Doctoral Dissertation

Examining the Influences of Urban Forms on Travel Behavior and Location Affordability: Case Study of Rawalpindi-Islamabad, Pakistan

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Doctoral Program in Policy Science

Graduate School of Policy Science

Ritsumeikan University

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（都市形態が交通行動と立地取得可能性に与える影響の検証～パキスタンのラワルピンディ・イスラマバードを事例として～）

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Abstract of Doctoral Dissertation

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Taking theoretical and empirical evidence from the previous studies on built-environment, and housing and transportation planning, this dissertation established a hypothesis that urban form indicators significantly influence one's travel behavior, travel satisfaction, and associated costs. This hypothesis is then tested using three different analyses. This dissertation is the extension of the major findings obtained during masters' independent research work, which determines the accessibility of bus rapid transit service (BRT) located in Rawalpindi-Islamabad Metropolitan Area (RIMA). Since this result included only one service facility, i.e., BRT, the doctoral thesis argues that travel behavior more service facilities should be explored along with the travel costs to examine the residence's location affordability.

Several studies have stated that easy access to urban facilities from residential locations determines whether a household feels attached to the community's-built environment that they are currently living in, hence, giving birth to a concept of location attachment. Though several studies focus on the residents' level of accessibility, they target only one facility using one case study. Hence, empirical studies on the access capacity of urbanites to multiple service facilities are also a handful.

Furthermore, housing and transportation affordability studies have continuously supported the theory of location affordability (LA) which states that residents living in proximity to transit and other facilities spent less income share on transportation costs, offsetting high housing costs. However, the broader thesis in this dissertation argues that urban form measures and travel behavior could also determine LA and produce unique results when applied in the developing city context.

This research employs a mixed-method approach, i.e., spatial and statistical analyses, to address the city-wide accessibility to five service facilities, and the factors affecting transportation (T) costs in RIMA context. Residential parcels were extracted from Google Earth, and addresses for service facilities were taken from official private and government websites. This data was then geocoded in ArcGIS. Additionally, nine study sites were chosen to conduct household survey and 435 valid samples were collected from the selected sites.

First, the GIS analysis found that dividing the service facilities into their respective large-scale and small-scale dimensions was influential in determining the city-wide accessibility in RIMA. The results indicated significant discrepancies with access to low-order and high-order service facilities across RIMA. In conclusion that the provision of a lower proportion of service facilities should be considered when establishing affordable housing for low-income people.

Second, the multivariate regression demonstrated that the household characteristics significantly impacted transportation (T) costs, followed by the distance from the city center. Meaning that when moving towards the city core, the average T costs decreased substantially. Additionally, frequent and often public transportation (PT) usage, and frequent visits to education facilities showed significant positive associations with T costs. The findings suggest that policymakers consider affordable locations close to service facilities when establishing affordable housing schemes. Pakistan have built housing schemes on a large scale for low-income people at locations with low proximity to service facilities, causing high transportation costs. These factors may influence the livelihood of an average household who depends highly on PT. The research findings can contribute to the literature on affordable housing policies, accessibility, travel behavior, and location attachment.

Keywords: Accessibility, housing and transportation costs, location affordability, location attachment, Rawalpindi-Islamabad.

Acknowledgment

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I left my family and friends in Pakistan and began my journey of studying abroad in 2013 in the bachelor's program and continued it until the doctoral program. Not a single day goes by when I do not miss my parents and friends. Their prayers, abundant love, and trust have kept me motivated and unstoppable toward my goal for the past nine years. Though I do not verbally thank them more often, their names, along with the names of my supportive friends, are always in my prayers for their health, long life, and happiness.

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Chapter 1: Introduction

1.1. Research background

Large cities in Pakistan continuously face rapid population growth resulting in extreme urbanization leading to an acute shortage of affordable housing and urban facilities. The Government of Pakistan launched the National Housing Policy (NHP) in 2001, which dictates several national policies and plans for land development to meet the need for housing demand (Salman et al., 2018). This set of policies is thorough in allocating the housing budget at the provincial and regional levels, interest rates, taxes, and land provision. However, these policies have neglected other urban forms and transportation service indicators that can potentially impact affordability. With this policy gap, public and private developers have struggled to meet the affordable housing demand with proximity to service facilities, especially public transportation (PT). Further, the high correlation between vehicle ownership and its usage confirmed the development of suburban private gated communities for the high-income population, leaving behind the disadvantaged groups.

Because of rapid urbanization, countries worldwide are launching mega-scale social housing programs. Buckley et al. (2016) stated that billions of dollars had been invested by 16 developing countries as subsidy programs in recent years. When planning to develop affordable housing for low-income people, developers traditionally locate them on urban fringes, as seen in European and North American cities (Fenton et al., 2013). A study in France showed that only 10% of social housing was built in Paris, which houses 20% of the French population (Wong and Goldblum, 2016). Developers face two hurdles when building affordable housing projects in city centers: high land costs and development permission covering large land areas (Chen et al., 2015; Libertun de Duren, 2018). Examples from Beijing (Dang et al., 2014) and Brazil and Mexico (Libertun de Duren, 2018) show that developers target city outskirts to build affordable, public, and social housing to cater to low-income and very low-income households. This affordable housing development practice in suburban areas may lead to several social issues such as an increase in poverty, income group segregation, and poor access to service facilities (Ryan and Enderle, 2012; Woo and Kim, 2016), as well as the spread of fatal diseases and high crime rates. Arguably, local planning and developing authorities locate affordable housing where there is no access to other service facilities, as seen in Nigeria (Iben, 2013), China (Ma et al., 2018; Yang et al., 2014), Chile

(Martines et al., 2018), and the United States (Woo and Kim, 2016). Though several studies spatially analyzed poor access to service facilities around affordable housing locations, they have targeted only one facility, such as public transportation, health, or food, in one case study.

Zeng et al. (2019) examined the accessibility deprivation to service facilities amongst Affordable Housing Communities compared to Other Housing Communities in Nanjing, China. They used spatial analysis to calculate the accessibility score to shopping, health, PT, education, and recreation facilities. They divided these facilities into their respective lower and high sub-divisions to examine the city-wide accessibility to small-scale services located in the neighborhood at convenient walking distances and large-scale facilities available away from the residential areas. However, the accessibility score for sub-divided facilities was statistically analyzed to determine the households' access satisfaction based on a questionnaire survey rather than a city-wide spatial analysis using ArcGIS. Also, this study did not emphasize the geographical location of Affordable Housing Communities (AHC) to show which city area is well equipped with the services. Instead, they compared Other Housing Communities (OHC) comprising market price housing hosting middle- and high-income people to show the accessibility deprivation among low-income households in AHC. Therefore, the RIMA case establishes the framework of the theoretical relationships between accessibility, deprivation, and location attachment to determine whether the current residential location provides better accessibility to service facilities, impacting access satisfaction and relative deprivation.

Furthermore, when accessing the desired destination, households take a particular course of action to reach their destination. Some use private vehicles, while others may use PT available in the city. Developed countries like Japan, China, the United States, and Singapore are well equipped with rail-based transit systems to facilitate commuters for daily travel. On the contrary, developing countries like Pakistan are still deprived of such infrastructure and use the bus-based transportation system, which is often considered a low-quality PT service. In RIMA, BRT, and other small and medium-sized paratransit transportation operators face difficulties enhancing service qualities due to lack of land-use planning, deprived service quality, and no integrated feeder services. Paratransit has several definitions; however, one commonly characterizes it as "urban passenger transport service mostly in highway vehicles operated on public streets in mixed traffic; it is provided by private or public transport operators and is available to certain groups of users or the general public; but it is adaptable in its routing and scheduling to individual user's desires in varying degrees" (Vuchic, 2007).

Though these services have the advantage of running in narrow streets to provide high accessibility where high-capacity feeder buses cannot penetrate, only the highly dependent people on paratransit are loyal commuters despite showing satisfaction below the acceptable level (Cervero, 2007). Besides, paratransit in RIMA is still running illegally without a formal registration and monitoring system (Adeel, 2009). Additionally, the transportation planners show no intention of improving these services concerning the organization, maintenance of the vehicles operating, and law enforcement of licensed routes (Imran, 2009). These factors could be the primary reasons discouraging private vehicle users from shifting to transit services in RIMA. Paratransit quality and trip satisfaction have become a pressing issues and need further exploration based on commuters' perceptions.

Extensive studies have conducted commuters' satisfaction surveys to understand the performance of PT, such as rail transit, BRT, and paratransit services. Studies show that a passenger satisfaction survey is a significant indicator to determine PT service quality (Aniley and Negi, 2010; Ojo, 2019), which affects passenger loyalty (Zhao et al., 2014). These surveys include on-time service, travel speed, travel time, service frequency, fare, safety and security, and cleanliness attributes that could substantially determine overall service satisfaction. Mouwen (2015) found that metro users emphasized ride fares and onboard information more than drivers' behavior towards passengers and driving style. They concluded that the passengers showed higher satisfaction with cleanliness, reliability, and ride fares for bus services than for rail services. One study of New York BRT found that service frequency, on-time performance, and travel speed are the highlighting factors (Wan et al., 2016). The Beijing Southern Axis BRT survey in China revealed that its BRT system received high satisfaction for cleanliness, comfort, and reliability amongst captive users compared to choice users (Deng and Nelson, 2012). The study on two on-board surveys on Miami and Orlando BRTs also highlighted the importance of service frequency, reliability, comfort, and travel time (Baltes, 2003). Cao et al. (2016) found that ease of use, travel safety, and comfort while waiting at the station are essential attributes to determining overall BRT performance. Research on BRT in Minnesota's Twin Cities pointed out that transit operators must prioritize service operation hours, safety while riding, travel time, and reliability to improve the overall BRT performance (Wu et al., 2020).

These qualities can compare perceived satisfaction with the service quality promised by the public transport operators. However, to determine BRT service quality, most studies established interior service parameters such as cleanliness, safety, proper seating, female compartments, and comfort while riding. Still, the exterior parameters such as the access capacity of the passengers to reach BRT via various modes, ease of transfer, waiting time at bus stops, travel time, travel speed, and passengers' overall trip satisfaction from home to BRT demand extensive exploration. One study in Bangkok concluded that despite high dissatisfaction with paratransit service quality for direct trips, passengers showed a positive attitude towards paratransit as feeders for MTSs (Tangphaisankun et al., 2010). Moreover, the research suggested that improving safety, convenience, and comfort could increase commuters' satisfaction. However, this research lacked commuters' overall satisfaction when using paratransit services, and the specific service attributes that affect trip satisfaction were also not available.

Overall, previous studies focus on internal factors to determine BRT service quality, overlooking external factors (e.g., accessibility). Therefore, examining the level of accessibility towards BRTs through travel modes and their provided services affecting trip satisfaction demands extensive attention. Consequently, it is essential to investigate the factors influencing the choice of using various transportation services as feeders for BRT in a developing city in Pakistan, which can be a lesson for other transportation planners in other developing states. The policies derived from such research can help improve the transportation system, enabling car users to modal shift and increase BRT ridership. By doing so, it can potentially stimulate land development around BRT stations, promoting residential-based transit-oriented development (TOD).

Despite several affordable housing programs being established globally, policymakers consider affordable housing a critical challenge. Developers are interested in affordable housing schemes in the city's outskirts even though location significantly impacts expenditure on housing. Additionally, housing in areas away from the city center usually has low connectivity with essential amenities, especially PT, which affects housing affordability, contributing to the unaffordability of low-income households. Also, it is challenging to define the housing cost ratio—what is spent on the overall housing costs to determine housing costs. Several studies suggest that measuring housing costs from shared household income should not be the only criteria to assess affordability. Therefore, adding to the most popular income-cost ratio, i.e., 30%, a new indicator of transportation expenditure, has been considered meaningful to measure housing affordability (Sabri et al., 2013; Yusoff et al., 2014), with the income-transportation costs ratio of 15%. These two expenses take the most significant portion of household income and can reveal various patterns of affordability, especially in locations with less accessibility to facilities (Dewita et al., 2018).

The Center for Neighborhood Technology (CNT) introduced the housing and transportation costs, or H+T costs, also known as location affordability (LA), which changed the dynamics of housing affordability criteria: Areas considered unaffordable for many years became affordable, and the affordable urban peripheries are now deemed unaffordable. Over time, studies show that urban form indicators such as distances from residential areas to the central city and transportation services, density, and service facility diversity could also be incorporated into the LA index (Cai and Lu, 2015; Coulombel, 2017; Smart and Klein, 2017). A study in São Paulo metropolitan region created an affordability measure of combined H+T costs that includes an opportunity cost related to commuting time (Acolin and Green, 2017). The study found that the proportion of households spending less than 30% on housing or less than 45% on the combined H+T has increased over time. Studies in the United States suggested a transportation affordability benchmark of 20%, having an H+T costs benchmark of 40%–50% (Guerra and Kirschen, 2016). One study in Paris also concluded that low-income groups preferred living in the city suburbs when considering only housing expenditure (Coulombel, 2018). However, integrating transportation costs into the calculation showed that moving near a city core eases H+T costs (Coulombel, 2018).

The LA studies determined that multiple accessibility measures, synergized with urban form indicators, are essential to measuring transportation costs. Smart and Klein (2018) attempted to criticize measuring LA using complex accessibility measures as independent variables to determine the dependent variable of transportation expenditure, which is "imperfectly predicted." Even though they used a simplified accessibility measure using data from the Panel Study on Income Dynamics (PSID), only a singular indicator drives the individual-based PSID data. Moreover, previous studies (Boarnet et al., 2011; Cervero and Kockelman, 1997) explicitly demonstrated that multiple accessibility indicators are necessary at various geographical scales to determine the impact of urban form on travel mode choice and travel behavior.

Recently, Makarewicz et al. (2020) attempted to improve the method adopted by Smart and Klein (2018) by doing two analyses on the same PSID data across US states. First, they looked for patterns in household incomes across various urban forms. Following this analysis, they conducted an Ordinary Least Squares (OLS) regression for multiple variant analysis to determine household transportation expenditure by taking urban forms, transit access, and household characteristics, as independent variables. After conducting an OLS regression analysis, the authors made several essential observations. Though mean housing expenditure was higher amongst households from urban areas, the mean transportation cost was higher amongst families from suburban areas with lower incomes (Makarewicz et al., 2020). Both Smart and Klein (2018) and Makarewicz et al.

(2020) analyzed housing and transportation costs using the same data, and both used only job accessibility, which is arguably not enough. Hence, it is essential to examine access to other non-work facilities such as education, health, transportation, and shopping to determine household expenditure comprehensively. Therefore, the current study in Rawalpindi-Islamabad Metropolitan Area (RIMA) aims to fill this gap using a household questionnaire survey.

The H+T relationship proposes that affordable housing developers and transportation planners must collaborate to optimally locate and establish mega affordable housing projects near PT services and other urban facilities. Besides developing affordable housing projects for disadvantaged groups, city planners face difficulties increasing service facility usage. Failure to upgrade the old city technologies might cause complications in implementing the infrastructure of citizens' choice (Angelidou, 2014). This hindrance could be due to residents who might consider services like PT unsafe, inconvenient, and time-consuming (Mulley and Moutou, 2015). The cities' sprawl associated with low-density neighborhoods might cause low or no access to essential service facilities, leading to long travel times and shifting to private vehicles (Mattingly and Morrissey, 2014). Therefore, Mulley and Moutou (2015) insisted that local city planners regularly encourage residents to utilize service facilities, ensuring attachment to the community, resulting in a good long-term relationship.

Travel patterns of any city vitally contribute to the decision-making of sustainable transportation planning. Transportation modes operating within the city also help develop an integrated transportation network, and many regional governments are making strenuous efforts to establish a balanced modal share to run sustainable transportation modes. The purpose of a modal split and the shifting between modes enable commuters to utilize a reliable and sustainable mode when making daily trips. Besides, a rapid increase in urban population has caused high private automobile demand, making the traffic and transportation systems precarious. The primary reason for high vehicle ownership is the lack of a prudent PT structure in developing cities that enables urbanites to pursue alternative means of mobilization. Other reasons such as a desire to own a car, status complex, spatial location, and lenient government policies for vehicle ownership also contribute to the large volume of private vehicles on the roads (Tabassum et al., 2017). Besides, a common mindset in developing cities is that PT mostly serves to transport only low- or no-income people, and high-income people are likely to travel in their private vehicles.

1.2. Research problem

The core problems identified in this research are the mobility and affordability constraints of RIMA residents at various geographical settings, especially when observing disadvantaged populations. Though developers, through public-private partnerships, have established several housing societies in RIMA, their definitions of affordable housing and overall affordability are extremely subjective since they target mid-income to high-income households. To respond to the high demand for affordable housing units for disadvantaged groups, city planners worldwide follow an international threshold to measure housing affordability, i.e., 30% (HUD, 2019). Pakistani urban planners have failed to clarify this threshold when developing housing societies and associated services. The publicly accessible Pakistan NHP 2001 excluded several urban indicators to determine an affordable location for housing comprehensively. Excluding households' preferences regarding housing location, satisfaction with the built environment, and access to service facilities restrict planners and developers from building low-cost housing at optimal locations. Pakistan needs updated affordable housing policies that can guide the relevant stakeholders, such as governments at national, provincial, and local levels and private entities that put effort into planning and establishing affordable housing schemes across Pakistan.

Furthermore, though existing studies have attempted to empirically investigate accessibility deprivation and place attachment to service facilities, their results are usually based on sociological and psychological models that neglect the concept of city and regional policy processes. To optimally increase service facility usage, it is essential to analyze household preferences, household characteristics, and degree of location attachment. However, previous service management studies usually focused on the performance and quality of urban facilities, ignoring the residents' attitudes towards access satisfaction and travel behavior and their comparison with the city-wide regions equipped with the service facilities.

1.3. Research hypothesis and research questions

Based on the conceptual and theoretical framework that captures the influence of geographical location and travel behavior on the access capacity to service facilities and the associated costs, this study has developed two major hypotheses; a) urban form influences households' decision of choosing a travel mode when traveling to their desired destinations and their access capacity to service facilities in RIMA context. Additionally, instead of using one facility as a proxy for multiple facilities to determine the access capacity, analyzing access capacity to multiple frequently used facilities and dividing them into their respective dimensions from small-scale to large-scale could provide a comprehensive understanding of the households' access capacity and deprivation if the proximity to such facilities is extremely low, and b) the results derived using LAI to determine the impact of travel expenditure on location affordability across the geographical regions of a city in most of the Western south-east Asian, and Middle-Eastern countries, would be different from the outcome in the RIMA context. In other words, the households facing the trade-off of higher housing costs and low transportation costs in the city center, and low housing costs and high transportations costs in suburban areas in RIMA, Pakistan, might not be consistent with the trade-off of the households in previous studies. RIMA's case study can unveal the unique insights to the factors effecting the transportation costs among low-income and well-off groups.

Therefore, this research is being driven by the following main research question and three sub-questions;

Main research question: To what extent do urban forms influence households' travel mode choice and location affordability in RIMA, Pakistan?

1. What factors influence travel mode choice to reach RIBRT?
2. Do households have high satisfaction with access to service facilities compared to the city-wide availability of such facilities?
3. To what extent LAI determines location affordability in RIMA context? What factors influence househod's transportation costs?

1.4. Research framework and dissertation structure

This section overlays the research framework this thesis adopted to promote the development of affordable housing in RIMA by revisiting the weak housing policies in Pakistan. The thesis structure is mentioned in Figure 1, followed by the dissertation framework in Figure 2. After the introduction (*Chapter 1*), the dissertation is organized in the following manner;

Chapter 2 provides empirical evidence of literature on BRT systems worldwide and how they provide accessibility when using informal paratransit services in developing nations. The importance of passengers' perception and their satisfaction when using BRT is also picturized in this chapter.

Chapter 3 highlights the importance of measuring the level of accessibility when planning to locate affordable housing for low-income people. Households' access capacity to urban facilities can determine whether they easily access desired facilities or feel deprived if the residence is located in an area with no or low access to service facilities.

Chapter 4 lays the foundation for the housing and transportation costs index, its fundamentals, derived concepts over time, and empirical evidence in global studies. It identifies the threshold researchers have used to measure housing costs, transportation costs, and combined housing and transportation costs out of shared household income.

Chapter 5 provides a detailed explanation of Pakistan's housing and transportation development conditions. It first gives an overview of urban development in Pakistan, describing the causes of rapid urbanization and the role of national, provincial, and local governments. Then, the state of policies and planning for affordable housing and transportation are highlighted in separate sections.

Chapter 6 provides the overall accessibility performance of BRT in RIMA. It highlights the description of socio-economic characteristics, travel patterns, and satisfaction levels when using various transportation modes to reach the RIBRT.

Chapter 7 demonstrates the spatial analysis to determine the citywide accessibility to service facilities from residential areas in RIMA. Then, a sub-analysis using a statistical model of household surveys was conducted to examine the household characteristics, access satisfaction with service facilities, and the degree of location attachment.

Chapter 8 highlights the empirical evidence of housing and transportation expenditure among RIMA households and the impact of urban form and travel behavior on these expenditures using statistical tools.

Chapter 9 closes the dissertation by summarizing the fundamental concepts used in this thesis and the empirical evidence based on the RIMA case study. It also provides detailed housing and transportation policy implementations to guide policymakers and developers, and inform other academics in similar fields.

