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Transforming Urban Environments: Understanding the Social Implications of Metrobus (MBS) Service Development in Lahore, Pakistan

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Abstract: This research investigates how the Lahore Metrobus system (MBS) influences perceptions of urban space quality through the lens of urban design and transport infrastructure. Lahore is undergoing significant urban changes with the introduction of a newly constructed mass transit system, which thus necessitates a joint development strategy to preserve its cultural heritage. Recent evolutions in transport planning has heightened the interest in analyzing the way mobility factors affect the perceptions of a place's quality. The gap in previous work lies in the limited focus on qualitative, human-centered perspectives regarding the impacts of public projects like the MBS on urban space quality. This study uniquely fills this void by examining the influence of the MBS on people's lives and the quality of urban spaces. Comparing pre- and post-Metrobus scenarios, along with questionnaire surveys of riders and shopkeepers, exposes the neglect of the social image during design and construction. The system was implemented with a focus solely on hard, core infrastructure, thereby neglecting soft components such as area development, social and cultural value, and human-centered design. The government should unite transport agencies, stakeholders, and the public to craft a joint policy for enhancing revenue, ridership, and fostering transit-oriented development (TOD). Research findings will help in achieving social and cultural sustainability for upcoming transport lines in Pakistan, as well as directions for other developing nations looking to implement mass transit networks.

Keywords: developing nations; human-centered design; mass transit system; social and cultural sustainability; transport infrastructure; transit-oriented development (TOD)

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1. Introduction

Cities and the built environment are closely intertwined, with the design, layout, and quality of the built environment playing a significant role in shaping the character and functionality of urban areas. The built environment is a product of urbanization, and it is the process of population growth and economic development that leads to the expansion of cities and towns. Today's rapidly urbanizing world is primarily focused on achieving sustainability within cities. According to the United Nations, the global urban population is expected to reach 66% by 2050 [1], which poses substantial challenges to social and environmental sustainability. Furthermore, many studies have linked the uniform and often inequitable forms of contemporary urban spaces to environmental and social problems [2]. Cities consume about 70% of the world's resources and are significant contributors to greenhouse gas emissions [3], with the transport sector being a major source [4]. Therefore, investing in public transport is a sustainable solution to overcome the urban mobility

challenges interlinked with the city. As Clark (1958) [5] argued, transport is the maker and breaker of cities, with its multiple social, economic, and environmental impacts. As one of the essential elements of sustainability, the social aspect is less considered in evaluating transport systems than its economic and environmental aspects [6]. Most public projects are evaluated for their socioeconomic progress, while the link between public transport infrastructure and place quality is rarely the research focus [7].

In developing nations, cities face unique challenges in fully embracing opportunities for sustainable urban development compared to their developed counterparts. These challenges include ordering short-term transport requirements over long-term sustainability goals, dealing with fragmented institutional frameworks, struggling with coordination across sectors, and navigating regulatory constraints. Many Asian cities are investing heavily in mass transit systems, which could lead them toward either transit-oriented or auto-centric traffic-congested urban models. While some cities are gradually introducing mass transit options, reshaping urban forms and fostering collaboration in the transportation sector both remain formidable tasks. Lahore, Pakistan's cultural hub, has taken steps toward sustainability with the initiation of a mass transit system, but effective planning approaches are needed to leverage these services for urban revitalization. Therefore, this research aims to explore how mass transit systems can effectively address modern urban challenges in developing cities by implementing comprehensive sustainable development strategies.

Furthermore, conventional quantitative assessments often overlook subjective evaluations and qualitative investigations of transit projects, despite their significance in shaping sustainable and appealing urban environments. The research underscores the importance of public perceptions in fostering urban attractiveness and sustainability [8]. However, cities in the early stages of public transportation development lack sufficient empirical evidence in this regard. This paper aims to bridge this research gap by examining the impact of transport infrastructure development from a social perspective by focusing on Lahore, Pakistan, a developing country in South Asia. The research findings aim to inform future transit projects in Pakistan and may offer insights applicable to other developing countries, particularly in South Asia. This study establishes the following objectives to attain its primary goals:

- To evaluate the urban transformation of the city after the MBS infrastructure addition.
- To analyze the effects of MBS infrastructure on the human perspective and to explore the project's social image.

The rest of the paper is organized as follows: Section 2 offers a comprehensive literature review, examining the correlation between transport infrastructure and urban form. It emphasizes the social function of urban spaces and the role of transport infrastructure in enhancing the urban experience. Section 3 outlines the methodology, thereby combining qualitative analysis with a quantitative approach to identify the inferable models among MBS users and shopkeepers. Its subsequent part provides a brief history of the case study context and an overview of the MBS. In Section 4, the results from the pre- and post-comparison rider and retailer models are, respectively, presented and discussed. Finally, Sections 5 and 6 accentuate the importance of user perception for creating a sustainable city, the limitations of this research, and some helpful recommendations for current and future projects. The research procedure is illustrated in Figure 1.

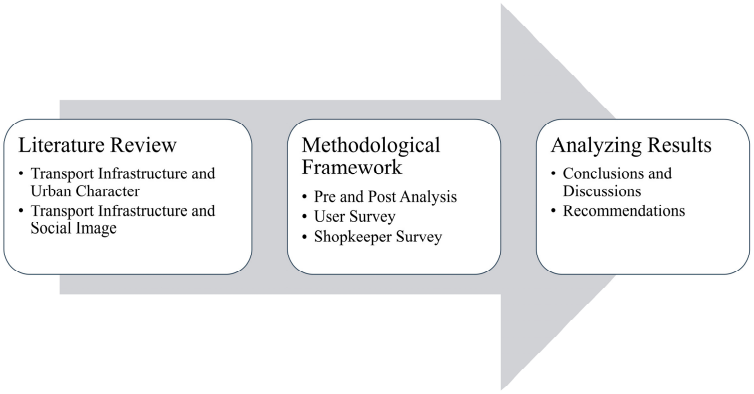


Figure 1. The research procedure.

2. Literature Review

2.1. Transport Infrastructure and Urban Character

The built environment is a multifaceted concept that defines human-made settings for human activities, including buildings, parks, neighborhoods, and infrastructure like water supply, power supply, and transportation systems [9]. It combines places and spaces that are shaped by people, thus providing basic urban design elements.

Transport infrastructure is vital in studying urban form as it divides urban spaces into distinct segments, as well as connects them and facilitates human activities that link social, financial, and environmental aspects with urbanization and population growth [10]. The transportation system and city characteristics are closely connected. Urban regeneration influenced by transportation infrastructure has multiple impacts on the physical form of the city, and it affects the shape and quality of urban life. These impacts occur directly through the addition of transit infrastructure, which alter the area's character, as well as indirectly, i.e., through developments along the corridor.

In recent decades, industrialization and reliance on automobiles have significantly altered the urban built environment, thus promoting a sedentary lifestyle. This has led to urban sprawl, which diminishes connectivity and disrupts the sense of place in cities [2]. Old cities and their surroundings were characterized by the prominent design of public squares, streets, and buildings, which formed the vibrant communal face of the community, contrasting with contemporary urban practices [11–13]. Contemporary urban communities are developed based on modern planning principles, focusing on land use patterns, population density, diversity through separation, and efficient transport and infrastructure links. However, this approach often overlooks the traditional public and cultural roles of city spaces [12–16]. Therefore, strategic planning is crucial for sustainable and coordinated transportation, as well as for integrating diverse travel modes to enhance convenience, promote active travel, and mitigate climate change impacts [17].

2.2. Transport Infrastructure and Place Making

Existing or newly created spaces should be integrated into a cohesive urban environment to promote city integration, enhance sustainability, and meet public needs [18]. The relationship between urban spaces and the people who occupy them is reciprocal, with individuals shaping spaces and being influenced by them simultaneously [19]. In modern urban development, there is a growing focus on investing in sustainable mobility and public transportation. Transit infrastructure is now seen not just as a means of facilitating movement, but also as a catalyst for fostering social interaction [20]. Moreover, there is a growing recognition of transit spaces as integral components of public areas [13]. Transport infrastructure, its components, interconnections, and participant involvement significantly contribute to shaping an appealing living environment. It is crucial to evaluate how transportation hubs can be optimized and to implement effective management practices to enhance their functionality for human interaction and the knowledge economy, and this

can be achieved by incorporating human-centered design principles [21]. In the creation of these vibrant, human-centric spaces, a place-making approach [22] has surfaced as a focused strategy to scrutinize the fundamental aspects of these procedures, which has been achieved by particularly emphasizing community-led initiatives and the creative sector's role [23].

The city's mobility network encompasses various transportation modes, locations, roads, pathways, events, and interactions. Place-making goals are assigned to each place and corridor within the system to fulfill specific objectives. In recent years, investing in mass transit systems has been promoted as a strategy to curb urban sprawl and revitalize modern cities [24,25]. Public transport is instrumental in shaping cities and their broader urban areas, thereby serving as a crucial element in the creation of a place. One major aspiration for applying or extending transport infrastructure is to use it as a spatial planning tool to attain extensive urban development objectives. This is to promote friendly and healthy cities with an improved quality of life [26,27]. According to Olesen and Lassen [28], the dominant relationship between mass transit and city characteristics is twofold: the transit system forms cities, but key city features also shape transport infrastructure. In this regard, the social image is also very important among various influences, as cities are socially built spaces, whereas place making refers to the pursuit of turning a "space" into a "place" by giving meaning to its users [29]. This urban design approach prioritizes people over infrastructure by creating public spaces that are more than just utilitarian, but rather places that inspire and promote social interaction and cultural exchange, as shown in Figure 2. It identifies that public spaces play an essential role in the social and cultural life of communities, and that they are critical to creating a sense of place and identity. Its principles overlap with transit-oriented development, as well as human-centered design, mixed-use development, public participation, and sustainability.

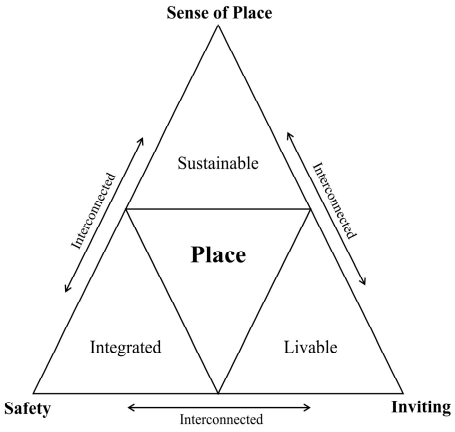


Figure 2. The basic dimensions of a place. Source: https://www.pps.org/, accessed on 22 January 2023.

Therefore, transport infrastructure presents an arbitrator link that opens chances for sustainable social growth [30]. In contrast, failing to consider the social component of infrastructure expansion may have negative consequences for both the scheme and people [31]. Transport infrastructure can be integrated into place-making policies to rejuvenate cities and foster economic, social, and environmental development. Bus and train stations can become focal points for communities, thereby stimulating activity and revitalizing surrounding areas. Social actors, including architects, town planners, and residents, play a crucial role in shaping urban spaces. User experience and satisfaction are key considerations, as they influence the level of improvement and the needs of the community [32]. The quality of place could be firmly connected with the quality of design in the urban built environment. It effectively integrates the processes and outcomes of development,

renewal, and sustainability of places, alongside their design, creating a comprehensive place-shaping approach [33].

2.3. Social and Cultural Sustainability

The social dimension of sustainability (Figure 3) often receives less attention than economic and environmental aspects, leading some public projects to prioritize socioeconomic performance over social considerations [6]. Mulliner et al. [8] argue that the perception of people for the quality of their environment significantly influences sustainable urban development. Urban design, especially in public transit planning, performs a vital role in enhancing inhabitants' subjective well-being. Selecting a transport strategy goes beyond cost-effectiveness; it reflects a lifestyle that can affect various population segments differently. A socially and culturally sustainable transportation system prioritizes equity, inclusivity, and the preservation of cultural heritage. It is a key component in building resilient and vibrant communities for the present and future. Therefore, transit facilities, from bus stations to major train hubs, can serve as focal points, thereby revitalizing communities and contributing to the overall vibrancy of urban areas.

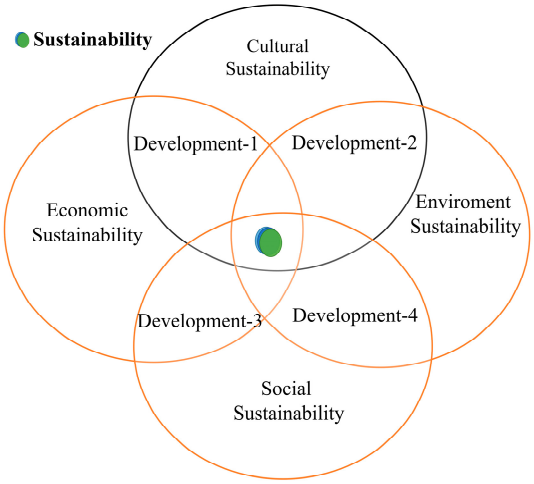


Figure 3. The spheres of sustainability.

