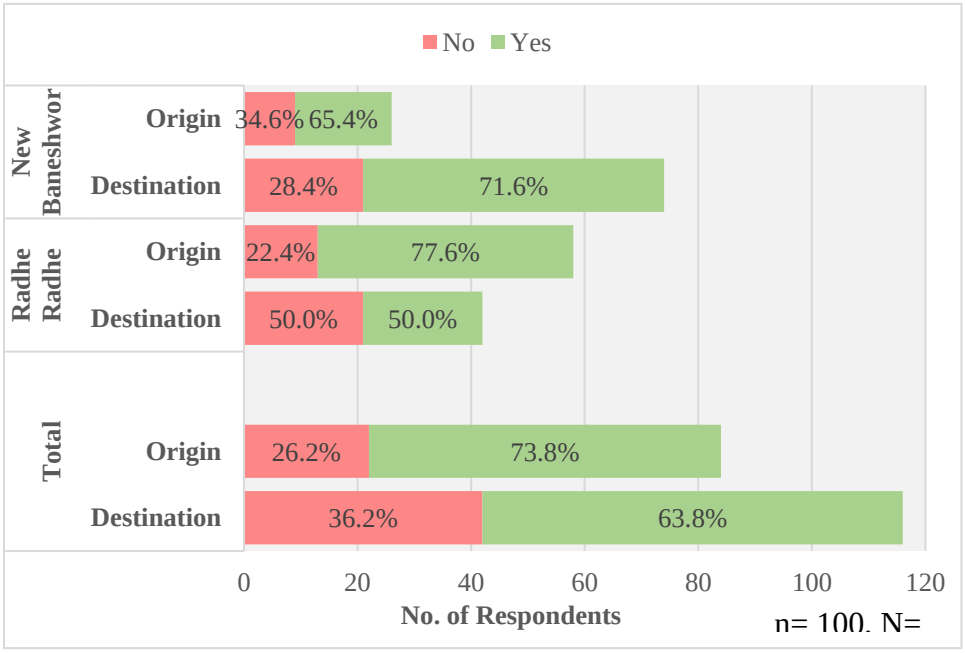

Chart 6.21: Respondents by Origin and Destination

6.1.4 Influencing Factors

The factors that were important for the respondents willing to shift (N= 136) were listed as comfort, lower price, safety and security, accessibility and connectivity, reduced travel time, reliable timetable and on-board services. Of all these factors, reduced travel time had the most crucial influence, while on-board services had the least influence on those willing to shift (N= 136), as shown in Chart 6.22.

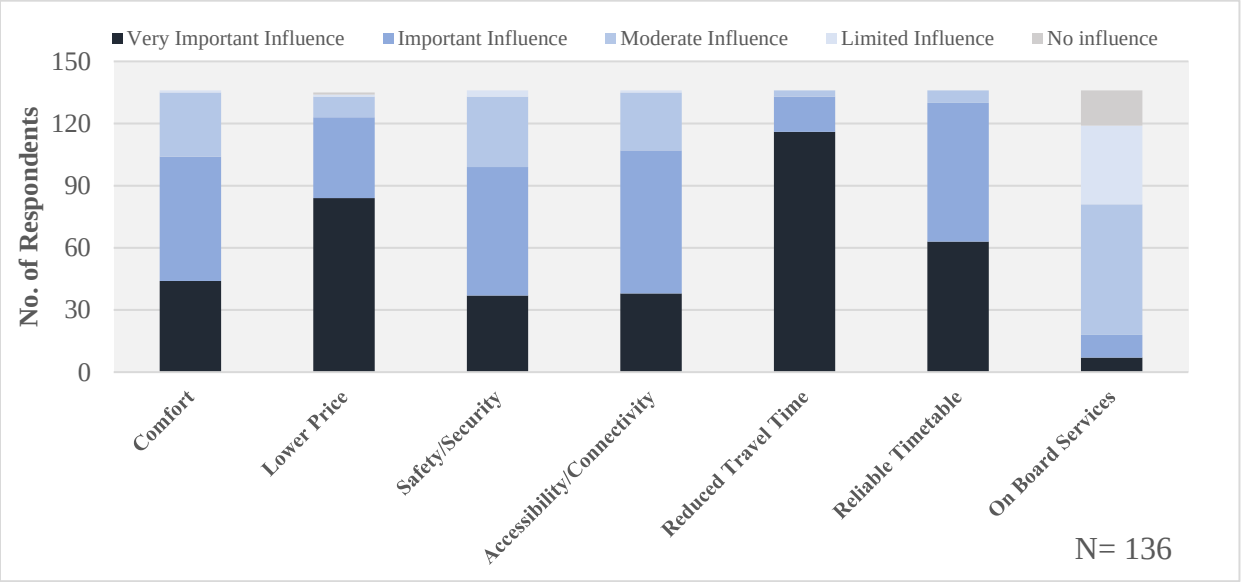

Chart 6.22: Influencing factors that would facilitate shifting to Metro

6.2 Land Use Analysis

As seen in the influence area of New Baneshwor, it consists of institutions, commercial, mixed-use buildings and residential areas. The hierarchy of roads influences land use. Central to the junction, the primary highway predominantly consists of commercial land use and institutions. Along the secondary roads, it consists of mixed-use developments and along the tertiary roads are the residential area with mix use development in the junctions. The land use in New Baneshwor is compact, dense and diverse. The observed land use of New Baneshwor has been illustrated in Figure 6.2.