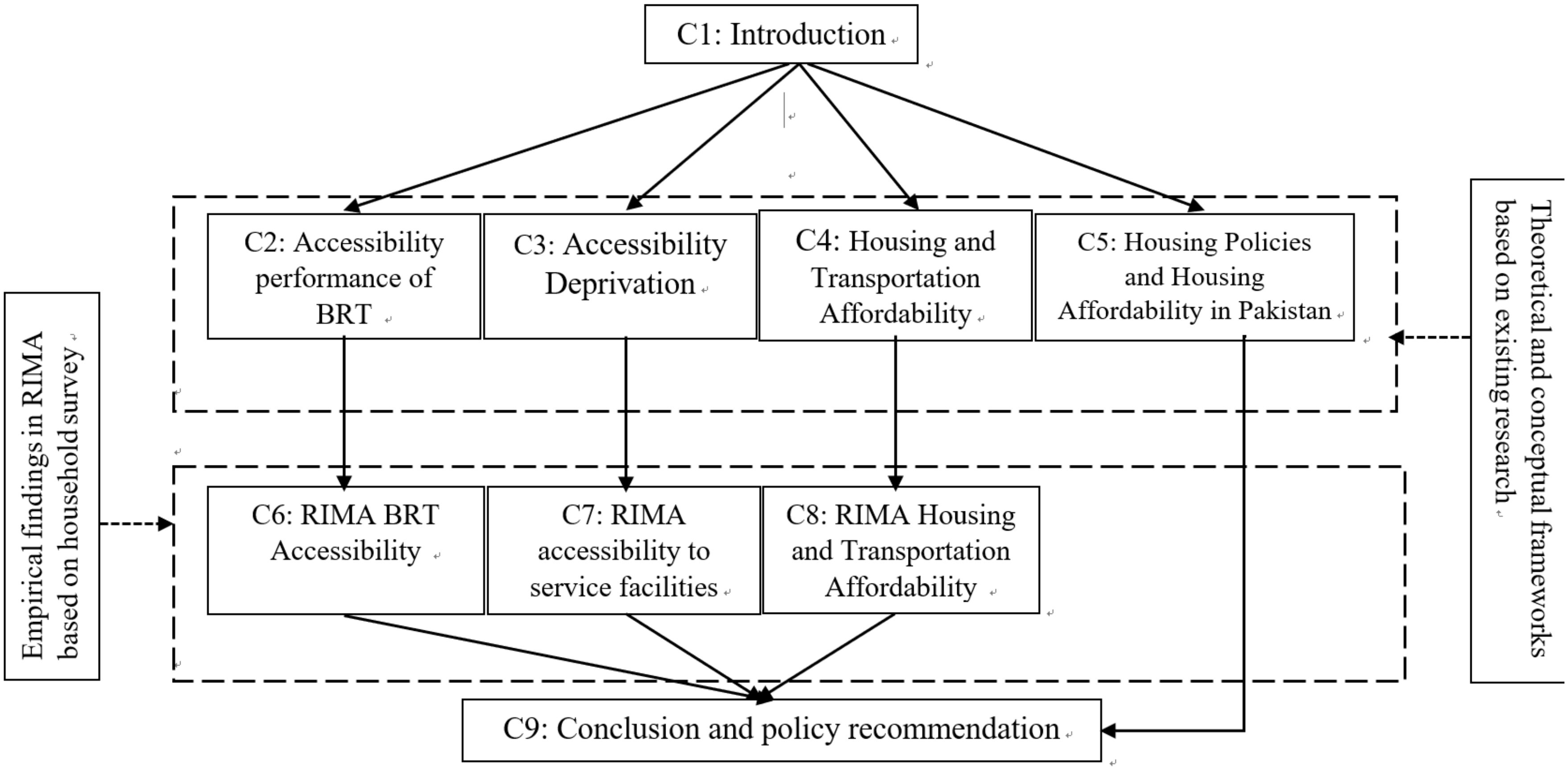

Figure 1 Dissertation structure
Note: C = Chapter; BRT = Bus rapid transit; RIMA = Rawalpindi-Islamabad Metropolitan Area.

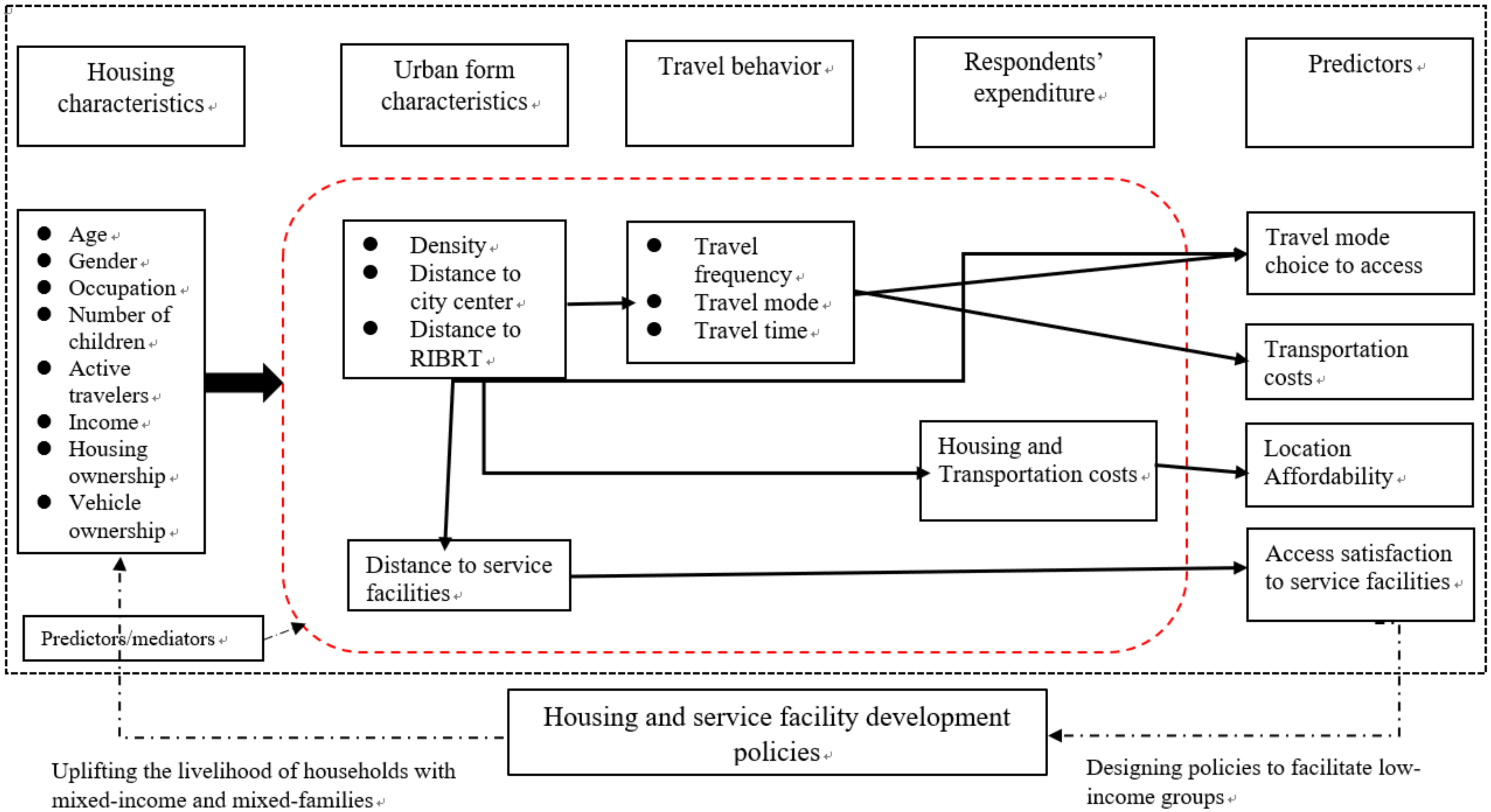

Figure 2 Research framework based on existing theories, concepts, and empirical evidence.
Notes: RIMA = Rawalpind-Islamabad Metropolitan Area; BRT = Bus rapid transit; H+T costs = Housing and Transportation costs.

Chapter 2: Accessibility to Bus Rapid Transit as Public Transportation Systems

"*The one thing we need to do to solve our transportation problems is to stop thinking that there is one thing we can do to solve our transportation problems*". (Robert Liberty)

2.1. Introduction

Many developing countries face a rapid increase in their urban population, which has caused a high travel demand, especially for private automobiles, making the traffic and transportation systems highly unstable. Susilo and Kitamura (2008) argued that the ownership and usage of cars affect the structure of urban settings and travel behaviors. The primary reason for high vehicle ownership is the lack of prudent public transportation (PT) structures in developing cities. Without proper access to PT, the urbanites pursue alternative means of mobilization: their private vehicles. Besides, it is common in growing cities that PT serves its purpose primarily to transport only low or no-income people.

Transport authorities in developing cities have installed a bus rapid transit (BRT) system as a high-quality rubber-tire system that delivers secure, cost-effective, and fast services in metropolitan areas (ITDP, 2019). BRT system consists of dedicated lanes with signal-free busways and well-designed stations aligned at the center of the roads. It also includes off-board fare collection to smoothen the operations. According to the BRT data, more than 160 cities have installed BRT due to its affordability and potential for stimulating urban growth (Global BRT Data, 2018). A few successful examples are Ottawa, Bogota, and Curitiba (the birthplace of BRT), where high-capacity feeder buses are well-integrated with the BRT systems for better accessibility from inner cities to the main transit stations.

BRT has proved to be substantially cost-effective in terms of money and implementation time (Carlos, 2010). BRT brings a unique image much different than conventional buses. Few developing cities such as Jakarta, Bangkok, Istanbul, and Manila have planned and implemented started phases of BRT infrastructure. This implementation should pay attention to regional issues, especially in a built environment that substantially contributes to the BRT's success. A BRT system can be successful if a strategy is made for a well-designed plan integrated with land usage for both transit and road networks (Satiennam et al., 2006). However, many developing cities implement

BRT without land use integration; it gives birth to many regional issues such as suburbanization, increases in traffic, and air pollution. Thus, achieving expected results from the BRT built in this state becomes nearly impossible.

2.2. Bus rapid transit (BRT) systems

BRT has received substantial attention from the policymakers in developing cities to mitigate transportation issues mainly because of its cost-effectiveness (ITDP, 2019) and "rail-like" characteristics (Levinson et al., 2003). These characteristics make BRT an affordable mass transit service (MTS) compared to rail transit systems. A complete BRT network consists of integrated high-capacity feeder bus services with the main BRT corridor, as seen in Bogota, Curitiba, and Ottawa (to name a few). The integrated feeder buses provide better access to BRT from residential areas, substantially increasing modal split (Levinson et al., 2003). However, some developing cities such as Beijing, Dhaka, Bangkok, Lahore, and Rawalpindi-Islamabad have established only a single corridor without any feeder network. As a result, the already existing informal incumbent transportation operators irregularly function as a feeder to transport commuters to BRT.

Since paratransit service popularity is growing in the developing world, several existing studies have also established encouraging policies to promote its usage both as a direct service and MTS feeder (Tangphaisankun et al., 2010; Satiennam et al., 2006; and Shafiq-Ur-Rehman et al., 2012). This promotion may be because paratransit can provide its services when needed, especially in a market that lacks regular bus services. It is a flexible and low-cost service widely spread in the city area for better coverage in developing regions. On the contrary, various studies discourage the usage of paratransit as an MTS feeder, stating that these services may be functional for the short term but might not be accepted as regular BRT feeders. This may be because these services are arguably unsuitable to be an integral part of any MTSs due to functional and operational gaps (Duarte and Rojas, 2012; Gilbert, 2008; Gomez, 2007; Tabassum et al., 2016). Though these services have the advantage of running in narrow streets to provide accessibility where high-capacity feeder buses cannot penetrate, only the highly dependent people are the loyal commuters despite showing satisfaction below the acceptable level (Cervero and Golub, 2007).

Additionally, if integrating high-capacity feeder buses with MTS such as BRT is not feasible due to planning and financial constraints, using the already existing informal paratransit becomes the only available option. Commuters' perception and trip satisfaction are essential to understanding the provided service level to formally integrate paratransit with BRT. In this way, transportation operators can improve the service quality of these paratransit services up to an acceptable level for potential integration with the BRT system. Unfortunately, literature about transportation policy and planning has not paid serious attention to the commuters' perception satisfaction level of using paratransit services to reach BRT. Moreover, focusing on the factors contributing to choosing paratransit or any other mode as a BRT feeder is also a handful.

2.3. Role of paratransit as BRT feeders: A compliment or a complication?

Whether paratransit can be an integral part of BRT even after the modification is still under debate when planning MTSs such as BRT. Transportation planners prioritize a comprehensive BRT network integrated with regular feeder buses without including incumbent informal paratransit to increase ridership. As evident in Bogota's case, before the launch of the BRT system called TransMilenio, Bogota's public transportation was filled with conventional paratransit such as micro and minibusses (Gilbert, 2008). During the first phase of launching TransMilenio, this system included paratransit operators as part of the formal transit service. The TransMilenio operators attempted to formalize the paratransit to improve their service standards. Those paratransit operators who did not live up to the drawn conditions by the significant stakeholders were then forced out of the main corridor lines (Gilbert 2008). Later on, with the expansion of the TransMilenio phases, the stakeholders and associations realized that this coordination among BRT and paratransit became the primary issue since it was not giving the expected results. Therefore, TransMilenio operators forcefully removed that paratransit and replaced them with formal high-capacity feeder buses over time (Gomen, 2007). Furthermore, the integration of BRT with paratransit is a complicated task because BRT requires regular planning and monitoring (Duarte and Rojas 2012). In contrast, paratransit operates relatively in the context of no planning and regulations.

Another example of a relationship between BRT and paratransit was well-documented in Santiago, which included the implementation of TransSantiago to modernize the public transportation system (Salazar, 2015). The study stated that paratransit operators were not interested in getting involved in this BRT system because they were private cooperatives. Paratransit operators were first included in the systems as a social responsibility similar to Bogota. However, after the implementation of extended phases, those operators could not accept the formal regulations of the BRT stakeholders, resulting in their relocation to the peripheral regions of the city (Salazar, 2015). Hence, new high-capacity feeder buses were launched as an integral part of the BRT system.

These examples mentioned above suggest that transportation policymakers may consider paratransit as an integral part of MTSs only if they strictly follow the regulations assigned by the stakeholders. Among many restrictions, some may include modifying and maintaining the vehicles and abiding by the schedule and routes. If these regulations are not followed strictly, the informal paratransit services are likely to be dismissed from the formal BRT system and forced to operate away from the main corridors. Nevertheless, the current state of paratransit in developing cities is considered below the acceptance level mainly because of the low service level, making it a complicated transportation service.

2.4. Survey-based passengers' attitude

2.4.1. Public transportation service quality

Previous studies have shown that evaluating customer satisfaction is essential to determine the customers' behavior towards perceived service across various industries (Petrick and Backman, 2002). PT is one of such industries that is utilized all around the globe; hence, a passenger satisfaction survey is a significant indicator to determine PT service quality (Aniley and Negi, 2010; Ojo, 2019), which affects the passengers' loyalty as well (Zhao et al., 2014). These surveys are usually employed to examine the satisfaction with specific service attributes that can directly reflect the overall PT performance. These attributes typically include (but are not limited to) on-time service, travel speed, travel time, service frequency, fare, safety and security, and cleanliness are some of the most commonly used attributes to determine the overall perceived service satisfaction. It shows that the product service highly influences the passengers' satisfaction, which fluctuates depending on the type of PT and its infrastructure. Mouwen (2015) found in the Netherlands' case study that metro users emphasized ride fares and on-board information more than the driver's behavior towards passengers and driving style. They concluded that the passengers showed higher satisfaction with cleanliness, reliability, and ride fares for bus services than for rail services. This result is worth noticing because the bus services in many developing cities show poor overall performance compared to rail-like services. One study of New York BRT found that service frequency, on-time performance, and travel speed are the highlighting factors (Wan et al., 2016). The study about Beijing Southern Axis BRT in China revealed that this BRT system not only positively influenced property value but received high satisfaction with the cleanliness, comfort, and reliability amongst captive users compared to choice users (Deng and Nelson, 2012). The study on two on-board surveys on Miami and Orlando BRTs also highlighted the importance of service frequency, reliability, comfort, and travel time (Baltes, 2003). Cao et al. (2016) found in their study on Guangzhou BRT that ease of use, travel safety, and comfort with waiting at the station are essential attributes to determining the overall BRT performance. They concluded that transit passengers showed satisfaction with rail service, followed by BRT and road-based bus services. The service attributes like the ease of use, ride comfort, service convenience, travel time, and comfort while waiting at the station contributed to the satisfaction difference (Cao et al., 2016). Research on BRT in twin cities, Minnesota, pointed out that transit operators must prioritize the service operation hours, safety while riding, travel time, and reliability to improve the overall BRT performance (Wu et al., 2020).

The studies above have shown that passenger surveys to measure BRT's service quality are essential to determine the transit system's performance and can be used for comparative assessment with other PT systems. Furthermore, the relationship between BRT service attributes and passenger satisfaction substantially helps to revise, improve, and establish new policies to enhance PT performance and passenger loyalty.

2.4.2. Accessibility via feeders

The service qualities and access to public transportation are linked directly or indirectly with life quality. Several studies, as mentioned in the preceding section, have attempted to set the parameters that reflect the commuters' perception of BRT service attributes to determine service quality and loyalty to the transit system in developed and developing cities (Eboli and Mazulla, 2007; Van Lierop and El-Geneidy, 2016). These qualities are set to compare the perceived satisfaction with the service quality promised by the public transport operators. However, most studies established interior service parameters such as cleanliness, safety, proper seating, female compartments, comfort while riding, and many more to determine BRT service quality. However, the exterior parameters such as the access capacity of the passengers to reach BRT via various modes, ease of transfer, waiting time at bus stops, travel time, travel speed, and passengers' overall trip satisfaction from home to BRT demand extensive exploration.

A handful of research evaluates the commuters' perception of accessing BRT using feeder modes. One study on Dhaka BRT (Shafiq-Ur-Rehman et al., 2012) attempted to integrate BRT with rickshaw services. They concluded that incorporating rickshaws with BRT remains challenging due to; 1) the vehicular structure of rickshaws, 2) the intricate BRT station designs needed for integrated operation, and 3) the distrust of paratransit among commuters in general. This research lacked survey-based perception to determine the service quality of rickshaws when using them as feeders to ensure that customers will remain loyal if the integration plan works. One research in Bangkok concluded that despite high dissatisfaction with paratransit service quality for direct trips, passengers showed a positive attitude towards paratransit as feeders for MTSs (Tangphaisankun et al., 2010). Moreover, the research suggested that improving safety, convenience, and comfort could increase commuters' satisfaction. However, this research also lacked commuters' overall satisfaction when using paratransit services, and the specific service attributes that affect the trip satisfaction were also not available.

2.5. Conclusion

This chapter focused on the accessibility towards BRT using other feeder modes such as informal paratransit services and the service quality based on the passengers' perceptions. It also highlights the fact that paratransit services around the globe are too complicated and low-quality services to be considered for integrating with mass transit systems such as BRT. Additionally, previous studies focused on the internal factors to determine BRT service quality, overlooking the external factors, i.e., accessibility. Therefore, examining the travel behavior of commuters using certain travel mode to access BRT to determine BRT accessibility performance and the impact on travel mode choice demands extensive attention. Such research in the global South, especially in Pakistan, is a handful. Therefor, it has become essential to conduct empirical research to explore the factors influencing the choice of using various transportation services as feeders for BRT in a developing city in Pakistan, which can be a lesson for other transportation planners in other developing states. The policies derived from such research can help improve the transportation system, enabling the car users to modal shift and increase the BRT ridership. This research in RIMA adds to this transportation literature by providing another perspective of commuters' perception of paratransit as BRT feeders.

Furthermore, appropriate improvement in the service quality of paratransit services may result in the integration of such services with BRT network, potentially stimulating land development around the transportation network.

Chapter 3: Does Relative Accessibility Deprivation Influences Access Satisfaction?

"The one argument for accessibility that doesn't get made nearly often enough is how extraordinarily better it makes some people's lives. How many opportunities do we have to dramatically improve people's lives just by doing our job a little better?" (Steve Krug)

3.1. Introduction

This thesis chapter focuses on the conceptual and theoretical framework of accessibility and relative deprivation faced by households when accessing service facilities in an urban area. It highlights the importance of measuring the level of accessibility when planning to locate affordable housing for low-income people. Households' access capacity to urban facilities can determine whether they easily access desired facilities or feel deprived if the housing is located in an area with no or low access to service facilities.

The Department of Economic and Social Affairs of the United Nations published "World Urbanization Prospects 2019," which detailed the rapid urbanization amongst the less and least developing nations over the past three decades (UN, 2019). Cities around the globe are now competing to provide enough resources, such as services, facilities, and infrastructure, to enhance their residents' quality of life (Jung et al., 2015). Zeng et al. (2019) argued that affordable housing for disadvantaged groups is essential as it is a fundamental element of the global housing development systems. For instance, Ibem (2013) stated that providing clean water, sanitation, electricity, and social infrastructure is key to building a healthy human settlement with an appropriate living environment. Such infrastructure development should meet residents' demands to foster citizens' connections to the services and the overall community. However, for these large-scale developments to succeed, a guaranteed number of regular users is critical. Mulley and Moutou (2015) cautioned that large-scale investments to develop service facilities sometimes fail to achieve the goal because such facilities cannot find regular users.

