A COMPARATIVE PUBLIC TRANSIT ACCESSIBILITY AND EQUITY ASSESSMENT FOR PUBLIC BUS AND MRT: A CASE STUDY OF DHAKA, BANGLADESH

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Word count: 4,617 words text + 10 tables/figures × 250 words (each) = 7117 words

Submission Date: **November 18, 2018**

ABSTRACT

The changing wave of national transportation policies, shifting its course from ensuring mobility towards accessibility, has been quite a new phenomenon in developing countries. The National Integrated Multimodal Transport Policy (NIMTP) 2013, not only focuses on providing accessibility through integrated sustainable transportation modes but also emphasizes on transit equity when a transportation investment decision is made. Down this line, the government of Bangladesh has undertaken the development of Mass Rapid Transit (MRT) to curb the city's transportation issues, among so many, namely traffic congestion. The study intended to assess accessibility and equity across TAZs using a multimodal network dataset. The study mainly focused to evaluate how the proposed MRT would impact accessibility and transit equity to the prevailing context created by the public bus network. Working population across the TAZs were classified into low - income and high-income groups based on their association in low-skilled job industry and high-skilled job industry. The population of these groups were considered as demand, and the accessibility scores were compared against them to analyze how the introduction of MRT would influence equity. Accessibility estimates were made for 30 minutes, 45 minutes and 60 minutes interval. Development of Lorenz curve and Gini index revealed that the introduction of MRT is less likely to contribute to improve inequity between these groups even though accessibility is likely to increase significantly within groups. These result would contribute to help understand the gap between the formulated national level policy and the extent of execution from the context of a developing country.

Keywords: Public transit, Accessibility, Equity, Employment opportunity.

INTRODUCTION

The aim of any integrated transport policy is to improve the travel mode choice that helps people to achieve opportunities that are not available at the trip origin. Accessibility measures provide an indicator as to what extent this aim is being met [1]. Accessibility measures have been gaining momentum as an indicator of public transit performance and affordable housing. This allows for a more balanced approach to transportation analysis than traditional measures such as mobility-based measures of performance [2]. Litman described this phenomenon as a paradigm shift compared to the traditional way of identifying and evaluating transportation problems and investment decision making [3]. While mobility-based planning favors automobile-oriented development, accessibility-based planning considers improvement to alternative modes by offering more choices for the captive riders [4].

Transportation plans in Dhaka, the capital city of Bangladesh, has been mostly focusing on mobility-oriented solutions until the last decade where traffic congestion is causing a yearly loss of 3.2 billion working hour equivalent to billions of dollars' worth of economy [5]. Although the national policies of Bangladesh highlighted ensuring accessibility, little has been done to implement them. Strategic Transport Plan (STP) considered accessibility as one of the primary goals and objective assessments [6]. National Integrated Multimodal Transport Policy (NIMTP) included accessibility as its prime objective [7]. This policy set increasing accessibility across all walks of lives as one of the investment criterions as well.

A major share of longer distance home – to – work trips in Dhaka city are performed using public transport [8]. In this context, the Dhaka Mass Rapid Transit (MRT) project was proposed in the STP in 2010 and revised in 2015 [9]. MRT, as defined by the STP, consists of both the Bus Rapid Transit (BRT) and the Metro rail. The project seeks to modernize the city's mass transit mode. However, the change in accessibility brought about by the project is yet to be evaluated with closer insights. The primary purpose of transportation is to enable people to reach their valued destinations such as employment opportunities and provide accessibility. So, the study focused on how the proposed MRT would change transit equity given the prevailing transit inequity created by the public bus network.

LITERATURE REVIEW

Ingram stated that the term accessibility is not well defined till now [10]. Even though the discussion was done in many literatures, a common definition for accessibility is hard to find [11]. Hansen first defined accessibility as a measure of overcoming spatial separation to some distributed activities [12]. In recent times, accessibility is referred to as the ease of reaching valuable destinations within a given travel time [13] [14]. Valuable destinations can be employment opportunities which are income generating activities [15]. Total employment can also be used as a measure of attractiveness of an area [16]. Distance, travel time or monetary units can be considered as cost to reach the destinations [17] [18].

Geurs & Eck identified three perspectives to measure accessibility – infrastructure-based, activity-based and utility-based measures [19]. Activity-based measures include potential-accessibility measure. Potential measures estimate the accessibility of opportunities in zone i to all other zones under diminishing influences [20]. This measure is also known as the Hansen

measure and has widely been used for analyzing accessibility to different destinations such as jobs [21, 40]. This study used potential-accessibility measures to estimate and assess the variation of accessibility to employment opportunities. One of the advantages of this measure is that it works for assessing accessibility where data is scarce [20].

Studies show that employment accessibility varies with location and most job inaccessible areas are usually located at the periphery of a city or region [2]. It was also found in the same study that centrally located areas tend to have highest job accessibility in a city. Levinson found that accessibility was associated with economic productivity and property values [13].

Accessibility to jobs or other interests is instrumental to the development of sustainable transport and sustainable urban development [22]. Sustainable urban development emphasizes the importance of accessibility for economic development, environmental objectives and equitable access. Transit's inaccessibility can deter development to low-income people [23,41]. Early transportation equity focused on welfare and profit maximization without considering disproportionality for different classes and groups [24]. In developing countries, focus has turned towards how public transport can bridge the gap between welfare recipients and job locations in various forms since the last decade. Equity has been a major concern for providing public transport and demands for legislative attention in many countries [25].

DATA AND METHODS

Dhaka City was divided into 92 TAZs by Dhaka Transport Coordination Authority (DTCA). These TAZs were used as the origins and destinations for network analysis.