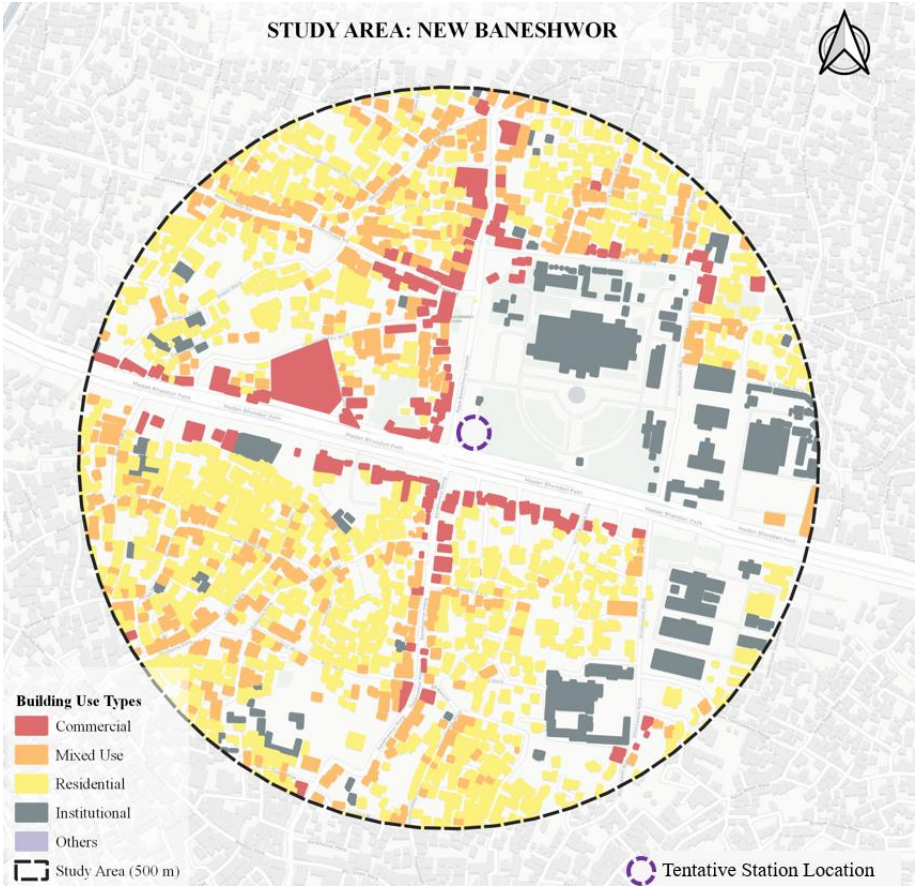

Figure 6.2: Building use of Study area- New Baneshwor within 500m
Source: Google Map, OpenStreetMaps Contributors and Field observation

As observed in Radhe Radhe, it predominantly consists of residential areas and agricultural land. Along the highway, it consists of commercial and mixed land use. Commercial and mixed-use development is seen along Bhatbhateni supermarket. Across it is a high-rise construction building adjoining it is a government official trial centre. The observed land use of Radhe Radhe has been illustrated in Figure 6.3.

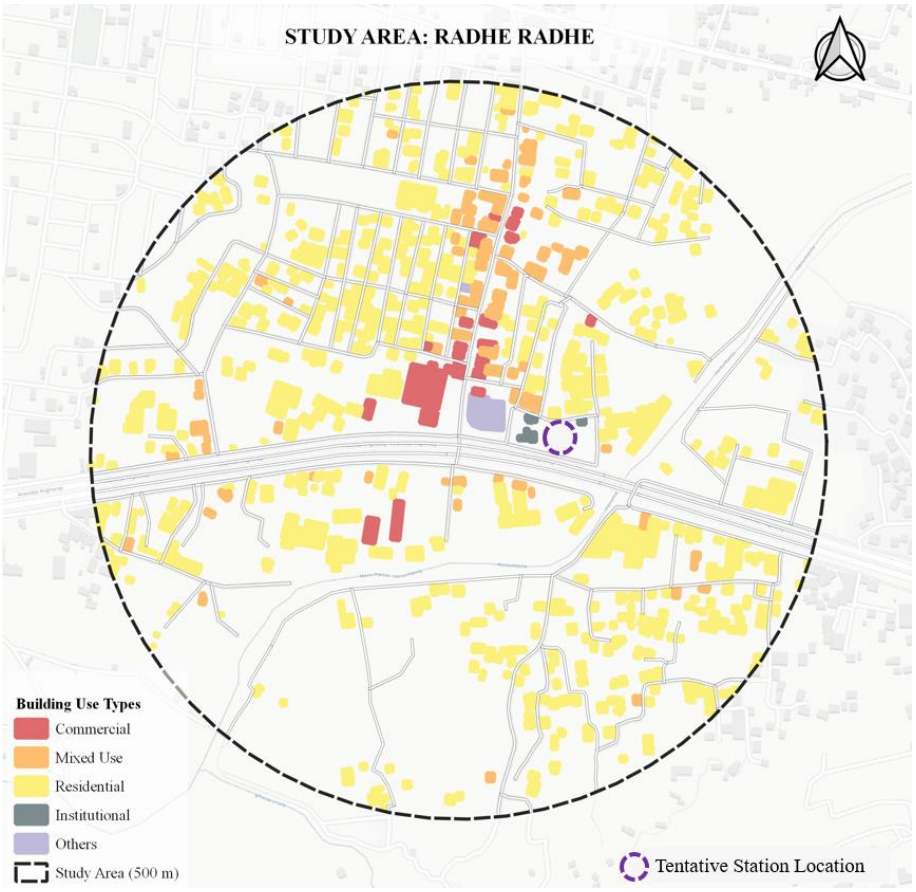

Figure 6.3: Building use of Study area- Radhe Radhe within 500m
Source: Google Map, OpenStreetMaps Contributors and Field observation

6.3 Likely Effect of Station Development

With inferences drawn from the case studies, the various likely changes that could occur in the study area with the development of metro station. In New Baneshwor and Radhe Radhe, there could be more commercial area around the station area, mixed-used at a distance further from the station and fewer residential areas in the outermost area, as shown in Figure 6.4. This could be the immediate effect of the metro station in these areas. However, the commercial zone in New Baneshwor could be more than that of Radhe Radhe, while the residential site in Radhe Radhe could be more than New Baneshwor.

In terms of spatial development, New Baneshwor could have a vertical expansion, as the area is saturated and there are very few vacant spaces for horizontal development. While in the case of

Radhe Radhe, there could be horizontal development and sprawl in the vacant/ agricultural areas. The agricultural land will more likely be developed into construction sites for new buildings more rapidly. More significant changes in the spatial settlement pattern in Radhe Radhe can be expected. Moreover, there could be a change in the building use type, such as a change from residential to commercial or a change of the existing commercial into homogenous or heterogenous commercial or institutional type.