Moreover, recent developments in transport planning also highlight the need to analyze how mobility factors influence the perceptions of a place's quality. Therefore, this paper emphasizes the importance of image and quality enhancement within broader urban development goals for city rejuvenation, thereby aiming to elevate a city's status as sustainable, socially equitable, and livable. Table 1 addresses a gap in the literature where public projects are predominantly evaluated for socioeconomic progress using quantitative approaches. It focuses on the qualitative, human-centered perspective after implementing a transit project. Particularly crucial for developing countries, this study provides insights to inform long-term plans for sustainable urban development, thus filling a void often dominated by studies from the developed world.

Table 1. The key findings and limitations of the literature review.

Author/Study	Year	Key Findings	Limitations	Study Area
Bharmoria & Sharma [34]	2024	This study utilizes surveys and the analytic hierarchy process technique to assess the impact of the degraded visual quality on the streetscape by focusing on its implications for social, economic, and environmental factors.	It lacks longitudinal data for tracking changes and does not consider external factors influencing urban aesthetics, such as cultural shifts or economic fluctuations.	Himachal Pradesh, India

Table 1. *Cont.*

Author/Study	Year	Key Findings	Limitations	Study Area
Abdul et al. [35]	2023	The study's findings are based on a literature synthesis	It has limitations regarding the scope of the study and potential challenges in generalizing findings.	Literature Reviews from 1993 to 2021
Diaz et al. [36]	2023	Assess how respondents perceive changes in the transport system and the built environment after implementing the BRT system using a structural equation modeling (SEM) approach.	The focus on low-income neighborhoods may limit insights into income-related impacts. Concurrent social investments or interventions could obscure the specific impact of the BRT, thus complicating the analysis.	Barranquilla, Colombia
Caldera et al. [37]	2022	The study applies a sustainable centers framework consisting of 7 principles and 21 associated design practices to 4 different urban fabric types.	As it is part of an ongoing project, it indicates potential temporal constraints in fully assessing the long-term impacts of the applied framework.	Townsville, Sydney, Melbourne, and Perth, Australia
Adeel et al. [38]	2021	The paper conducts a visual preference experiment, wherein it investigates the variation in nine built environment attributes across certain choice sets. Multinomial logit models are used to discern the preferences of three target groups.	Limited representation of diverse station contexts due to the focus on only four sample stations. Additionally, the stated choice experiments lack consideration of a broader range of identified attributes.	Lahore, Pakistan
Gary and Elsa [18]	2020	The study focused on green infrastructure to enhance value and contribute to the creation of a sense of place in public realm projects.	The idea that is used as the focus of the paper has limitations such as practitioner barriers, maintenance issues, ecological gentrification, and funding challenges.	Glasgow, Scotland
Milena and Suzana [39]	2020	The study highlights the potential of place making in sustainable urban facility management, and it emphasizes stakeholder engagement, ease of involvement, and the role of design professionals.	It has limited coverage and needs further research on the post-intervention for a comprehensive assessment.	Belgrade, Serbia
Raffaello et al. [40]	2019	The research highlights the potential and practical implications of place making in sustainable urban facility management, and it emphasizes the importance of stakeholder involvement and a shared vision for transforming public spaces.	It covers only part of the process related to the creation of an idea for the transformation of public space. Continued research after the intervention is required for a comprehensive understanding of the approach's effects.	Doha, Qatar

3. Methodology and Case Study Context

3.1. Methodology

In Phase I, a qualitative methodology was employed to discern the alterations in the urban fabric of neighboring developments after the implementation of the Lahore MBS. The researchers undertook the main fieldwork in 2022 to observe these changes, utilizing

Google Earth images from 2012 as foundational maps for comparison. The Lahore MBS spans a 27 km route, including an 8 km elevated section and a total of 27 bus stations, 18 of which are at-grade and 9 are elevated. To dissect the alterations in the urban landscape post-implementation of the MBS, 8 stations were meticulously selected based on their distinctive characteristics, thereby serving as pivotal nodes reflecting significant changes. This selection process involved a preliminary field survey, encompassing stations from both elevated and at-grade categories across diverse urban settings. Comprehensive field surveys were conducted at all stations to gauge the extent of the transformation.

Through utilizing Google Earth and the photographs depicting the specific areas from 2012 and 2022, alongside researcher observations, changes were delineated, and differences were graphically illustrated. Given the commencement of the Lahore MBS operations in February 2013, the satellite images from 2012 were established as the baseline reference year.

This study utilized a combination of methods and resources to identify and visually represent the changes, including old and new photographs, aerial views, and an analysis of Google Earth images for the designated areas pre- and post-MBS. The subtask focused on evaluating the design integration with the surrounding aesthetics using on-site photography. Figure 4 illustrates the locations of the selected stations, while their details are compiled in Table 2. The route traverses diverse residential and commercial zones, so the typical land use distribution along the selected stations is shown in Figure 5.

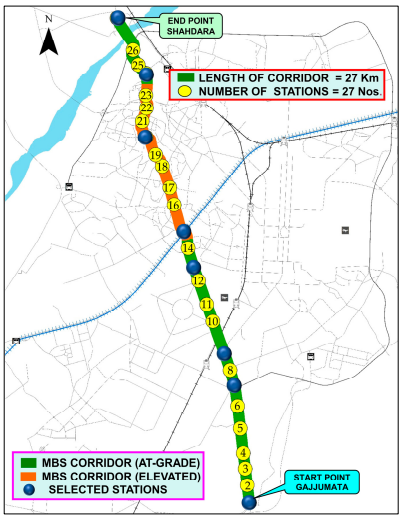


Figure 4. The selected stations along the Greenline route.

Table 2. Characteristics of the sample MBS stations in Lahore.

Station Name	Development Context	Typology	Ridership Passenger/Day	Land Use
Shahdara Station	Terminus	At Grade	10,000–15,000	Residential, commercial, industrial, and green space
Azadi Chowk Station	Inner Core	At Grade	<5000	Commercial, green, residential, and religious buildings
M.A.O College station	Interchange Station	Elevated Station	5000–10,000	Commercial, educational, residential, green space, and institutes
Canal Station	Brownfield Development	Elevated Station	5000–10,000	Institutes, commercial, and residential
Kalma Chowk Station	Urban Redevelopment	At Grade	5000–10,000	Commercial, residential, educational, and green space
Qainchi Station	Urban Redevelopment	At Grade	<5000	Residential, industrial, and commercial,
Chungi Amar Sidhu Station	Urban Infill	At Grade	5000–10,000	Residential and commercial
Gajjumata Station	Greenfield	At Grade	10,000–15,000	Industrial, commercial, and vacant land

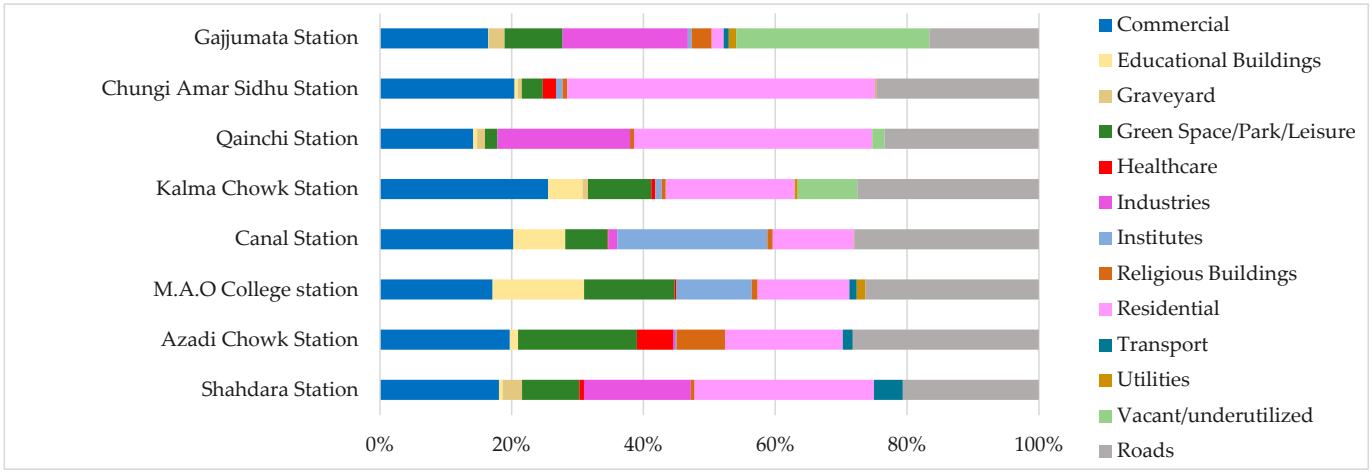


Figure 5. Land use characteristics of the selected stations.

In Phase II, the detailed questionnaire survey that was conducted with MBS passengers and shopkeepers along the bus corridor provided a robust foundation for understanding the travel behavior and social image of the MBS in the context of the city [35]. The researchers' major fieldwork was completed in 2022 through the execution of a detailed questionnaire survey with MBS passengers and shopkeepers along the bus corridor. Moreover, it aimed to identify the difficulties of the people, who were either bus users or shopkeepers, in the immediate surroundings.

The survey was conducted on all days of the week and at random hours (morning, afternoon, or evening hours). Questionnaires were developed separately for bus users and shopkeepers (see Figure A1 in Appendix A.1 and Figure A3 in Appendix B.1), thus taking into account the multi-dimensional nature of the project. Therefore, the questionnaires included impact variables like the satisfaction level of the travelers, the city's image, the modal shift, the air quality, the light quality, happiness, affordability, and increase in business. Some indicators were also added for evaluating the usefulness, quality, and proficiency of the MBS, as shown in Figure 6. The daily average ridership data were set as the population size and were used to calculate the sample size for the data collection. The sample size was calculated using Kohran's formula [41].

$$Sample\ Size = n = \frac{N}{1 + Ne^2} \quad (1)$$

It became evident that achieving a maximum range of perspectives required diverse respondents. Consequently, it was determined that the respondents should represent various age groups, genders, and professions. However, it was noticed that, during the implementation of this approach, the initial surveys revealed that the individuals at MBS stations were often too preoccupied to participate. As a result, the researchers employed convenience sampling by assembling at MBS stations and requesting passing riders to participate voluntarily in the survey. Subsequently, the survey was conducted with those who willingly spared time. However, it is important to mention that the respondents were diverse, reflecting a wide range of backgrounds and perspectives. All 27 stations of the MBS were sampled equally to depict Lahore along with its geographic extent. A total of 400 questionnaires were collected from different user groups at different times. However, limited accessibility to the MBS for elderly individuals, mothers with children, and individuals with physical disabilities due to the absence of escalators at all stations hindered their participation in the survey.

The shopkeeper survey targeted eight selected stations from Phase I as the MBS construction has entailed acquiring various areas to incorporate supporting infrastructure, thus consequently altering the character of those areas. The survey aimed to gauge the

perspectives of shopkeepers regarding this project and to assess how their shops were affected during or after its implementation.

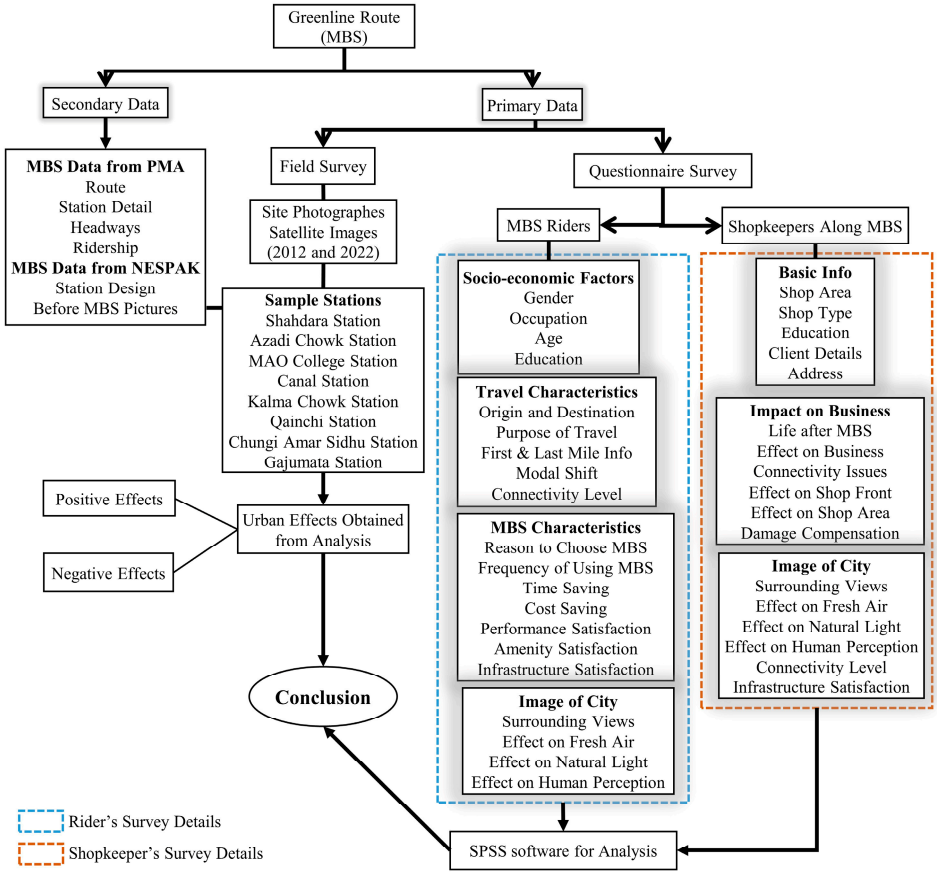


Figure 6. Indicator identification flow diagram.