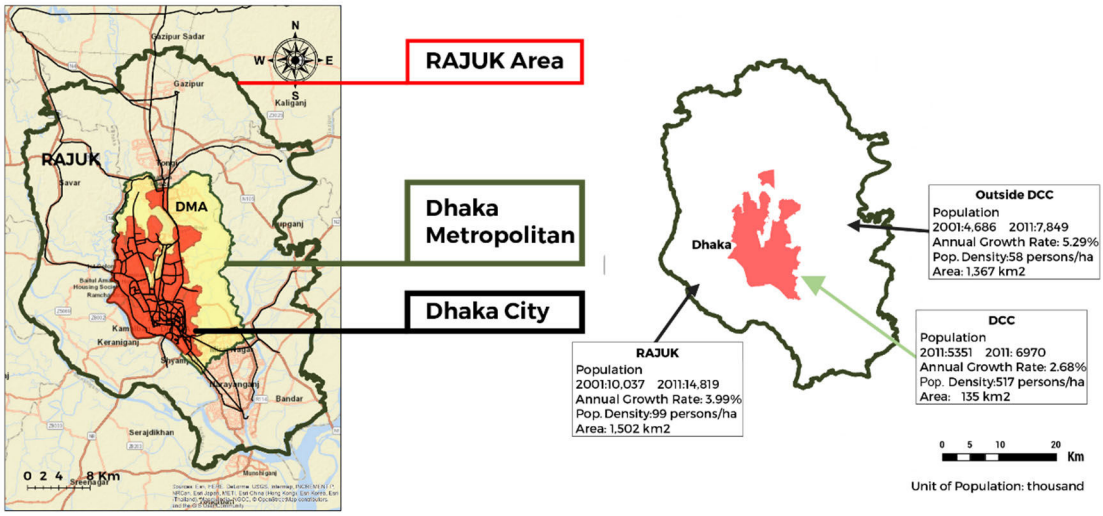
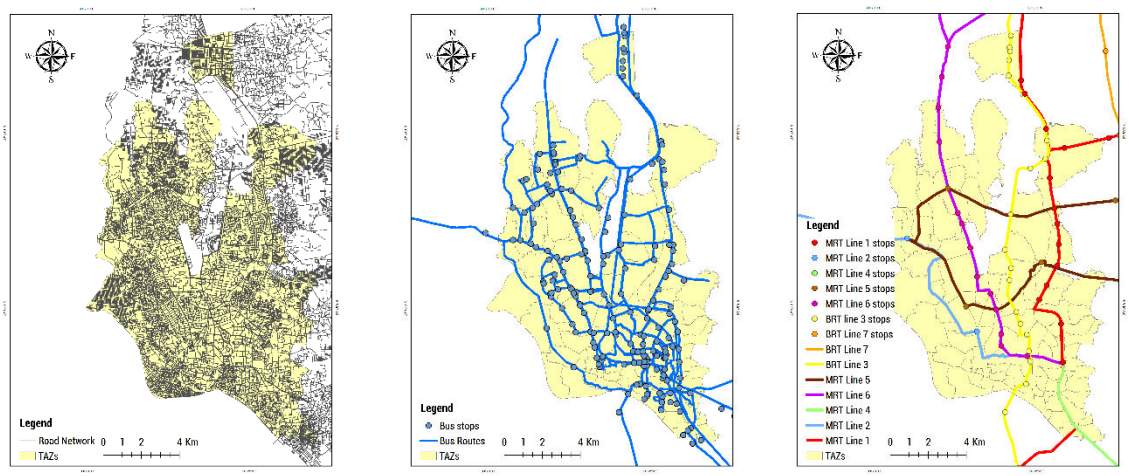


Figure 1: Study area (Source: Dhaka Transport Coordination Authority (DTCA), 2015)

For this purpose, the centroids of the TAZs were chosen to represent the spatial unit [26] [27] [28] [29] [30]. According to a study, an area of 58 sq. km. or less can be represented with its centroid [31]. The average area of the TAZs is 1.46 sq. km. So, it can be assumed that the centroid of the TAZs would be an acceptable disaggregation of the entire study area.

Network Analyst tool of ArcGIS was used to simulate the traffic flow of the city and identifying the reachable destinations from each TAZ. For network analysis tool to work, complete road network including the bus routes and proposed MRT routes were developed. OpenStreetMap for Dhaka was used as the road network [32]. Bus and proposed MRT routes were collected from the DTCA [33]. There are 226 bus routes totaling in 194.87 km. The proposed MRT project has seven lines consisting of five Metro Rail lines and two Bus Rapid Transit (BRT) lines as shown in Figure 2.



(a) (b) (c)

Figure 2: Routes of the study (Source: OpenStreeMap, DTCA)

The bus stops and MRT stations were used as transfer points for switching between transport modes. It was assumed that rickshaws, a local non-motorized three wheeler, would work as feeder service to avail the prevailing public bus and proposed MRTs. Since travel Time was chosen as the deterrence function, speed of the modes was needed to calculate this variable. After extensive field survey and cross-checked with available references, the speeds were chosen as follows: seven km/h for bus ([5], 30 km/h for metro rail [34], 23 km/h for BRT [35] and six km/h for rickshaws [33]. Waiting time for bus and rickshaws were considered as 15 minutes [33] and 4 minutes [36] respectively. In case of Metro rail and BRT, average waiting times were estimated 3.5mins [34] and 3mins [35] respectively.

Using this multimodal network, an O-D Matrix was generated with the help of Network Analyst Tool. This matrix identifies the reachable destinations from each TAZ. Like many other developing countries, data availability is a big concern and always stands on the way of research work. Therefore, Total Persons Engaged (TPE) across TAZs was used as a proxy variable for job opportunity available assuming no vacancy exists. This data was collected from Economic Census, 2013 prepared by the Bangladesh Bureau of Statistics (BBS).

Employment Accessibility for each TAZ was calculated using the following formula:

$A_i = \sum_{j=1}^{n} \frac{O_j}{T_{ij}}$ [37]

Where A_i = Accessibility measure of TAZ i to potential opportunities in TAZ j

O_j = Number of jobs accessible from TAZ i in TAZ j

T_{ij} = Travel time on public transport between TAZ i and j

Working population across the TAZs were classified into low - income and high-income groups based on their association in low-skilled job industry and high-skilled job industry. Economic census of Bangladesh confirms18 industry sectors prevailing in Dhaka. They were divided into low - skilled jobs and middle or high skilled jobs. Low skilled jobs include "Manufacturing", "Construction", "Whole sale and retail", "Repair of motor vehicles and motorcycles", and "Transportation and storage" [23]. High skilled jobs are comprised of "Mining and quarrying", "Electricity, gas, steam and air conditioning supply", "Water supply, waste management, sewerage and remediation activities", "Hotel and restaurant", "Information and communication", "Financial and insurance activities", "Real estate activities", "Professional, scientific and technical activities", "Administration and support service activities", "Public administration and defense, compulsory social security", "Education", "Human health and social work activities", "Art, entertainment and recreation" and "Other service activities" [23]. To measure equity, the Gini index was measured using an approximation formula which is:

$\boldsymbol{G_1 = 1 - \Sigma_1^n (X_k - X_{k-1})(Y_k + Y_{k-1})}$ [25]

Where $\boldsymbol{G_1}$ = Gini Index

$\boldsymbol{X_k}$ = Cumulated proportion of the population variable for k = 0, …., n with $\boldsymbol{X_0} = 0$ and $\boldsymbol{X_n} = 1$

$\boldsymbol{Y_k}$ = Cumulated proportion of the accessibility variable for k = 0, …., n with $Y_0 = 0$ and $Y_{\boldsymbol{n}} = 1$

RESULTS AND DISCUSSIONS

Figure 3 depicts that TAZ 1 experiences the lowest employment accessibility score among all the TAZs. Location of this particular TAZ has been identified as the reason behind this. Being isolated on the northern part of the city has caused this TAZ to have the lowest accessibility score. Figure 3 also offers that accessibility scores of 30 and 45 minutes interval for public bus and 30 minutes interval for proposed MRT are found to be affected by outliers.