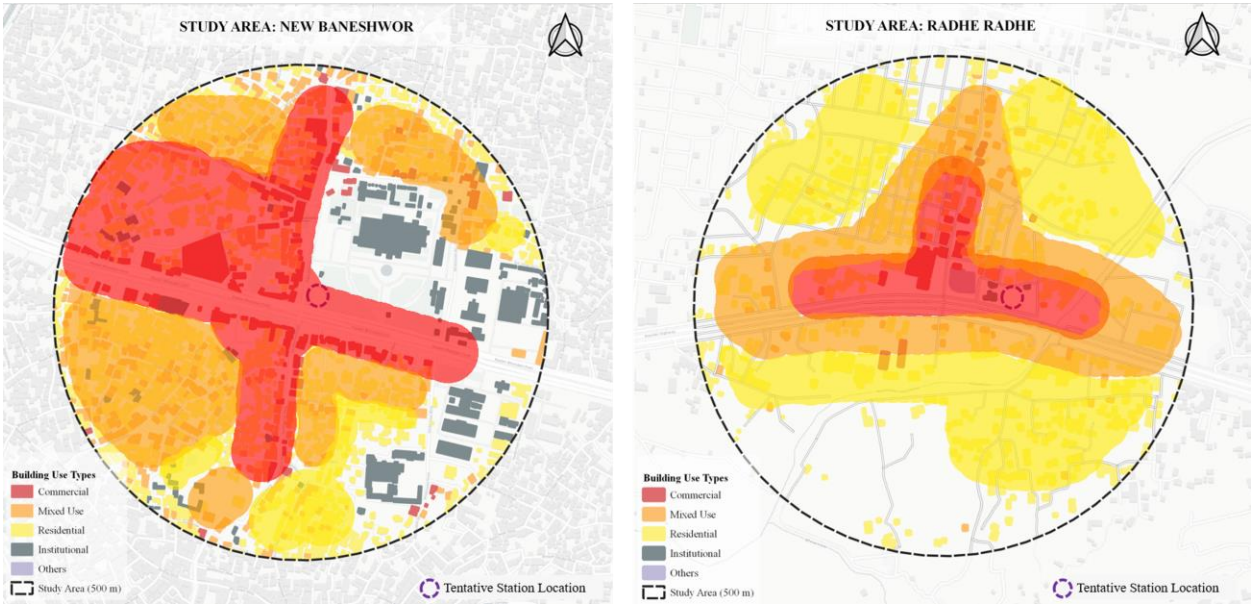

Figure 6.4: Likely effect of Station Development

7 CHAPTER SEVEN: CONCLUSION AND RECOMMENDATION

7.1 Conclusion

Low occupancy and unregulated services of public vehicles have contributed to the augmented number of private vehicles on the roads; this has further added to the traffic volume, which has worsened the traffic congestion. With a gradual population increase and increasing travel demand, a comprehensive mass transportation strategy is essential for a long-term vision of economics, efficiency, energy, and the environment. An excellent public transportation system encourages pedestrian-friendly cities and transit-oriented development while reducing fuel consumption, reliance on private vehicles, traffic congestion, and pollution, thus, significantly contributing to the upliftment of the quality of life for the inhabitants. In the context of Kathmandu, the Metro could be one of the optimum MRT systems since it can serve the city's residents' current and future transit needs.

Many types of research on the MRT often focus on technical and operational issues, and the users' perceptions are rarely taken into account. However, this research studies commuters' travel behaviour and willingness to shift. The research was conducted in one of the central hubs of the city, New Baneshwor, and the other was born in the periphery of the town, which is in its emerging phase, Radhe Radhe of the Kathmandu Line. The two areas have different settlement and mobility patterns. The mobility pattern of their present commute to work and the factors that would influence the commuters to shift to the metro are researched.

The results from this study suggest that the trip distance is directly related to the willingness to shift. People who commuted medium to long distances were significantly willing to shift compared to those commuting short distances. A significant proportion of low-income groups were unwilling to shift as they lived nearby within a short distance or were commuting on foot or a cycle. On the other hand, the majority of the high-income and middle-income groups were willing to shift, which could be due to the factors such as unmanaged public transportation, increasing fuel prices, traffic congestion, and air pollution, among others. Moreover, most public and private vehicle users were willing to shift, which implies that people are anticipating a new reliable, efficient public mass transit system with improved infrastructure. People’s willingness to shift to an alternative reflects

the city's need for mass transit. The most crucial factor that encouraged the commuters to shift to the metro was the reduced travel time.

However, about 30% of the respondents had no idea about metro. This implies that the city needs more research to be conducted with active public participation and to create public awareness. Although 69.5% of the respondents knew about the metro, only less than half of them had travelled in metro; out of which most of them had travelled in Delhi metro.

Despite the settlement patterns of the two-study area being very different, the responses were indifferent to spatial patterns. New Baneshwor had 70%, and Radhe Radhe had 66% willingness to shift. Due to the area's saturation and lack of available land for horizontal growth, New Baneshwor could experience a vertical increase in spatial development. The vacant and agricultural regions of Radhe Radhe could experience horizontal growth and sprawl. Radhe Radhe's spatial settlement pattern may undergo more profound modifications. The study area's hierarchy of roadways currently impacts how land is used. It primarily uses commercial land along the main road, close to the intersection. Mixed-use developments are located along secondary and tertiary roads, respectively, while residential areas are located along primary roads, and mixed-use developments are located at intersections.

Stakeholders and decision-makers should learn from this research on how potential users could feel about the metro and what conditions might make the switch to the metro easier. The field observation and public perspective helped to understand the context and its ground realities. Studies as such should be done to help make policies toward a better city for the inhabitants. Additionally, planned densification around metro stations and integration with current transportation modes and regulations are necessary for a successful transit system. The conclusions from this study will be supportive for decision-makers, practitioners, policymakers, urban planners, transport planners, and scholars, among others. This research would add to new knowledge and can be used as a reference for future work by organizations and institutes working on urban mobility, MRTs and land use.

7.2 Recommendations

Reliable public transportation is a need in our context. The number of low occupancy vehicles should be replaced by an alternative of high occupancy vehicles such as MRTs. This could address

the traffic congestion likely to happen in a few decades. Road networks connecting through the shortest route should be directly related to the station area to facilitate a convenient commuting environment. More awareness about the MRTs and their benefits should be created among the public so that the public can evaluate their impact on their social, financial and environmental aspects of life. Transit-oriented development of cities should be developed with compact neighborhood development. Pedestrian-friendly infrastructures should be built to encourage walkable distances to and from the station location. Development should be regulated to prevent haphazard development. More research should be carried out to analyze the peoples' willingness to shift to metro from their current mode of transportation. Since MRTs are very expensive, they should be subsidized by the government. About two-thirds of the respondent was willing to shift to the metro, which indicates that the public is seeking an alternative; MRT is the one that fulfils their needs. The amount of time saved from short trip distances and time can be invested in other productive work. This can further contribute to the economy.

7.3 Further Studies

The study was limited to two station locations on the Kathmandu Line of the proposed Metro system. Further studies can be done on the topics listed below:

- Various station locations of other proposed routes can be studied.
- There is potential for more research on an integrated study of land use and mass transit system.
- Policy review and recommendation related to urban transportation
- Using financial incentives to encourage public transportation may also be a worthwhile area of research.

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9 APPENDICIES

APPENDIX A: Survey Questionnaire

Survey on Mobility Pattern and Peoples' Willingness to use Metro

Masters in Urban Planning Thesis
This survey is being done by Subina Shakya, student of M.Sc. in Urban Planning. The data collected will be used to establish indicator about the peoples' willingness to shift to Metro from Public and Private Vehicles. All information will be kept confidential.

* Required

1. Name of the respondent

2. Age of the respondent *

Mark only one oval.

- ◯ Below 20
- ◯ 20-30
- ◯ 30-40
- ◯ 40-50
- ◯ 50-60
- ◯ above 60
- ◯ Other: _____

3. Gender *

Mark only one oval.

- ◯ Male
- ◯ Female
- ◯ Others

4. Ethnicity

Mark only one oval.

- ◯ Brahmin
- ◯ Chettri
- ◯ Newar
- ◯ Tamang
- ◯ Gurung
- ◯ Madhesi
- ◯ Others (Please Specify)

5. Ethnicity if Others:

6. Highest Education Attainment: *

Mark only one oval.