Due to time constraints, the shops located near MBS stations were selected using the snowball sampling method. Sixty questionnaires were filled out by shopkeepers. To facilitate the respondents, the questionnaires were translated into Urdu, the local language (refer to Figure A2 in Appendix A.2 and Figure A4 in Appendix B.2). Moreover, the utilization of IBM SPSS Statistics 29 for data analysis, coupled with descriptive and cross-comparison statistical approaches, enhanced this study's rigor. This approach ensured the production of consistent and reliable results.

3.2. The Case Study Context

Lahore is the second-largest city in Pakistan with more than 2000 years of history, and it is also known as the "cultural heart of Pakistan". In compliance with the 2017 census, its population has increased to 11,126,285, with a yearly growth rate of 4.07% since 1998 [42]. Lahore was formerly administered by the Mughal Realm, and then under the British Raj as part of the Indian subcontinent. It then became part of the Islamic Republic of Pakistan, which achieved its independence in 1947. Currently, Lahore is composed of a dense walled city in addition to lesser dense urban and peripheral parts to the south and southeast [43]. Several historical buildings, mosques, temples, churches, tombs, and gardens make the city an attractive tourist destination. It is a vibrant metropolitan area with numerous business and trading opportunities, as well as an imminent technology hub.

The city has undergone several transformations due to urban regeneration, heritage conservation, and inflexible infrastructure policies. Previously famous as the "Mughal City of Gardens" [44], Lahore has suffered from urban decay and escalating land prices in recent years. One major project is the Lahore Rapid Mass Transit Rail Project (LRMTRP) [45]

which includes 97 km of rail lines to offer sustainable transport in Lahore. The project was split into two stages: Phase I comprises the Greenline (also known as the Metrobus system (MBS) and has been operational since 10 February 2013) and the Orangeline (operational since October 2020). Phase II includes two proposed lines, as shown in Figure 7: the Blueline and Purpleline. Nevertheless, the problem identified in these infrastructural projects was that they were developed in isolation and gave little respect to the city's character [46]. In consideration of these factors, Anwar et al. [47] also mentioned the dominance of the transport infrastructure in urban form, thus changing the whole character of the city. There was no integrated plan or strategy for these large-ticket infrastructure projects [48]. Therefore, the mobility planning in Lahore must take into account all the integrally connected and richly layered aspects of their collective lives. This aim forms the basis of this research in terms of further evaluating these interventions from social actor perspectives.

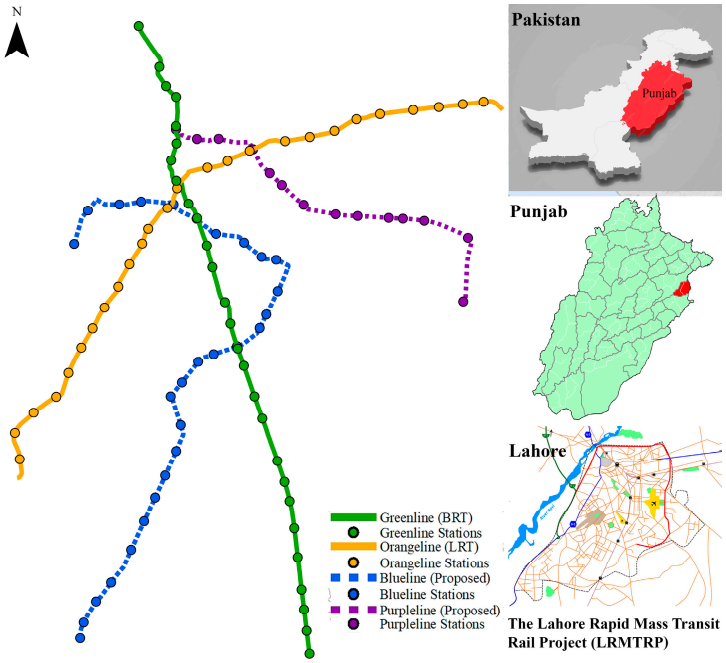


Figure 7. Lahore city with its existing and proposed mass transit lines. Source: PMA.

Lahore Metrobus System (MBS): The Greenline

The Greenline (MBS) is the first mass transit system in Pakistan, and it passes through the heart of the city on a 27 km route north to south. Within this corridor, from Gajjumata to Shahdara, 19 km is at-grade while an 8 km section is elevated. The construction of the Lahore MBS began in March 2012, with bus operations commencing in February 2013. The project's design involved collaboration between local and Turkish experts. The Traffic Engineering and Planning Agency (TEPA), in conjunction with the Lahore Development Authority (LDA), oversaw its construction for 11 million USD/km [49]. The infrastructure was developed under a joint venture between the Government of Punjab (GoP) and the Turkish Government, adhering to the Build-Operate-Transfer (BOT) policy [50].

The MBS line consists of a dedicated fenced lane measuring 10 m in width, and it was planned as a two-lane unified bus lane. It incorporates 27 bus stations, each with dual curb-side platforms, and it integrates nine pedestrian bridges along its trajectory. Some stations offer parking for bicycles and motorcycles, with some also accommodating cars. Every station platform spans 81 m in length and 3.5 m in width, and they feature three bus bays capable of accommodating three articulated buses concurrently. The platforms are accessible via escalators, stairs, pedestrian bridges, or underpasses with turnstiles, thereby ensuring controlled ingresses and egresses. Presently, the MBS runs 64 articulated buses

at 50 km/h (maximum speed), which maintain an average speed of 26 km/h and 2 min headways. Commuters enjoy level boarding via four platform sliding doors (PSDs) at every bus bay. System monitoring and control occur at the Arfa Software Technology Park in Lahore. The signal priority at eight intersections and real-time bus updates are provided by the Intelligent Transportation System (ITS) and the Passenger Information System (PIS), respectively, thus enhancing efficiency and reliability [51].

4. Result Analysis of the Case Study

4.1. Urban Form Analysis

The Lahore MBS traverses over diverse areas, ranging from densely populated to less dense, from low to high levels of affluence, and from smaller to larger plot sizes around the BRT stations. It connects central business districts to peripheral areas. Below is the urban form investigation of the selected areas:

Shahdara Station. The Metro bus commences its route from Shahdara Station, which is situated at the renowned Shahdara Mor—a major entryway to the city of Lahore. One side connects to the ancient Ravi Link, the other to SKP Road, the third allows traffic from various cities, and the fourth serves as an entry point to Lahore city via Ravi Bridge. Traffic congestion arises due to high vehicular volume, thus leading to frequent gridlocks. Figure 8 illustrates the recent developments, including the addition of a terminus station in the middle of the road, as well as bus parking and park-and-ride facilities, and compares them against the pre-MBS scenario. A dedicated path is available from Shahdara Station, but it merges with the mixed traffic that occurs near Ravi Bridge. Shahdara Station also acts as a transfer point for commuters from other cities. Limited drop-off space results in buses stopping near a pedestrian bridge, causing bottlenecks with Qingqi rickshaws (paratransit mode). High daily boarding at Shahdara is attributed to commuters from the outskirts of Lahore traveling to the city for work or education, thus leading to long queues at ticketing booths. The area is still under transformation because construction is underway for a dedicated lane for the MBS and Shahdara flyover to tackle traffic congestion issues.

Before: satellite image 2012. After: satellite image 2022.

Figure 8. Before and after comparison of Shahdara Station.

Azaadi Chowk Station. This is a bustling junction in Lahore, and it is known for its proximity to General Bus Stand, the densely populated walled city area, and iconic landmarks such as the Badshahi Majid and Minar-e-Pakistan. The implementation of the MBS has profoundly transformed the urban character of this area. Figure 9 emphasizes the prevailing prominence of transport infrastructure within the current road space compared to the pre-MBS era. Initially, an at-grade station was established in the median, accompanied by a pedestrian bridge. Subsequently, the pedestrian bridge was dismantled, and an elevated roundabout (signal-free) was introduced to alleviate traffic congestion (see Figure 10). This signal-free facility accommodates commuters traveling from the Railway Station to Niazi Interchange, as well as the traffic from Bhati Chowk heading toward the Railway Station and making U-turns for all of the following three directions: Railway

Station, Bhati Chowk, and Niazi Interchange. Underground passages were constructed to facilitate access to the MBS station. It underscores the necessity of restructuring feeder routes to eliminate overlap and introducing new routes to cover unserved regions. Furthermore, meticulous planning is essential to integrate these informal modes effectively, as well as to leverage transit investments. Their contributions to first- and last-mile connectivity, as well as feeder bus routes, could expand the influence zones of transit stations and facilitate TOD development.

Before: satellite image 2012. After: satellite image 2022.

Figure 9. Before and after comparison of Azaadi Chowk Station.

(**a**) (**b**)

Figure 10. (**a**) At-grade station in February 2013. (**b**) Construction of an elevated roundabout in May 2014.

MAO College Station. This junction is a prominent location in Lahore, connecting major roads such as Lytton Road, Sanda Road, and the old Anarkali Road, and it is close to significant landmarks. A raised station in front of Hailey College is approached via a footbridge, offering a panoramic vista of the surroundings. The elevated station is linked by two roundabouts and a connection for upcoming transit lines. The Orangeline train passes through a junction with underground passages, which has led to the demolition of several shops for construction. Figure 11 depicts satellite images of the area before and after the addition of transport infrastructure, thereby showcasing the changes over time. The area still holds potential for future development opportunities.

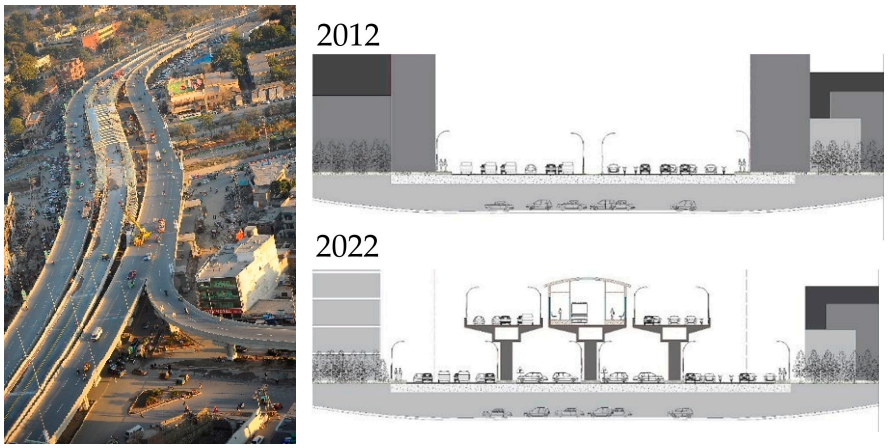
Before: satellite image 2012. After: satellite image 2022.

Figure 11. Before and after comparison of MAO College Station.

Canal Station. The Canal Station area lies along the banks of the Lahore canal and is bordered by the affluent residential neighborhood of Muslim Town. It serves as a significant junction in Lahore, and it is a key entry point of traffic from the M-2 Motorway, Jail Road, and Wahdat Road. Positioned parallel to a flyover, the elevated Metrobus station features a slip lane providing access to Wahdat Road. Utilizing the space beneath the flyover for vehicle parking and landscaping, the station is centrally located amidst educational institutions, scientific research laboratories, the Wahdat Colony, and commercial establishments, making it a vibrant hub. Pedestrian underpasses on either side offer access to the station, with entry points crowded with hawkers and Qingqi rickshaws. Figure 12 exhibits satellite imagery capturing the area both before and after the integration of transport infrastructure, providing a visual representation of the temporal evolution of the form. Following the construction of the MBS corridor, this area became inundated with concrete infrastructure (see Figure 13a). Over the past two decades, street sections near Canal metro station have evolved significantly. Road widening occurred in 2000, followed by the construction of an underpass on the canal road in 2004. In 2013, three overhead bridges were added to the BRT system. The transformation of a road section at Canal Station is depicted in Figure 13b. Despite heavy traffic during peak hours, no bicycle lanes were introduced in the roadway sections, with bicyclists sharing the carriageway with motorized traffic. Overall, the MBS has not given priority to non-motorized transport. However, the presence of the canal road has resulted in proper tree cover along the canal.

Before: satellite image 2012. After: satellite image 2022.

Figure 12. Before and after comparison of Canal Station.



(**a**) (**b**)

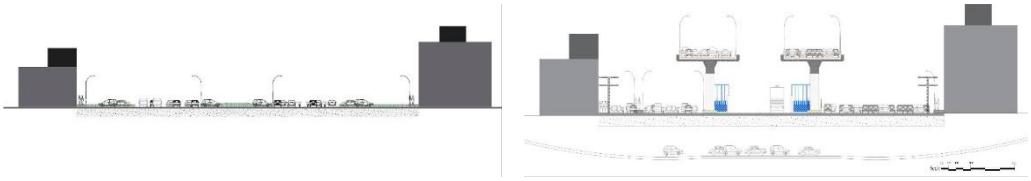
Figure 13. (**a**) The flyover and elevated station dominating the area. (**b**) Transformation of a road section at Canal Station (adapted from [52]).