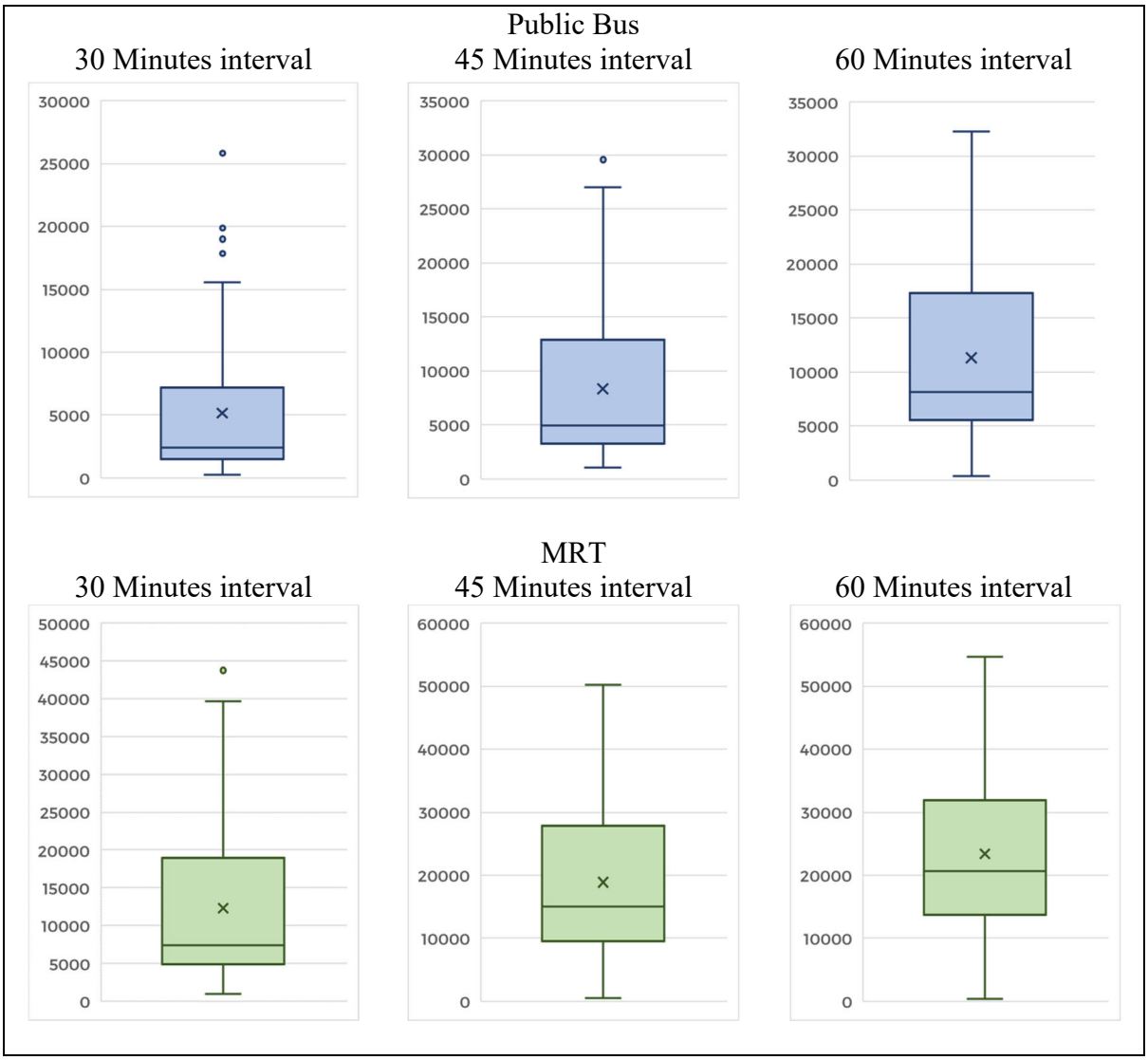


Figure 3: Distribution of accessibility score for 30, 45 and 60 minutes interval for Public Bus and MRT (Source: Author)

This initial observation shows that proposed MRT is likely to provide better accessibility with greater time interval and brings up the areas with poor accessibility to a better off status. However, the shift is not proportional, the better off areas are even more benefitted by the proposed MRT project. When the accessibility scores are mapped with respect to the TAZs of Dhaka city (Figure 4, Figure 5, Figure 6), the highest employment accessibility appeared not in the city's spatial center, rather a little towards Southern part of the city (Figure 6). This is because the southern part of Dhaka was the historical core of the city and earlier commercial regions are located there including Motijheel, the most dominant CBD of the city (RAJUK, 2016). For the same time interval, MRT is likely to provide better accessibility, and some of the peripheral TAZs are likely to reach up to moderate accessibility. An estimated 52% of the TAZs shifts above the mean accessibility level in 30 minutes interval time when MRT is introduced.

A significant spread effect can be seen for 45 minutes interval for proposed MRT (Figure 5). Public bus accessibility does not increase significantly, while most of TAZs including peripheral

areas are likely to acquire considerable accessibility up to moderate level due to MRT. When travel time is increased to 60 minutes, proposed MRT is likely to provide better accessibility to the peripheral areas in the north (Figure 6). More areas are covered in the higher accessibility regions. Even areas which did not have an accessibility score for MRT in 30 minutes interval is now able to reach valuable jobs. An estimated 88% of the TAZs would shift above the mean accessibility level for switching to MRT from public bus. Compared to current public bus routes, proposed MRT is more likely to significantly increase accessibility ($p < 0.05$).

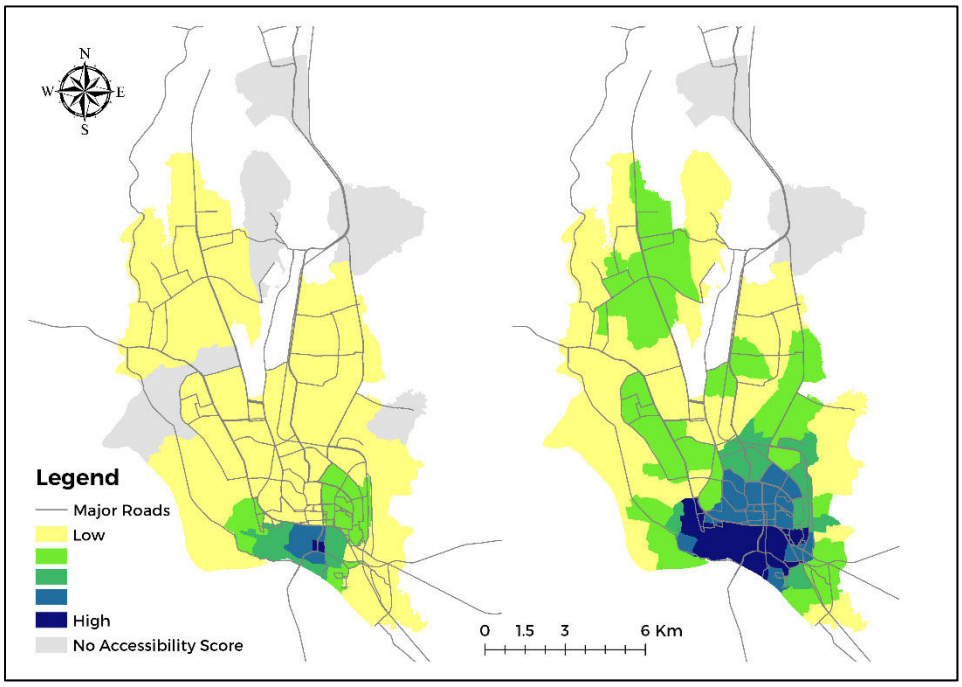


Figure 4: Map of accessibility scores of the TAZs for 30 minutes interval (Left: Bus; Right: MRT) (Source: Author)

For the same travel times, proposed MRT provides better accessibility than public bus. Accessibility measured for proposed MRT under 45 minutes travel time demonstrates a better accessibility than the public bus could offer in 60 minutes travel time. Proposed MRT thus provides similar or better accessibility than public bus saving 15 minutes travel time. Accessibility, likely to be offered by proposed MRT and measured for 30 minutes time interval, makes it possible to reach around the same no. of jobs as compared to public bus for 60 minutes travel time.