- ◯ Primary/Secondary School
- ◯ SLC
- ◯ Plus 2/Diploma
- ◯ Bachelors
- ◯ Masters/Ph.D

7. New Baneshwor:

Mark only one oval.

- ◯ Home (Orgin) *Skip to question 9*
- ◯ Work (Destination) *Skip to question 10*

8. Radhe Radhe:

Mark only one oval.

- ◯ Home (Orgin) *Skip to question 9*
- ◯ Work (Destination) *Skip to question 10*

Work Destination

9. Address of your Work

_____

Skip to question 11

Home

10. Address of your Home

_____

_____

_____

_____

_____

Socio-Economic Data

11. Housing Status *

Mark only one oval.

- ◯ Rental
- ◯ Ownership
- ◯ Hostel
- ◯ Apartment
- ◯ Other: _____

12. Designation/Profession: *

Mark only one oval.

- ◯ Business/Owner
- ◯ Private Employee
- ◯ Government Employee
- ◯ Others (Please Specify)

13. Designation/Profession Others:

_____

14. Monthly Income (NRs): *

Mark only one oval.

- ◯ Less than 20,000
- ◯ 20,000-40,000
- ◯ 40,000-60,000
- ◯ 60,000-80,000
- ◯ 80,000-1,00,000
- ◯ Above 1,00,000

15. No. of Family Members living with you: *

Mark only one oval.

- ◯ 0-1
- ◯ 2-4
- ◯ 5 or more

16. No. of other Family Members Employed/Business *

Mark only one oval.

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4 or more

17. Any Form of Disability *

Mark only one oval.

- ◯ Yes
- ◯ No

18. Does your household own a Vehicle (including bicycle) ? *

Mark only one oval.

- ◯ Yes *Skip to question 19*
- ◯ No *Skip to question 20*

Vehicle Ownership

19. Number of Vehicle Ownership *

Mark only one oval per row.

	0	1	2	More than 2
No. of Cars:	◯	◯	◯	◯
No. of Bike/Scooter:	◯	◯	◯	◯
No. of Cycle:	◯	◯	◯	◯

Section B

20. How long does it take to reach the Bus stop?

Mark only one oval.

- ◯ 5 minutes
- ◯ 10 minutes
- ◯ 15 minutes
- ◯ 20 minutes
- ◯ More than 20 minutes

21. Primary Mode of Transport used to Travel to Work *

Mark only one oval.

- ◯ Public Transport *Skip to question 22*
- ◯ Private Transport *Skip to question 25*
- ◯ Ride Sharing (Pathao/Tootle) *Skip to question 28*
- ◯ Taxi *Skip to question 28*
- ◯ Cycle *Skip to question 28*
- ◯ Walk *Skip to question 28*
- ◯ Other: _____

Public Vehicle Type used

22. Which Public Transport do you use? *

Mark only one oval.

- ◯ Bus
- ◯ Micro
- ◯ Tempo
- ◯ Mini Van
- ◯ Other: _____

23. How much Time does the Public Vehicle take Waiting for passengers at Stops?

Mark only one oval.

- ◯ 2 minutes
- ◯ 5 minutes
- ◯ 10 minutes
- ◯ 15 minutes
- ◯ 30 minutes
- ◯ More than 30 minutes

24. Comfort Level of the Current Public Transport *

Mark only one oval.

	1	2	3	4	5	
Not Satisfied	◯	◯	◯	◯	◯	Highly Satisfied

Skip to question 28

Private Vehicle Type used

25. Which Private Transport do you use? *

Mark only one oval.

- ◯ Bike/Scooter
- ◯ Car
- ◯ Bicycle
- ◯ Other: _____

26. Comfort Level of your Current Private Transport *

Mark only one oval.

	1	2	3	4	5	
Not Satisfied	◯	◯	◯	◯	◯	Highly Satisfied

27. Reason for not using the Public transportation?

Mark only one oval.

- ◯ Uncomfortable seating
- ◯ Crowded
- ◯ Comparatively more Travel time
- ◯ Less frequency of bus service
- ◯ Other: _____

Your Travel Details

28. What is your Total Time taken to Travel to Work from Home? (one way) *

Mark only one oval.

- ◯ Upto 15 minutes
- ◯ 15-30 minutes
- ◯ 30-45 minutes
- ◯ 45-60 minutes
- ◯ More than 60 minutes

29. Distance from Home to Work (one way)

Mark only one oval.

- ◯ Less than 2 Km
- ◯ 2-5 Km
- ◯ 5-10 Km
- ◯ 10-15 Km
- ◯ More than 15 Km

30. What is your Travel Cost per trip? (one way)

Mark only one oval.

- ◯ 0 (No expenses)
- ◯ Less than Rs.30
- ◯ Rs.30 - Rs.60
- ◯ Rs.60 - Rs.100
- ◯ Rs.100 - Rs.150
- ◯ Rs.150 - Rs.200
- ◯ Above 200

Part C- Metro Rail

31. Do you know what is a Metro Rail? *

Mark only one oval.

- ◯ Yes *Skip to question 32*
- ◯ No *Skip to question 35*

if yes, Metro

32. Have you ever traveled in a Metro? *

Mark only one oval.

- ◯ Yes
- ◯ No

33. In which city have you used a Metro?

_____

34. Do you want Metro in your city? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe

Part D- Stated Preference

35. Stated Preference: Please choose one Option by comparing the benefits of your current transport mode and that a Metro would provide. *

	Alternative 1	Alternative 2
Transport choice	*Your current Transport mode (Car, Bike, Public Vehicle, Cycle)*	**Metro**
Time to reach to Transit/station from home		5-10 minutes
Travel Time (in-vehicle)		2 minutes per Km
Time to get from transit or to destination		5-10 minutes
Travel Cost		Rs.8 per Km
Comfort		Seats available/ Comfortable standing
Service frequency		Every 15 minutes
Additional Cost (Parking, maintenance)		No

Distance (Km)	Rate (Nrs)
0-2	16
2-5	32
5-12	48
12-21	64
21-32	80
Above 32	96

Mark only one oval.

- ◯ Alternative 1 *Skip to question 38*
- ◯ Alternative 2 *Skip to question 36*

If Alternative-2 (Metro)

36. Factors that would facilitate you to shift to Metro? *

Mark only one oval per row.

	No influence	Limited Influence	Moderate Influence	Important Influence	Very Important Influence
Comfort	◯	◯	◯	◯	◯
Lower Price	◯	◯	◯	◯	◯
Safety & Security	◯	◯	◯	◯	◯
Accessibility/Connectivity	◯	◯	◯	◯	◯
Reduced Travel Time	◯	◯	◯	◯	◯
Reliable Timetable	◯	◯	◯	◯	◯
On Board Services	◯	◯	◯	◯	◯

37. How likely are you to shift?

Mark only one oval.