Because of rapid urbanization, both emerging and developing economies are launching mega-scale social housing programs. Buckley et al. (2016) stated that multi-billion dollars had been invested by 16 developing countries as subsidy programs in recent years. When planning to develop affordable housing for low-income people, developers traditionally locate them on the urban fringes, as seen in European and North American cities (Fenton et al., 2013). Social housing in the inner city of London has been slightly reduced, and private entities are helping disadvantaged households to meet their needs (Fenton et al., 2013). A study in France showed that only 10% of social housing was built in Paris, which hosts 20% of the French population (Wong and Goldblum, 2016). Developers face two hurdles when building affordable housing projects in city centers; high land costs and development permission covering large land areas (Chen et al., 2015; Libertun de Duren, 2018). An example of Beijing shows that more than 70% of the affordable housing projects were located on the city outskirts between 1999 and 2009 (Dang et al., 2014). Similarly, Brazil and Mexico cases are consistent in constructing affordable housing in the urban periphery (Libertun de Duren, 2018). If this practice of choosing urban fringes to develop affordable housing is continued, it leads to several social issues such as increase in poverty, income group segregation and poor access to service facilities (Ryan and Enderle, 2012; Woo and Kim, 2016), as well as the spread of fatal diseases and high crime rate.

Other countries worldwide are facing the same issues concerning the location of affordable housing. Previous studies are persistent in stating that local planning and developing authorities locate affordable housing where there is no access to other service facilities, as seen in Nigeria (Iben, 2013), China (Ma et al., 2018; Yang et al., 2014), Chile (Martines et al., 2018), and the U.S. (Woo and Kim, 2016). Though several studies spatially analyzed poor access to service facilities around affordable housing locations, they have targeted only one facility, such as health, food, or recreational facilities, in one case study.

Therefore, a substantial examination of the access capacity to several local service facilities to identify the effect of accessibility deprivation on the quality of life demands extensive exploration. Also, it is essential to identify the target population living in different geographical locations. Zeng et al. (2019) examined the accessibility deprivation amongst Affordable Housing Communities in Nanjing, China, using spatial and statistical analyses. Another study focused on household surveys in social housing units (Norris and Hearne, 2016). To date, however, no study targets the residential areas near the city center and mid-urban and suburban regions to understand the accessibility deprivation in various geographical locations. This RIMA study establishes the framework of the theoretical inter-relation between accessibility, deprivation, and location attachment to determine whether the current residential location provides better accessibility to service facilities, which in turn impacts access satisfaction and relative deprivation.

3.2. Global perspective on affordable housing development

Although there exists no common definition of affordable housing that is considered standard in the view of urban and housing planners, there are some common aspects well-recognized in many previous studies. Affordable housing is any type of housing suitable for low-income groups that meet the affordability criteria such as mortgage costs, rent, or total price. These low-income households do not feel pressured to relocate someplace else when they can decently afford a specific housing. In this way, they can actively participate in social activities, maintain a good livelihood, and experience upward mobility in social class over time. Even though academics and housing scholars have been persistent about the importance of affordable housing, housing policies and supply has remained a domestic issue.

The development of affordable housing across the cities in developed nations started soon after World War II Fenton et al., 2013; Gorczyńska, 2017; Woo and Kim, 2016), and because of being highly dense and populated, such cities experienced a revitalization of social housing more than the construction of new affordable housing (Fenton et al., 2013; Varady and Matos, 2017). Usually, public-private partnerships are the key element for the new housing supply, involving the modernistic housing design that can match contemporary planning and development trends (Norris and Hearne, 2016). It is worth mentioning that the housing policy specifications are widely different in many developed countries (Varady and Matos, 2017). The revitalization process also faced negative criticism in neglecting the expansion of services and opportunities for the disadvantaged households when penetrating the affordable housing projects in the urban peripheries, as observed in the US (Woo and Kim, 2016). Similarly, in the United Kingdom (UK), social housing units are marginalized in the outer cities due to social housing commodification and inner-city gentrification (Fenton et al., 2013).

In developing countries' contexts, affordable housing projects are being built at a large scale, having new designs for affordable housing development due to rapid urbanization and inequality (Buckley et al., 2016; Chen et al., 2015; Libertun de Duren, 2018). The governments are the dominating authorities when planning affordable housing development, followed by the private entities (Libertun de Duren, 2018; Zou, 2014). Since land costs in the central city are extraordinarily high, private entities locate affordable housing in the urban fringes (Dang et al., 2014; Libertun de Duren, 2018; Martinez et al., 2018), resulting in poor access to service facilities for low-income households (Ma et al., 2018; Martinez et al., 2018; Yang et al., 2014). Xu (2011) stated that the central government possesses the authority to choose local government officials and authorize the given actions, such as affordable housing development. However, when policies are designed, the location factor of affordable housing is usually neglected. After the mandate is in action, the local government must take responsibility for housing funds allocation (Tian, 2015). The central government usually initiates affordable housing development since local authorities are reluctant to take action (Chen et al., 2015; Zhou and Ronald, 2017), especially when developing affordable housing in the inner-city. The reason is that commercial and private housing infrastructure brings the most revenue (Tao et al., 2010; Wei and Chiu, 2018).

Consequently, projects like affordable housing, which bring in the most negligible revenue and take most government subsidies, are located in the urban fringes. In China, it has been reported that local governments have demolished deprived communities in central urban areas to make spaces for new commercial and other potentially profitable development (Shi et al., 2016; Stephens, 2010). As a result, those residents in deprived communities have no choice but to relocate to the supposedly affordable housing in suburban regions, jeopardizing job related travels and social interaction in the new neighborhood (Liu et al., 2017). The affordable housing residents in suburban areas reported high dissatisfaction with the built environment due to the insufficient access to PT and other service facilities (Huang and Du, 2015). Shen (2017) also insisted that such residents are at the brick of marginalization due to a lack of decent job opportunities in the suburbs.

3.3 Accessibility

Accessibility or the attempt to define accessibility began several decades ago when different perspectives were established, yet no concrete definition has been put forward. Cowan (2005) stated that accessibility eases neighborhood residents' access to services, goods, places, and other infrastructure in terms of urbanism. The UN Sustainable Development Goals (SDGs) designated accessibility to PT as a development indicator and defined it as convenient access to PT for a particular population (UN, 2021). Overall, these definitions indicate that accessibility shows how urbanites in a small city or a large metropolitan area can access services and facilities when made available.

Accessibility to particular urban facilities has become a measuring tool to assess the quality of housing units (Olawuni et al., 2007), residents' livelihood (Apparicio et al., 2008; Ibem, 2012), and service and facilities equitable distribution (Maroko et al., 2009). Knowledge and active research are increasing into the accessibility to various service facilities for residents of multiple characteristics across the globe. These research activities mainly focus on physical, financial, and economic accessibility. Apparicio et al. (2008) and Lotfi and Koohsari (2009) also focused on these types of accessibility. Lotfi and Koohsari (2009) argued that it is vital to consider the location of the residential area and the location of service facilities surrounding it to determine the quality of accessibility to service facilities. Physical accessibility explains the association of the population distribution and the supply of the services (Islam and Aktar, 2011). Therefore, measuring the service quality, distance to the services, service location, time taken, and cost when accessing the existing services or facilities is essential to determine physical accessibility. This study in RIMA concentrates on physical accessibility that consists of the spatial location of the residents and the distance covered to access various service facilities in an urban area.

Brussel et al. (2019) attempted to improve the Sustainable Development Goal (SDG) 11.2 in terms of transportation planning. They argued that this SDG indicator has some drawbacks, so they introduced two accessibility indicators using the case of the transportation system in Bogota. The SDG 11.2 indicator not only oversimplifies transportation demand but also fails to address inequalities as well (Brussel et al., 2019). Their findings highlighted that nearly 92% of the urbanites were able to access bus stops within 500 meters of walking distance, indicating high proximity to PT service in Bogota. The bus stop densities are much higher in the central city with commercial activities than in low-income neighborhoods (Brussel et al., 2019). This disparity also impacts access to job opportunities in suburban areas, i.e., only 20% could access jobs, causing long travel time when commuting to work.

Other studies connected accessibility with social exclusion, emphasizing the influence of a difficulty in accessing opportunities on residents' social participation. It means that low accessibility to jobs and other service facilities can be the potential indicator of social exclusion (Casas, 2007). Some studies indicated that the households experiencing day-to-day accessibility are complicated to measure using conventional accessibility indicators (Wang et al., 2020). However, activity-space-based[*] measures can capture robust interpersonal differences to help understand the accessibility differences in one population group (Wang et al., 2020). One study used activity-space-based measures to determine the segregation of the residents in public and private housing to examine the activity-space features and how much residents are exposed to the daily opportunities in a social environment (Wang and Li, 2016). Studies have examined the accessibility to services and facilities across social groups, i.e., women (Kwan, 1999), young

[*] Activity space is defined by Golledge and Stimson (1997) as "the subset of all locations within which an individual has direct contact as a result of his or her day-today activities".

individuals with disabilities (Casas, 2007), and ethnic minorities (Tan et al., 2017), using activity-space-based indicators.

Furthermore, previous studies have made essential advances concerning socio-spatial inequality and social exclusion, focusing mainly on a single service or facility. These services and facilities include public parks (Chang and Liao, 2011), health facilities (Zhou et al., 2020), exercise facilities (Hillsdon et al., 2007), and food (Kestens et al., 2010). However, the attention to comprehensively measuring the households' accessibility to multiple facilities is minimal due to a lack of relevant data identifying the number and types of service facilities in a specific geographical location. Additionally, the mere existence of the facility in a neighborhood does not state its importance because the worth of services and facilities varies among individuals. The importance of service facilities was examined using a household questionnaire in one study, which revealed that commercial facilities were of high importance, followed by education, health, and recreational facilities (Wang et al., 2020). Such studies are much needed in South Asian countries like Pakistan to perform a degree of accessibility to multiple facilities from residential areas. Also, a comparative analysis of city-wide accessibility and households' access satisfaction can help design affordable housing policies for low-income groups.

3.4. Deprivation

Researchers have defined "deprivation" as a socioeconomic concept that describes the lack of access to urban facilities amongst disadvantaged groups. Deprivation is measured either for a specific population in an area or a small society. The disadvantaged group is necessarily compared with the relatively well-off group to clearly understand the low-income group's deprivation. Though the measurement method for deprivation has changed over time, current studies focus on measuring the limited access to the various services ranging from food, clothing, transportation to education, housing, and other social services (Maguire et al., 2015; Ouyang et al., 2017; Yuan et al., 2018). The UK's Multiple Deprivation Index (IMD) and the Deprivation Index (NZDep) in New Zealand are popular indices used to measure deprivation.

Inequalities in access capacity to urban facilities affect people's overall living standards and physical and mental health, turning deprivation into multiple deprivations. For example, Maguire et al. (2015) showed that poor access to healthy food leads to over-consumption of less healthy types of food, leading to obesity. Xiang et al. (2018) showed that upward social mobility becomes harder to achieve with poor access to quality education. Therefore, poor access to various facilities impacts not only low-income groups' quality of life but also the overall development opportunities.

Previous studies have shown that establishing affordable housing at locations with little access to service facilities may result in social issues such as poverty, high crime rate, poor living environment, and low satisfaction level amongst low-income households compared to the financially strong group (Crook et al., 2016; Woo and Kim, 2016; Zeng et al., 2019). Most affordable housing planning and policies focus on providing appropriate housing units for the needy but usually overlook the provision of adequate service facilities for low-income groups (Woo and Kim, 2016). Furthermore, the residents' satisfaction with the overall built environment and housing location is often ignored. Additionally, studies that attempted to measure the overall accessibility to service facilities lacked development methodologies. Finally, most studies only used statistical analysis and not geographical analysis to determine accessibility level to service facilities. Since the studies have not focused on geographical analysis, city planners must focus on public opinion when locating public housing units or service facilities.

3.5. Location attachment

Researchers gave ample attention to identifying the contributing factors that constitute location attachment. Gustafson declared three aspects of place attachment: from one's within, interaction with each other, and interaction with the surroundings (Gustafson, 2001). Overall, the location attachment variables are deeply associated with the psychology and management of the environment since they explain how people react to an environment that they live in for a long time (Patterson and Williams, 2005; Scannell and Gifford, 2010; Trentelman, 2009). Additionally, sociocultural factors can also identify place attachment as they explain the "place identity" and "place dependence" that overall build the dan nature of the sociocultural dimension (Trentelman, 2009). Proshansky et al. (1983) identified a place identity as self-dimensions, meaning the physical arrangement of the combinations of a location. In contrast, Wijaya et al. (2018) referred to place dependence as the utility of a specific location, meaning whether an individual or a group can use the physical arrangement of that location in a way they desire. Nowadays, researchers are developing a model to synergize the interaction of place as a location to perform social activities and nature. Such activities can help one format self-identity (Davenport et al., 2010; Sampson and Goodrich, 2009).

Other than place attachment, previous studies have also examined community attachment, which explains how people connect with the residence location based on the level of socialization that creates an emotional attachment to their homes due to social relationships. The residents' behavior can show this attachment to a particular community within that location (Liu et al., 1998). The residents' behavior and community participation have been declared a benchmark to assess community attachment (Hummon, 1992; Sampson, 1988). Additionally, Gursoy and Denney (2004) suggested that community attachment can also be determined based on how individuals feel about their surroundings and whether they desire to continue living in that community or move somewhere else (Gursoy and Denney, 2004). Overall, studies have shown that one's attachment to a certain place or community and the criteria that provide values to the attachment is very complex and depends on the size, type, and class of the society, social interaction, participation, and residence duration.

Though studies have conceptualized accessibility to service facilities and the level of location attachment to some extent, both elements have been discussed in separate fields with different variables. Further, residents' access capacity to services or facilities, satisfaction level, and attachment to the residence location have not been explored in developing South Asian cities.

Therefore, we aim to integrate these elements by using the case of Rawalpindi-Islamabad, Pakistan, to spatially assess the city-wide accessibility level of service facilities to residence location and statistically examine the access satisfaction and location attachment. The results could also highlight what type of households are deprived of what kind of service facilities. These findings can help develop suitable planning strategies and housing policies to locate affordable housing units at optimal locations where services, especially PT, provide easy access to low-income groups.

This study introduces the term "location attachment," which is the same concept as that of place attachment, space attachment, or community attachment used in previous studies to explain the long-term bond of residents with the location that they are currently living in, as described by Giuliani and Feldman (1993). The term location attachment is part of a project examining the impact of travel behavior in an urban form on location affordability and location attachment. Those who live in a certain neighborhood for a long time tend to develop an attachment to that area and have a sense of belonging (Hay, 1998), making that place part of their self-identity, which shows the importance of the physical environment (Proshansky et al., 1983).

3.6. Conclusion

Given that this research is being conducted in response to an acute shortage of affordable housing in Pakistan, this chapter highlights the importance of housing location when planning to build affordable housing for low-income people. The literature review encapsulates the accessibility deprivation theories associated with the accessibility capacity of affordable housing households. These theories have been tested using various accessibility measures to examine relative deprivation. The literature begins with the affordable housing situation around the world and the role of local governments when locating affordable housing in the urban setting. Countries worldwide have defined affordable housing according to their social demographics and housing policies. Most studies stated that housing developers target suburban areas and city peripheries to locate affordable housing for low-income households, resulting in low access to various facilities. This low access causes accessibility deprivation and social exclusion, meaning that daily long travels to a destination disable the households from participating in a social environment, which ultimately impacts the attachment to the residential location.

This chapter highlights the studies that used various quantitative parameters to determine relative accessibility deprivation among households living in affordable housing. The findings can contribute to several prudent housing policies ranging from public-private partnerships and incorporation of accessibility indicators in planning documents to determining a fixed budget to maintain affordable housing in an area near services and facilities.

Chapter 4: Location Affordability (LA): Urban Form and Travel Behavior

"I would rather own a little and see the world than own the world and see a little of it". (Anonymous)

4.1 Introduction

Urbanization has been a growing phenomenon in developing nations for more than two decades. As a result, economic and spatial development has been restructured away from the city center, causing urban sprawl. This sprawl has led to an acute shortage of affordable housing for low-income people in proximity to service facilities, a substantial increase in vehicle ownership in the transportation sector proportionate to growing car usage, and a decrease in BRT access. Cunningham and MacDonald (2012) stated that housing could provide social and economic opportunities to households. When located in a proper neighborhood, this housing could provide advantages of goods and services, especially PT. Urban planners and policymakers consider housing a critical component since it takes a significant portion of the household's income.

Housing affordability is a complicated phenomenon consisting of housing costs, other expenses of standard living, and household income. These costs are often assessed using the economic indicators and overlook additional costs such as transportation and accessibility. Whitehead et al. (2008) highlighted that housing affordability is traditionally measured using only housing expenditures out of the shared income. Households spending <30% of the monthly income on housing would suggest housing location as affordability; however, if the household income range is in the bottom 40%, it would indicate that the household is facing affordability stress. Being easy to measure and with limited variables, the housing affordability criterion is adopted internationally in housing policies (Mulliner et al., 2013). However, the housing costs measuring approach has been criticized in the housing and transportation literature as this approach does not involve transportation and accessibility costs (CNT, 2012; Isalou et al., 2014; Mattingly and Morrissey, 2014; ITF, 2017).

The Center for Neighborhood Technology (CNT) of the Department of Housing and Urban Development (HUD) recognized the importance of transportation costs after housing costs and established the Housing Transportation Affordability Index to determine the affordability of households' residential locations. Later in 2013, this index, which consists of combined housing and transportation (H+T) costs, was improved to Location Affordability Index (LAI) after methodological flaws were fixed, and it received official approval for implication purposes (Haas et al., 2016). The LAI is a standardized affordability measure of residential location based on H+T costs for policymakers to strategically determine affordable sites for mixed-income groups. (HUD, 2017). The 45% of overall location affordability (LA) benchmark comprises 30% housing costs plus 15% transportation costs (HUD, 2017; 2019). This concept was not only utilized in developed cities such as Washington DC (CNT, 2010), Paris (Coulombel, 2018), and London (Cao and Hickman, 2017), but also in developing cities such as Qom city, Iran (Isalou et al., 2014), Mexico (Guerra and Kirschen, 2016) and Indonesia (Dewita et al., 2019). These studies showed that an area was affordable (<30%) for the households living in the city periphery when measuring only housing costs. Still, when combined with transportation costs, the expense rose to more than 45%, making it less affordable for the households in the same region.

Since transportation costs is highly associated with household income and residence location, it significantly affects low-income groups. Households usually make trade-offs by either prioritizing affordable housing in a less accessible area with high transportation costs or an expensive house in a city center with lower transportation costs (Fenton et al., 2013).

Besides the simple H+T costs measurement, policymakers and developers must consider other indicators that substantially influence households' H+T costs. These additional indicators include economic (Sean and Hong, 2014; Thaker and Sakaran, 2016), location (Olanrewaju et al., 2018), urban form (Źróbek et al., 2015), and housing structure (Teck-Hong, 2012) indicators that substantially influence buyers' and renters' decisions to choose a resident. The *housing indicators* by Mariadas et al. (2019) include housing price and family income, and rents. Additionally, Li et al. (2014) consider that payment period of length, mortgages, and interest rates are essential to purchase residential property. These factors showed a positive association with housing affordability (Zainon et al., 2017).

Housing locations greatly influence housing costs. The distance factor influences the buyers' or renters' preference in deciding the residential area (Sean and Hong, 2014). When housing units are located in the city periphery or less dense neighborhoods with a lack of proper access to urban amenities, it may seem affordable. However, the average long distances and car dependence for accessibility may burden the households with transportation costs (Currie, 2010; Mattingly and Morrissey, 2014).

On the contrary, houses in a high-density city center tend to have high rents and mortgages, having an average less travel distance to various facilities without depending on private vehicles

(Ewing and Cervero, 2010; Van Acker and Witlox, 2010). These housing costs gradually decrease with the increase in the distance from the city center (Mattingly and Morrissey, 2014), offsetting the transportation costs because households highly rely on private vehicles due to no access to PT. This dependence on personal vehicles correlates with multiple cars in one family and long daily travel distances and time.

The urban form attributes of the neighborhood have shown evidence of affecting housing affordability. Sean and Hong (2014) defined a neighborhood as the region where people with common interests live together. Usually, people prefer a neighborhood with a good built environment and low crime rates (Źróbek et al., 2015). Such neighborhoods positively influence housing prices since people show a willingness to pay higher prices to live in a high-quality community (Thaker and Sakaran, 2016). The urban form also impacts ones' travel mode choice when commuting to work, education, health, and many other facilities. This travel pattern, in turn, influences the transportation costs of one household.

Previous studies empirically identified housing structural attributes as essential indicators for buyers or renters in decision-making. These attributes include housing size, number of bedrooms/bathrooms, and a house garden (Teck-Hong, 2012). Hurtubia et al. (2010), Sundrani (2018), Opoku and Abdul-Muhmin (2010), and Chia et al. (2016) concluded that the number of bedrooms and bathrooms are significant parameters to buying a house due to privacy issues. These attributes mentioned above substantially share the H+T costs to construct the overall LA. Though this model is well-practiced in the northern part of the globe, no attention has been given to it in South Asian countries.