The changing color patterns reveal that improvement in accessibility scores are not uniform. The accessibility scores improve in the north-south direction much faster than in the East-West direction. As seen in Figure 2, most of the bus and proposed MRT routes in Dhaka are aligned in the north-south direction resulting in a likelihood for the TAZs near them to improve their accessibility faster. The eastern and western TAZs did not improve as much as compared to the northern TAZs. These TAZs are highly reliant on local and collector road system to get access to the arterial roads before they could avail the facility.

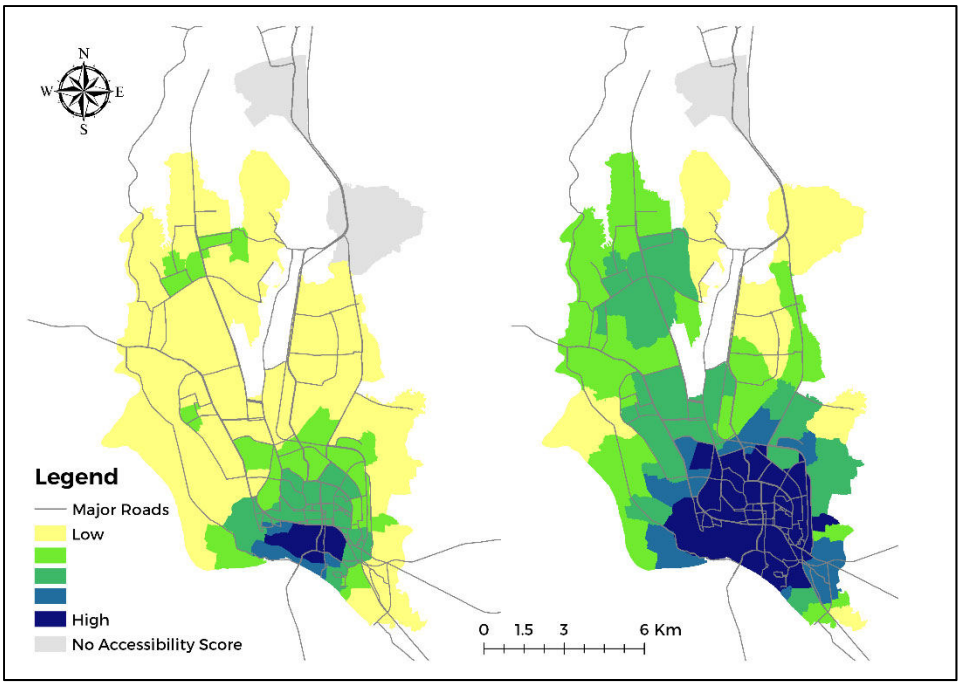


Figure 5: Map of accessibility scores of the TAZs for 45 minutes interval (Left: Bus; Right: MRT) (Source: Author)

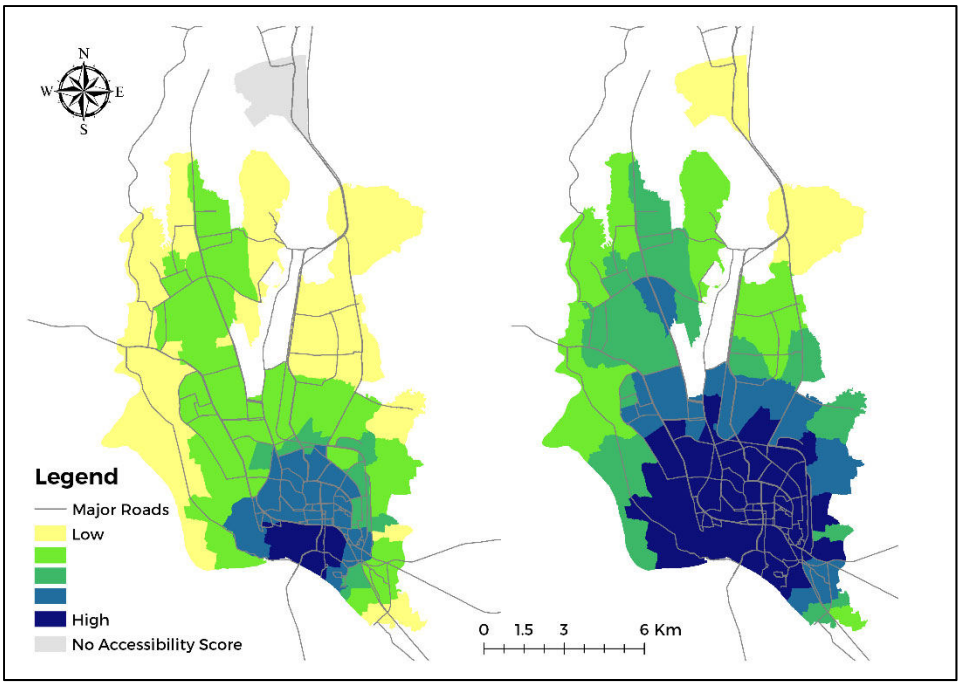


Figure 6: Map of accessibility scores of the TAZs for 60 minutes interval (Left: Bus; Right: MRT) (Source: Author)

SECTORAL COMPARISON

It has been recognized that proposed MRT indeed improves public transit accessibility, adding to the current public bus transit system but the distribution of the benefit across various groups calls for the transit equity concern. Working population across the TAZs were classified into low - income and high-income groups based on their association in low-skilled job industry and high-skilled job industry. Based on these two categories, analysis was conducted to identify whether the introduction of proposed MRT decreases the disparity between the two groups or does it favor one over the other. For this aspect, accessibility maps were prepared for both these groups (Figure 7, Figure 8 and Figure 9).

Comparing before and after scenarios from the figures, it is evident that introduction of the proposed MRT benefits both the low and medium or high-income class jobs. Such as in Figure 7, before introducing MRT, both low and medium or high-income jobs have low accessibility scores. Only a handful of TAZs were in high accessibility zone with medium or high-income jobs having a more spread in moderate accessibility level. This situation is likely improves for both the groups when the proposed MRT would be realized. Medium or high-income jobs get benefitted more in terms of accessibility while a lot of TAZs get improved for low income jobs but still lagging behind medium or high-income class. Accessibility measured for 45 minutes and 60 minutes travel time offer similar findings as well (Figure 8 and Figure 9 respectively). With increasing travel time interval public transit accessibility is likely to be improved for low skilled sectors. However, the growth is likely to be lagging behind compared to that of medium or high skilled sector. For low skilled sector, a much greater number of TAZs have now moved up from low accessibility zones for 45 minutes travel time. Medium or high skilled sectors display that for 45 minutes travel time, most of the TAZs now have moderate to high accessibility with only a handful suffering from low accessibility.

Under 60 minutes travel time, it is observed that most of the TAZs are likely to experience higher accessibility for medium or high skilled jobs while for low skilled jobs, with a striking improvement in accessibility as compared to bus only situation, the improvement is still not as satisfying compared to the accessibility benefits likely to be enjoyed by the high-skilled jobs (Figure 9). The medium or high skilled sector has moved from the majority being in the low accessibility zones using bus for 30 minutes travel time to the majority being in the high accessibility zones using proposed MRT for 60 minutes travel time. Since proposed MRT increases accessibility, it has comparatively higher impact on high-skilled jobs shedding a sense of disparity between the groups.