◯ 25%
◯ 50-75%
◯ 100%

Remarks

38. Notes

APPENDIX B: Final Presentation Comments

S.N	Examiners	Comments	Response
1)	Mr. Kumar Prasad Lohani (External Examiner)	Land use could be elaborated more	Addressed in Pg. No.68
		Add willingness in further Research Objectives	Added in Pg. No.8
2)	Er. Chakravarti Kanth (External Examiner)	Avoid usage of future tense in chapter-1 of thesis report	Corrected Pg. No. 3
		Mention the willingness case studies whether it was done before the metro system or after the metro system in report	Mentioned in Pg. No.31
3)	Dr. Jib Raj Pokhrel	Policy review and recommendation for urban transportation	Could not be incorporated due to time limitation, however, I have included it in further studies

APPENDIX C: Site Photographs

Figure 9.1: Unmanaged Transportation in Kathamandu

Figure 9.3: Study area condition in New Baneshwor

Figure 9.2: Study area in Radhe Radhe

APPENDIX D: IOE Graduate Conference Paper

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Date: October 11, 2022

To Whom It May Concern

This is to confirm that the paper titled "*Analyzing Willingness to Shift to Proposed Metro Rail System for Work Trips: A Case of New Baneshwor and Radhe Radhe*" submitted by **Subina Shakya** with Conference ID **12062** has been accepted for presentation at the 12th IOE Graduate Conference being held in October 19 – 22, 2022 at Thapathali Campus, Kathmandu.

Khem Gyanwali, PhD
Convener,
12th IOE Graduate Conference

IOE Graduate Conference
[Placeholder for Publication Information]

Analyzing Willingness to Shift to Proposed Metro Rail System for Work Trips: A Case of New Baneshwor and Radhe Radhe

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Abstract

With the increasing population in Kathmandu, there seem to be challenging mobility issues. Low occupancy and unregulated services of public vehicles have resulted in more private vehicles on the road. As such, in the last few decades, the number of new vehicles in the city has tripled, adding to the traffic volume and traffic congestion. Thus, the city is in dire need of efficient and reliable public transportation: one that would encourage walkable communities and transit-oriented development while lowering fuel consumption, reducing dependency on private vehicles, and reducing traffic congestion and pollution. To solve these problems, various studies on Mass Rapid Transit (MRT) are being conducted. This study seeks to examine the rarely studied yet crucial element—the perspective of potential users. Using the Stated Preference survey, the willingness to shift of 200 respondents in the proposed metro station location at New Baneshwor and Radhe Radhe was conducted through direct interviews. The results suggest that about two-thirds of the respondents were willing to shift to the metro. The study has discovered some intriguing relationships between willingness to shift and factors including income, distance, mode of transportation, and origin and destination. Findings from the study revealed that the respondents willing to shift were mainly those with trip distance more than 2 km; high and medium-income groups; commuting by ride-sharing, private, and public vehicle users; while those unwilling to shift were those commuting less than 2 km; low-income group; and those commuting on foot or on cycle. Although there were significant differences in the settlement patterns of the two-study area, the responses were indifferent to spatial patterns. Hence the study concludes that there is a need for MRT in the city as the current public transport infrastructure has failed to meet the needs of the commuters.

Keywords

Willingness to Shift, Mass Rapid Transit, Metro Station, Stated Preference

1. Introduction

1.1 Background

The country's capital, Kathmandu - the administrative and commercial center, has seen tremendous urbanization over the last few decades. According to the census of 2021 [1], Nepal's urban population is 1,92,91,031 people, accounting for 66.08 percent of the total population, while the rural population is 99,01,441 people, accounting for 33.12 percent. In the next few years, the population boom will probably result in a massive increase in travel demand and numerous transportation issues. The rapid growth of the population and their mobility needs is challenging and has resulted in significant traffic congestion and pollution.

One of the biggest concerns with the current system is unmanaged transportation. As most of the public transport system of the valley is operated by private companies, they are composed of low occupancy vehicles, which leads to the increased number of private vehicles on the road. Further, traffic congestion, air pollution, and traffic accidents have become serious concerns as the number of automobiles and trips increases [2]. As per the latest available data [3], the new vehicle registrations have been increasing nearly three to four-fold in the last few decades. In 2074/75 (2017/18), Nepal had a total of 32,21,042 registered vehicles, out of which 11,72,413 were in Bagmati Province accounting for 36.40 percent of the total, which was the highest in comparison to other provinces, and most of these vehicles run on the roads of Kathmandu Valley. There

Pages: 1 – 8

is a misconception in Nepal, that road widening solves traffic congestion, it can only bring temporary relief; however, as long as the number of vehicles continues to rise, road widening will be ineffective [4]; a phenomenon commonly referred to as induced demand. According to a study from the Metropolitan Traffic Police Division, if all vehicles in Kathmandu valley were to be queued, at 7.2 million feet, it would be longer than the total length of the valley roads i.e. 4.5 million feet [5]. This implies that the city is heavily reliant on motorized vehicles and much priority has been given to vehicular roads. With the average speed of vehicles in the core area during peak hours being around 7 km/hr, the Kathmandu Valley, therefore, is in severe need of a Mass Rapid Transit (MRT) system that can transport thousands of passengers every hour [6].

Figure 1: Proposed Metro Routes and Study Areas [6]

To address the various issues of challenging mobility, the Government of Nepal (GON) has planned various Railway and Metro networks across the country. There are various ongoing studies about the Mass rapid transit in Kathmandu. This research refers to the study of 'Kathmandu Metro Rail Vision 2040' by Dr. Binod L. Amatya for the Metro feasibility, routes lines, and station location. Out of the various routes shown in *Figure* 1, the Kathmandu Line running along the east-west direction will be considered for this research. The Kathmandu Line of the proposed Metro route connects the two districts of Kathmandu and Bhaktapur respectively. This route connects Banepa- Sanga- Bhaktapur- Sallaghari- Thimi- Koteshwor- Bhrikuti Mandap- Tankesor- Kalanki-New Satungal- Thankot. It is estimated to be 54 km running east-west and connecting with both the Arniko Highway and the Prithivi Highway. This corridor passes through important urban areas with significant growth and has a catchment region with a large number of potential travelers. Out of the various proposed stations along the route, this research will examine the station location at New Baneshwor and Radhe Radhe within 500 m of its influence zone.

It is now vital to adopt efficient and effective measures to ease mobility with Metro being one of the MRT that enhances greater mobility for the inhabitants. Moreover, a shift from private vehicles to public transportation is required. However, there is a need to carry out the assessment of peoples' pre-launch willingness to shift from their current mode of transportation to MRT as it is a subject of relatively little research. Thus, the study seeks to examine the people's willingness to commute to work by metro and explore the circumstances under which they would be motivated to do so.