Kalma Chowk Station. This is a busy junction on Ferozepur Road surrounded by affluent communities, connecting to Qasur and Model Town Society on one side, Qaddafi Stadium on another, and Barkat Market to Gulberg on the third side. It serves as a significant node connecting Liberty Market and Barkat Market—two major markets in Lahore. The urban landscape of Kalma Chowk has undergone significant transformation with changes in road infrastructure and building functions. Figure 14 showcases the newly added infrastructure in the current road section compared to the pre-MBS scenario. To address traffic issues on Ferozepur Road, a flyover was constructed, thereby replacing the iconic Kalma landmark. The Kalma Chowk Station was incorporated beneath the overpass, featuring an underground passage for convenient approach and crossing. The service roads flanking the MBS corridor also serve as parking areas. A vehicular underpass and U-turn were included for the Barkat Market to Gulberg link. Although travel distances have been extended by the presence of flyovers and U-turns, the urban environment has become more structured and free from hassle.

Before: satellite image 2012. After: satellite image 2022.

Figure 14. Before and after comparison of Kalma Chowk Station.

The LDA is responsible for the development control in this area. According to the LDA building bylaws, buildings cannot be constructed directly on the property line, instead requiring owners to provide setbacks in front of their buildings. These setbacks delineate boundaries between public and private spaces. The service roads alongside the MBS corridor also serve as parking areas. The road section of Kalma Chowk before and after MBS construction is depicted in Figure 15. No demolitions were necessary in the Kalma Chowk station area as the right of way (ROW) width was sufficient for construction. The distance between the opposing building lines was 65.5 m, thus accommodating the entire MBS infrastructure [52].



Before: road section 2012. After: road section 2022.

Figure 15. Transformation of a road section at Kalma Chowk Station (adapted from [52]).

Qainchi Station. This station is crucial due to its proximity to the factory area and surrounding residential community. The implementation of transport infrastructure, such as an MBS station, footbridge, and overpasses, has significantly transformed the area. This development necessitated land acquisition, road widening, and the demolition of buildings. Figure 16 illustrates the newly added infrastructure in the current road section of Qainchi Station compared to the pre-MBS scenario.

Before: satellite image 2012. After: satellite image 2022.

Figure 16. Before and after comparison of Qainchi Station.

Chungi Amar Sidhu Station. The Chungi Amar Sidhu station is surrounded by predominately lower-income housing colonies like Gulistan and Sitara Colony. Commercial plots are small, and residents typically live in compact houses. Local streets often serve as playgrounds for children. The Chungi junction has undergone significant improvements, including road widening and the introduction of a roundabout, resulting in a notable reduction in congestion and traffic jam issues. Figure 17 displays the newly added infrastructure in the current road section compared to the pre-MBS scenario, while Figure 18 display the transformation of a road section. An important aspect of the changed urban fabric is the addition of new shops, which were reconstructed following the demolition during the MBS construction. The roundabout, designed for pedestrians and motorcyclists, was constructed in 2014 following the completion of the MBS project to address congestion and traffic problems, thereby resulting in a much-improved situation in one respect. On the other hand, the roadways lack dedicated pedestrian spaces, thus posing challenges for pedestrians. U-turn bridges dominate the landscape, and local shop owners perceive these structures as detrimental to their businesses due to the obstruction of visual accessibility to their shops. Service roads separate commercial activities from the carriageways, serving as parking areas and platforms for informal sellers adjacent to the MBS station. Sidewalks are obstructed by electric poles or encroached upon by shop owners, while service roads are occupied by bikes, rickshaws, and cars. Despite substantial investment by the Punjab government in U-turn bridges and motorized transport infrastructure, a sense of place making is still lacking.

Before: satellite image 2012 After: satellite image 2022

Figure 17. Before and after comparison of Chungi Amar Sidhu Station.

Before: road section 2012 After: road section 2022

Figure 18. Transformation of a road section at Chungi Amar Sidhu Station, where the demolished building space is highlighted in red color (adapted from [52]).

Gajjumata Station. The MBS route concludes at Gajjumata Station. Figure 19 illustrates the addition of a terminus station in the middle of the road, featuring bus parking and park-and-ride facilities compared to the pre-MBS scenario. Following the MBS station construction, the area saw increased industrial and commercial activities, along with densification.

Before: satellite image 2012. After: satellite image 2022.

Figure 19. Before and after Comparison of Gajjumata Station.

4.2. User Survey

To gauge the impact of the MBS on the daily life of travelers, a detailed Commuters Response Survey was conducted, questioning a total of 400 commuters. The analysis and presentation of descriptive statistics for different variables were done graphically, and a Chi-square test was used to assess the relationship between various variables. The analysis of the results is given below.

According to the rider's survey, most respondents were demographically male at 56%, "student" was the most common occupation at 48%, and job holders were represented at 25%. Furthermore, 62% of the user age range were between 15–30 years, while 24% lay between 31–45 years. The major inclination of the respondents was an Inter-level education at 52% (Figure 20). Most metro bus users were youngsters and college or university students, who utilized the service regularly. The frequency of usage was 43% who used the metro bus regularly, 46% off and on (occasionally), and 11% for the first time. The purpose of the trip was education, work, and personal reasons with 39%, 26%, and 35%, respectively. Regarding the acceptance of the project, riders were asked about their reason for choosing the metro ride, where 29% found it speedy, 14% comfortable, 11% selected

it because of a lesser fare, 7% found it a safe mode of travel, 13.5% preferred it due to the availability of a bus after every three minutes, 22.5% of people were in favor of all the qualities mentioned prior, while only 3.3% selected it because of no other choice (Figure 21). Respondents were inquired about the origin and destination station for their trip. Canal and Shahdara stations were prominent for origin stations, with 14.3% and 14%, respectively. For destination points, MAO College, Bhaati, and Shahdara stations were prominent with 9.3%, 10.8%, and 18%, respectively (Figure 22).

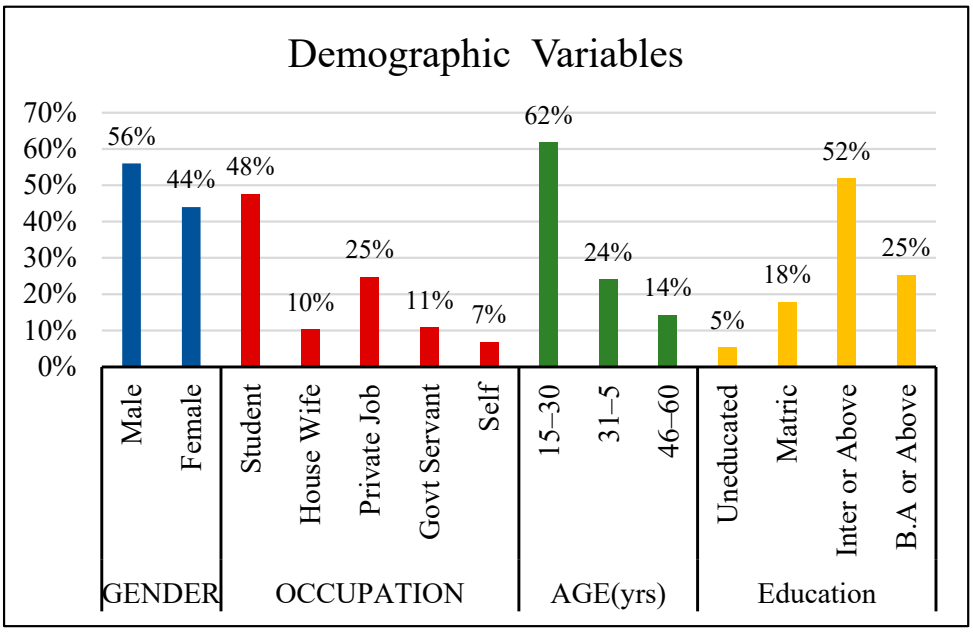


Figure 20. Demographic details from the survey results.

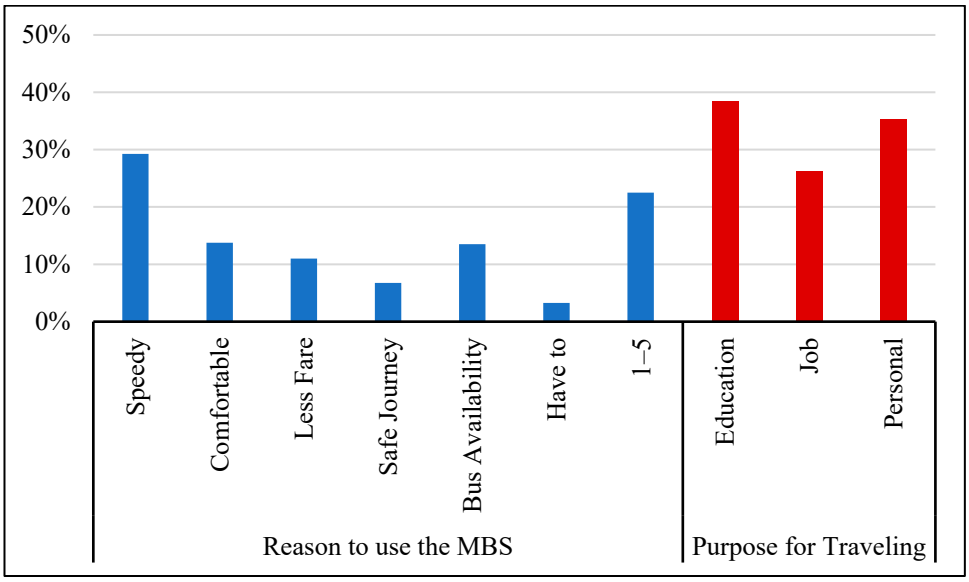


Figure 21. The reasons and purpose given for using the MBS.

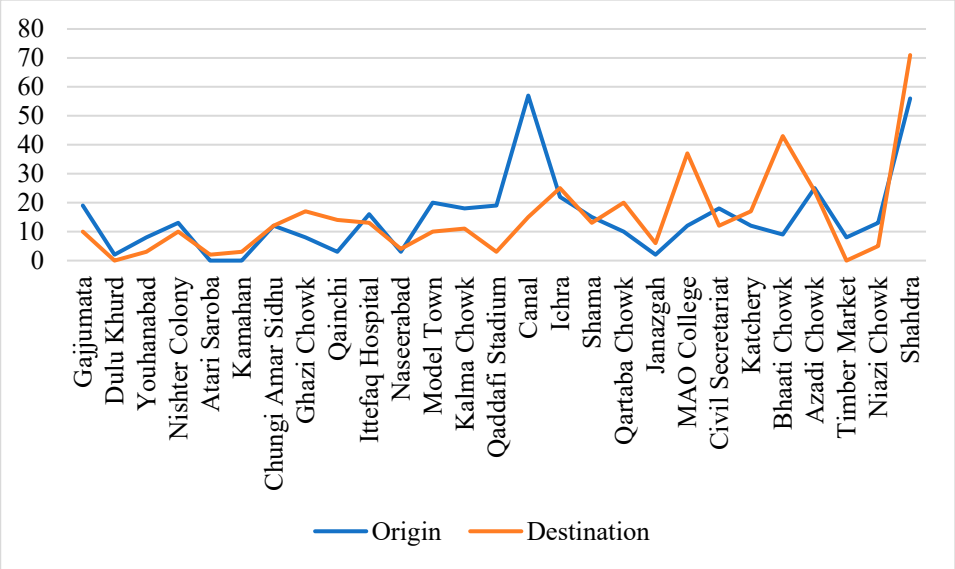


Figure 22. The origin and destination station details of the respondents.

It was observed that metro buses are overcrowded every time, which shows it was needed at the hour. People were asked whether they had used any local bus before the MBS: 55% said yes, 16% said no, and 29% said off and on. This is also consistent with the literature [53]. Before the start of operations in February 2013, the majority of MBS passengers traveled by bus and van. These results were positive because people tend to use public transport as it is Lahore's first mass transit project, which is common in many successful countries but was lacking here. Furthermore, 74% agreed that the metro ride saved their time (Figure 23). People were asked whether they were satisfied with the MBS's advanced facilities (escalators, TVM, etc.). Most of the respondents were satisfied with the services as 20.5% strongly agreed, 37.5% agreed, and 37.5% agreed to some extent. The overall metro user was satisfied, and the response was positive, where 4.5% marked its efficiency at 10–30%, 17.5% placed it at 30–50%, 43.5% opted for 50–70%, and the remaining 34.5% selected 70–100%.