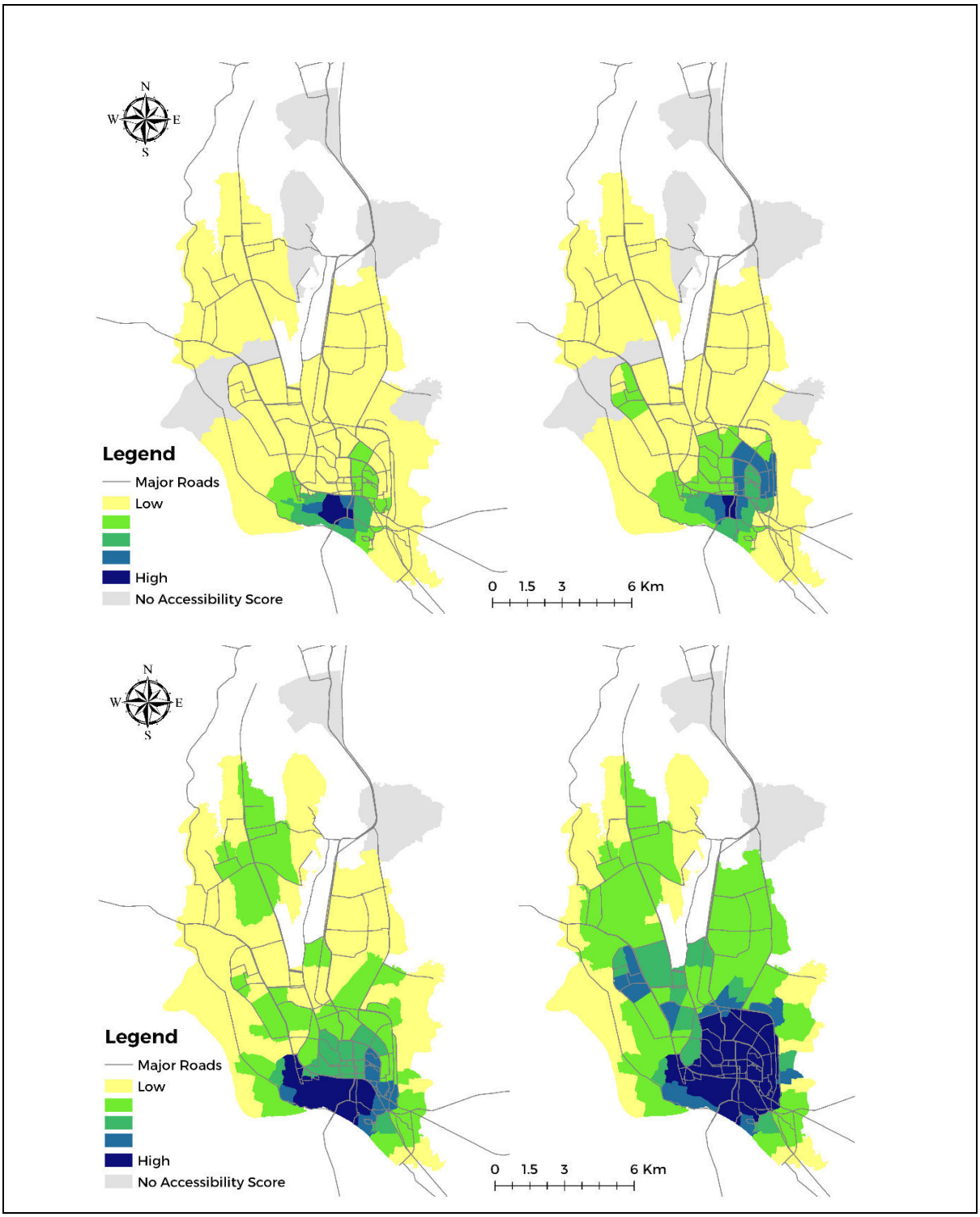


Figure 5: Accessibility of low and medium or high-income jobs before and after MRT for 30 minutes travel time (Source: Author)

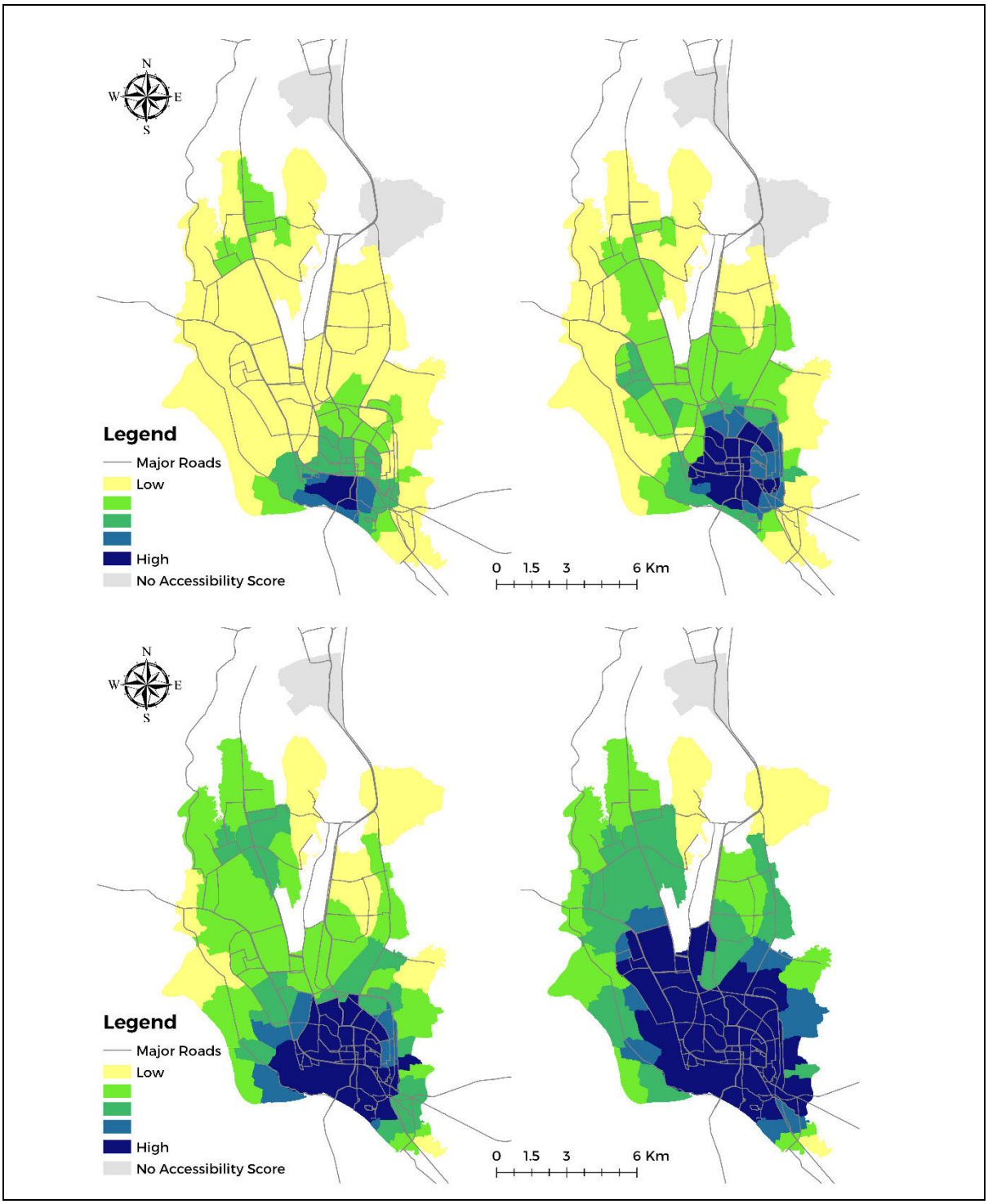


Figure 6: Accessibility of low and medium or high-income jobs before and after MRT for 45 minutes travel time (Source: Author)