1.2 Research Objective

The main aim of this research is to study the Metro as MRT and examine the willingness of the commuters to shift to metro in the proposed station location in New Baneshwor and Radhe Radhe. Further specific research objectives are:

- To assess the current travel behavior in commuting work trips.
- To study the settlement and mobility pattern around the station points.

1.3 Scope and Limitations

The research will be looking into the work-based mobility pattern in New Baneshwor and Radhe Radhe within 500 meters of the transit influence area. The two metro stations for this research are approximately located and assumed. The exact location, alignment, and area of the stations are not exact or well-defined. Purposive sampling was done for collecting data.

2. Literature Review

Mobility is an important part of human life; it is a defining characteristic of modern society. To address the systemic character of the urban mobility system, one must first have an understanding of how the use of

urban land, transportation networks, and the activities of urban families and businesses are interconnected. In a city, people commute in order to fulfill needs for work trips, educational trips, leisure trips, etc. Since it determines the amount of travel required, a person's activity space is a crucial trip generation component. For this, a variety of modes of transportation are available which is the modal choice. This decision is influenced by a number of variables, including price, technology, accessibility, preference, travel distance, and money [7].

2.1 Metro as Mass Rapid Transit (MRT)

Mass Rapid Transit (MRT) is a term used to describe modes of urban public transport (both road and rail-based) that carry large volumes of passengers quickly [8] and runs on specific fixed tracks or with exclusive use of the potential common track, along predetermined lines with designated routes with specific stops [8]. A mass transit system is a necessary component of a big city's sustainable transportation system, and it may have a significant impact on how a city develops in the future in emerging nations, resulting in a kind of urbanism that is transit-friendly [8]. The benefits of MRT include its space efficiency, relatively high speeds and passenger capacities, and greater quality of service compared to other transport modes [8]. Some of the examples are heavy rail transit, light rail transit and bus rapid transit [8]. Metro is a heavy rail transit that is by far the fastest mode of MRT. They are mostly elevated or underground in the system. They are also the most expensive MRT type per square kilometer with speeds ranging from 30 to 80 km/hr and a potential capacity of about 60,000 passengers/hr/direction [8]. Although it takes longer construction and implementation period as compared to other types of MRTs, it has a very good public transit integration, interaction with land development, system image, and passenger attraction [8].

2.2 Factors that Influence Choice of Travel Mode

Making decisions concerning public transportation alternatives affects how a community will develop in the future. According to DeWitte [9], a variety of complicated elements influence how individuals decide how to go to their destination, and these decisions may be made consciously or unconsciously. This process is known as a modal choice, and there are three distinct approaches to it: rationalist (with time and cost), socio-geographical (with a spatial component), and socio-psychological (with attitudes), with the rationalist approach being the most often used method [9]. According to Olsson [10], the factors that influence the choice of travel mode can be classified as (i) hard and soft factors; (ii) internal and external factors; and (iii) subjective and objective factors. Hard factors are easier to quantify than soft factors [10]. Travel time, the value of time, travel cost, reliability, and capacity are hard factors while comfort, service, and knowledge are examples of soft factors. Attitudes, socioeconomic and demographic characteristics, habits, and the perception of control are all internal factors whereas travel time and expense are external influences [10]. Socioeconomic characteristics such as gender and age, as well as trip-related factors such as purpose, are among the objective determinants [10]. Valuations of the alternative's traits, attitudes, and lifestyle are examples of subjective factors. These are more difficult to quantify because they are based on an individual's perception [10]. For public transport, the transport-related attributes that describe the travel standard factors are divided into the timetable, comfort, on-board service, safety, and quality of satisfaction [11].

2.3 Revealed Preference (RP) and Stated Preference (SP)

The research employed two techniques of survey for the collection of data namely revealed preference (RP) and stated preference (SP). Revealed preference data represents data collected in the actual scenario by asking decision-makers about the actual choice they have made. The constraints faced by decision-makers during the choice process are pre-existent in RP data and this adds to the reliability and validity of the data but limitation exists in alternatives, attributes and attribute levels [12, 13]. Stated preference data represents the choice stated by decision-makers in a hypothetical situation presented to them. This can lead to situations where respondents may not consider constraints at the time of making choice. Therefore, the hypothetical alternatives should be as realistic as possible. With SP data we can explore alternatives, attributes, and attributes level and make predictions outside technological frontiers [12, 13]. SP survey will be employed to study a hypothetical situation of having a travel mode of metro and RP will be employed to know about the existing travel behavior.

3. Study Area

The two-study area, as shown in *Figure* 1, has been selected on the basis of their relative population density and their location on the Kathmandu Line Route of the proposed Metro System. The two-study area, New Baneshwor of Kathmandu Metropolitian city and Radhe Radhe of Madhyapur Thimi municipality is investigated for this research. The study neighborhood has been limited to a 500 m radius from the main road junction.

4. Methodology

The research was carried out using a mixed-method to examine the commuter's willingness to shift to metro from their current mode of transport. The main focus was to explore the work-based travel pattern of the people and their willingness to shift to a Metro when commuting for their daily work trips generated and attracted in the study area. Thus, this research is based on a pragmatic paradigm. In the targeted locations, questionnaire surveys were conducted through face-to-face interaction with respondents.

The current travel behavior of the commuters was explored through Revealed Preference (RP) and a hypothetical situation about their willingness to shift to Metro under the given circumstance was done through the Stated Preference (SP) survey. With reference to this, the two options were given to the respondents: 'Alternative 1'- current mode of transportation and 'Alternative 2'- shifting to Metro. To evaluate these, various parameters such as comfort, travel cost, travel time, and frequency of Metro were stated alongside to compare the two alternatives. The travel cost per kilometer, travel time, and frequency have been taken as reference from Delhi Metro Rail Corporation [14].

For the sample size, a confidence level of 90% and a margin of error of ± 8.5% has been considered. Hence, the sample size at each location was determined to be 100 (n= 100). A total of 200 questionnaires survey were conducted (N= 200). The relationship between Commuters' willingness to shift and determining variables like income, distance, modes, origin and destination were cross-tabulated and analyzed using IBM SPSS 26. Field observation of existing infrastructure and services was done to better understand the context from the standpoint of development.

5. Result and Discussion

5.1 Settlement Pattern

5.1.1 New Baneshwor

The study area in New Baneshwor lies in ward no. 10 and 31 of Kathmandu Metropolitan City with an average density of 26,813.08 people per sq.km of land [15]. New Baneshwor is one of the central hubs which is densely populated and saturated. Moreover, it is mainly dominated by commercials, institutions, and mixed uses in the center while residential and hostels lie in its periphery as illustrated in *Figure* 2. Thus, this makes it a center of attraction for various trips such as work trips, educational trips, shopping trips, and leisure trips. The amalgamation of numerous land use makes this neighborhood interesting. However, very few changes have been observed in the built-up area over the last decade which could be mostly due to the saturation of developable land to build upon.