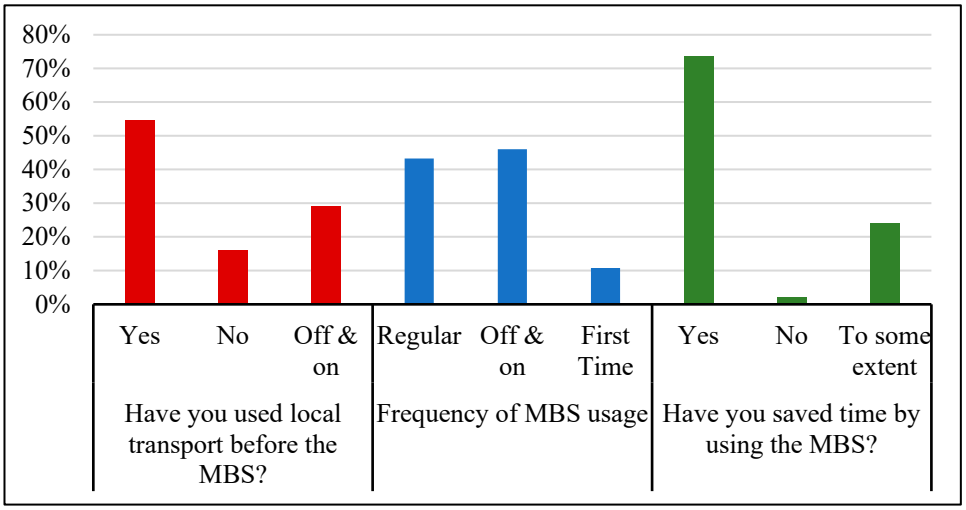


Figure 23. Indicators related to MBS acceptance.

The MBS is suitable for people living in the surrounding areas of the bus corridor, those who can access the metro bus on foot or by a paratransit mode (Qingqi rickshaw), or people who are using the service for the long route. According to a user survey, 45% of people reach the MBS station by walking and 36% by feeder bus or rickshaw. Moreover,

10% of users come with someone who drops them at the metro station, and 8% came in a personal car or bike. The respondents were asked about their vehicle parking, and it was found that 72% used metro parking, 9% parked at nearby stations (as parking space is not provided at all stations), and 19% parked elsewhere (Figure 24).

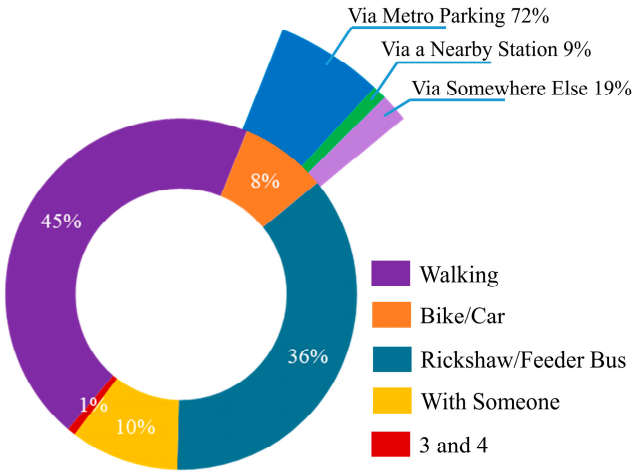


Figure 24. How do you reach your MBS station?

During planning and construction, many areas were acquired for design purposes. Buildings were broken down, and the city's urban character was affected. Ferozpur Road, which majorly consists of commercial shops, uses the roofs for services or storage. Commuters were inquired about the ambiance of their surroundings while traveling on the MBS. Around 40% graded it as good, 2.3% as bad, 39% had a mixed feeling of good and bad at various patches of the corridor, and around 19% did not notice their surroundings while traveling (Figure 25).

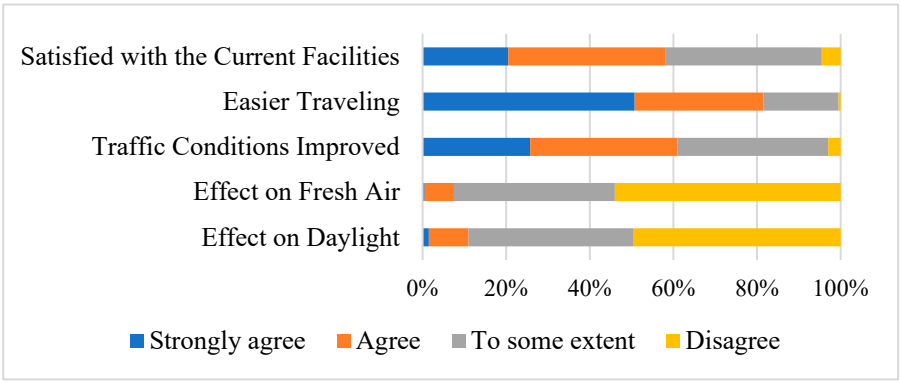


Figure 25. Indicators related to the project's impact and effects on the surroundings.

However, in some places, the elevated pathway provides the best views of historical buildings, such as the Government College and the shrine of Lahore's patron saint, Data Ganj Bakhsh (Data Darbar). But the problem is that such a view is not available to all road users, e.g., those walking, living, or working under the daunting shadow of the high-rise track (Figure 26).

(**a**) (**b**)

Figure 26. (**a**) View of the elevated track near Qartaba Station. (**b**) View of the Rotary at MAO College Station.

The urban character of Lahore (City of Gardens) has changed a great deal over time. The construction of bridges, flyovers, underpasses, and other infrastructure facilities like the MBS corridor has played a major role in changing the city's image. At-grade stations and the fenced bus corridor has generated a barrier effect, thereby creating psychological discomfort because of the fragmentation of the existing environment. For elevated stations, huge concrete flyovers standing over piers have dominated the city's main artery. People were asked for their opinions regarding these structures: 77% were satisfied and considered it positive as the city is developing, 20% found it congested as it has blocked the whole vision, and 3% of users found these giant structures scary (Figure 27). Furthermore, 26% strongly agreed that traffic conditions were improved by providing pedestrian bridges and underpasses, 35% just agreed, 36% agreed to some extent, and 3% disagreed. People were asked whether traveling within the city had become easier after the metro bus. It was found that 50% strongly agreed, 31% agreed, 18% agreed to some extent, and 1% disagreed.

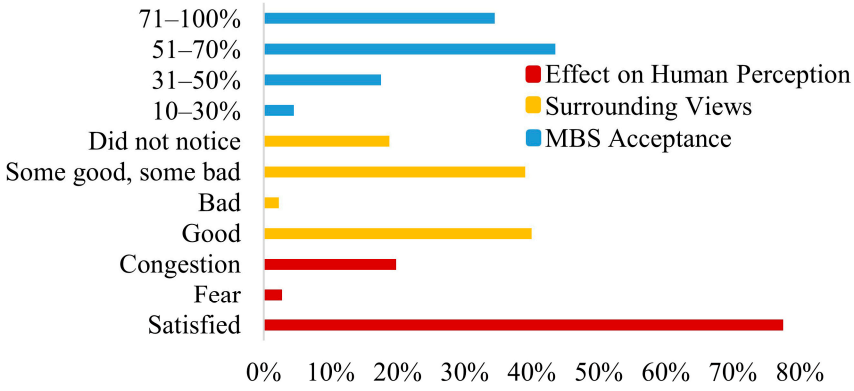


Figure 27. Results from the user survey on the effect of the MBS on the urban environment.

4.3. Shopkeepers Survey

A detailed questionnaire survey of 60 shop owners along the bus corridor was conducted to estimate the impact of the MBS on their daily lives and businesses. An analysis of the results is given below.

The MBS route traverses Lahore's busiest traffic corridor, Ferozepur Road, which serves as a vital thoroughfare for thousands of daily commuters traveling between Shahdara and Kasur for work. It covers many commercial areas, supporting a variety of businesses, such as auto shops, building materials shops, grocery stores, garments shops, and accessories stores. The survey results show that 88% of the shop areas ranged between 1/2 marla (12.6 sqm) and 21/2 marla (63.2 sqm). Among shopkeepers, 38% have attained education at the "Inter or above" level, 28% have completed "Matric", and 17% have no

formal education. In addition, 65% of shopkeepers had both clienteles, while 25% had only local clients because of their business type (Figure 28).

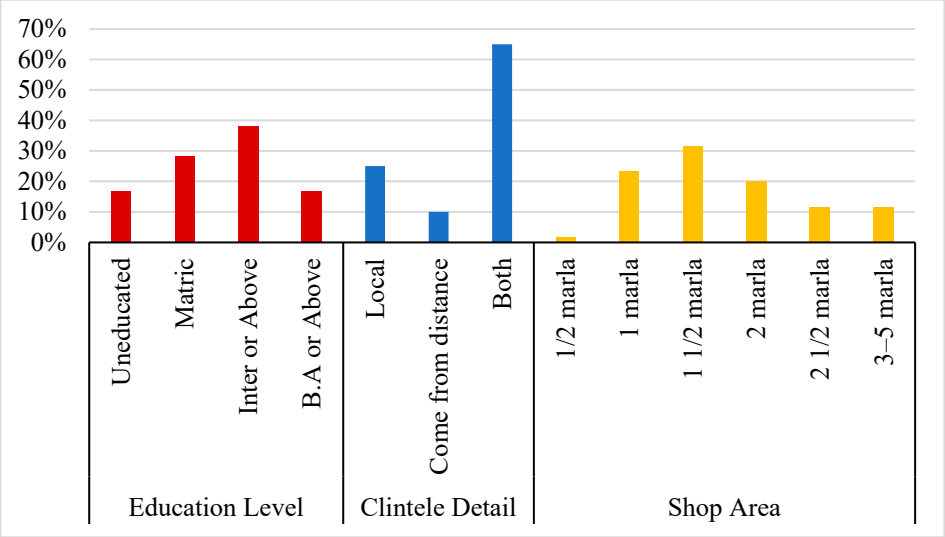


Figure 28. Clientele details from the shopkeepers survey.

Shopkeepers were asked about the change in their lives after the construction of the MBS: 7% said it brings ease in their life, 48% said it brings difficulty, and 45% found no change. Those who said they had an easier life after the MBS were asked to further state their reasons for this sentiment, and it was advised that the increase in clientele for their shops near metro stations was a predominant reason. Shopkeepers who mentioned difficulties in their lives due to MBS were further asked to state the reasons for the difficulties. Those shopkeepers complained about the decline in their clients. Due to the signal-free route, traffic is a high speed, so people do not stop and pass through the shops. Secondly, drop-off areas are unavailable for service lanes, so people cannot stop or purchase their desired items. Shopkeepers say they gained their main clientele from nearby areas affected by flyovers, overhead bridges, and the central barrier, and 13% of respondents said that they find difficulty in linking with the other side of the fenced corridor, while 40% agreed to some extent. This problem was found to be prominent with at-grade stations (Figure 29) as pedestrian crossings are available under busways for elevated portions. The respondents were also further asked about the effect on their businesses, where 6.7% of respondents marked an increase in their business after the MBS was constructed, while 46.7% found no change and 46.7% mentioned a loss in their business.

Shopkeepers were asked about the light quality after the flyovers and elevated stations were constructed: 15% of people agreed with this new reality, 50% accepted it to some extent, and 33% disagreed with it. During the survey, they were asked about the air quality after the flyovers and elevated stations were constructed. It was found that 28.3% of people strongly agreed, 46.7% agreed to some extent, and 18.3% disagreed with the new arrangement. Shopkeepers were inquired about their opinions regarding the additions to infrastructure like the MBS corridor, flyovers, underpasses, and bridges: 13% of them were satisfied and considered it compulsory for city development, 43% found it congested as the city now has a messy look, and 44% of respondents found these gigantic structures scary (Figure 30). Moreover, 30% of the respondents strongly agreed that traffic conditions within the city improved because of the provision of underpasses and pedestrian bridges, 27% agreed to some extent, and 42% disagreed.

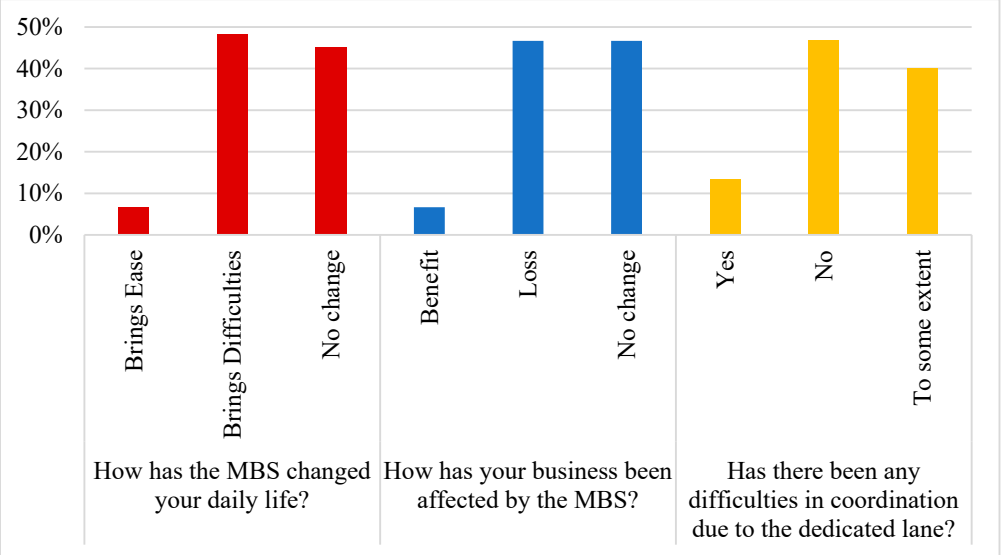


Figure 29. Survey results on the project acceptance among shopkeepers.