4.2 Global literature on location affordability: Empirical evidence of housing and transportation expenditure

Policymakers still consider affordable housing a critical challenge among government and private developers, and these challenges are even significant among low-income groups in developed and developing nations. Globally, several affordability measures are in use that have resulted in various outcomes, offering new housing schemes and public policies. Though location significantly impacts household expenditure on housing, developers are keen to establish affordable housing schemes in the city's outskirts with low connectivities with essential amenities, especially PT, since it hampers housing affordability. The poor supply of housing facilities impacts the housing service quantity utilized by the residents and the service prices, contributing to the standard housing that is usually unaffordable to many households. Many families cut off their non-housing expenses such as food, clothing, clean water, health, and quality education when facing affordability constraints with substantial private and social costs.

Countries around the globe have established different affordable housing programs depending on the location, household socio-demographic and economic indicators, and government support. One study contends that housing affordability should not be assessed based on housing costs out of the shared only short-run household income Abeysinghe and Gu (2011), and proposed calculating housing costs based on the lifetime household income. However, this approach may not work for other developing countries due to the unavailability of secondary data. Also, it is challenging to define the housing costs ratio that is spent on the overall housing costs that determine housing affordability for specific households. As mentioned in the previous section, the most popular income-cost ratio is 30%, meaning that if a household is spending <30% of their income on all the needed housing expenditures, the housing is considered affordable (Nepal et al., 2010).

Recently, a new indicator of transportation expenditure has been considered to measure housing affordability (Sabri et al., 2013; Yusoff et al., 2014). It is regarded as the second-largest expenditure after housing costs, showing a comprehensive understanding of the overall affordability in a neighborhood. One study stated that the combined H+T costs could reveal various patterns of affordability, especially in locations with less accessibility to facilities (Dewita et al., 2018). Several studies in Europe are consistent with the importance of incorporating transportation costs as it comprises three important indicators; vehicle ownership, vehicle usage, and PT. *Vehicle ownership* is the number of vehicles belonging to one household costing annual tax, maintenance, insurance, and sometimes parking. Vehicle usage costs are fuel consumption, toll fees, and parking fees. *PT* costs are usually monthly ride fares. PT is an essential pillar for building sustainable and smart cities, and better accessibility to such facilities has shown to be beneficial for disadvantaged groups (Miller, de Barros, Kattan, & Wirasinghe, 2016; Rayle, 2015).

The CNT first introduced LAI to improve the Housing and Transportation Affordability Index criteria. After improving the model for several years, CNT developed an online publicly accessible mapping tool that factored transportation costs in the housing affordability at small geographical scales (CNT, 2012). This index clearly showed that those areas considered unaffordable for many years became affordable, and the affordable urban peripheries were deemed unaffordable now. This shows that a house with a low price may not be considered affordable if it is located in an area with low accessibility to other services, especially when PT costs are high. Research has shown that accessibility is another essential measure that positively influences transportation costs from residence to work or other facilities regarding time and money (Cai & Lu, 2015; Coulombel, 2017; Smart & Klein, 2017).

After the H+T index or LAI has been introduced, several recent studies either employed this index or established a similar one based on the area or particular geographical conditions. A study in São Paulo metropolitan region created an affordability measure of combined H+T costs that also includes an opportunity cost related to the commuting time (Acolin and Green, 2017). They found that the number of households spending less than 30% on housing or less than 45% on the combined H+T has increased with time. Behrens and Venter (2005) conducted a study in South Africa and discussed that households spending 10% of their income on transportation is determined as affordable. Studies in America suggested the transportation affordability benchmark be at 20%, having H+T costs benchmark at 40-50% (Guerra & Kirschen, 2016). One study in Paris also concluded that low-income groups preferred living in the city suburbs when considering only the housing expenditure (Coulombel, 2018). At the same time, integrating transportation costs into the calculation showed that moving near a city core eases H+T costs (Coulombel, 2018).

Research in car-dominant regions concluded that housing located in city outskirts and peripheries are less affordable compared to the location near the city center, highlighting overall negative correlation between housing costs and transportation costs (Lau, 2013; Mattingly and Morrissey, 2014; Vidyattama et al., 2013; Wu and Zhao, 2015. This relationship proposes that affordable housing developers and transportation planners must collaborate to optimally locate and establish mega affordable housing projects near transit services and other urban facilities. Transportation costs are taking a significant portion of household income due to escalating fuel prices, especially in developing nations. Northern cities are striving to promote TOD policies to mitigate the H+T costs issue, and it is worth examining such issues to deliver affordable housing to low-income groups.

Even though the LAI has received criticism (Guerra and Kirschen, 2016), this concept is still growing. The LAI has been examined in various studies on housing choice vouchers (Tremoulet et al., 2016), TOD-induced transportation expenditure (Dong, 2019; Renne et al., 2016), neighborhood affordability and resilience of the housing market (Wang and Immergluck, 2019), foreclosure housing crisis in the US (Hartell, 2016) and neighborhood opportunity and LA (Acevedo-Gracia et al., 2016). Wang and Immergluck (2019) explored the relationship between

LA and US national housing foreclosure recovery by examining 300 metro areas. They concluded that high LA caused foreclosure decline in highly dense central cities compared to suburban areas. They suggested establishing affordable housing schemes near transit and determining more affordable locations near high-density urban markets. The housing choice voucher study highlighted that low-income participants could live in locations with affordable neighborhoods. However, the H+T cost analysis was somewhat inadequate, which could have been due to low transportation costs (Tremoulet et al., 2016).

Overall, recent studies have proven the significance of transportation costs and access to PT and other facilities when measuring housing affordability. This access to services in various geographical locations refers to location efficiency (Henry and Goldstein, 2010). Residents usually prefer making trade-offs between H+T costs when considering family income and access to facilities (Khamr, 2011).

4.3. Urban form, travel patterns, and location affordability

4.3.1. Urban form and location affordability

Most of the studies that have examined the interrelationship between transportation systems and land development, and the impact of transportation expenditures on LA among households at different spatial scales, have mainly focused on hundreds of United States (US) metropolitan areas. The LAI has also been proven instrumental when calculating housing affordability in different regions. Only two known studies—on Qom, Iran (Isalou et al., 2014) and Bandung, Indonesia (Dewita et al., 2019)—focused on the said interrelationship in developing cities. The study in Qom, Iran, used this index to validate Location Affordability (LA) measures among central and suburban districts (Isalou et al., 2014). Their descriptive analyses suggest that housing costs were much higher for central district residents (>57%) with proximity to several facilities. In contrast, the transportation costs and the combined H+T costs were much higher for the subdistrict residents with high access deprivation.

Furthermore, Dewita et al. (2019) incorporated urban form variables such as the distance to the city center and residential density to determine the affordability of a location by assessing the combined H+T costs. Their boxplot analysis indicated that housing costs among formal/private housing units are much higher than informal/public housing. The data envelopment analysis (DEA) concluded that government housing units and informal settlements were much more affordable than standard housing units (Dewita et al., 2019).

As stated earlier, H+T costs make up the most dominant expense of the household income. These costs are highly influenced by household characteristics, housing location, proximity to transit services, jobs, education, and other facilities that determine the travel mode choice. Smart and Klein (2018) argue that household characteristics stand out as dominant factors that significantly impact transportation cost in the LAI model compared to other urban form indicators, including a compact city center and mid-urban and suburban regions. They determine that transit and other urban attributes can significantly affect transportation costs when controlling for household characteristics. Similarly, other studies have also shown consistent empirical results that, though urban form attributes are essential to the calculation, they are secondarily crucial to individual and household characteristics (Ewing and Cervero, 2001; 2010; Stevens, 2017).

The LA studies determined that multiple accessibility measures, synergized with urban form indicators, are essential to measuring transportation costs. Smart and Klein (2018) attempted to criticize the practice of measuring LA using complex accessibility measures as independent variables to determine the dependent variable of transportation expenditure, which is "imperfectly predicted." Even though they used a simplified accessibility measure using data from the Panel Study on Income Dynamics (PSID), only a singular indicator drives the individual-based PSID data. Moreover, previous studies (Boarnet et al., 2011; Cervero and Kockelman, 1997) explicitly demonstrated that multiple accessibility indicators are necessary at various geographical scales to determine the impact of urban form on travel mode choice and travel behavior. That is why regressing only job accessibility is not enough, and analyzing access to other non-work facilities such as education, health, transportation, and other facilities is essential. Using household surveys to investigate the impact of travel patterns on public facilities and transportation expenditure, the current study in RIMA aims to fill this gap.

Recently, Makarewicz et al. (2020) attempted to improve the method adopted by Smart and Klein (2018) by doing two analyses on the same PSID data across the American states. First, they looked for the patterns in household incomes across various urban forms. Following this analysis, they conducted an Ordinary Least Squares (OLS) regression for multiple variant analysis to determine household transportation expenditure by taking urban forms, transit access, and household characteristics as independent variables. With 8,004 samples in hand, they divided the households into four blocks (urban, mid-urban, suburban, and rural), with suburban being overrepresented in the overall sample. After conducting OLS regression analysis, they made several essential observations. Though mean housing expenditure was higher amongst households from urban areas, the mean transportation cost was higher amongst families from suburban areas with lower incomes (Makarewicz et al., 2020).

Furthermore, the H+T cost trade-off results support the hypothesis of LA, stating that the H+T costs decrease from suburban/rural to urban areas. It shows that housing prices fluctuate with the availability of neighborhood opportunities. However, the neighborhood opportunity and housing affordability trade-off among low-income families with children is a weak relationship (Acevedo-Garcia et al., 2016). Other than income, status as a single parent and a couple without children also influence transportation costs. Deka (2015) analyzed the Consumer Expenditure Survey (CES), which showed that single-family owners of detached housing spent more on H+T costs than the single-family owners of attached housing, who spent less on transport. This furthers the research on the high housing costs burden associated with the tendency of households to make a trade-off by paying for housing and other necessary child-related commodities such as food, clothing, education, and health. Chetty et al. (2015) argued that children under 13 years of age living in low-poverty neighborhoods have better academic records, resulting in better income than their high-poverty neighborhood counterparts. This pattern is supported by substantial evidence showing capitalization on high-opportunity neighborhoods resulting in higher overall housing prices. However, the proof of neighborhood trade-offs with transportation costs is limited.

Few studies have paid attention to the relationship between TOD neighborhoods and transportation costs, while there have been extensive studies focusing on the travel pattern differences within and outside TOD areas. This is possible because household transportation costs cannot be easily obtained micro-spatial (Smart and Klein, 2018). That said, the LAI is the most comprehensive tool to determine relative affordability in different housing markets using the available H+T cost information.

4.3.2. Urban form and travel patterns

Other than household characteristics and urban form indicators, numerous researchers have empirically assessed and determined that built environment indicators such as walkability, proximity to transit services, educational and health units, and other recreational facilities determine travel mode choice and travel behavior. Several studies have referenced Cervero and Kockelman (1997) and adopted the three Ds—density, diversity, and design—and included a fourth 'D'—demographics. The synthesis of fifty studies done by Ewing and Cervero (2001) clearly shows that socioeconomic indicators have a primary influence on trip frequency compared to the built environment. However, the built environment indicated a more substantial impact on trip length. Thus, the built environment remained dominant when assessing the overall and cumulative vehicle mileage traveled because the built environment affects the trip length and travel mode choice.

Though most empirical methods examining the interrelationship of the built environment and travel patterns have no concrete conclusions, some concepts have been globally accepted. Two studies argued that the jobs-housing distance becomes shorter with higher population density, and the modal split to transit and walk increases (Hui and Yu, 2013; Kim and Brownstone, 2013). Similarly, mixed land use with high-opportunity neighborhoods enables residents to walk to work (Ding and Lu, 2016). Better road connectivity in an urban setting increases green travel modes (Sung et al., 2014), allowing residents to access multiple facilities during the same trip (Choi and Zhang, 2017). Though some TOD studies have stated no significant relationship between TOD neighborhoods and car ownership, it has been shown that moving to transit-rich areas significantly reduced car usage (Cao et al., 2019; Chatman et al., 2019). These studies have continuously proven that locally built environment characteristics influence household characteristics and their travel patterns. This is because the density of public facilities, such as education, health, shopping, and entertainment, varies in different neighborhoods, depending on the distance away from the city center. By looking at these studies, RIMA also shows a similar case since the public facility densities are markedly gradient when moving toward the city center.

Mouratidis et al. (2019) argued that qualitative and quantitative studies had formalized the rationales, motivations, and drawbacks affecting the built environment's association with travel patterns, indicating a causal relationship between the two rather than only a correlation. Regardless, this emerging literature on urban form, travel patterns, and neighborhood income disparity has primarily focused on Western societies. For example, studies in US metropolitan areas showed that job accessibility and the travel mode used significantly impacted transportation expenditure (Makarewicz et al., 2020; Smart and Klein, 2018). In contrast, only a handful of empirical analyses took place in the global south. This dearth of investigation calls for an extensive exploration of H+T costs integrated with the urban form in developing nations since the urban form's association with LAI is still a new and complicated topic.

4.4 Conclusion

This thesis chapter examines the theoretical, conceptual, and empirical literature related to housing and transportation affordability and the impacts of urban form and travel patterns on household expenditure. The established research globally associated with H+T costs and urban form indicators has shown that incorporating transportation costs in the household monthly expenditure is essential to determine whether a household with specific attributes could afford housing depending on the location. The H+T Index and the improved LAI have contributed significantly to comprehensively measuring housing affordability and facilitating urban planning to enhance affordability with better resources.

Nevertheless, the investigation on the impact of the combination of the H+T costs of LA is minimal. Also, the definition of housing affordability and transportation affordability and the measuring parameters varies in different studies conducted in various metropolises, substantially affecting the outcome and the policy implications. Though the Melbourne, Australia study divided the transportation costs based on weekday travels and weekend travels, it did not consider the households' travel frequency. Such studies are in great demand in metropolitan cities in Pakistan, experiencing rapid urbanization and a low supply of affordable housing. This study in RIMA contributes insight into the developing region to analyze H+T costs comprehensively, household characteristics, and travel patterns with family income across neighborhood differences. It improves the H+T costs analysis by introducing the travel frequency indicator, which details the travel patterns of one household in different regions. Additionally, this study does not use only job accessibility as a proxy for other facilities to measure the influence on household expenditure. This proposed measure has the policy and planning that robustly determines the location affordability for a reasonable supply of affordable housing, service facilities, and PT.

Chapter 5: Housing and Transportation Deprivation in Pakistan: Case Study of Rawalpindi-Islamabad Metropolitan Area

"Need affordable housing. Why? Because the strong economy actually drives up rents and those people who are at the bottom of the income spectrum or on fixed incomes can't afford rent". (Andrew Cuomo)

5.1. Introduction

This thesis chapter provides a detailed explanation of Pakistan's housing and transportation development conditions. It first gives an overview of urban development in Pakistan, describing the causes of rapid urbanization and the role of national, provincial, and local governments. Then, the state of policies and planning for affordable housing and transportation are highlighted in separate sections. The literature gathered comprises government reports, reviewed articles, and empirical studies. A small sample of published reports and review articles demonstrate the urban development issues and the provision of affordable housing and transportation in Pakistan as it faces rapid urbanization. Thus, a significant lack of empirical studies examining low-income households' housing affordability issues based on social and economic factors, residential satisfaction with their current housing, and attachment with the residential built environment. In the case of transportation studies, several empirical studies have explored the transportation issues among different social groups to construct suitable policies for potential improvements. This study can also help spread awareness amongst all the sectors responsible for urban development in Pakistan and other developing nations.

Pakistan faces substantial pressure from urbanization to host more than 200 million people. This number is increasing at a 3% yearly growth rate, which is estimated to rise to 380 million by 2050 (Kugelman, 2014a). This rapid growth rate means that government should ensure necessary resources concerning infrastructure, food, health, and education in urban areas since they contribute to nearly 80% of the country's gross domestic product (GDP) (Karrar and Qadeer, 2013). Pakistan is one of the South Asian countries facing rapid migration to large metropolitan cities for high-quality job and education opportunities. It is incredibly challenging to provide adequate housing infrastructure to help those in need (Malik and Wahid, 2014). The developed countries' human sources are considered an asset for the city development, and in the same manner, cities tend to provide them with proper housing with the influx of the human source. Though planning and developing groups in Pakistan are striving to improve the conditions of slums, they do not pay attention to the inevitable rise of the informal squatter settlements due to the migration of new groups and becoming urban poor (Malik and Wahid, 2014).

It is not ideal for a city to stop urbanizing, as it may restrict it from social and economic development. However, urbanization without planning reduces the friction of slum and informal squatter colony development, illegally occupying government-owned land simply because of the low affordable housing stock (UNHSP and UNESCAP, 2008). That is why cities must provide the urban poor with an adequate supply of housing and transportation infrastructure, health, education, green space, and many more facilities to keep experiencing prosperity. This migrated group of urban poor consists of low-income people, individuals, or family holders from rural or underdeveloped cities who seek to experience a better lifestyle. Currently, Pakistan faces a substantial deficit of more than 10 million housing units, with existing affordable housing being below satisfaction level (Jabeena et al., 2015). In addition, the current transportation services across the country entail insufficient structure, low-quality service, inaccessibility to people living further away than walking distance, and unfriendly to different social groups, resulting in various issues such as social exclusion and opportunities for jobs, and high-quality education.

The housing deficit speaks to the immediate improvements in current housing policies to meet the housing supply. The delay in establishing affordable housing projects raises speculation among the public that local governments are not interested in enhancing the livelihood of low-income households; instead, focusing more on the political agenda to remain in office. Therefore, collaboration and innovation are needed across policymaking and developing authorities to establish an effective mechanism for building urban infrastructure, with affordable housing at priority since it facilitates a large labor force. These houses can significantly contribute to economic growth by reducing poverty (GoP, 2015). Social science researchers also stress that research on housing demands, residents' satisfaction with housing conditions, and built environment is a handful and must be explored.

5.2. Urban development in Pakistan: Are we cursing urbanization?

UN-HABITAT and UNESCAP (2008) described urbanization as natural population growth and the cause of rural to city migration. This phenomenon comes with job opportunities and the demand for housing and commercial facilities. Why do people desire to move to metropolitan and developed cities instead of living in the rural or suburban regions? Many suggest that cities are the only places that possess the recipe for keeping urbanites' incomes high. Infrastructure ranging from transportation and residential areas to health and recreational facilities provides enough reason to attract people of different social groups. Asia is the only continent experiencing rapid urbanization, with Pakistan as the fast-growing nation in the Southern part of Asia.

Current statistics show that the urban poor is increasing considerably in the global underdeveloped and developing nations compared to the relatively standard pace of urban population growth in other countries. One study shows that 72% in Africa, 43% in the Pacific and Asia, 32% of the urban population live in slums in Latin America, and 30% in Northern Africa and the Middle East (Jaitman and Brakarz, 2013). Urbanization in Pakistan is growing 3% annually, making it the fastest-growing nation in South Asia. It has been estimated that Pakistan's urban population will increase to nearly half from one-third by the end of 2025, and a study using density-centered estimates states that urban peripheries have already reached 50% (Planning Commission of Pakistan, 2011). Urbanization in Pakistan shows a promising future but also seems to be problematic: it contributes to the country's economic growth with job opportunities with a wide range of corporates and provides high-quality education opportunities in various disciplines (Kugelman, 2014b), but it can put the already frustrating labor market under immense burden if the cities are not equipped with necessities such as accessible employment, housing, and transportation infrastructure, education, health, and recreational facilities. Failure to address these concerns can restrict human development, resulting in a weak contribution to the economy and society.

5.2.1 Urbanization and growth

This section of the chapter reviews a portion of the United Nations Development Program (UNDP) report, *Development Advocate Pakistan* since little research is available in Pakistan empirically assessing the urban growth of Pakistani metropolitan cities. The report advocates that urbanization positively influences innovation in technology and the economy (Hassan and Malik, 2018). However, many developing countries experience urbanization without economic growth; instead, it can be recognized with prudent public policies (p. 12). If not planned and managed correctly, cities can become urban slums with concentrated poverty and inequality. Though the Pakistani government focused on vertical housing development to control urban sprawl, the government must consider the negative consequences entailed by their vulnerability to natural disasters (p. 12). Energy-saving insulation, parking, sports, and recreational facilities must be supplied to successful high-rise projects.

More importantly, fast-growing cities usually demonstrate a well-functioning governing structure. Powerful and well-organized governments contribute substantially to the cities' economic growth because such authorities generate decent revenues on their own and provide other urban amenities (Hassan and Malik, 2018). Pakistan is the sixth most populated country in the world and in the category of the fastest urbanizing economy. Figure 3 highlights Pakistani cities with higher growth rates than the national growth rate of 2.77% and the population increase from 1998 to 2017. It shows that at 6.12%, Lahore is the fastest-growing metropolitan area, followed by Peshawar at 5.29% and Islamabad at 4.83%. However, it is unfortunate that Pakistani cities have yet to develop an organizational structure that mandates and is financially self-sufficient, putting incredible pressure on the local governments with scarce urban resources.