Figure 2: Building Use Type within 500m of New Baneshwor

5.1.2 Radhe Radhe

The study area in Radhe Radhe lies in Ward no. 4,5,6 and 9 of Madhyapur Thimi municipality, Ward no. 5 of Suryabinayak municipality, and Ward no.1 of Bhaktapur with an average density of these wards of 5,500.14 people per sq.km. of land [16]. The Hanumante river flows across from the northeast to the southwest direction in the study area. It is a newly developing settlement on the periphery of the city which is less densely populated. With a hierarchy of

commercial, mixed-use, and residential buildings developed along the road hierarchy, Radhe Radhe is a freshly emerging area. Residential buildings predominate in this area thus being the main source of trip productions. Although the northern side of the Araniko Highway has seen a boom in commerce, its southern side has mostly agricultural land and residential with few mixed usages as illustrated in *Figure* 3. Over the last decade, this area has experienced rapid growth in the built-up area, largely as a result of the availability of agricultural and vacant lands on the outskirts of the city that are being developed into new residential and mixed-use structures.

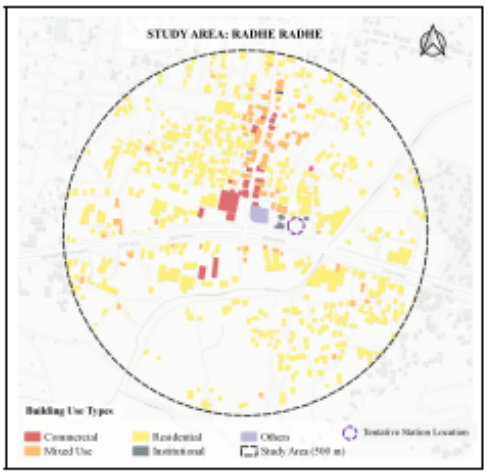

Figure 3: Building Use Type within 500m of Radhe Radhe

5.2 Socio-Demographic Background

The survey was carried out during the month of June and July of 2022. The survey responses were collected from employees and business people, who commuted to or resided in New Baneshwor and Radhe Radhe. Among those respondents, 56.5% were male and the remaining 43.5% were female. 97.5% of all the respondents belonged to the age group of 20 to 50 years. Also, 52.5%, 26%, and 16% of the respondents have completed their bachelor's degree, higher secondary education, and master's degree respectively; while the rest 8.5% only had school-level education. Likewise, 53% of the respondent were private employees, 41% were business persons and 6% were government employees. Of the respondents, 14.5% earned low income (less than NRs.20,000 per month), 69.5% earned medium income (NRs.20,000 to NRs.60,000 per month), and the remaining 16% were found to be in high income (NRs.60,001 per month and above) category.

5.3 Travel Behavior

In terms of travel behavior, 79.5% of respondents used private transport (bike, scooter, or car) to commute to work, 15.5% used public transport, 4% commuted through walk/cycle, and the remaining 1% used ride-sharing as their primary mode of transport.

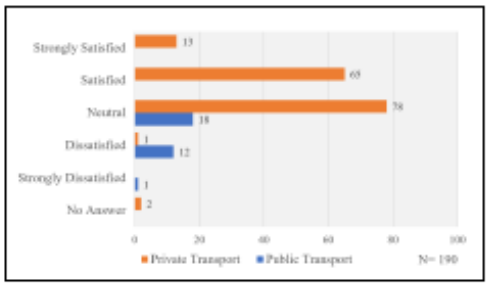

Figure 4: Comfort level of Current Mode of Transportation

As *Figure* 4 illustrates, among the public and private vehicle users (N= 190), 78 out of 159 private users were satisfied with their current mode of transportation and the other half were neutral about it. On the other hand, 18 out of 31 public transportation users were neutral in satisfaction with their travel mode and the remaining 13 were dissatisfied to some degree. The majority of the respondents were traveling distances of 2-5 Km. About three-forth of the respondents in New Baneshwor and more than half of the respondents in Radhe Radhe indicated that it was their point of destination and origin respectively.

5.4 Willingness to Shift

Overall, it was found that 68% of the respondent are willing to shift to metro while 32% of the respondent are not willing to shift. 136 respondents opted for Alternative 2 which was the metro while 64 opted for Alternative 1 which was their current means of transport.

Despite the settlement pattern of the two-study area being very different as presented in *Figure* 2 and *Figure* 3, the responses were indifferent to spatial patterns. Overall, New Baneshwor had 70% and

Radhe Radhe had 66% willingness to shift. While those not willing to shift were mainly because they were not willing to walk to and from the station, and the comparative travel cost and travel time were almost similar to their current travel pattern. It could also be as they belonged to a low-income group, living nearby and commuting by walking/cycling.

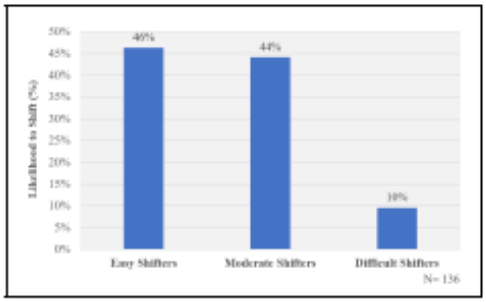

Figure 5: Respondent by Likelihood to Shift

Moreover, those who were willing to shift had various degrees of likeliness to shift. Those willing to shift 100%, 75% to 50%, and 25% are classified as easy shifters, moderate shifters, and difficult shifters respectively. Likewise, out of those willing to shift (N= 136), 46% were easy shifters, 44% were moderate shifters and 10% were difficult shifters as shown in *Figure* 5.

Willingness to shift was analyzed with different indicators relating to individuals' present status that was collected through the SP questionnaire survey among the total respondents (N= 200). These include– (i) income group; (ii) current mode of transportation; (iii) trip distance; and (iv) origin and destination.

5.4.1 Income Group

A significant percentage of 81.3% of the high-income group were willing to shift, followed by 67.6% of the medium-income group and only 55.2% of the low-income group was willing to shift. It was interesting to find out that 44.8% of the low-income group people were not willing to shift, it was mainly because they were living in rented spaces nearby within 2 km distance from their work location.

The majority of high-income and middle-income groups (81.3% and 67.6% respectively) were willing to shift, which could be because of unsustainable soaring fuel prices, the high price of electric vehicles, the traffic chaos during peak hours, and unmanaged public transport services. The additional time and energy required to reach the station from the origin and from station to destination could have been one of the reasons for those not willing to shift. The convenience of private vehicles and the location of current bus stops at a closer distance from the commuters' origin/destination of the trip in comparison to the location of the proposed metro station could be another reason for the unwillingness among the public to shift to metro.

5.4.2 Current Mode of Transportation

As *Figure* 6 illustrates, 100% of ride-sharing users, 87.1% using public transport, 66% of private transport users, and only 25% walking/cycling were willing to shift. The relationship between the current mode of transport and willingness to shift was found to be significant ($p < 0.05$).