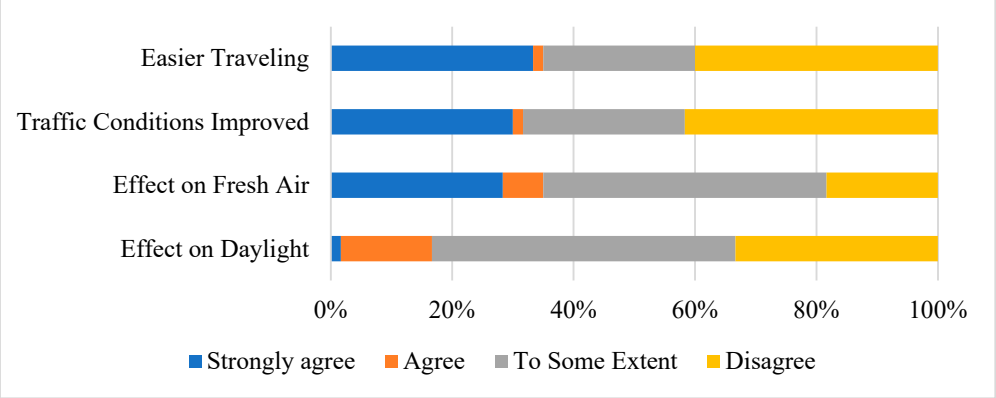


Figure 30. Results from shopkeepers survey on the effect of the MBS on the urban environment.

Shopkeepers were asked whether traveling within the city has improved due to the MBS: 33% strongly agreed, 25% agreed to some extent, and 40% disagreed. The MBS route passes through the busiest artery of Lahore, which has a variety of businesses and congested areas. Due to the construction of MBS stations, pedestrian bridges, and underpasses, many shop fronts have been affected. This factor was evaluated during the survey, and 52% of respondents said that their shop fronts were affected due to these structures, while 40% accepted it to some extent. During the planning and construction of the MBS, several areas were acquired. Therefore, many shops were damaged either wholly or partially in this process. This aspect was further explored during the survey, where 42% said shops were damaged, while 42% marked it to some extent (Figure 31). Shopkeepers who said their shops were damaged due to the construction of MBS were asked further about whether any compensation from the government was given for this loss. The majority said the government gave no compensation, while 24% said the matter was under discussion.

Figure 31. The effect on shops due to MBS construction.

5. Inferences and Discussion

This research employs a multifaceted descriptive analysis to comprehensively understand the social impacts of the Lahore MBS on various stakeholders, including the built environment, commuters, and local shopkeepers. The findings offer valuable insights for policymakers, urban planners, and stakeholders who are aiming to balance the development of efficient mass transit systems with the preservation of a city's cultural identity and economic vitality.

Functionality. The advent of the MBS has brought about profound transformations along its route, notably enhancing connectivity and orderliness in certain locales. Take, for instance, Kalma Chowk, a pivotal junction along Ferozepur Road. The urban configuration of the Kalma Chowk vicinity has undergone significant revisions, and it is marked by various alterations in road infrastructure and building functionalities. Despite Kalma Chowk's mixed-use activities and attractive commercial plazas, as well as its surrounding higher-income residential communities, the overall impression of the area reflects a car-centric society with limited accommodation for active transport users. Figure 32 illustrates the loss of indigenous character in favor of transport development, which has resulted in a more organized and efficient urban form. It offers a visual comparison of the pre and post scenarios, highlighting the disappearance of historical landmarks, which may evoke an emotional response in citizens.

(**a**) (**b**)

Figure 32. (**a**) View of the Kalma landmark. (**b**) View of the added infrastructure.

Similarly, the MBS track has created numerous sites with a significant capacity for upcoming development and financial growth. Take, for instance, the MAO College intersection, which is currently undergoing changes and adjustments with the construction of the Orangeline route. Similarly, the vacant land near Gajjumata holds promise for prospective growth and commercial endeavors. Furthermore, a significant at-grade portion of the route

with a steel-fenced corridor is splitting the city in half (see Figure 33). This arrangement has led to challenges for walkers and automobiles in accessing the opposite part because U-turns and crosswalks are now located at greater distances. In this regard, Adeel et al. [38] presented graphical scenarios to local stakeholders, including radical designs prioritizing pedestrian crossings over vehicular traffic using underpasses. BRT users, residents, and commercial building users responded positively to these scenarios. However, officials from the Local Development Authority expressed concerns about the feasibility of implementing such designs due to the high cost and limited borrowing capacity of the Punjab Government.

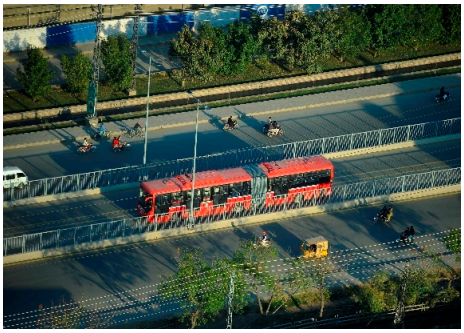


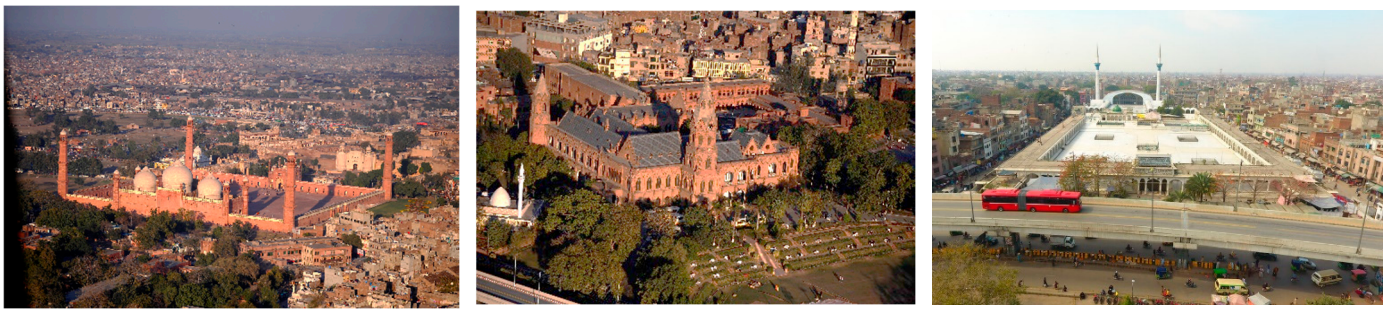
Figure 33. A steel-fenced corridor dividing the city into two parts.

The MBS prioritizes transportation needs rather than aligning with the urban morphology of Lahore due to insufficient allied infrastructure for informal modes and foot traffic. The absence of integrated facilities at Shahdara and Bhaati stations has led to congestion caused by buses and rickshaws, thereby affecting other traffic flow (see Figure 34). Similar challenges are evident at Canal Station, which has highlighted the need for improved spatial design to enhance the quality of the area.

(**a**) (**b**)

Figure 34. Missing allied infrastructure: (**a**) At Shahdara Station. (**b**) At Bhaati station.

Aesthetics. Some of the sections of the elevated route of the MBS infrastructure, including elevated stations and footbridges, offer picturesque views of historic sites such as the Badshahi Mosque, GC University, and Data Darbar, which enhance the overall aesthetic of the city (see Figure 35). However, this aspect undermines the potential of the elevated route to support cultural heritage preservation.



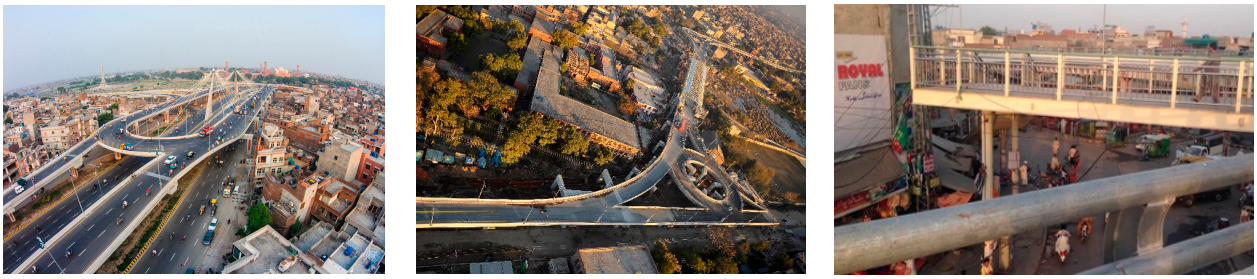
(**a**) (**b**) (**c**)

Figure 35. Views of historical buildings: (**a**) Badshahi Mosque. (**b**) GC University. (**c**) Data Darbar.

Conversely, certain segments of the elevated sections of the route have exposed unappealing aspects of the city, while also unveiling previously unused rooftop spaces of shops, thereby raising privacy concerns for neighboring houses (as shown in Figure 36). The extensive infrastructure of flyovers, numerous bridges, and station designs have led to the dominance of transportation facilities in many areas, resulting in a complex urban form that can be visually obstructive. A case in point is Azaadi Chowk station, MAO College station, and Chungi Amar Sidhu station (Figure 37).

(**a**) (**b**)

Figure 36. (**a**) View of rooftops along the route. (**b**) View of the residences around the route.



(**a**) (**b**) (**c**)

Figure 37. Dominance of the transport infrastructure: (**a**) At Azaadi Chowk Station. (**b**) At MAO College Station. (**c**) At Chungi Amar Sidhu Station.

In this regard, the majority of the commuters perceived the ambiance of the surroundings positively or neutrally, thus allowing room for further improvements provided that a pleasant ambiance along the corridor can contribute to a more enjoyable travel experience and further encourage the use of public transport. Moreover, a significant portion of commuters that do not notice their surroundings during traveling may suggest engagement in activities like using electronic devices or discomfort with observing their surroundings.

Likewise, the high satisfaction rate regarding giant infrastructure additions is possibly due to their functionality and contribution to transport development. However, concerns about congestion and obstructed views highlight the need for careful urban planning and

design considerations when implementing such structures to mitigate negative impacts on the cityscape. Similarly addressing the fear associated with the giant structures may require public awareness campaigns or design interventions aimed at improving the aesthetics and integration of these structures within the urban environment.

Transport pattern. Results from the riders and shopkeepers shed light on the project's social image, which was overlooked during its design and construction. The project, implemented solely as a transportation component, has limited benefits beyond moving people. A closer examination of the rider survey results showed that regular users of the metro bus are students, majorly college students, as the age group of the riders was between 15–30 yrs, and the education level was of an Intermediate grade. This fact was also confirmed by a cross-tabulation analysis of the purpose of traveling with age group and frequency of using the MBS (see Figure 38). Their Chi-square test results, which show a strong association between these variables, are presented in Table 3.

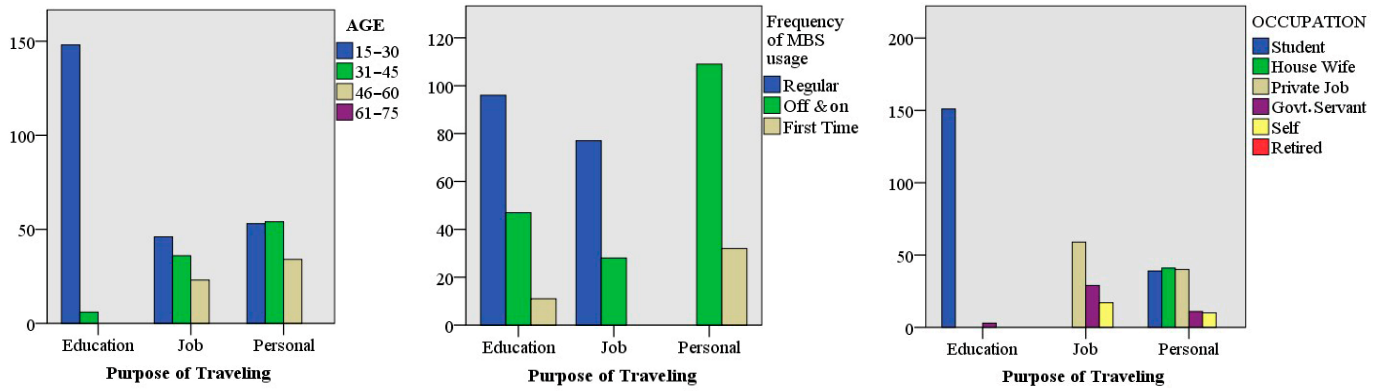


Figure 38. Crosstabulation analysis of the purpose of traveling vs. (**a**) age, (**b**) frequency, and (**c**) occupation.

Table 3. Chi-Square Test Results.