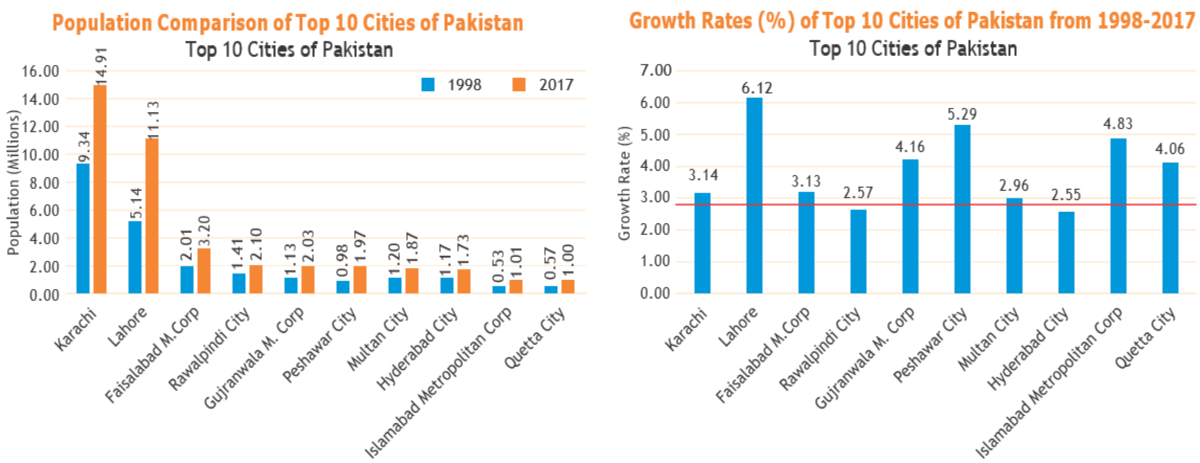

Figure 3 Comparison of population and growth rate in 10 Pakistani countries
Source: Pakistan Bureau of Statistics (2017)

5.2.2. Is urbanization a curse for Pakistan?

Urbanization is considered a blessing in the developed world, which is not the case in developing economies such as Pakistan. Pakistani metropolitan cities are experiencing aggressive sprawl, exhibiting a low density of 6,000–10,000 people per square kilometers (sq-km) against the urban centers in developed countries, where densities have risen to more than 500,000 persons per sq-km (Hassan and Malik, 2018). This low density is causing the service facilities to be less accessible for different social groups, and the problem is growing with unmet housing supplies due to limited financial resources, making the area unlivable. The situation is worsened with the takeover of informal squatter settlements, mobility constraints, and environmental pollution. Moreover, the suburban areas are not embedded in the definition of "urban," as these areas tend not to exceed the population of 30,000, which is the benchmark of being considered urban. Governments also keep the infrastructure finance expenditure to the minimum because the developers would have to finance the mega structures and service facilities if the area is considered urban.

Global cities create a pool of talented and skillful youth through urbanization to efficiently turn it from being challenging into an opportunity. When interacting and researching together, these brains become the catalyst for technological innovation and economic growth. In the case of Pakistan, which contains the largest youth population, i.e., 130 million (GoP, 2011), and is experiencing a large influx of this group into a developed urban area, the economic agglomeration is mainly in the informal sector. This rise in the informal sector could be because a significant proportion of this group comes from rural areas with low education and low skills that are insufficient for production and economic growth and are eventually incorporated into the burden category. That is why the policy and planning experts should realize that this is a critical moment to revise the strategies for urbanization to become a complement to cities' prosperity.

Perhaps it can be said that urbanization is not a curse for the developing nations per se. Instead, the absence of well-structured government authorities collaborating amongst the planners and the developers to welcome urbanization with preparedness is the primary challenge. Hence, fully capacitated and integrated institutions bring true policy implementation success when dealing with modern urban management issues. Therefore, policymakers must initiate the collaboration to enhance civic participation, harnessing the urbanization benefits.

5.3. Affordable housing policies and households' affordability complex: What was promised and what was delivered.

5.3.1. How to define low-income households in the Pakistani context?

One government report focusing on Punjab housing schemes and one study that conducted interviews with government officials defined those urbanites earning less than PKR 25,000 as low-income households (GoPb, 2014; Hadeem et al., 2016). One study set the benchmark between PKR 14,000 and PKR 30,000 as the income criteria for eligible target groups on an emergency list of affordable housing provisions (Figure 4). Malik et al. (2019) compiled data on affordable housing and showed that several housing projects in Punjab consider households with PKR 30,000 as eligible groups (Table 1). This table shows that the housing sizes ranging from 3 marlas to 5 marlas are for households earning around PKR 30,000. These conditions are central parameters for mitigating low-cost housing issues, provided the complex institutional framework is well addressed, and it monitors the construction costs depending on the housing size.

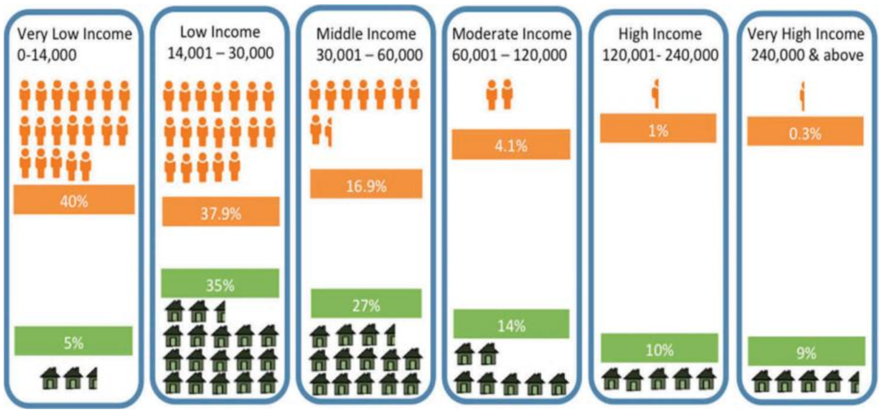

Figure 4 Overview of different income groups in Punjab in relation to the housing shortage.
Source: UrbanUnit (2018)

Table 1 Low-cost housing schemes corresponding to the households' income

Public low-cost housing schemes	Income criteria for eligibility	(Rs/month) House category
Ansaar Model City, 2008	PKR 30,000	3-marla houses
Ashiana Quaid Lahore, 2011	PKR 20,000	2-marla and 3-marla houses
Ashiana Housing Scheme, Faisalabad, 2012	PKR 30,000	5-marla plots and 3-marla houses
Ashiana Housing Scheme, Sahiwal, 2012	PKR 30,000	5-marla and 3-marla houses
Ashiana and Iqbal, Barki Road, Lahore, 2016	PKR 50,000	500, 600, and 700 sq ft apartments

Note: 2 marla = 450 square-feet (sq-ft), 3 marla = 675 sq-ft, 5 marla = 1125 sq-ft.
Source: Data compiled by Malik et al. (2019)

5.3.2 Why is Pakistan facing an affordable housing crisis?

Previous studies have clearly stated that the neglect from national and provincial governments is the root cause of the affordable housing crisis, and they have discussed the chronic challenges through a multi-dimensional lens. The need for effective institutional frameworks (Shah and Afridi, 2007), attention to housing at a local level while ignoring the national and regional levels (Ahmad and Anjum, 2012), and for housing policy revision to establish housing markets (Tariq et al., 2018) has been thoroughly discussed. Pakistan's population density rose from 48.7 pp/sq-km in 1950 to 286.5 in 2020 (UN, 2019). Even with this fast growth rate, the housing development is around 0.15

million units against 0.35 million demanded housing units in urban areas (Hasan and Arif, 2018). This significant shortage is mainly because of inappropriate housing policies, finances, and planning, resulting in inaccessibility to the urban facilities and giving birth to slums and sprawls.

The federal government is the primary entity that formulates the Five-Year plans for urban policies under Physical Planning and Housing (PP&H), receives foreign aid, and distributes development budgets to provincial and local governments. One study analyzed Pakistan's urban policies and concluded that the housing sector is left behind in terms of budget allocation in one of the Five-Year plans (Qadeer, 1996), as seen in Table 2. Furthermore, the attention to development policy programs gradually shifted from affordable housing development to the expansion of infrastructure related to community utilities, especially for government ministers and bureaucrats (Qadeer, 1996), probably because of the sheer lack of political will from the government side, causing catastrophe amongst public institutions. This lack of development policy programs resulted in the emergence of the private corporation to take responsibility for filling the gap in affordable housing demand.

Table 2 Policy initiatives in Five-year gaps

Policy initiation at the federal level	**Year**	**Main objective**
5-year plans	Every 5 years	To maintain fiscal allocations for development in each sector
Housing Building Finance Company (HBFC)	1952	To provide housing loans and financial assistance for affordable housing
National Housing Policy (NHP)	2001	To provide guidelines toward sustainable housing markets
Housing Advisory Group (HAG)	2002	To implement NHP
Vision 2025	2014	A housing information system will be established to provide data on housing supply and demand

Despite formulating several Five-Year plans for urban policies, most remained incomplete or were never initiated because of several internal and external limitations. First, unstable political regimes, domestic wars, and several military martial laws suspended activities under public institutions; instead, the housing planning departments that were acknowledged as provincial government operations were taken over by the central government due to military ruling (Qadeer, 1996). Second, the geographical location of Pakistan plays a significant role in the complex political economy. International wars and the large influx of Afghan refugees between 1980 and 1990 due to the war on terror markedly resulted in the population growth of Sindh and Khyber Pakhtunkhwa (KPK) provinces (Kugelman, 2013).

The Government of Pakistan formulated the NHP, addressing the national housing issues and the parameters to resolve them through leniency in taxation and stipends, support for private builders, and public-private partnership (GoP, 2001). Later on, the Housing Advisory Group (HAG) was established in 2002 to monitor the implementation of NHPs, which also took the role of sustainably providing affordable housing at the provincial level. One study argued that the inability of households to buy a house or any urban property is because of the absence of affordable housing policies, continuous increase in land prices and construction costs, and considerable investment in private real estate (Islam, 2015). Subsequently, the observed expansion of informal settlements or slums is a result of the unacceptable performance of the provincial government in affordable housing provision (Malik et al., 2019).

5.3.3. Current state of housing policies: Promised vs. Delivered

The official NHP 2001 is still in use, emphasizing resource mobility and small mortgage loans initiation through local institutions (GoP, 2001). It also calls for the refinancing of housing projects through international aid from agencies such as the World Bank (WB), Asian Development Bank (ADB), and Japan International Cooperation Agency (JICA). Additionally, the NHP not only encourages the construction sector to build low-cost housing for low- and middle-income households but also discourages the displacement of families living in informal or slum settlements until housing is allocated for relocation. Several political parties have promised to deliver affordable housing schemes over the years, but very little has been achieved (Table 3). These policies only supported the building sectors in terms of finance, tax reduction, and expansion of informal settlements through regulations. The NHPs insist that the provincial governments apply legislative measures for the administrative sector to implement effective policy so that lower and middle-class households can benefit from it. However, since many in the middle-class lack collateral and government jobs, they are unable to acquire a loan to purchase residential land or already built housing. Further, high-interest rates on such loans usually make property unaffordable for poor households. Due to neoliberal housing and economic policies, families tend to approach the market that is now dominated by private tycoon developers such as Defence Housing Authorities (DHA), Askari, and Bahria Town (BH).

Table 3 Performance of political parties in the provision of affordable housing in Pakistan

Political Parties	Housing Projects	Results	Causes
Pakistan People Party (PPP) during the reign of Shaheed Benazir Bhutto in 2008	• SBBHC to facilitate around 15,000 families; • Allocation of 350 acres of land across Karachi; • Challans (Offical payment receipts) worth PKR 170 million were issued in 2016.	• SBBHC did not acquire the promised land; • Hyderabad: PKR 4.6 million were to be paid to land utilization department to cater to 300 families, but did not happen; • Mirphukhas: 12 arces of land for 200 families and 5 acres for 120 families, but no operation.	• The required payment and the transfer of land ownership was delayed; • Financial irregularities; • No administration.
• Pakistan Muslim League (PML-N) during the reign of Nawaz Shareef in 2013	• Apna Ghar Housing Scheme; • 1000 cluster for 500 houses each within five years.	• Only PKR 10 million were allocated against the request of PKR 350 million;	• No chief executive officers and related staff to manage the projects; • No government will.
• Pakistan Tehreef-e-Insaf (PTI) in the reign of Imran Khan (*current government*)	• 5 million houses across Pakistan.	• Failed RMT development under PDA; • Out of 26,000 allocated housing plots, only 600 houses were built; • Only water and electricity are available to the residents; • Promise of cooking and heating gas provision, still not delivered.	• PDA accused of using allocated money on other projects.

Notes: SBBHC = Shaheed Benazir Bhutto Housing Cell;
RMT = Regi Model Town;
PDA = Peshawar Development Authority;
Source: Hasan and Arif (2018).

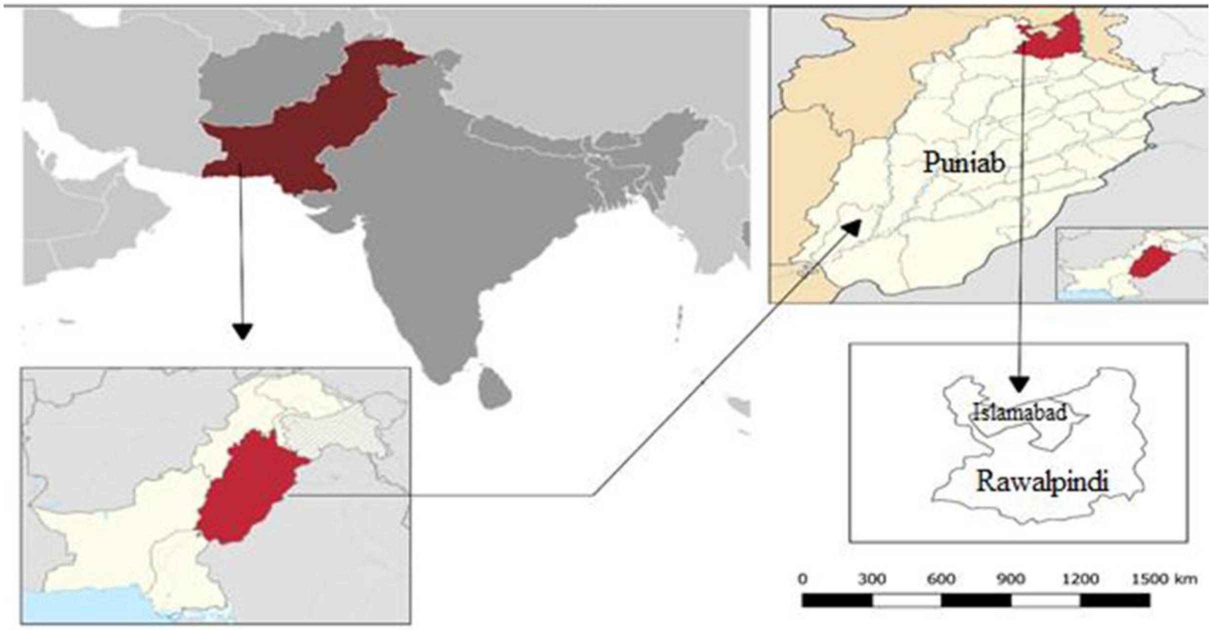

Figure 5 Study area: Rawalpindi-Islamabad Metropolitan Area (RIMA)
Source: Rehman and Jamil (2021)

5.4. Housing and transportation planning in Rawalpindi-Islamabad Metropolitan Area (RIMA)

RIMA is considered one of the largest urban areas in the Punjab province of Pakistan (Figure 5). Islamabad is the capital city of Pakistan, whose population has grown from 100,000 to 1.30 million between 1951 and 2014. At the same time, Rawalpindi has become the third-largest city with 4.5 million people, after Lahore and Faisalabad. RIMA are considered twin cities since they depend on each other economically and socially. Islamabad is the only planned city and an economic hub: people from various suburban and rural areas migrate to seek employment or higher education. On the other hand, Rawalpindi is an unplanned city with scattered settlements, but recently, many urban developers have been attracted to Rawalpindi to develop planned housing communities. RIMA has been facing rapid urbanization for the past several years, causing urban sprawl and high vehicle ownership. Sprawl and car dependency help reduce friction in the development of gated communities in the two cities' peripheral regions, resulting in low proximity to public transportation and several other service facilities. The following sections provide a detailed description of housing and transportation infrastructure in RIMA;

5.4.1. RIMA Housing societies

RIMA has several planned housing societies due to private builders' public-private partnerships and individual efforts, including gated and non-gated communities usually suitable for middle to high-income people in government, army, or run businesses. Housing units in such societies range from medium-sized to luxury villas that cater to a high lifestyle. Though gated communities such as Bahria Town claim to provide affordable housing schemes in proximity to service facilities for low-income people. The names of the legal housing communities in RIMA taken from the Capital Development Authority (CDA) official website (https://www.cda.gov.pk/housing/) and Rawalpindi Development Authority (RDA) official website (https://estateland.com.pk/list-of-legal-housing-schemes-in-rawalpindi/) are given in the Appendix A.

It can be seen that Rawalpindi has attracted significant real estate investment from government and private entities. Most of the locations are near motorways that connect RIMA with Sindh and KPK provinces. Hence, such locations are prescribed as optimal to live and future investments. There may be more housing schemes in RIMA; the ones listed above are legal and highly recommended for family-oriented households. However, social science researchers must conduct empirical studies to explore households' residential satisfaction, including the travel behavior, housing location choice, and cost associated with housing and transportation. The findings of such studies could guide policymakers and developers in establishing concrete housing development plans.

5.4.2. RIMA Transportation infrastructure

The first phase of the BRT Red Line (hereafter as RIBRT), launched in June 2015, is 22.4 km long, with 68 articulated buses running on the dedicated lane located on the main Murree Road that connects two cities (Figure 6; Taken from https://www.zameen.com/). The first station on this corridor starts from Saddar (city center) in the Rawalpindi region to Pak Secretariat in Islamabad (see Appendix A for the name of the stations). It runs six days a week from 06:00 to 22:00, whereas on Sundays, the timing is from 07:00 to 22:00. Table 4 shows other characteristics of BRT. Additionally, RIMA PT comprises 95% of paratransit services, i.e., 12-seater pickup wagons (Figure 7A) and 18-seater Hiace minivans (Figure 7B), operating on limited routes assigned by the location transportation authorities. Additionally, informal transportation services lie in three-wheeled Rickshaws (Figure 7C) and taxi-like services. There is no rail mass transit system in RIMA, but there is a fully functioning bus rapid transit (BRT) in a dense mixed land of commercial and government offices. One study states that high low-income levels in RIMA have also caused significant PT affordability challenges (Adeel et al., 2016). This section briefly reviews the NESPAK report designed to assess the current PT condition and plan the RIMA BRT network and a few empirical research on RIMA PT accessibility and associated costs.

The BRT network plan 2022 involves four main BRT corridors integrated with feeder buses (NESPAK†, 2015); however, the Red Line is the first single corridor with no integrated feeder bus in RIMA (Khan and Shiki, 2018). It provides access to only eight percent of the people within ten minutes of walking distance (Adeel et al., 2014). That is why Rawalpindi's already existing informal paratransit services help transport people to BRT stations and other parts of the city. Unlike BRT service, the fare of the paratransit services is not fixed. According to the NESPAK report, the fare cost of non-AC mini wagons is PKR 15 within four kilometers of travel distance; however, the fare increases up to PKR 33 within 30 km (NESPAK, 2015; pp 67). This lack of integrated formal feeder buses could be why BRT fails to stimulate redevelopment around its corridor for residential purposes, triggering high vehicle ownership and decreasing friction of gated community developments in suburban areas.

Table 4 Characteristics of Rawalpindi-Islamabad BRT Red Line

Characteristics of BRT RED Line	**2014-2015**
Length of Corridor	22.4 km (8.6 km elevated)
Capacity of Corridor	12,465 passengers/hour/direction
Size of Fleet	68 articulated buses
No. of Bus Bays/Station	3
Speed (Average)	32 km/hour
Cost of the Infrastructure	US $ 419 Million
Fare price per trip	PKR 30 (fixed)
Ridership without feeder services	135,005 passengers/hour/direction/day

Source: NESPAK, 2015

Moreover, a newly emerged private transportation service called *Careem* (Figure 7D; similar to Uber) also functions as a feeder for RIBRT. Careem can be ordered from home using a mobile application as a private service for a single client or "share a ride" with other passengers as carpooling. Since it is a private service, the minimum fare starts from PKR 250 and increases depending on the distance traveled. The fare can either be paid online or by cash. Therefore, following and implementing sustainable transportation principles has become extremely important to make RIMA transportation more socially, economically, and environmentally sustainable. These two cities have faced traffic congestion due to the increasing demand for private motor

† National Engineering Services Pakistan (NESPAK) conducted extensive field research in RIMA to produce traffic model and evaluate transportation structure to recommend BRT corridors plan until 2020.

vehicles because of the rise in living standards. Also, a lack of sincere management of traffic strategies, adequate land use, and proper transportation planning has contributed to elongating travel time, heavy fuel consumption, a rise in pollution, and sprawling suburban areas. The Punjab Government constructed a BRT system in the twin cities by considering these factors.

Figure 6 Bus rapid transit in RIMA
Source: https://www.zameen.com/

A B

C D

Figure 7 Informal paratransit services, and formal taxi-like Careem service
Source: Figures 7A, 7B and 7C were taken during field work, for Figure 7D (official Careem website: https://www.careem.com/en-ae/cities/islamabad/)

5.4.3. RIMA trips and modal split

In RIMA, besides conventional PT, motorbikes, and cars are also the major transportation modes for a daily commute. Several commuters' trips, their purpose, and modes used in Rawalpindi-Islamabad are summarized in the table, while the percentage of the trip purpose and trip modes are given in Table 5. According to the official report, among the modes used to commute, public transportation (1,224) dominated the sample, followed by motorbike (1,035), then car (651). Specifically, home-based work trips mainly used cars for *"from home and to home trips"*. Whereas among the "*from home trips*", for obvious reasons, public transportation was an accessible transportation mode (223) for Home-based School trips, the exact figure goes for "*to home trips*". This shows that PT in RIMA is popular among the student population since most do not own any vehicle.