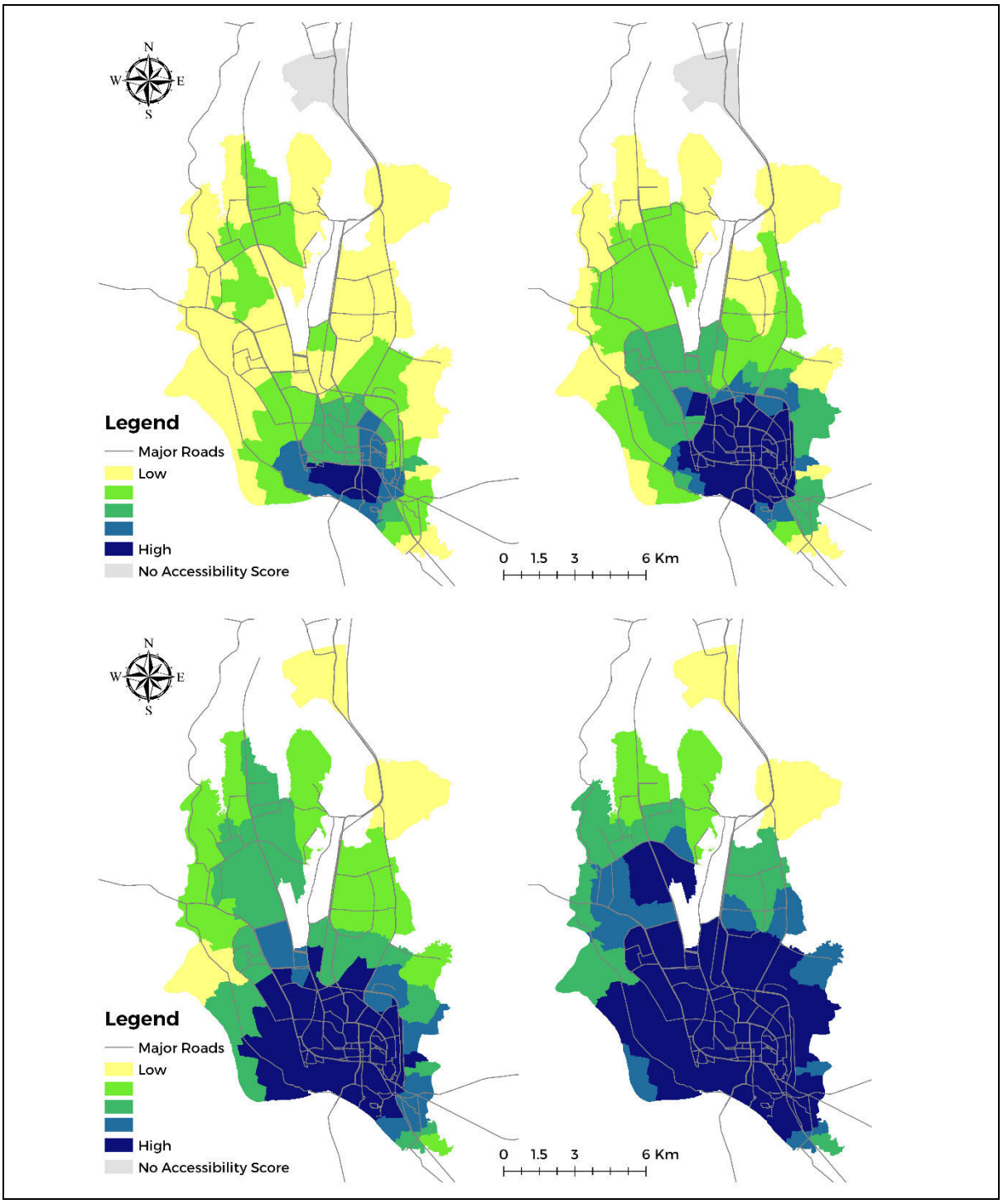


Figure 7: Accessibility of low and medium or high-income jobs before and after MRT for 60 minutes travel time (Source: Author)

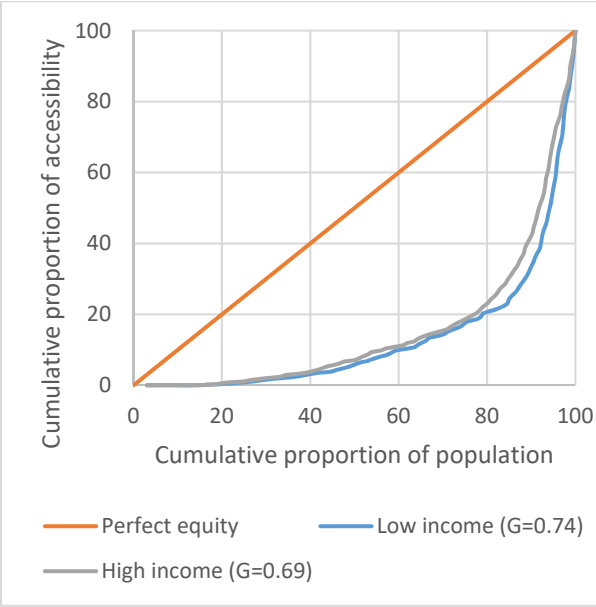
If only one of the sectors is considered and the progress is cheked, then it reveals how the situation improves for the sector with travel time. In case of medium or high skilled sector, it reveals that the accessibility likely to take place due to the introduction of the proposed MRT for 30 minutes travel time is almost comparable to that of provided by the bus with a travel time of 60 minutes. Proposed MRT could reduce travel time required for by almost half for medium or high skilled jobs. At 45 minutes travel time, proposed MRT could provide a rather high accessibility to almost half of the TAZs in Dhaka, and at 60 minutes travel time, almost all of the work force engaged in high-skilled jobs would enjoy high accessibility.