	Value	df	Asymp. Sig. (Two-Sided)
Purpose of Traveling vs. Age Group			
Pearson Chi-Square	126.698 [a]	4	0.000
Likelihood Ratio	156.619	4	0.000
Linear-by-Linear Association	95.596	1	0.000
N of Valid Cases	400		
Purpose of Traveling vs. Frequency of MBS Usage			
Pearson Chi-Square	174.387 [a]	4	0.000
Likelihood Ratio	234.403	4	0.000
Linear-by-Linear Association	99.146	1	0.000
N of Valid Cases	400		
Purpose of Traveling vs. Occupation			
Pearson Chi-Square	364.838 [a]	8	0.000
Likelihood Ratio	438.033	8	0.000
Linear-by-Linear Association	78.941	1	0.000
N of Valid Cases	400		

[a]. 0 cells (0%) have expected count less than 5.

The data highlight the Canal and Shahdara Stations as major origin points, as well as the MAO College, Bhaati, and Shahdara Stations as significant destination points within the MBS network. Their significance was confirmed by the daily ridership data of the sample stations in Phase I. The survey results indicate that the MBS is well-suited for users

living in the surrounding areas, with a significant portion accessing it through walking or feeder bus services. The current public transport system in Lahore is composed of two mass transit lines, a feeder bus service, paratransit modes (Qingqi and auto rickshaws), and ride-hailing services (Uber, Cream, and Bykea). The feeder bus service (SPEEDO) in Lahore is currently working with 170 buses, covering a network of 584 km across 19 routes and 453 stops [51]. The mass transit lines along with feeder routes cater to one third of the city's geographical expanse, thus leaving other areas to rely on paratransit modes. Anwar et al. [54] also mentioned that both lines are working far below their capacity and catering to only 5% of daily motorized trips in the city. The user survey results confirm that the MBS is limited to serving surrounding people only, and the observational survey in Phase I mentioned many of the shortcomings in the existing system that are behind this failure.

Similarly, 55% of commuters are using feeder buses, a paratransit mode, or being dropped off to reach the metro station, which demands the seamless integration of these modes within the system. Phase I highlights the absence of essential allied infrastructure, such as designated drop-off areas for personal cars or bikes, parking spaces for paratransit modes, and continuous footpaths. The lack of these facilities creates bottlenecks around the entry or exit points of crowded stations, thereby disrupting traffic flow in the surrounding areas.

The presence of differing perceptions among shopkeepers regarding the impact of the MBS highlights the complexity of its effects on local businesses. While some shopkeepers benefit from increased foot traffic near metro stations, others face challenges such as reduced customers due to changes in traffic patterns and infrastructure.

The shopkeeper survey results highlight the importance of addressing accessibility challenges posed by fenced corridors along at-grade stations to support the vitality and sustainability of local businesses along the MBS. A significant proportion of respondents reporting the impact on their shop fronts and damage to their shops highlights the disruption caused by MBS construction activities on local businesses. Furthermore, the lack of compensation for damages indicates a potential area of concern and dissatisfaction among the affected shopkeepers, which could have implications for their livelihoods and their perceptions of government support.

6. Conclusions and Recommendations

6.1. Conclusions

This study helps us understand the intricate relationship between transport infrastructure development and the social fabric of cities, with a focus on Lahore, Pakistan. The main findings are as follows:

Transport infrastructure has significantly impacted the area, which is evident in features such as the unsightly steel fence lining the route and the lengthy winding road suspended overhead, which cast extensive shadows and contribute to the complexity and visual obstruction of the urban form. While huge transport infrastructure projects have always posed challenges for policymakers, positive outcomes cannot solely be attributed to the project's hard components, as suggested by [55]. The Lahore MBS project, completed in a record time of eleven months, primarily focused on hardcore infrastructures like route design, station design, and modern facilities. In contrast, soft components like area development, social and cultural value, and human-centered design were overlooked, as indicated by the survey results. The researchers' observations, along with user and shopkeeper surveys, revealed perceptions about various aspects like surrounding views, experiences with giant structures while traveling, etc. While the survey indicates overall satisfaction with the giant structures (stations, bridges, flyovers, and elevated tracks), notable concerns about congestion and visual obstruction exist among some respondents. These results underscore the importance of balancing functionality with aesthetic and urban design considerations in transportation infrastructure development. Understanding and addressing the specific concerns raised by shopkeepers are crucial to ensuring balanced development and a positive impact of transportation infrastructure on local businesses and communities.

Upon analyzing the eight key nodes along the MBS route, it becomes apparent that several areas have undergone development and transformation as a result of this project, thus offering the potential for stimulating economic activity and enhancing mobility. Survey results also indicate that users and citizens highly value the MBS system and its advanced facilities. This is further supported by the significant ridership of 180,000 passengers per day, as reported by the PMA. Additionally, according to Hameed and Anjum [56], the MBS has reduced private motorbike trips on the main Ferozpur Road by 55%, thereby improving the city's environmental conditions. Kashif [57] assessed the MBS in comparison with the international best practices credited in the BRT Standard by [58], and they graded the MBS as standard with a score of fewer than 55 points. Moreover, discussions with local experts and survey results has indicated that it is an improved public transport service. Crowded buses, as noted in observational surveys, are common, indicating high demand for the service but also potential challenges such as comfort and efficiency. Thus, its long-term impacts in terms of sustainability can only be envisioned if the social and cultural characteristics of the city are attached to it. Likewise, addressing the difficulty in linking across the fenced corridor, especially at-grade stations, is vital for ensuring seamless pedestrian access and facilitating interactions between businesses and customers on both sides of the corridor. In conclusion, this research proposes soft interventions to enhance the social image of the project, along with long-term coordination strategies aimed at optimizing transit services and achieving social and cultural sustainability.

6.2. Recommendations

A small-scale, strategic improvement is often the first step toward improving the experience of living, working, and playing in a place. A harmonious building skyline should be achieved on both sides of the route through height zoning to rid the unpleasant visual picture that results from the MBS. Noise and pollution reduction should also be a policy measure in this regard. The usage of noise-proof construction material in the adjacent buildings supported by landscaping/pollution control infrastructure can provide the desired results. Moreover, addressing the concerns raised by shopkeepers, such as providing drop-off areas and mitigating the impact of high-speed traffic on local businesses, could help alleviate the difficulties faced by shopkeepers.

The Brownfield development concept can be used to enhance surrounding places that are not in use, like old railway tracks or the roofs of commercial shops, which are either abandoned or used as storage places. Globally, there are so many examples where waste spaces have been transformed into popular community places. These urban green spaces will catalyze social interaction by reconnecting neighborhoods and revitalizing surrounding communities. Moreover, by converting an ordinary roof to a green roof or a space for solar panels, environmental sustainability can also be achieved (Figure 39).

(**a**) (**b**)

Figure 39. (**a**) Existing leftover roof spaces. (**b**) Proposed idea. Source: https://understandsolar.com/can-you-put-solar-panels-on-a-flat-roof/ (accessed on 23 November 2023).

In this regard, investing in sustainable transport infrastructure has proven to be a powerful catalyst for attracting private investment into historically ignored urban areas [59]. The spaces below elevated pathways, bridges, and flyovers can be transformed to soften the image and make hospitable infrastructure. These can be transformed into useful urban parks or park lets by an adaptive reuse strategy, which can reunite the fragmented artery and increase livability (Figure 40). It should be landscaped with visually appealing vistas, tiny green areas, or parks by keeping in mind the safety and comfort of the MBS users and other pedestrians. Budget allocations for green development including tree plantations and flower vegetation should be prioritized. By doing this, the journey becomes visually pleasing to the passengers, as well as to other road users.

(**a**) (**b**)

Figure 40. (**a**) An underpass park in Houston, Texas. (**b**) Underground at Ink Block, Boston. Source: https://archive.curbed.com/2017/1/9/14183876/freeway-underpass-park-public (accessed on 23 November 2023).

BRT Ahmedabad is a good example to follow regarding historical and cultural values. The city renewal plan is part of the project, and the Nehru revitalization project is linked with the BRT service. Similarly, strategies can be made to uplift the old historic urban fabric of Lahore along the route. Historical places and monuments along the MBS route can be selected for renovation to promote cultural diversity and tourism so that the uniqueness of communities can be aided by transport, which increases the sense of belonging and ownership.

The city requires an integrated approach, i.e., transit-oriented development (TOD), to urban design and transit services that is harmonious with the urban morphology of Lahore. Place making is recommended for the rejuvenation of this transport infrastructure. As, in place making, public spaces are planned and designed with people in mind, and it helps to considerably improve the user experience. Place making and TOD principles overlap in their shared focus on creating vibrant, people-centric spaces. The convergence lies in both approaches promoting mixed-use spaces, pedestrian-friendly environments, and community engagement, thereby fostering a sense of place where people can live, work, and connect easily.

Transit-oriented design becomes feasible when transit investments precede or align with regional growth. The route is important because of the diversity of land uses, as well as the institutional and cultural entities that are linked with this route, such as Anarkali Bazar, Dinga Singh Building, Katchehry, Civil Secretariat, Punjab University Old Campus, and Government College Lahore. Therefore, the route has the potential for positive urban transformation with a diversity of land uses and historical importance. The Punjab Government must facilitate collaboration among transport agencies, PMA, investors, developers, and the public to formulate a joint development policy. This policy aims to boost revenue, increase ridership, and transition toward TOD, which involves retrofitting regeneration and the re-densification of established urban cores while promoting compact, transit-oriented urban expansion. As transit encompasses more than just rides but also urban living, the provincial government must offer financial and technical assistance to acquire, develop,

and manage land or buildings along the MBS route. This support should facilitate mixed land-use and mixed-income housing development on these properties. These findings serve as a guiding framework for future transit projects in Pakistan and provide valuable insights for other developing nations contemplating the implementation of mass transit networks.

This research is subject to limitations as its empirical aspect relies on field investigations, a comparative analysis of select stations, and surveys. Future studies should incorporate additional factors related to public transport, such as changes in travel patterns or property values, to bolster emerging economic insights. Furthermore, a detailed station-wise analysis is necessary to propose site-specific solutions and to develop area management plans incorporating ITS.

6.3. Theoretical and Practical Implications of Research

6.3.1. Theoretical Implications

This research offers theoretical insights into urban development and transport infrastructure planning, emphasizing the importance of considering social factors alongside economic and environmental assessments. It advocates for a human-centered approach, thereby challenging the prevailing focus on quantitative measures. This study highlights public transport's role in shaping cities, and it underscores its potential to enhance social cohesion and the overall urban experience. Theoretical advancements should integrate concepts of a sense of place and cultural identity by recognizing their significance in creating sustainable urban environments.

6.3.2. Practical Implications

This research offers practical implications for urban development and transport planning stakeholders. It underscores the importance of prioritizing user experience and considering the city's social and cultural fabric in infrastructure projects. Collaboration among policymakers is essential to align development with Lahore's cultural identity through transit-oriented planning. Additionally, integrating place-making strategies into infrastructure design can enhance urban life by creating vibrant community hubs. Continuous community engagement is crucial for addressing stakeholder concerns and ensuring project sustainability.

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Appendix A

Appendix A.1

Metrobus Commuter's Survey

The primary purpose of this questionnaire is to hear from Metrobus commuters themselves about the impact of Metro Bus System (MBS) on their life, daily mobility, urban development and environmental effects.

Gender: a. Male b. Female

Occupation: _____

Age (In years): a. 15-30 b. 31-45 c. 46-60 d. 61-75

Education: a. Uneducated b. Matric c. Inter or above

Travel details: Origin Station: _____ Destination Station: _____

Q no.1: Did you use any other traditional public transport before MBS for traveling within city?

a. Yes b. No c. Off & on

Q no.2: How many times do you use Metrobus?

a. Daily b. Off & on c. First time

Q no.3: Mark your reason to choose Metrobus for traveling?

a. Speedy of bus b. Comfortable c. Low fare d. Secure e. Quick availability f. Have to

Q no.4: What is the purpose of your trip today?

a. Education b. Job c. Shopping d. Medical e. Personal Reason

Q no.5: Do you think MBS has saved your travelling time?

a. Yes b. no c. To some extent

Q no.6: How do you reach Metro station?

a. By Walk b. Personal Car/Bike c. Rickshaw d. With Sometime

Q no.7: If you come by personal car/bike then where do you park it?

a. Metrobus Parking b. Nearest Station c. nearby

Q no.8: Mark your level of satisfaction with Metrobus efficiency?

a. 10-30% b. 31-50% c. 51-70% d. 71-100%

Q no.9: How do you find the surrounding views while travelling in Metrobus?

a. Good b. Bad c. Some good, Some bad d. Didn't Notice

Q no.10: Are you satisfied with the latest facilities (Escalators, TVM) provided by the Metrobus?

a. Strongly Agree b. Agree c. To some extent d. Disagree

Q no.11: Do you think that quality of daylight is decreased due to the construction of flyovers, bridges and elevated stations?

a. Strongly Agree b. Agree c. To some extent d. Disagree

Q no.12: Do you think that quality of fresh air is decreased due to the construction of flyovers, bridges and elevated stations?

a. Strongly Agree b. Agree c. To some extent d. Disagree

Q no.13: How do you feel by looking at these newly constructed flyovers, bridges, elevated pathway along with elevated stations?

a. Satisfaction b. Fear c. Congestion

Q no.14: Do you think traffic conditions are improved by providing pedestrian bridges and pedestrian underpasses?

a. Strongly Agree b. Agree c. To some extent d. Disagree

Q no.15: Do you think Metrobus has improved connections within city?

a. Strongly Agree b. Agree c. To some extent d. Disagree

Figure A1. The MBS commuter survey.