Similarly, Table 6, highlighting the percentage of the total sample concerning transportation modes used for specific purposes, shows that among all the types of trips, walking dominated the trips made for *other purposes* (43%), motorcycle and car for trips to *work* (28%) and (30%), respectively, and PT was majorly used for trips to *schools* (50%). This data suggests that young students commuting to educational students are more likely to use PT services, while people owning cars or motorbikes use these modes for daily commute to work facilities.

Table 5 Number of Trips and Transportation Modes

Transportation modes	From Home				To Home			Total
	HBW	HBS	NHBW	HBO	HBW	HBO	HBS	
Motorbike	112	24	296	234	112	234	24	1,035
Car	195	29	173	15	195	15	29	651
Public Transportation	139	223	438	31	139	31	223	1,224
Total	446	276	906	280	446	280	276	2,910

Note: "HBW= Home Based Work trips, HBS= Home Based School trips, HBO= Home Based Other trips and NHBW=Non-Home Based Work trips".
Source: NESPAK (2015)

Table 6 Percentage of trip purposes and transportation modes used in RIMA.

Type of Trips	Walk	Motorcycle	Car	PT
HBW	10	28	30	32
HBS	18	18	14	50
HBO	43	16	23	18
NHBW	19	22	25	34

Note: PT = Public transportation
Source: NESPAK (2015)

5.4.4. Rawalpindi-Islamabad transportation user characteristics and distribution analysis

Figure 8 shows that commuters with a monthly salary between *Rs. 2,001-4,000* constituted 48%, the sample's largest public transportation usage group, compared to the "salary not mentioned" group (21%), *Rs. 4,001-6,000* group (11%) and 2% of *Rs. 6001-10,000.*

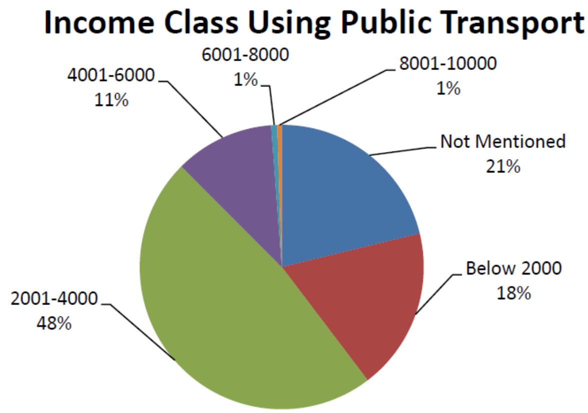

Figure 8 Household income of PT users in RIMA
Source: NESPAK (2015)

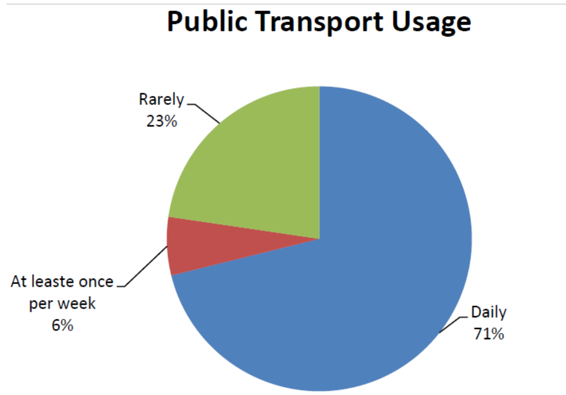

Figure 9 PT usage in RIMA
Source: NESPAK (2015)

Moreover, Figure 9 shows that out of the total sample, a high percentage of the PT users was among daily commuters (71%), compared to rare users 23% and once-a-week users (6%). It means that a high volume of the RIMA sample depends on PT. Furthermore, within this sample, 34% of the users considered the punctuality of the public transportation service as *Bad*, which is a higher percentage compared to *Good* (30%), *Fair* (26%), *Very Bad* (6%), and *Very Good* (4%). This data showed that despite high dependence on PT, commuters still consider the service far below the acceptable standard.

5.4.5. Travel patterns and associated costs in RIMA

Adeel et al. (2016) conducted an empirical survey on the disadvantaged population and examined the activity exclusion of those who live in various parts of RIMA. Their findings show that only 26% of men travel daily for work and education purposes, while only 11% of women travel for work and 2% for education. Around 78% of men are reported traveling for religious duties compared to only 2% of women (Adeel et al., 2016). Similarly, fewer women than men can operate a car or motorbike, leaving them dependent on male family members to help them commute. Also, their study finds that 82% of women use private vehicles for work and 77% for education, while only 34% of men do so for either activity. Furthermore, 96% of men in the underdeveloped part of the study area prefer to walk for religious duties, and 58% are reported walking to work as compared to 8% of the women. This disparity seems to arise from women's lack of trust in paratransit. There are no separate compartments for women, and harassment is a real fear.

In addition, the authors find that the cost of transit services is a major concern for 57% of the respondents, with distance to the bus, availability, and wait times a problem for 35-42%. The low-income population reported spending around Rs 3000 ($27) a month on transit services, while people who live in suburban areas, farther away from work or school, reported spending around Rs 5000 ($45) a month (Adeel et al., 2016). Though men expressed more concerns due to their frequent use of transit services, female respondents had concerns about harassment (even a slight touch from a strange man) and the discomfort of using transit for long-distance travel. Similarly, people who live in the developed areas of RIMA and who have high incomes of around Rs 100,000 ($980) reported spending around Rs 20,000 ($190) per month on transit (Adeel et al., 2016). This shows that the low-income population spends a higher proportion of its earnings on transit as compared to the higher-income population. Therefore, many people cut back on activities that depend on using transit. As the dissatisfaction with transit services keeps increasing, people either buy automobiles or find jobs within walking distance from their homes.

5.5. Conclusion

This research was conducted in response to the high demand for affordable housing units, transportation services, and associated service facilities to meet the needs of disadvantaged groups. Though NHP 2001 incorporated housing policies using various measuring indicators, it excluded the indicators of the accessibility to the proper PT services and other urban facilities associated with the location for affordable housing and residents' preferences. Also, housing costs such as monthly rent and housing maintenance are the only parameters mentioned in the national policy to develop affordable housing schemes. At the same time, parameters such as transportation costs, land use, and built environment indicators can optimally identify suitable locations near service facilities such as education, shopping, clean drinking water, transit, and other infrastructure to establish housing projects.

This chapter explored the performance of the housing and transportation institutional framework in providing facilities using government reports and reviewed studies on housing policies and some empirical findings on RIMA transportation services. This chapter began with the process of urbanization: how the Pakistani government is dealing with urban development regarding the provision of housing, PT, health, education, and other services to facilitate low-income people, both indigenous and migrants. Then, various national housing policies were examined. The institutional framework is complicated by poor policy vision due to the lack of political will, causing no implementation of affordable housing policies for needy households. This chapter highlighted the existing jurisdiction and responsibilities of the previous and current government, which can bring up suitable recommendations in the broader context for the government at all levels. Reexamining the organizational structure of governments at all levels to mitigate disorders and overlapping roles, provide for efficient collaboration across planning and developing sectors in housing markets, and assign new housing authorities for effective policy execution, gives some consideration to building an institution-oriented government.

Furthermore, this chapter briefly examined the small section of the NESPAK report focusing on the plans for the RIMA BRT corridor. A network of BRT corridors was planned and recommended to be established before 2024, but only one corridor is operational without an integrated feeder bus network. Besides the people living within walking distance from the single RIBRT corridor, others use different kinds of low-quality paratransit to reach the RIBRT from remote areas. Those who possibly cannot find any paratransit route near their residence take Careem as a feeder because of the rapid development of the gated communities in suburban areas. Due to the lack of PT near the suburbs, people have no choice but to use either their private vehicles or take a “call and ride” Careem service.

Chapter 6: Survey-Based Travel Behavior to Measure Accessibility Towards Bus Rapid Transit in Rawalpindi-Islamabad, Pakistan

"You can't understand a city without using its public transportation system." (Erol Ozan)

6.1. Introduction

The preceding chapter stated that transportation planners are unable to establish effective policies to improve transportation services due to missing data based on commuters' perceptions of the existing systems. Therefore, it is essential to examine the commuters' travel behavior that can determine the accessibility performance of RIBRT. This chapter focuses on exploring the travel behavior of BRT in RIMA (later referred to as RIBRT) to determine the accessibility towards RIBRT. It answers the sub-research question 1, i.e., "*What factors influence travel mode choice to reach RIBRT?*" by highlighting the factors contributing to a certain travel behavior when accessing RIBRT. Figure 10 shows the location of RIMA, the third-largest metropolitan region in Punjab province.

Travel patterns of any city vitally contribute to the decision-making of sustainable transportation planning. Transportation modes operating within the city also help develop an integrated transportation network, and many regional governments are making strenuous efforts to establish a balanced modal share to run sustainable transportation modes. The purpose of a modal split and the conversion between modes enable the commuters to shift towards a reliable and sustainable mode when making daily trips. This chapter discusses the travel behavior of the respondents to evaluate the conditions of trips made using various transportation modes to reach the RIBRT.

Many developing countries face a rapid increase in their urban population that has caused a high travel demand, especially for private automobiles, making the traffic and transportation systems precarious. The primary reason for high vehicle ownership is the lack of a prudent PT structure in developing cities. This lack enables the urbanites to pursue alternative means of mobilization. Additionally, other reasons such as a desire to own a car, status complex, spatial location, and government policies for vehicle ownership also contribute to the large volume of private vehicles on the roads (Tabassum et al., 2017). Besides, it's a common mindset in the developing cities that PT mostly serves to transport only low- or no-income people, and high-income people are likely to travel on their private vehicles. By accepting the facts above, policymakers in developing cities are giving considerable attention to mitigating transportation issues by establishing mass transit systems (MTSs) such as BRT systems (see Chapter 2 for more information on BRT).

Mostly and optimally, MTSs are established in highly dense areas to ensure better ridership and possibly reduce the prevalence of private automobiles. One of the ways to achieve high ridership is to have a well-established and integrated network of MTSs with feeder buses spread around the city for efficient accessibility (ITDP, 2017). Most PT-dependent, who use paratransit services and RIBRT, are members of the low-income population (data shown in NESPAK, 2015). Low BRT accessibility towards inner-regions and outskirts (Khan, 2021), the enjoyment to travel on private automobiles (Ye et al., 2017), and travel distance (Mouratidis et al., 2019) might be the primary obstacles for RIBRT in achieving the goal of attracting users other than low-income population citizens.

Though these services have the advantage of running in the narrow streets to provide high accessibility where high-capacity feeder buses cannot penetrate, only the highly dependent people on paratransit are the loyal commuters despite showing satisfaction below the acceptable level (Cervero, 2007). Besides, paratransit in RIMA is still running illegally without formal registration and monitoring system (Imran, 2009). Additionally, the transportation planners show no intention of improving these services concerning the organization, maintenance of the vehicles operating, and law enforcement about licensed routes (Imran, 2009). These factors could be the primary reasons discouraging private vehicle users from shifting to transit services in RIMA. That is why paratransit quality and trip satisfaction has become a pressing issue and needs to be further explored based on commuters' perception.

The empirical analysis in this chapter has three scientific contributions. (a) It reveals whether the distance from the residential area to the nearest RIBRT station influence the travel mode choice. (b) It also highlights the significance of the commuter charateristics such as income, vehicle ownership, travel purpose, and travel frequency using RIBRT. Handful of research is focused regarding such predictors. (c) Commuters' satisfaction with external service attributes when using certain mode may also determine whether those services are acceptable to be integrated with formal RIBRT network. The main finding of this research also has societal contributes surrounded by the sustainable mobility discourses and the quality of urban life. The analysis of which travel mode is popular than other, who is using such mode, and for what reasons reveals the association between social and environmental sustainability. The findings can have policy implications on transportation and urban planners can improve the travel experiences, thus influencing the livelihood in the cities.

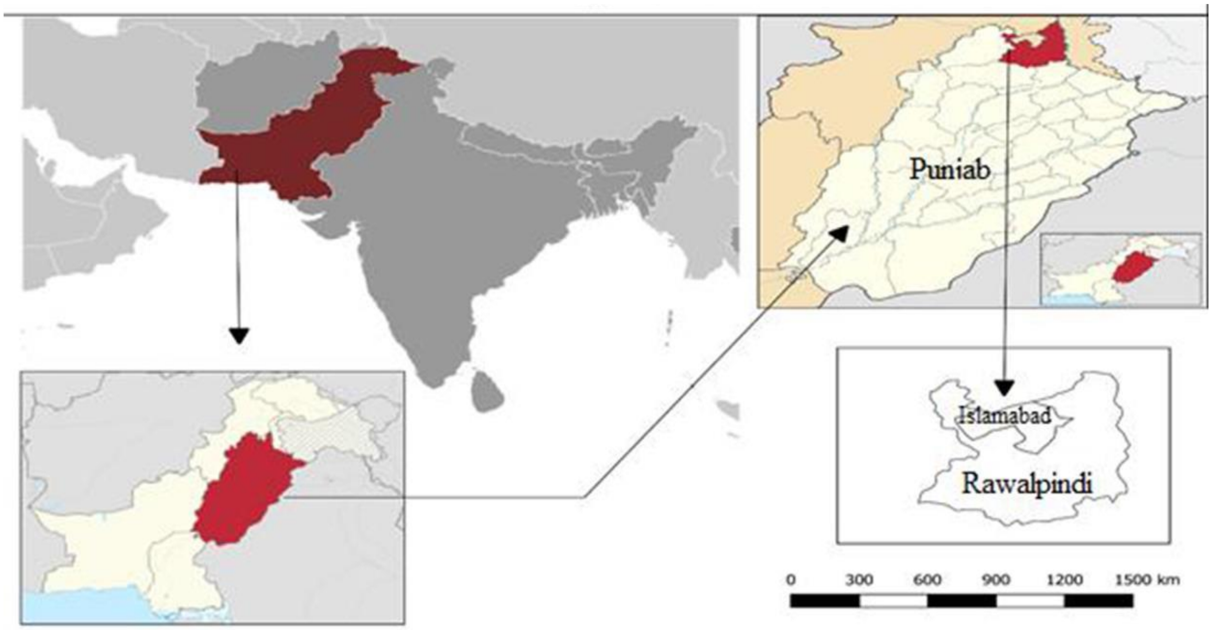

Figure 10 Study area: Rawalpindi-Islamabad Metropolitan Area (RIMA)

6.2. Data collection

To explore the factors that influence the travel mode choice when accessing RIBRT and the satisfaction with service quality of the chosen modes, I collected the commuter data by visiting RIBRT (see Appendix B for all the names of RIBRT stations) due to significant lack of government data on transit use, distance traveled, and travel behavior. First, the ridership data for the first week of January 2017 was obtained from Punjab Mass Transit Authorities (PMA) during the field trip to RIMA in 2018 (see Appendix C for detailed ridership data). From this ridership data, three stations, namely Station 1 = Saddar, Station 6 = Chandni Chowk, and Station 9 = Shamsabad, were chosen as study sites (Red circles in Figure 11). Due to time and cost constraints, stations only in Rawalpindi were selected based on the ridership data, both from and to the selected stations. Station 1 is the first station of the RIBRT Red Line located in the central city of Rawalpindi, primarily occupied by commercial areas such as retail shops, restaurants, shopping malls, and education facilities in its surrounding. Station 6 has somewhat similar characteristics as Saddar. Whereas other than the commercial area, the residential area can be found within 500 meters of Station 9, providing better proximity to home. The mean ridership clearly shows that Station 1 is the busiest, followed by Stations 9 and 6 (Appendix C).

Since quantitative method was employed for this study, I distributed questionnaire surveys at the selected RIBRT stations for four days; one weekend (Sunday) and three weekdays. The respondents completed the questionnaires in less than five minutes on average. Since young adults (between the ages of 18 and 50) frequently travel by using city transportation services, they were the target population for this study. The surveyors stopped the potential target population based on their appearance after the passengers egressed the bus and walked towards the exit. Overall, 240 valid samples were successfully collected, with a response rate of 48.6%.

The questionnaire survey included three sections. The first one consists of socioeconomic and demographic characteristics, including *age*, *gender*, *employment status*, *income*, and *vehicle ownership* of the respondents. The second section included travel behavior such as *frequency* and *purpose* of BRT usage, *travel modes choice* to reach RIBRT, and *origin* and *destination.* The third part highlights the satisfaction with the external factors of the travel modes borrowed from the previous studies. Table 7 describes seven service attributes and trip satisfaction used in this study. The survey participants evaluated the service attributes based on the 5-point Likert-scale method, that is, 1 = Very Dissatisfied, 2 = Dissatisfied, 3 = Normal, 4 = Satisfied, and 5= Very Satisfied. The sample implies that all the respondents were RIBRT users. For this study, I adopted the socioeconomic and demographic characteristics from previous research that showed a substantial effect on the choice of transit service as a travel mode (Hunecke et al., 2010).

Table 7 Service attributes, their description and authors of previous studies

Service Attributes	Service Attribute Description	Source
Availability	The availability and area coverage of the feeder services to gain access to MTSs	Gahlot et al., (2013)
Waiting time	Time consumed when waiting for the feeder mode at the stops and the comfort level;	Mahmoud and Hine (2016)
Travel time	Time consumed in feeder mode when traveling towards BRT; this includes frequent stops and vehicle exchanged;	Feng (2014)
Travel Speed	Speed of the feeder mode when traveling towards BRT;	Eboli and Mazulla (2007)
Ease in Transfer	The comfort of transfering from feeder mode to BRT station;	Mahmoud and Hine (2016)
Safety	Concerns about safety and security while waiting at stops or in-vehicle, and even driving skills;	Dorion et al., (2009) Mahmoud and Hine (2016)
Overall service quality	Perceptions concerning the overall service provided by the paratransit operators;	Morton et al., (2016)
Trip satisfaction	Satisfaction with the trip from origin (home) to BRT station	Susilo and Cats (2014)

6.3. Respondents' characteristics and travel behavior

The nature of the sample reflects young, low-income people and students in the chosen study area (See Table 8). Around 94% of the total sample ranged from 18 to 35 years, with an average

age of 23.04. Additionally, about 67% were male, 63.3% were students, nearly 60% had no income, and around 53% did not own any vehicle. It is safe to state that the majority of BRT users are low-income without any vehicle ownership.

Table 9 summarizes the travel behavior of the respondents when accessing BRT from home. Five travel modes were considered as the main modes to access the nearest BRT station. These travel modes are categorized as *green services* (walk/bicycle), *kiss and ride* (dropped by a family member), *paratransit* (HiAce minibusses/pickup wagons), *rickshaws,* and *Careem*. The descriptive indicated that nearly 50% of the sample used BRT daily. The percentage differs among non-daily BRT users for seldom, once-a-week, and twice-a-week BRT users. Around 35% used BRT for education purposes compared to 31.25% of work-related travels. Paratransit services (45.82%) were dominant among the sample compared to nearly 23% of Careem users, 15.83% used green services, and the remaining group used rickshaws and kiss-and-ride modes (approximately 15%). The major portion of the sample could access BRT within 30 minutes (around 70%) compared to 2.08% of users who traveled for more than one hour to reach the BRT station. The *distance* in kilometers from respondents' residents to RIBRT was calculated using ArcGIS. It shows that five kilometers was the average distance in the whole sample. However, it was worth noticing that some respndents traveled more than 60 kilometers to reach BRT. This is could be because people usually come from other small districts of Rawalpindi city that are located around the edges of the city.

Table 8 Descriptives of respondents' characteristics

Characteristics	Frequency	Percentage	Characteristics	Frequency	Percentage
Age			**Personal Income (PKR)**		
<18	9	3.75%	0	143	59.58%
18-35	225	93.75%	1-25,000	38	15.83%
36-53	5	2.08%	25,001-50,000	41	17.08%
>54	1	0.42%	50,001-75,000	8	3.33%
Gender			75,001-100,000	10	4.17%
Female	79	32.92%	**Vehicle Ownership**		
Male	161	67.08%	Car	30	12.50%
Occupation			Motorbike	75	31.25%
Students	152	63.33%	Bicycle	8	3.33%
Government Employees	11	4.58%	No Vehicle	127	52.92%
Private Employees	60	25.00%			
Own Business	9	3.75%			
Others	8	3.33%			

Characteristics	Mean	S.D.	Minimum	Maximum
Age	23.04	4.65	16	51
Personal Income (PKR)	16,333.33	24983.12	0	100,000

Note: USD. 1 =PKR.139.9 in 2018.

Table 9 Respondents' travel behavior characteristics

Characteristics	Frequency	Percentage	Characteristics	Frequency	Percentage
Frequency			**Travel time (min)**		
Daily BRT users	119	49.58%	0-14	56	23.33%
Non-Daily BRT users	121	50.42%	15-29	111	46.25%
Travel mode choice			30-44	41	17.08%
Green service	38	15.83%	45-60	27	11.25%
Kiss and ride	18	7.50%	>60	5	2.08%
Rickshaw	19	7.92%	**Purpose**		
Paratransit	110	45.82%	Education	85	35.42%
Careem	55	22.92%	Work	75	31.25%
			Others	80	33.33%

Characteristics	Mean	S. D.	Minimum	Maximum
Time taken from home to RIBRT (min)	25.66	15.78	5	70
Distance from home to RIBRT (km)	5.10	8.56	0.18	66.64

Green services = Walk or bicycle.