100% of those commuting to work by ride-sharing were willing to shift as it would be cost-effective for them. 75% of those commuting to work by walking or cycling were not willing to shift, it could be because they were commuting short walkable distances and belonged to low-income groups living nearby. 87.1% of those commuting to work by public transport were willing to shift, it could be because they were traveling medium to long distances and the alternative of metro was fulfilling the need for reliable and efficient public transportation. Two-thirds of private transport users were willing to shift as it was time and cost-effective and had the advantage of not having to ride or drive by themselves.

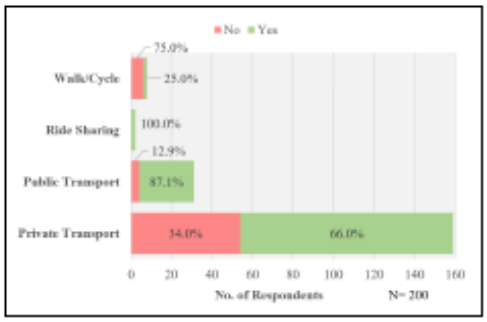

Figure 6: Willingness to Shift by Current Mode of Transportation

5.4.3 Trip Distance

The trip distance (one way) was divided into 3 categories as short distances up to 2 km, medium

distances ranging from 2 to 10 km, and long distances more than 10 km. It was found that 22.5% of the respondents traveling short distances, 79.7% traveling medium distances, and 73.3% traveling long distances were willing to shift as presented in *Figure* 7. In addition, the relation between trip distance and willingness to shift was found to be significant ($p < 0.05$). The majority of those commuting medium to long distances were willing to shift as it would be beneficial for them in terms of cost, time, and comfort. While more than three-fourths of those commuting short distances up to 2 km were not willing to shift as they were living nearby and for them, it would take more time and cost to reach the station.

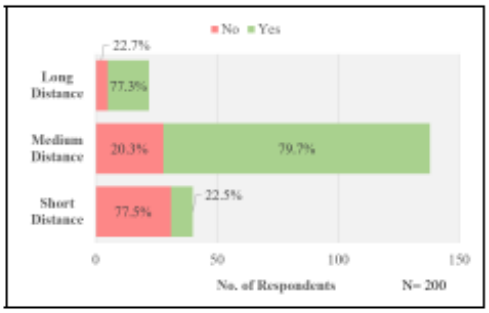

Figure 7: Willingness to Shift by Trip Distance

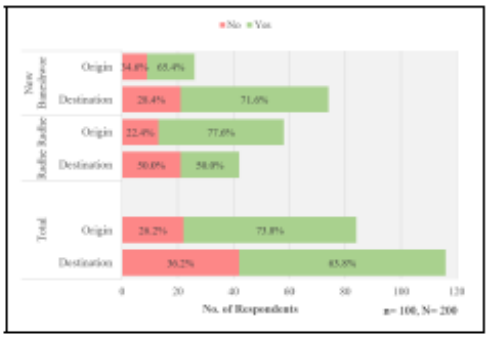

Figure 8: Willingness to Shift by Origin and Destination

5.4.4 Origin and Destination

Of all the respondents (N= 200), the study areas were a point of origin for 42% and a point of destination for 58%. Of those, 73.8% of individuals who had the study area as their point of origin and 63.8% of those who had it as their point of destination was willing to shift as illustrated in *Figure* 8. About two-thirds of trips originating and ending in New Baneshwor (n= 100) were willing to shift. On the other hand, three-fourths of trips originating and only half of the trips ending in Radhe Radhe (n= 100) were willing to shift. This could be a result of Radhe Radhe being a location of trip production as opposed to the case of New Baneshwor being a location of the trip attraction.

5.5 Level of Influence

As *Figure* 9 illustrates, of all the factors such as (i) comfort; (ii) lower price; (iii) safety/security; (iv) accessibility/connectivity; (v) reduced travel time; (vi) reliable timetable; and (vii) on-board service– reduced travel time had the most important influence while on-board services had the least influence for those willing to shift (N= 136),

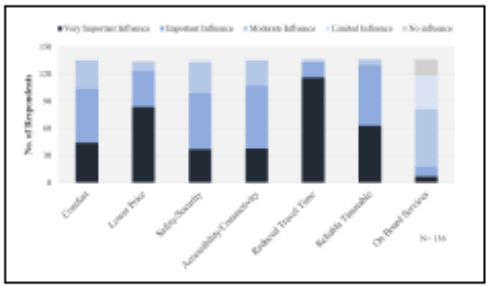

Figure 9: Factors Influencing the shift to Metro

6. Conclusion

Low occupancy and unregulated services of the public vehicles have contributed to the increased numbers of private vehicles on the roads hence adding to the traffic volume. For a long-term vision of economics, efficiency, energy, and the environment, a comprehensive mass transportation strategy is essential. A good public transportation system encourages pedestrian-friendly cities and transit-oriented development while reducing fuel consumption, reliance on private vehicles, traffic congestion, and pollution; thus, significantly contributing to the upliftment of the quality of life for the inhabitants. In the context of Kathmandu, the Metro could be one of the optimum MRT systems since it can serve both the current and future transit needs of the city's residents.

The results from this study suggest that the trip distance is directly related to the willingness to shift. People who commuted medium to long distances

were significantly willing to shift as compared to those commuting short distances. A significant proportion of low-income groups were not willing to shift as they were living nearby within a short travel distance or were commuting on foot or on a cycle. On the other hand, the majority of the high-income and middle-income groups were willing to shift, which could be due to the factors such as unmanaged public transportation, increasing fuel prices, traffic congestion, and air pollution among others. Moreover, a majority of public and private vehicle users were willing to shift which implies that people are in anticipation of a new reliable, and efficient public mass transit system with improved infrastructure. People's willingness to shift to an alternative reflects the city's need for mass transit. The most crucial factor that encouraged the commuters to shift to the metro was the reduced travel time.

This research would provide insights to stakeholders and decision-makers about the potential users' attitudes toward the metro and the factors that would facilitate the shift to the metro. The field observation and public perspective helped to understand the context and its ground realities. Studies as such should be done to help make policies toward a better city for the inhabitants. Additionally, planned densification around metro stations and integration with current transportation modes and regulations are necessary for a successful transit system. The findings from this study will be useful for the decision-makers, practitioners, policymakers, urban planners, transport planners, and scholars among others to access new information, which might assist them in better comprehending potential users' viewpoints and permit new decisions to match their expectations regarding the new service. In addition, this research would add to new knowledge and can be used as a reference for future work by organizations and institutes working on urban mobility, MRTs, and land use.

Further Studies. The study was limited to two station locations on the Kathmandu Line of the proposed Metro system. Various station locations of other proposed routes can be studied. There is potential for more research on an integrated study of land use and mass transit system. The use of financial incentives to encourage public transportation may also be a worthwhile area of research.

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