Appendix A.2

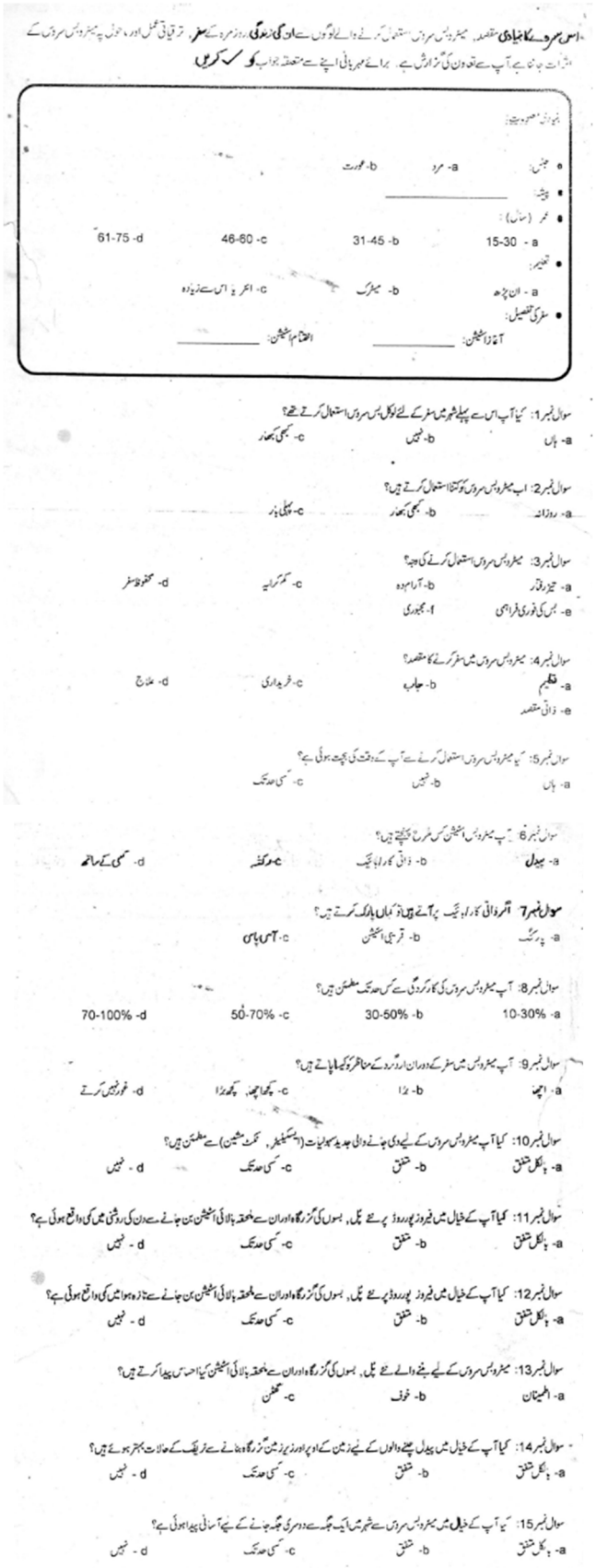


Figure A2. The MBS commuter survey in Urdu.

Appendix B

Appendix B.1

Shopkeeper's Survey

The primary purpose of this questionnaire is to hear from shopkeepers along the Metrobus route, about the impact of Metro Bus System (MBS) on their business, daily mobility, urban development and environmental effects.

Education: a. Uneducated b. Matric c. Inter or Above
Shop Type: _____
Shop Area: _____
Address: _____
Customers Detail: a. Come from nearby b. Come from outside c. Both

Q no.1: How your life has changed due to Metrobus?
b. Bring Ease b. Bring Difficulty c. No Change

Q no.1-a: If it bring ease then state reason?
_____

Q no.1-b: If it bring difficulty then state reason?
_____

Q no.2: Do you find any difficulty in connection to the other side due to dedicated fenced lane for Metrobus?
a. Yes b. No c. To some extent

Q no.3: How your business is effected due to Metrobus?
a. Benefit b. Loss c. No Change

Q no.3-a: If you get benefit then how much?
a. 10-30% b. 31-50% c. 51-70% d. 71-100%

Q no.3-b: If you get loss then how much?
a. 10-30% b. 31-50% c. 51-70% d. 71-100%

Q no.4: Do you think that quality of daylight is decreased due to the construction of flyovers, bridges and elevated stations?
a. Strongly Agree b. Agree c. To some extent d. Disagree

Q no.5: Do you think that quality of fresh air is decreased due to the construction of flyovers, bridges and elevated stations?
a. Strongly Agree b. Agree c. To some extent d. Disagree

Q no.6: How do you feel by looking at these newly constructed flyovers, bridges, elevated pathway along with elevated stations?
a. Satisfaction b. Fear c. Congestion

Q no.7: Do you think traffic conditions are improved by providing pedestrian bridges and pedestrian underpasses?
a. Strongly Agree b. Agree c. To some extent d. Disagree

Q no.8: Do you think Metrobus has improved connections within city?
a. Strongly Agree b. Agree c. To some extent d. Disagree

Q no.9: Is your shop front effected due to Metrobus?
a. Yes b. No c. To some extent

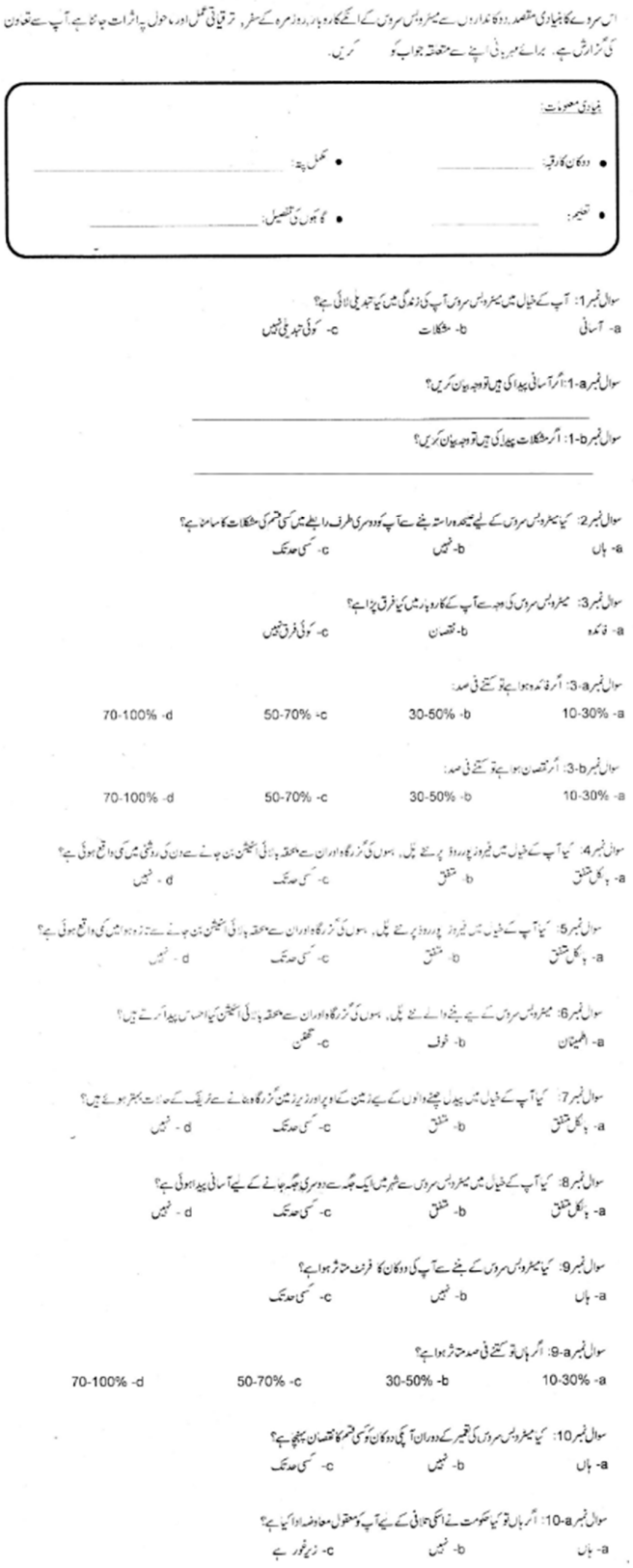
Q no.9-a: If yes then how much?
a. 10-30% b. 31-50% c. 51-70% d. 71-100%

Q no.10: Is your shop effected during the construction of Metrobus?
a. Yes b. No c. To some extent

Q no.10-a: If yes then did the Government compensated for it?
a. Yes b. No c. Under Discussion

Figure A3. The shopkeepers survey.

Appendix B.2


اس سروے کا بنیادی مقصد دوکانداروں سے میٹروبس سروس کے آنے کے کاروبار، روزمرہ کے سفر، ترقیاتی عمل اور ماحول پر اثرات جاننا ہے۔ آپ سے تعاون کی گزارش ہے۔ برائے مہربانی اپنے سے متعلقہ جواب کو کریں۔

بنیادی معلومات:

- دوکان کا رقبہ: _____
- مکمل پتہ: _____
- تعمیر: _____
- گاہکوں کی تفصیل: _____

سوال نمبر1: آپ کے خیال میں میٹروبس سروس آپ کی زندگی میں کیا تبدیلی لائی ہے؟

a- آسانی b- مشکلات c- کوئی تبدیلی نہیں

سوال نمبر1-a: اگر آسانی پیدا کی ہیں تو وجہ بیان کریں؟

_____

سوال نمبر1-b: اگر مشکلات پیدا کی ہیں تو وجہ بیان کریں؟

_____

سوال نمبر2: کیا میٹروبس سروس کے لیے متبادل راستہ بننے سے آپ کو دوسری طرف رابطے میں کسی قسم کی مشکلات کا سامنا ہے؟

a- ہاں b- نہیں c- کسی حد تک

سوال نمبر3: میٹروبس سروس کی وجہ سے آپ کے کاروبار میں کیا فرق پڑا ہے؟

a- فائدہ b- نقصان c- کوئی فرق نہیں

سوال نمبر3-a: اگر فائدہ ہوا ہے تو کتنے فی صد:

a- 10-30% b- 30-50% c- 50-70% d- 70-100%

سوال نمبر3-b: اگر نقصان ہوا ہے تو کتنے فی صد:

a- 10-30% b- 30-50% c- 50-70% d- 70-100%

سوال نمبر4: کیا آپ کے خیال میں فیڈر روڈ پر بننے پل، بسوں کی گزرگاہ اور ان سے منسلک پیدل انٹیگریشن بن جانے سے دن کی روشنی میں سی واقع ہوئی ہے؟

a- بالکل متفق b- متفق c- کسی حد تک d- نہیں

سوال نمبر5: کیا آپ کے خیال میں فیڈر روڈ پر بننے پل، بسوں کی گزرگاہ اور ان سے منسلک پیدل انٹیگریشن بن جانے سے تاروہا میں کمی واقع ہوئی ہے؟

a- بالکل متفق b- متفق c- کسی حد تک d- نہیں

سوال نمبر6: میٹروبس سروس کے لیے بننے والے نئے پل، بسوں کی گزرگاہ اور ان سے منسلک پیدل انٹیگریشن کیا احساس پیدا کرتے ہیں؟

a- اطمینان b- خوف c- تحفظ

سوال نمبر7: کیا آپ کے خیال میں پیدل چلنے والوں کے لیے زمین کے اوپر اور زیر زمین گزرگاہ بنانے سے ٹریفک کے حالات بہتر ہوئے ہیں؟

a- بالکل متفق b- متفق c- کسی حد تک d- نہیں

سوال نمبر8: کیا آپ کے خیال میں میٹروبس سروس سے شہر میں ایک جگہ سے دوسری جگہ جانے کے لیے آسانی پیدا ہوئی ہے؟

a- بالکل متفق b- متفق c- کسی حد تک d- نہیں

سوال نمبر9: کیا میٹروبس سروس کے بننے سے آپ کی دوکان کا فرنٹ متاثر ہوا ہے؟

a- ہاں b- نہیں c- کسی حد تک

سوال نمبر9-a: اگر ہاں تو کتنے فی صد متاثر ہوا ہے؟

a- 10-30% b- 30-50% c- 50-70% d- 70-100%

سوال نمبر10: کیا میٹروبس سروس کی تعمیر کے دوران آپکی دوکان کو کسی قسم کا نقصان پہنچا ہے؟

a- ہاں b- نہیں c- کسی حد تک

سوال نمبر10-a: اگر ہاں تو کیا حکومت نے اسکی تلافی کے لیے آپ کو معقول معاوضہ ادا کیا ہے؟

a- ہاں b- نہیں c- زیر غور ہے

Figure A4. The shopkeepers survey in Urdu.

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