Moreover, Figure 11 shows the visual distribution of the respondents' travel modes from the origin (residence) when accessing the nearest BRT station. The data was geocoded in ArcGIS 10.5. The dots represent the geographical residence location. The colors represent the travel mode: green as walking/bicycle, purple as kiss and ride, pink as rickshaw, dark blue as paratransit, and light blue as Careem. The BRT route's green and yellow regions illustrate one-kilometer and three-kilometer buffers, respectively. It was worth noticing that some respondents used green services to travel more than three kilometers. Also, with the increase in the distance from the origin to BRT stations, the travel mode choices became limited to only paratransit and Careem. Therefore, this study limits the comprehensive analysis of paratransit with Careem to assess the service quality of paratransit.

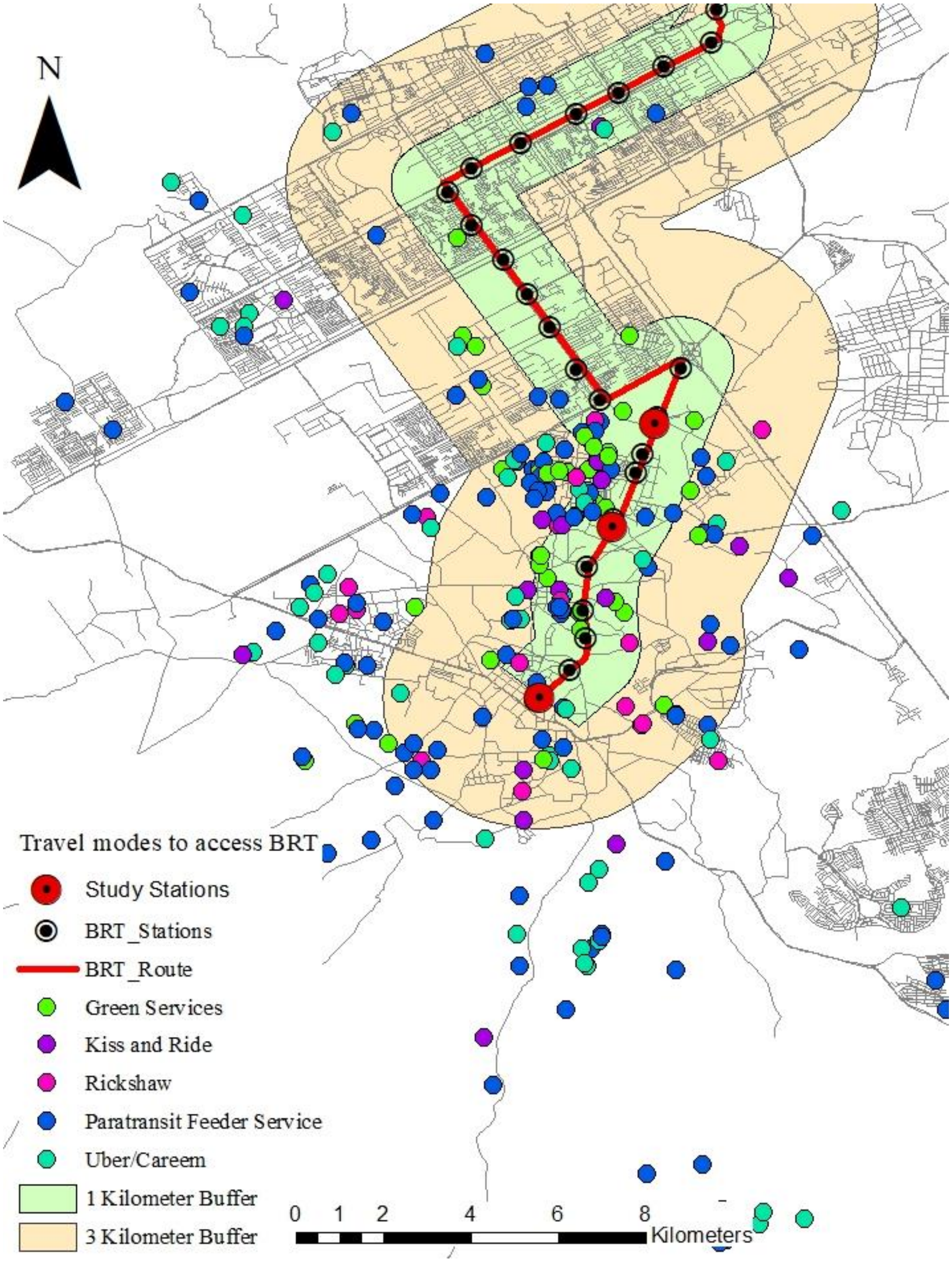

Figure 11 Visual display of respondents' travel mode choice from home to access RIBRT

6.4. Data analysis

It is essential to examine passengers' perceptions of the informal paratransit services to determine whether such services can be integrated as feeders for RIBRT. The comparative assessment of paratransit with relatively high-quality Careem services would highlight the weak aspects of paratransit for potential improvements.

For this purpose, the analysis is divided into two parts: First, the commuters' characteristics, travel behavior, and service attribute satisfaction levels were crossed-tabulated with feeder modes, i.e., paratransit (n = 110), Careem (n = 55) to understand the possible association. Second, binary logistic regression was employed to predict the significant association of respondents' characteristics with paratransit services. The details are given in the following sections.

6.4.1. Descriptives of service attribute satisfaction and overall trip satisfaction

First, I calculated the commuter satisfaction percentage with seven service attributes for paratransit and Careem services. These attributes are; availability, waiting time, travel time, travel speed, safety, ease in transfer, and overall satisfaction. Then, two trip satisfaction percentages from home to BRT were calculated, i.e., 1) between daily and non-daily BRT users for the whole sample, and 2) between paratransit and Careem. These percentages can help understand the type of commuters when self-selecting the feeder mode to reach BRT.

6.4.2. Logit model formation and specification

I designed a binomial logit model to comprehensively estimate the probability that the commuters would use paratransit (valued as '1' compare to Careem valued as '0') as feeders to reach BRT in the RIMA context. Given the probability of paratransit being chosen as a feeder is *p* for every individual commuter *i*, then the formulated logistic regression is expressed in terms of variables used in Equation 1.

$$\ln\left(\frac{p}{1-p}\right) = b + b_1 A_i + b_2 M_i + b_3 V_{mi} + b_4 V_{ni} + b_5 P_{ei} + b_6 P_{oi} + b_7 B_{ui} + b_8 D_{hi} \quad (1)$$

where A = age, M = male sample, V_m = Motorbike owners, V_n= No vehicle, P_e = Education purposes, P_o= Other purposes, B_u = daily BRT users, and D_h = Distance from home to BRT in kilometers. Among demographic characteristics, "Car" is set as a reference variable, while "Motorbike" and "No vehicle" ownerships are the dummy variables. Similarly, within travel behavior indicators, "Work-related" trip was set as a reference variable while, trips to "Education" facilities, and trips made for other purposes were included in the analysis as dummy variables.

This primary reported logit model was divided into three separate models for additional control variables. Model 1 includes only commuters' socioeconomic and demographic characteristics while controlling the travel behavior and urban form indicators. Model 2 includes socioeconomic and travel behavior characteristics while controlling the urban form indicators. Lastly, Model 3 included all the indicators to predict their statistical significance with choosing paratransit services as feeders to access RIBRT.

Since students with no income dominated the sample size, “monthly income” variable was excluded from the analysis non-significant result. Similarly, the occupation of the commuters was also removed due to the high correlation with travel purpose.

6.5. Cross-tabulation of commuter attributes with paratransit and Careem

Figure 12 highlights the cross-tabulation of commuter attributes with paratransit and Careem. It illustrates that young people under the age of 35 have an income less than PKR. 75,000, both workers and students, those without vehicle ownership, and daily BRT riders used paratransit as a feeder to access BRT. This analysis introduces some points worth noticing. For example, percentages of both men and women were almost equal when taking the paratransit.

Additionally, car and motorbike users preferred Careem to reach BRT. This could be because private vehicle users may prefer using Careem to enjoy their privacy, especially female BRT commuters. Since Careem is a door-to-door service that can be called using a mobile application, it is accessible from any residential location. Also, the gap in the usage of paratransit between daily and non-daily BRT users could be due to travel purposes and economic reasons. Those traveling to work or educational facilities theoretically take their trip more seriously than those using BRT for entertainment purposes.

Overall, this cross-tabulation suggests that paratransit was more prevalent among young and low-income people and those who used BRT daily. On the contrary, those who owned motor vehicles were inclined to use Careem more than paratransit. Additionally, the service satisfaction of these feeder modes also contributes substantially to choosing these modes, which is discussed in detail in the following section.

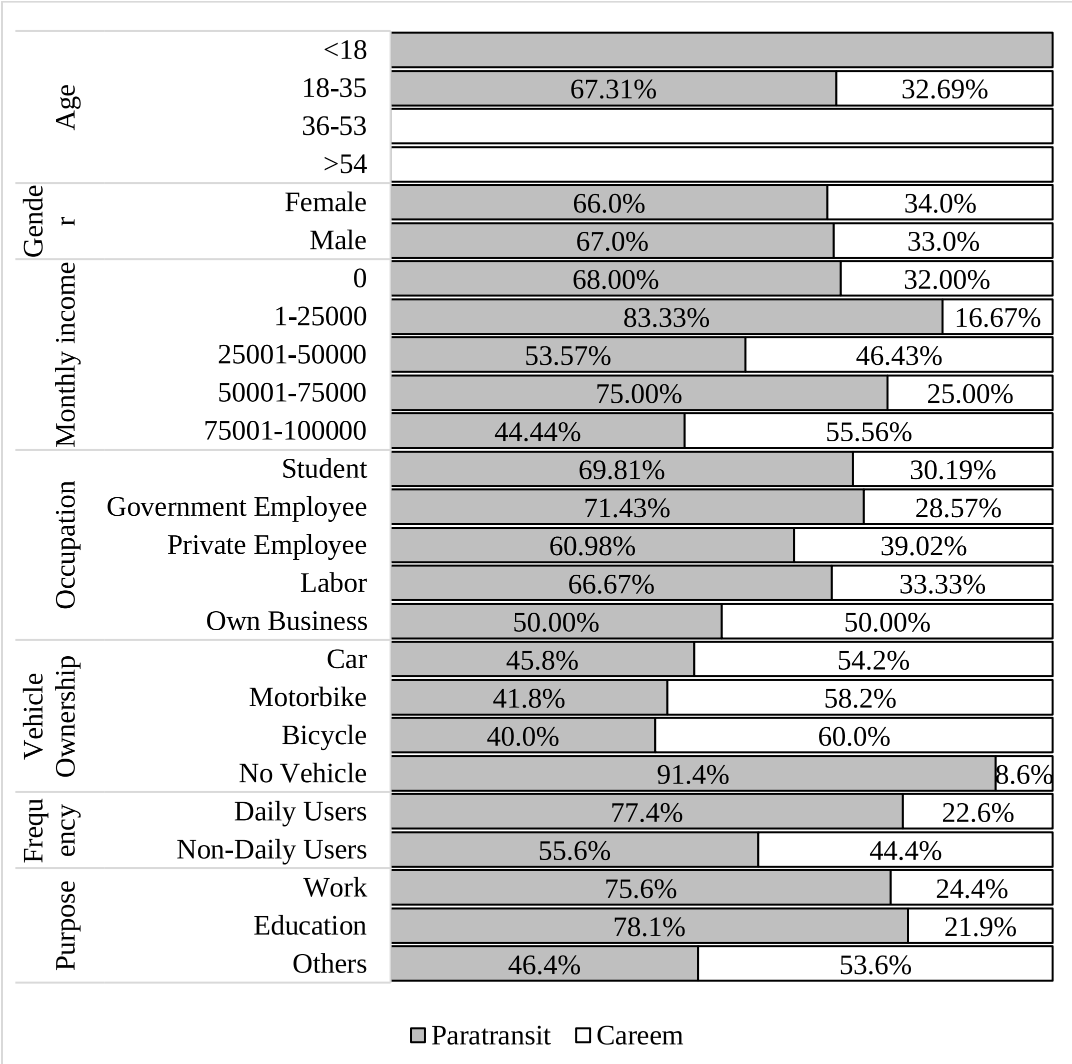

Figure 12 Cross-tabulation of respondents' socioeconomic and travel characteristics with paratransit and Careem (n=165)

6.6. Feeder modes regression analysis

The binary regression models predicting the usage probability of paratransit services are summarized in Table 10. The numbers across the predictors are the unstandardized coefficients (b) and the numbers in parenthesis are the standard error values. Overall, the logistic analyses indicate a significant statistical association of independent variables with the choice of paratransit.

6.6.1. Commuter attributes and the usage of paratransit as feeders

Among the socioeconomic indicators in the three models, age and male riders were not statistically associated with paratransit services. "Motorbike ownership" was not significantly associated with paratransit usage when controlling for travel behavior and distance from home to

BRT in Model 1. However, this relationship becomes statistically significant when adding travel indicators in Model 2 and travel and distance indicators in Model 3. Additionally, “no vehicle ownership” showed a significant statistical association with paratransit usage as feeders at a 99% confidence level in all models.

The positive association of motorbike and no vehicle ownership indicated that such commuters are more likely to use paratransit services compared to car owners. Since commuters without any vehicle ownership, being low-income as well, are highly dependent on public transportation services for daily commutes, they are highly dependent on paratransit to access RIBRT.

6.6.2. Influence of travel behavior on feeder mode choice

After adding travel indicators in Models 2 and 3, the daily travel to education facilities such as schools, colleges, and universities, did not show significant association with paratransit usage in both models. However, travel to destinations for various purposes showed statistical significance interval in Model 2 but remained insignificant in Model 3 after adding the controlled variable of urban form. Moreover, daily BRT users showed significant association with paratransit usage at 95% confidence interval in both models.

The negative relationship of travel for various purposes using paratransit indicated that commuters were less likely to use such services when accessing RIBRT. It was worth noticing that after adding controlled distance variable, this travel behavior became insignificant. This could be because such travelers are passive transit users who do not take their commute seriously. However, the positive association indicates that the frequent users of RIBRT are more likely to use paratransit services as feeders to access the nearest RIBRT station compared to non-daily travelers. This association may be because the paratransit services are substantially economical compared to Careem services. Therefore, low-income, or no-income commuters would afford to use paratransit services daily when traveling to work or education facilities.

Also, paratransit is an economical service, which makes it suitable for almost all groups of people. In that capacity, people exercising various types of occupations among daily BRT users are also inclined to take paratransit to access the RIBRT because daily BRT users are mainly active users of BRT.

6.6.3. Urban form matters when choosing travel mode.

The distance from commuters’ residence to the nearest RIBRT station also influences one’s capacity to choose a travel mode when using RIBRT. This urban form indicator remained a controlled variable in Models 1 and 2 and was added in Model 3. It showed a statistically significant association with paratransit usage at 95% confidence interval. However, this association is negative, meaning that with one unit increase in the distance, the commuters are less likely to use paratransit services in RIMA. This relationship is understandable because the further the distance is from the residence to the nearest RIBRT station, the more difficult it would get for the commuters to reach RIBRT. This is because paratransit routes from remote areas do not directly connect to RIBRT stations. Therefore, commuters would have to change to multiple paratransit vehicles to reach RIBRT, resulting in higher commuter costs. Furthermore, areas away from RIBRT are mostly occupied by gated communities. These communities host well-off residents who own multiple vehicle. Since their daily travel is mostly on cars, it is less likely for them to use paratransit to access RIBRT.

Table 10 Feeder modes logistic analysis

Respondents' predictors	**Model 1**	**Model 2**	**Model 3**
Socioeconomic and demographic characteristics			
Age	-.007	.006	.042
	(.040)	(.045)	(.051)
Sex			
Male (Reference: Female)	.365	.313	.190
	(.441)	(.513)	(.548)
Vehicle ownership (Reference: Car)			
Motorbike	.029	.965*	.990*
	(.438)	(.545)	(.555)
No Vehicle	2.909***	4.026***	4.401***
	(.578)	(.735)	(.811)
Travel behavior			
Purpose (Reference: Work)			
Education		.464	.668
		(.605)	(.646)
Other purposes		-1.170*	-1.092
		(.650)	(.680)
Usage Frequency (Reference: Non-daily users)			
Daily users		1.160**	1.113**
		(.537)	(.553)
Urban Form			
Distance from Home to BRT (km)			-.050**
			(.003)
Constant	-.343	-1.587	-1.549
	(1.016)	(1.527)	(1.691)
Nagelkerke R Square	.365	.503	.554
-2 Log Likelihood	159.663	135.763	130.561

***p<0.001. **p<0.05. *p<0.1.

6.7. Satisfaction with service attributes of paratransit and careem

The commuters' satisfaction levels with the seven attributes of two feeder modes were assessed to determine the overall performance of the transportation services. The 5-point Likert scale was converted into a 3-point Likert scale only for the descriptive analysis, meaning that “Very dissatisfied” and “Dissatisfied” were recoded as “Not satisfied” and “Very satisfied” and “Satisfied” were recoded as “Satisfied”. At the same time, “Neutral” remains as it is.

Figure 13 shows the service satisfaction of daily commuters using paratransit to access the BRT stations. The respondents who used paratransit as BRT feeders showed high dissatisfaction with *safety* (50.8%), *waiting time* (46.2%), and *travel time* (41.5%). Whereas ease in transfer to BRT stations and availability were the least dissatisfied attributes. The reason could be that, as mentioned in the NESPAK report, paratransit operates on multiple routes around RIMA and usually connects with Murree Road, where the Red Line runs (NESPAK, 2015). This connection possibly aids in transferring passengers from paratransit to the BRT station within only a few minutes of walking without crossing signals in-between. Secondly, the official report also stated that both the HiAce minibuses and pickup wagons run in a high volume around Rawalpindi (NESPAK, 2015); therefore, people can catch paratransit at any time of the day.

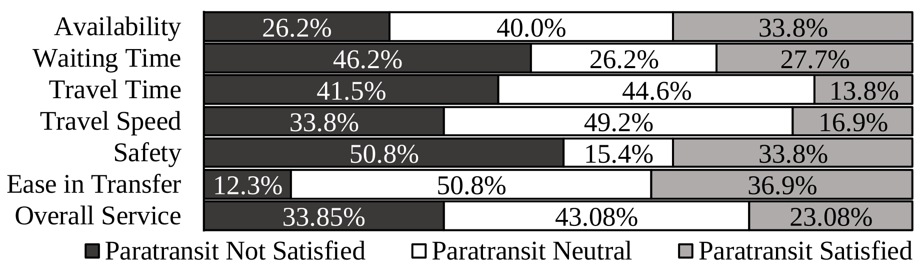

Figure 13 Satisfaction of Daily BRT users with Paratransit (n=110)

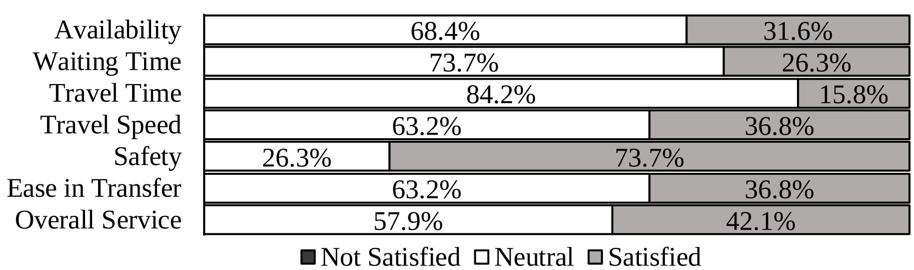

Figure 14 Satisfaction of Daily BRT users with Careem (n=55)

Figure 14 demonstrates the daily BRT users’ satisfaction with service attributes of Careem. Unlike paratransit, Careem users did not show dissatisfaction with any of the examined service attributes. However, it is worth noticing that respondents showed a “Neutral” feeling with six service attributes other than safety, and the respondents indicated the highest satisfaction with *safety* (73.7%). The reason could be the lack of privacy and comfort that daily travelers usually desire.

Overall, service satisfaction analysis of both transportation modes showed a significant difference among daily BRT commuters. Paratransit users showed dissatisfaction with all the service attributes, whereas Careem users did not show dissatisfaction with any examined service. This analysis suggests that Careem provides high-quality service to its commuters: hence, higher satisfaction levels. Whereas the service level of paratransit was considered below the acceptance level, and dissatisfaction was the consequence.

The "Overall service satisfaction" indicates a similar situation. Additionally, the satisfaction level with "Safety" is the weakest and negatively associated with using paratransit, meaning that the commuters indicated the highest dissatisfaction with paratransit compared to Careem. This negative association was consistent with the study conducted in Los Angeles, concluding that people concerned about their safety often are less likely to use transit services (Spears et al., 2013), in the RIMA context; informal paratransit. They stated that "attitude towards transit and personal safety concerns have a significant and consistent effect on the decision to use public transportation" (Spears et al., 2013).