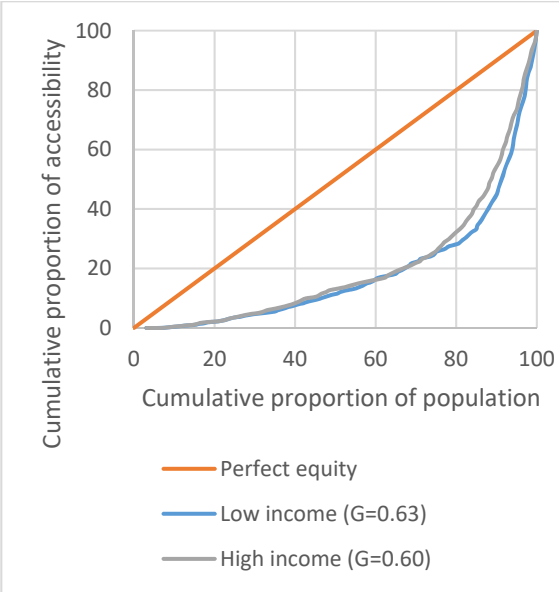
For the low skilled sector, similar pattern is realized when accessibility is likely to be offered by the proposed MRT within 30 minutes travel time is comparable to that of accessibility provided by the bus service to this sector in 60 minutes travel time. However, unlike middle or high skilled sector, for 45 minutes travel time the accessibility increase does not encompass the majority of the areas. For 60 minutes travel time, the situation improves even more and now almost half of the workforce engaged in this sector in Dhaka is likely to experience better accessibility.

IMPACT ON EQUITY

Lorenz curve and Gini indices were produced for all the scenarios in order to assess the change brought by the introduction of MRT.

30 minutes travel time





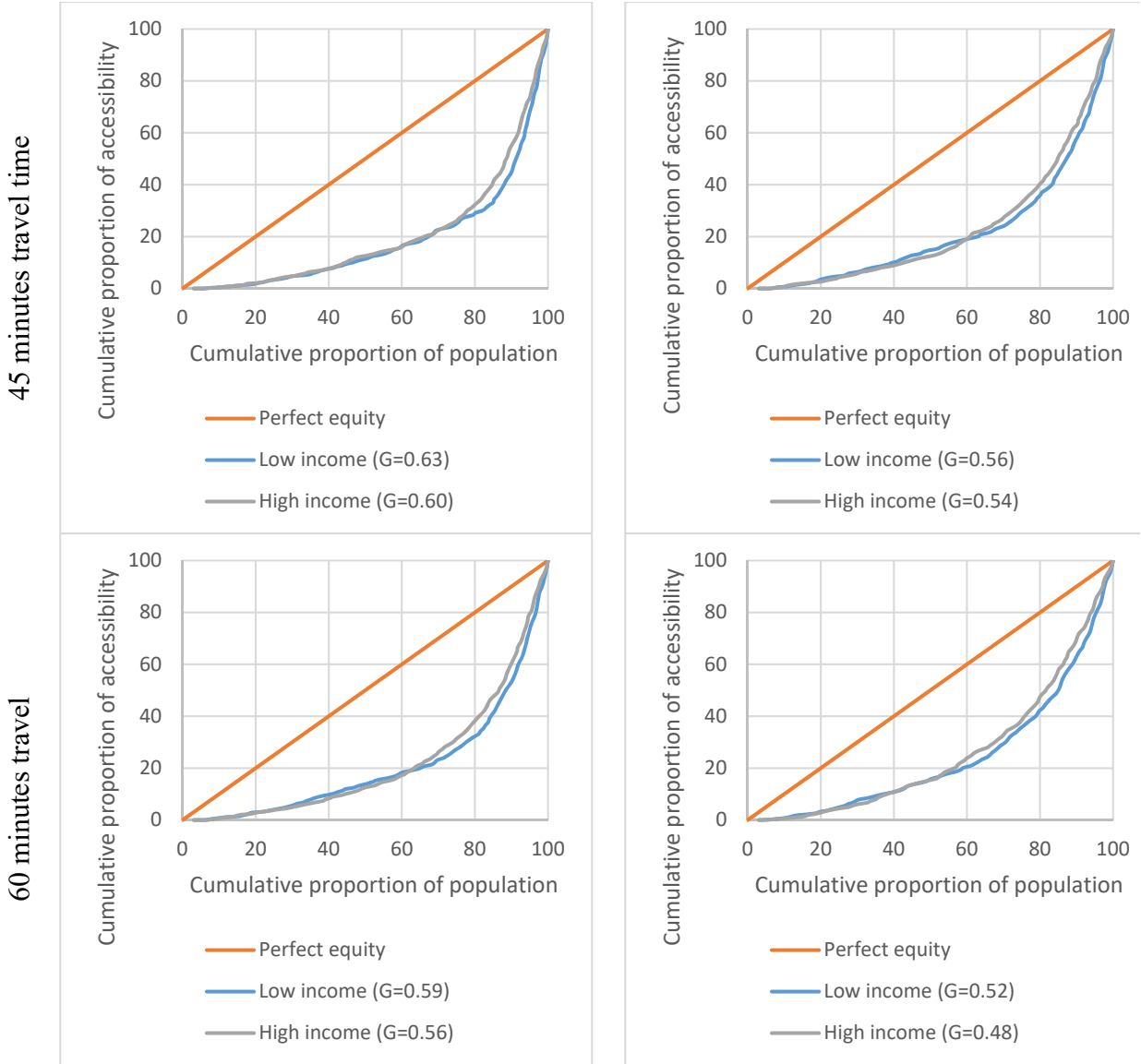


Figure 8: Lorenz Curve for before and after introduction of MRT (Source: Author)

For 30 minutes travel time, medium or high - skilled jobs have more equitable access as the index value for low income in present situation is 0.74 and high income is 0.69. Both of these values get decreased when MRT is introduced, and reduce to 0.63 and 0.60 respectively. For 45 minutes travel time, the gini index under public bus context, for low skilled jobs is 0.63 and for high-skilled is 0.60. The index scores get lowered down to 0.56 and 0.54 for low-skilled jobs and high-skilled jobs when MRT would start rolling. For 60 minutes travel time, the gini indices appear to be .59 and 0.56 for low- skilled and high-skilled jobs which lowered down to 0.52 and 0.48 respectively, when MRT would start operating.

The results showed a decrease in Gini coefficient within group at the cost of keeping the indices relatively constant between groups when compared under different travel time scenarios and shift in mode.

MAJOR FINDINGS AND CONCLUSION

The study concludes that with the addition of MRT, the accessibility of the TAZs in the study area would likely to improve significantly. The TAZs around the southern part of Dhaka enjoy the highest level of accessibility. Although the accessibility spreads outwards from the area with increasing travel times but it is not uniform. The areas around the routes benefit most due to their proximity to the service provided. Since most of the routes of Dhaka are North-South oriented, the improvement follows this pattern. The development primarily spreads in this direction and then spreads in the East-West direction following the secondary roads.

Following the overall development, the sectoral analysis reveals that although both the high and low-skilled jobs show the same growth pattern as the overall study area, their growth rate varies. For accessibility measured under same travel time, high-skilled jobs show better accessibility for most of the TAZs than low-skilled jobs.

In case of equity, it was observed that the pattern of improvement follows the accessibility growth. With increasing travel time, accessibility gets increased for both public bus and proposed MRT, after switching from bus to MRT, their scores are likely to improve even further. Therefore, the study suggests that inclusion of MRT could be accounted for improvement of overall accessibility within various groups of people as opposed to lessening public transit inequity prevailing the current condition as observed from Lorenz curve and Gini indices. Although the National Integrated Multimodal Transport Policy 2013 stated that projects would be undertaken towards ensuring equity for all but the results obtained in this study assume a mismatch between documented policy and likely reality.

