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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

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].

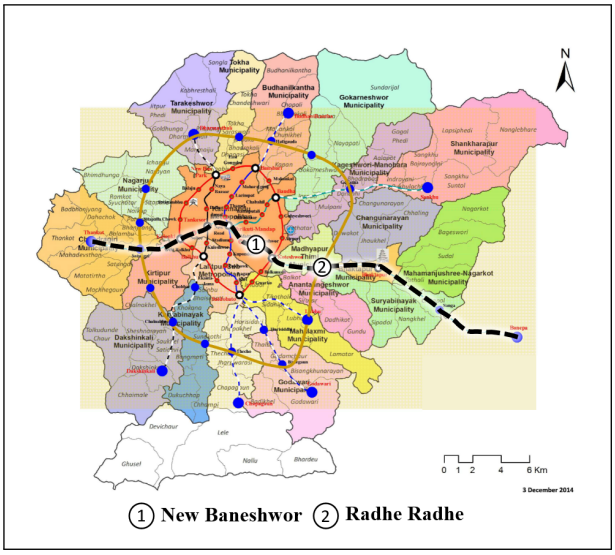

Figure 1: Proposed Metro Routes and Study Areas [6]

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 studies only 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 referred from 'Kathmandu Metro Rail Vision 2040'.

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. This research is based on a pragmatic paradigm. Moreover, purposive sampling was employed for the data collection which was conducted through questionnaire surveys.

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 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.

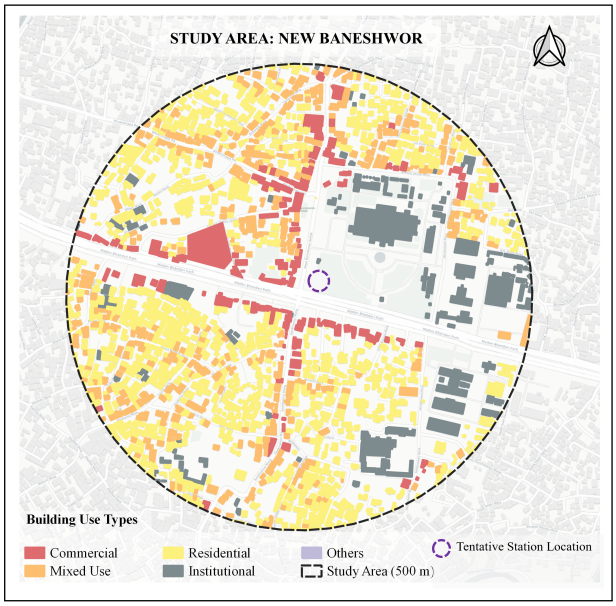

Figure 2: Building Use Type within 500m of New Baneshwor

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.

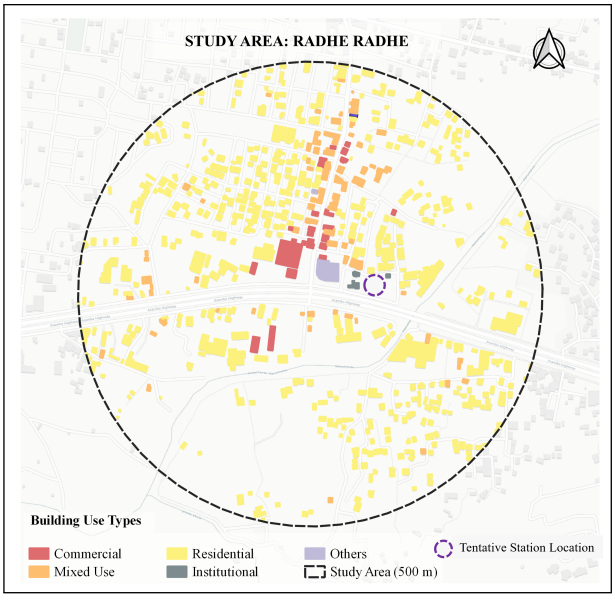

Figure 3: Building Use Type within 500m of Radhe Radhe

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.

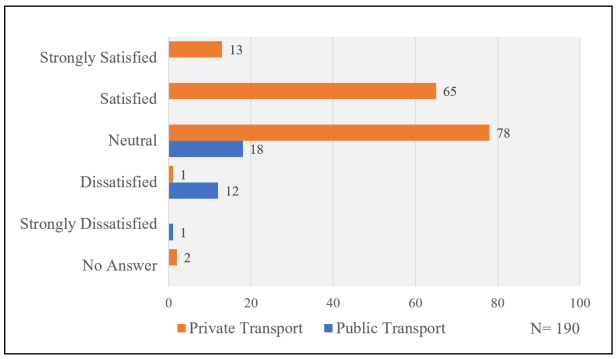

Figure 4: Comfort level of Current Mode of Transportation

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.