ACKNOWLEDGEMENT

The work was supported by the logistics and resources of the Simulation lab at the Department of Urban and Regional Planning, Bangladesh University and Engineering and Technology (BUET).

AUTHORS CONTRIBUTION STATEMENT

The authors confirm contribution to the paper as follows: study conception and design: Anindya Kishore Debnath, Md. Muntasir Bin Hossain, Atif Ibne Zoha Sreezon; data collection: Atif Ibne Zoha Sreezon, Md. Muntasir Bin Hossain; analysis and interpretation: Atif Ibne Zoha Sreezon, Md. Muntasir Bin Hossain; draft manuscript preparation: Anindya Kishore Debnath, Md. Muntasir Bin Hossain, Atif Ibne Zoha Sreezon. All authors reviewed the results and approved the final version of the manuscript.

REFERENCE

1. D. Halden, D. McGuigan, A. Nisbet and A. McKinnon, "Accessibility Review of Measuring Techniques and Their Application," The Scottish Executive Central Research Unit, 2000.
2. R. Cervero, T. Rood and B. Appleyard, "Job Accessibility as a Performance Indicator: An Analysis of Trends and Their Social Policy Implications in the San Francisco Bay Area," University of California, Berkeley, 1995.
3. T. Litman, "The New Transportation Planning Paradigm," ITE Journal, vol. 83, pp. 20-28, June 2013.
4. VTPI, "Online TDM Encyclopedia," Victoria Transport Policy Institute, 2006.
5. Y. L. Julia Bird, H. Z. Rahman, M. Rama and A. J. Venables, "Toward Great Dhaka: A New Urban Development Paradigm Eastward," World Bank, Dhaka, 2018.
6. D. "Strategic Transport Plan for Dhaka: Urban Transport Policy," Government of Bangladesh, Dhaka, 2005.
7. M. o. C. "National Integrated Multimodal Transport Policy 2013," Ministry of Communication, 2013.
8. D. "Dhaka Urban Transport Network Development Project: Environmental Impact Assessment," 2011.
9. T. L. B. G. I. and B. C. L. "The Strategic Transport Plan for Dhaka," GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH, Dhaka, 2010.
10. D. R. Ingram, The concept of accessibility: A search for an operational form, vol. 5, 1971, pp. 101-107.
11. C. Bhat, S. Handy, K. Kockelman, H. Mahmassani, Q. Chen and L. Weston, "Development of An Urban Accessibility Index: Literature Review," Texas Department of Transportation, Texas, 2000.
12. W. G. Hansen, "How Accessibility Shapes Land Use," Journal of the American Institute of Planners, vol. 25, no. 2, pp. 73-76, 1959.
13. D. M. Levinson, "Access Across America," 2013.
14. A. Guthrie, Y. Fan and K. V. Das, "Accessibility Scenario Analysis of A Hypothetical, Future Transit Network: Social Equity Implications of A Gtfs-based, Sketch Planning Tool," Transportation Research Board, 2016.
15. M. J. Breheny, "The measurement of spatial opportunity in strategic planning," Regional Studies, vol. 12, no. 4, pp. 463-479, 1978.
16. M. Dalvi and K. Martin, "The measurement of accessibility: Some preliminary results," 1976.
17. T. V. Mathew and K. V. K. Rao, Introduction to Transportation Engineering, Mumbai: NPTEL, 2007.
18. A. Cerdá, "Accessibility: a performance measure for land-use and transportation planning in the Montréal Metropolitan Region," School of Urban Planning, 2009.
19. K. T. Geurs and J. R. R. v. Eck, "Evaluation of accessibility impacts of land-use scenarios: the implications of job competition, land-use, and infrastructure developments for the Netherlands," Environment and Planning B: Planning and Design, vol. 30, pp. 69-87, 2003.
20. K. Geurs and J. R. v. Eck, "Accessibility Measures: Review and Applications," 2001.
21. B. J. Linneker and N. A. Spence, "An Accessibility Analysis of the Impact of the M25 London Orbital Motorway on Britain," Regional Studies, vol. 26, no. 1, pp. 31-47, 1992.

22. A. C. Ford, S. L. Barr, R. J. Dawson and P. James, "Transport Accessibility Analysis Using GIS: Assessing Sustainable Transport in London," ISPRS International Journal of Geo-Information, pp. 124-149, 2015.
23. X. Chen and A. Ni'Mary, "Examining the Transit Accessibility and Poverty Issues from New Perspectives in Richmond, Virginia," Transportation Research Records, 2016.
24. T. F. Welch and S. Mishra, "A Measure of Equity for Public Transit Connectivity," Journal of Transport Geography, vol. 33, pp. 29-41, December 2013.
25. A. Delbosc and G. Currie, "Using Lorenz curves to assess public transport equity," Journal of Transport Geography, vol. 19, no. 6, pp. 1252-1259, 2011.
26. M. Kordi, C. Kaiser and A. S. Fotheringham, "A possible solution for the centroid-to-centroid and intra-zonal trip length problems," 2012.
27. Z. Qiana and H. M. Zhanga, "On Centroid Connectors in Static Traffic Assignment: their effects on flow patterns and how to optimize their selections," 2012.
28. S. Putman, Urban residential location models, 1979.
29. F. D. Hobbs, Traffic Planning and Engineering: Pergamon International Library of Science, 1974.
30. D. J.-P. Rodrigue, "THE GEOGRAPHY OF TRANSPORT SYSTEMS," 2017. [Online]. Available: https://people.hofstra.edu/geotrans/eng/methods/sirep.html. [Accessed November 2017].
31. J. Morales, J. Flacke, J. Morales and J. Zevenbergen, "Mapping Urban Accessibility in Data Scarce Contexts Using Space Syntax and Location-Based Methods," Applied spatial analysis and policy, 2017.
32. O. F. "OpenStreetMap," 6 April 2017. [Online]. Available: http://wiki.osmfoundation.org/wiki/Main_Page. [Accessed November 2017].
33. DTCA, "Revised Strategic Transport Plan," Government of Bangladesh, Dhaka, 2016.
34. DMTC, "About MRT Line - 6," 2017. [Online]. Available: http://www.dmtc.org.bd/about/about-mrt-line-6. [Accessed May 2017].
35. DTCA, "About BRT," 2017. [Online]. Available: http://www.dtca.gov.bd/en/brt/. [Accessed May 2017].
36. S. M. Labib, Z. Rahaman and M. S. H. Patwary, "Comprehensive evaluation of urban public Non-Motorized Transportation Facility services in Dhaka," in Proceedings of The 8th MAC 2016, 2016.
37. D. Paolo, A. Matas and J. L. Raymond, "Job Accessibility, Employment and Job-Education Mismatch in the Metropolitan Area of Barcelona," 2014.
38. RAJUK, "Dhaka Structure Plan 2016 - 2035," Rajdhani Unnayan Kartripakkha, Dhaka, 2016.
39. RAJUK, "Dhaka Structure Plan 2016-2035," RAJUK, Dhaka, 2015.
40. A. Karner, D. Niemeier, "Civil rights guide and equity analysis methods for regional transportation plans: A critical review of literature and practice." Transport and Geography, 2013.
41. A. Karner, "Development of highly resolved spatial and temporal metrices of public transit accessibility and their application to service equity analysis" Presented at the Annual Meeting of the Transportation Research Board, 2016, Washington D.C., 2016.