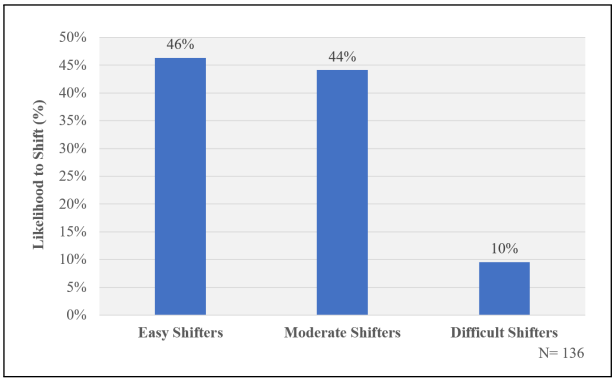

Figure 5: Respondent by Likelihood to Shift

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.

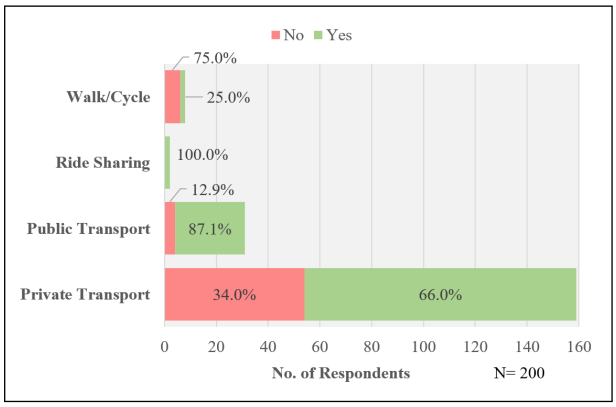

Figure 6: Willingness to Shift by Current Mode of Transportation

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.

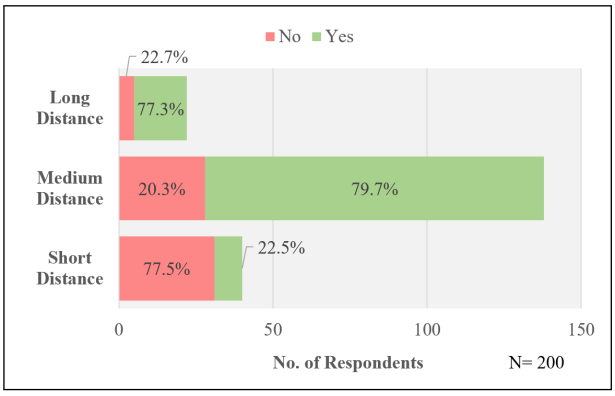

Figure 7: Willingness to Shift by Trip Distance

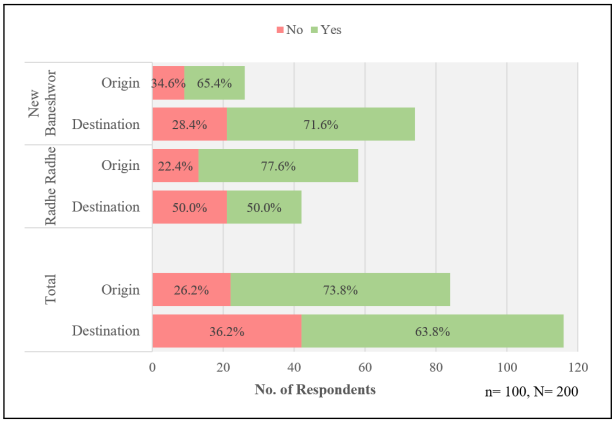

Figure 8: Willingness to Shift by Origin and Destination

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),

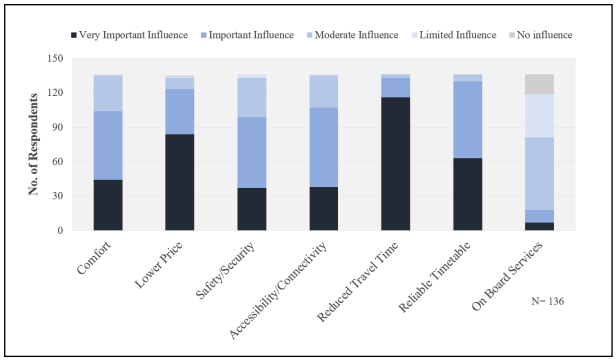

Figure 9: Factors Influencing the shift to Metro

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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