6.8. Satisfaction with home to RIBRT trip

It is essential to examine trip satisfaction when moving from one place to another on any transportation mode to determine the provided service quality of those modes for further improvement. Therefore, this research assessed the overall trip satisfaction levels of the respondents when moving from their homes to RIBRT stations using either paratransit or Careem as feeders. Figure 15 shows the overall trip satisfaction from home to RIBRT stations by the respondents using all the travel modes, i.e., 1) green modes, 2) kiss and ride, 3) paratransit, 4) rickshaw and 5) Careem. The results clearly showed dissatisfaction was much higher among daily BRT users (31.9%) than the non-daily commuters (16.53%). On the contrary, the proportion of daily commuters who felt satisfied was relatively low (23.53%) compared to the satisfaction stated by non-daily commuters (35.54%).

Furthermore, Figure 16 shows the trip satisfaction among those daily BRT users who chose either paratransit or Careem to access RIBRT. The results of these 165 respondents indicated that, not surprisingly, *Careem* users' dissatisfaction (5.26%) was far less than that of the *paratransit users* (46.15%) when making a trip to the nearest RIBRT station from home. However, surprisingly, Careem users did not show excellent trip satisfaction; instead, their perception of being neutral was high (84.21%). The proportion of satisfied paratransit users (15.38%) was higher than that of the satisfied Careem users (10.53%).

The analysis of the overall trip satisfaction from home to the RIBRT using paratransit or Careem is evident based on the service attribute satisfaction analysis in the previous section. Since Careem is a private door-to-door service that gives a similar experience as a personal automobile, people usually enjoy their individual and comfortable trips on Careem. On the contrary, paratransit users showed high trip dissatisfaction due to low satisfaction levels with paratransit service attributes.

This finding is consistent with various studies, suggesting that lower trip satisfaction levels are strongly associated with bus commutes (De Vos et al., 2016; St-Louis et al., 2014). Additionally, long travel times and in-vehicle congestion also had a significant and negative relation with trip satisfaction when using public transportation.

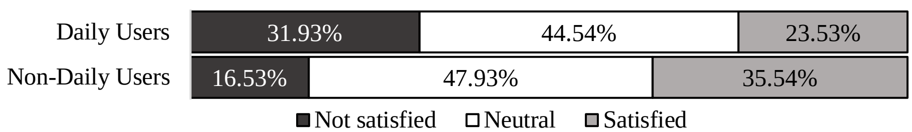

Figure 15 Overall Home to BRT Trip Satisfaction among whole sample (n=240)

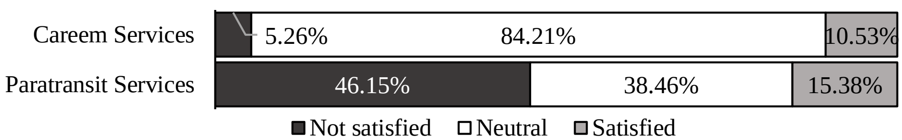

Figure 16 Daily RIBRT users' home to BRT trip Satisfaction with paratransit and Careem (n=165)

6.9. Conclusion

The chapter attempts to explore the survey-based travel behavior to reach RIBRT in the Pakistani urban city context. The quantitative method helped examine the impact of commuters' characteristics, their travel behavior, and the distance from home to the nearest RIBRT station on choosing a travel mode as feeder. The binary logistics regression, cross-tabulation between service quality attributes of paratransit and Careem, and trip satisfaction between daily and non-daily BRT users, and paratransit and Careem were conducted. The findings of regression revealed that amongst the commuter attributes, commuters with no vehicle ownership indicator had the most robust influence on paratransit being the more likely choice as a feeder. It means that car owners consider the service quality of paratransit as below the acceptance level and would choose Careem service if needed. On the contrary, those who travel daily, regardless of their income level, were more likely to choose paratransit to reach BRT. The location of the BRT corridor significantly contributes to this behavior. Since most of the stations in the Rawalpindi and Islamabad regions are surrounded by mixed land-use comprising jobs and education facilities, urbanites tend to use BRT who commute daily and save money by taking paratransit when living in a remote area.

Furthermore, the service attribute satisfaction predictors showed high dissatisfaction with “waiting time”, “travel time”, and “Safety” when using paratransit services. Consistency in the safety concerns was also evident in the studies of Bangkok (Tangphaisankun et al., 2010) and Belfast (Mahmoud and Hine, 2016). However, besides higher dissatisfaction, people are still loyal to paratransit in the RIMA context due to the large volume of such services on roads, which helps the people quickly catch them during most of the hours in the day. Additionally, trip satisfaction using RIBRT suggest that daily RIBRT users showed higher dissatisfaction with travel compared to non-daily RIBRT users. Mouratidis et al., (2019) found that travel satisfaction is highly influenced by the urban forms, and travel modes have the capacity to mediate such relationship. However, the relationship of trip satisfaction and urban form was not highlighted in RIMA study.

The overall survey analysis showed that the quality of accessibility provided by RIBRT feeders is deprived due to the current state of paratransit, making it too complicated to be considered for integration with RIBRT. To enhance the quality of accessibility for RIBRT, modifications in the paratransit network and service quality are essential. From the policy perspective, to enable the RIBRT commuters to use paratransit, it is necessary to strictly monitor the vehicle maintenance, passengers’ safety, timetable of arrival and departure from designated stops, and the completion of the routes on time. Installing the surveillance cameras on board and monitoring seating arrangements of both men and women would potentially help reduce criminal activities. Additionally, the government must provide financial aid to local transportation operators running paratransit that could help the operators maintain and modify the vehicle to be considered suitable for the BRT feeder integration plan. More precisely, the provision of separate lanes for the RIBRT feeder would substantially increase travel speed, which will reduce travel time and traffic congestion.

This analysis has its limitations. First, the collected sample is very small as there were time and cost constraints for a single researcher. Therefore, aspired researchers wanting to explore RIBRT more should obtain a larger sample size to generalize it better after excluding any obvious bias. Also, the service attribute of paratransit can be evaluated based on more meaningful variables in future research to further develop policies for improvement in other cities or countries.

As future research, it would be essential to examine the commuters' willingness to walk to transit from longer distances and willingness to pay when traveling a certain distance would also shed some light on the overall performance of small-scale public transportation as feeders for MTS. The impact of BRT feeder buses on land development and property values is only known in Bogota and Korea. Therefore, it can be suggested to explore this area in other developing cities to understand the potential of BRTs with and without feeder networks.

This chapter focused only on the accessibility to one service facility, i.e., RIBRT and did not discuss the residents' access capacity to several facilities. The next chapter focuses on the city-wide accessibility towards several service facilities in RIMA, and compare it with the absolute satisfaction of households when accessing such facilities.

Chapter 7: Relative Accessibility to Service Facilities and Residents' Satisfaction? Socio-Spatial Analysis

7.1. Introduction

Besides developing affordable housing projects for disadvantaged groups, city planners face difficulties increasing service facility usage. Failure to upgrade the old city technologies might cause complications in implementing the infrastructure of citizens' choice (Angelidou, 2014). This hindrance could be due to residents who might consider accessing services like public transportation as unsafe, inconvenient, and time-consuming (Mulley and Moutou, 2015), the cities' sprawl associated with low-density neighborhoods might cause low or no access to essential service facilities, leading to long travel time and shifting to private vehicles (Mattingly and Morrissey, 2014). Therefore, Mulley and Moutou (2015) insisted that local city planners regularly encourage residents to utilize service facilities. This regular use of the neighborhood facilities can ensure attachment to the community, resulting in a good long-term relationship. Residents care about their current location and establish a close bond with their residence environment (Casakin et al., 2015).

Though existing studies have attempted to understand the degree of city attachment amongst residents empirically, their results are usually based on sociological and psychological models that neglect the concept of city and regional policy processing. To optimally increase service facility usage, it is essential to analyze household preferences, household characteristics, and degree of location attachment. However, previous service management studies usually focused on the performance and quality of the urban facilities, ignoring the residents' attitudes towards access satisfaction and travel behavior. Thus, this chapter focuses on determining the city-wide accessibility of service facilities across urban forms in RIMA and compare it with residents' access satisfaction with such facilities. The analysis presented in this chapter fills the gap by spatially analyzing the city-wide accessibility to multiple service facilities and statistically comparing the access satisfaction of mixed-income groups. It attempts to answer the second sub-research question, i.e., "*Do households have high satisfaction with access to service facilities compared to the city-wide availability of such facilities?*".

7.2. Data collection

This study employed a quantitative approach to collect primary individual-based data to analyze LA and travel behavior to access service facilities across the urban form. Most of the indicators used in this study were borrowed from the Pakistan Living Standard Measurement Survey (PLSM), a district-level survey designed by the Pakistani government to measure the social living standard of the citizens. The service facilities in a built environment include four frequently used services such as utility stores, BRT, education, and health facilities. This study also included a fifth facility, drinking water plants (DWP from hereafter), which previous travel behavior studies have not used. Local authorities in RIMA have established clean water plants in several neighborhoods to access water for drinking purposes for free. These plants are easily accessible in many residential areas. Whereas other housing community residents either purchase gallons of water bottles at the supermarket or ask the markets to deliver the bottles to their homes every week. Therefore, this DWP facility differs from purchasing water bottles at grocery stores or supermarkets.

Nine study sites were chosen based on the multi-clustered stratified sampling. First, the distance of each site from the city center was measured to get the city core to suburban areas. Then, the distance of each site to the BRT stations was calculated to understand the proximity of residential areas to PT services. These distances were calculated using the distance tool in ArcGIS 10.5.1. Additionally, the housing density and the household demographics, indicated by the housing type (private housing scheme, public housing/apartment, and local self-built housing), were also significant in differentiating the unique features of each location.

The study sites include S1-1 (Asghar Mall Scheme), S1-2 (Naya Mohalla), S1-3 (Askari 10), S2-1 (Bahria Town Phase 3), S2-2 (Ghauri Town), S2-3 (Pakistan Housing Authority apartments, or PHA G-11/4), S3-1 (PHA G-7/1), S3-2 (PHA G-7/2), and S3-3 (F-10). The list of sites and sample frequency is given in Table 17; their geographical locations are shown in Figure 20.

Sites S1-1, S1-2, and S1-3 were selected within 5 km of the city center. The first two sites were scattered and poorly developed informal settlements where people usually built their own multi-level houses on flexible plot sizes. They were highly dense, with better proximity to schools, shopping stores, offices, BRT, and main roads. Since these two sites are located within 500 meters of BRT, then according to Dong (2021), residents can be considered TOD households. The third site was a formal gated housing site for army figures.

Three sites were selected within 5-10 km of the city center. Sites S2-1 and S2-2 were medium-density sites, and S2-3 was low-density. The former two sites were well-planned, private gated housing societies consisting of luxurious houses of different sizes and eye-catching structures mainly for high-salary groups. The latter was public housing to accommodate government officials within 0-5 km from the nearest BRT station.

Furthermore, three low-density sites were selected within 10-15 km. S3-1 and S3-2 were low-density sites comprising government-allotted public housing near BRT stations. These sites were mixed settlements dependent on motorized vehicles to access public facilities. Housing in S3-3 was somewhat similar to S2-1 (Bahria Town, phase 3); however, this site was not a gated community.

Within the selected sites mentioned above, a door-to-door household questionnaire survey was conducted from late February 2020 to early April 2020 in RIMA, Pakistan. These questionnaires were distributed to the households at their homes in the selected sites. The novel Coronavirus had newly emerged in Pakistan, but it does not affect the data collected from households, enabling the samples to be analyzed as general cases. On average, the survey completion time was less than 10 minutes. All respondents were confirmed to be above 18 years of age. Due to time and accessibility constraints, 435 valid samples out of 500 (a response rate of 87%) were collected from households at nine sites across the three urban forms. At S1-3 (Askari 10), special permission was required from the authorities to enter the premises and approach houses to collect data due to safety reasons. The data gathered were self-reported and coded into SPSS (version 26) for advanced analysis.

This study used spatial and statistical analysis to determine access capacity and location attachment among RIMA city core, mid-urban, and suburban households. I incorporated only frequently used service facilities rather than including every public and private facility in the twin cities that are usually not regularly visited. Previous studies mainly focused on education, health, shopping, PT, and recreational facilities (Zeng et al., 2019; Lotfi and Koohhsari, 2009); one facility in one case study. This study uses five frequently used service facilities. The names and addresses of these facilities were taken from government and private websites.

Education: All the levels of education facilities are included in this study since a majority of the families have children who go to schools, colleges, and universities. Pakistan does not have an elementary, middle, or high school system. Instead, schools are where students get ten years of education (equivalent to the first year of elementary until the first year of high school). College is only two years (equal to the second and third year of high school), where students study the introductory syllabus of the fields they wish to choose in university. Therefore, students who graduate from school must enroll in college before enrolling in a university; hence, this service is essential for their studies. From university onwards, the system is the usual one around the globe. The data for education facilities were taken from eduvision.edu.pk., and rcb.gov.pk.

Health: All the levels of health facilities, i.e., hospitals and clinics, across RIMA are included in this study, and they function the same as in any other country. The data for health facilities was acquired from oladoc.com and healthwire.pk.

Shopping: It is challenging to define grocery stores in developing countries like Pakistan. In developed countries like Japan and the US, low-level stores or convenience stores are well-established where people shop precisely the way they shop at supermarkets and marts. However, in Pakistan, grocery stores, also known as *Karyana stores* (utility or general stores), are underdeveloped and usually have only one shopkeeper. Customers usually ask the shopkeeper for the items they want to purchase rather than picking the items on their own. The high-level supermarkets and marts function somewhat similarly to those in developed countries. Usually, low-income people visit grocery stores more often because they cannot afford to shop at supermarkets for expensive monthly groceries. Furthermore, several online phone applications for grocery shopping deliver bought groceries at home. Since the data for the population that uses such applications are unavailable, this medium was excluded. The names and locations were taken from lookup.pk and khappa.pk, where information about grocery stores across Pakistan is available.

BRT: We included only BRT for the analysis because the up-to-date information about the number of buses, station names, routes, working hours, and fares is readily available on the official Punjab Mass Transit Authority (PMA) website; pma.gov.pk. In contrast, up-to-date information about low-level informal paratransit services could not be obtained; hence, we excluded these services from the analysis. The door-to-door taxi services called using an online application were also excluded since residents do not walk or use any other travel mode to get to taxis.

Drinking water plants (DWPs): To our knowledge, no study has analyzed access to DWP's before. Since tap water at home is considered highly unreliable for drinking purposes, local authorities have established DWPs across RIMA to access and utilize clean water free of cost, helping low-income groups. Though some neighborhoods can easily access this facility, others would either purchase water bottles (around 10 gallons) at the shopping stores or hire companies to drop the bottles at households' doorsteps. I used Google Maps to get the necessary data since no credible website was found for DWP.

The addresses of all service facilities were then located using Google Maps and then geocoded in ArcGIS for further analysis. I used RIMA's land use map to help to identify the residential parcels in RIMA. Later, Google Earth was employed to extract 1,010 residential parcels because government-made sub-district boundaries of RIMA were not available. These extracted parcels were geocoded in ArcGIS 10.5. When calculating the distances to each service facility, a centroid of each residential parcel was formulated to use them as origins.

Since the availability of national-level travel behavior data is an issue in Pakistan, we gathered our primary data by dividing the stratified sampling into two steps. First, I selected nine study sites for door-to-door household surveys based on the distance to the city core, density, and development type. Figure 17 shows the spatial distribution of study sites in RIMA. Second, three sites each were distributed five kilometers, ten kilometers, and fifteen kilometers away from the city core. The white area between the residential parcels and greenery is a mixture of commercial, army, and undeveloped regions. Table 11 describes the characteristics and sample frequency of each site. The first author noted the household address when distributing the questionnaire survey between February 2020 and April 2020. Out of the total questionnaires 500 given out, 435 valid responses were collected at a response rate of 87%.

Table 11 Study sites for surveys based on density, distance to BRT and city center and development type

Study Sites	Names of Study Areas	Distance to city center (km)	Development type	Sample
City core				
S1-1	Asghar Mall Scheme	0 - 5	Informal Self	48
S1-2	Naya Mohalla	0 - 5	Informal Self	49
S1-3	Askari 10	0 - 5	Formal Private	50
Mid urban				
S2-1	Bahria Town	5-10	Formal Private	51
S2-2	Ghauri Town	5-10	Formal Private	52
S2-3	PHA Apt. G-11/4	5-10	Public	40
Suburban				
S3-1	PHA Apt. G-7/1	10-15	Public	60
S3-2	PHA Apt. G-7/2	10-15	Public	40
S3-3	Sector F-10	10-15	Formal Self	45

Table 12 Comparison of household attributes across three groups

Household characteristics	City center	Mid-urban	Suburban	Household characteristics	City center	Mid-urban	Suburban
Gender				*Family size*			
Male	91.84%	94.41%	82.76%	< 4	18.37%	12.59%	18.62%
Female	8.16%	5.59%	17.24%	4 -7	72.11%	80.42%	80.00%
Age				8 - 11	8.84%	6.99%	1.38%
< 25	1.36%	0.00%	0.69%	12 - 15	0.68%	0.00%	0.00%
25 - 44	39.46%	39.16%	40.00%	*Frequent travelers*			
45 - 64	50.34%	49.65%	48.28%	< 3	32.65%	17.48%	42.07%
65 - 84	4.08%	7.69%	8.28%	3 - 5	66.67%	65.73%	54.48%
> 85	4.76%	3.50%	2.76%	6 - 8	0.68%	16.78%	3.45%
Marital status				*Occupation*			
Married	90.48%	92.31%	84.14%	Working adult	76.87%	75.52%	73.79%
Unmarried	9.52%	7.69%	15.86%	Unemployed/Student	23.13%	24.48%	26.21%
Family income							
0-49,999	66%	1.4%	0.0%				
50,000-99,999	29.3%	16.1%	13.8%				
100,000-149,999	3.4%	30.1%	37.9%				
150,000-199,999	1.4%	19.6%	26.2%				
>200,000	0.0%	32.9%	22.1%				

Note: The family income is in Pakistani Rupees (PKR).

The questionnaire survey was divided into three main parts: (1) *household characteristics* such as age, gender, marital status, employment status, income, family size, and frequent travelers, (2) *access satisfaction* with service facilities in question, and (3) *location attachment* to identify satisfaction with built space of residential location, and desire to live near transit. The first author completed all the surveys by asking questions since many households could not read or complete English questionnaires. Table 12 summarizes the household characteristics.

Out of the total sample, male respondents dominated all three groups probably because Pakistan is a segregated society, and male family members usually deal with the external matter, while women are the homemakers. It was challenging to communicate with the female members during the questionnaire survey collection as they were reluctant to talk to strangers at the door without male family members. Hence, male respondents dominated the sample.

Therefore, this study in RIMA creates a statistical model to examine household characteristics, access satisfaction with service facilities, and the degree of location attachment. It highlights the association of service facilities with residential areas at different geographical locations, focusing on low-income people to determine relative accessibility deprivation. The findings will contribute to the literature on accessibility deprivation in urban areas.

7.3. Analytical approach

7.3.1. Spatial analysis: City-wide accessibility to service facilities

The spatial analysis was conducted to determine the access level to five service facilities in the RIMA context and to compare the access satisfaction level of residents living in nine sites. Previous studies have employed various methods to spatially determine the accessibility of service facilities (Lotfi and Koohsari, 2009; Zeng et al., 2019). The "coverage" method can count the number of facilities within a catchment by defining the catchment and determining the accessible locations to households and housing neighborhoods. The "container" method can count the number of facilities within a fixed area and arbitrary boundaries. The "minimum travel cost" method requires travel survey data, including travel time, travel mode, and road congestion. The "gravity and two-step floating catchment" methods are the most difficult to employ since they deal with the service or facility size, which is challenging to obtain at the city level. Additionally, the minimum distance method can evaluate the distance from one point to the nearest service facility with a detailed accessibility assessment. It is a widely used method in studies (Pearce et al., 2006; Su et al., 2017; Zeng et al., 2019). Since residents face difficulty in reaching any service facility, I converted the distance in meters from residential neighborhoods to service facilities into walking time in minutes. Hence, the distance method was essential for this study. The data for Pakistani district and sub-district boundaries were not available. The boundaries, shown on Google map, ranging from a few hundred square meters to a few kilometers containing thousands of residents. Therefore, spatial analysis became exceptionally challenging. Thus, taking RIMA's land use map as guidance, residential parcels were extracted using Google Earth and recoded into ArcGIS to determine accessibility.

Furthermore, the distance from the residential location to any service facility requires an operational measure to show spatial accessibility. The standard distance tool in ArcGIS can measure the shortest path using a road network as a medium. However, in the RIMA context, the updated version of the shapefiles of the road network is not available. Also, it is almost impossible to determine the path and travel mode that residents usually take to reach the desired facility. Therefore, this study borrows the approach Zeng et al. (2019) adopted when estimating the distance and measuring the accessibility from residential parcels to service facilities.

Similarly, the distance was first converted into walking time since the walk to any service facility from home determines the quality of the built environment (Su et al., 2017). This travel mode is essential because people living in gated communities away from the city center have less or no access to service facilities within walking distance. Therefore, they are highly dependent on private vehicles to travel easily. Lu and Wang (2012) and Su et al. (2017) have suggested that residents are reluctant to walk with an increase in walking time; hence, the residents' tolerance for walking and the walking time fit a decay function. Additionally, an average adult walks at a speed from 55 to 110m/min, and 80m/min is the preferred walking speed (Rose et al., 2005). Therefore, similar to Zeng et al. (2019), this study borrows the same standard. The accessibility levels used by converting the distance and the accessibility scores assigned to each residential parcel are given in Table 13. The evaluated scores to an individual facility compute the overall accessibility score to all the facilities for city-wide residential parcels.

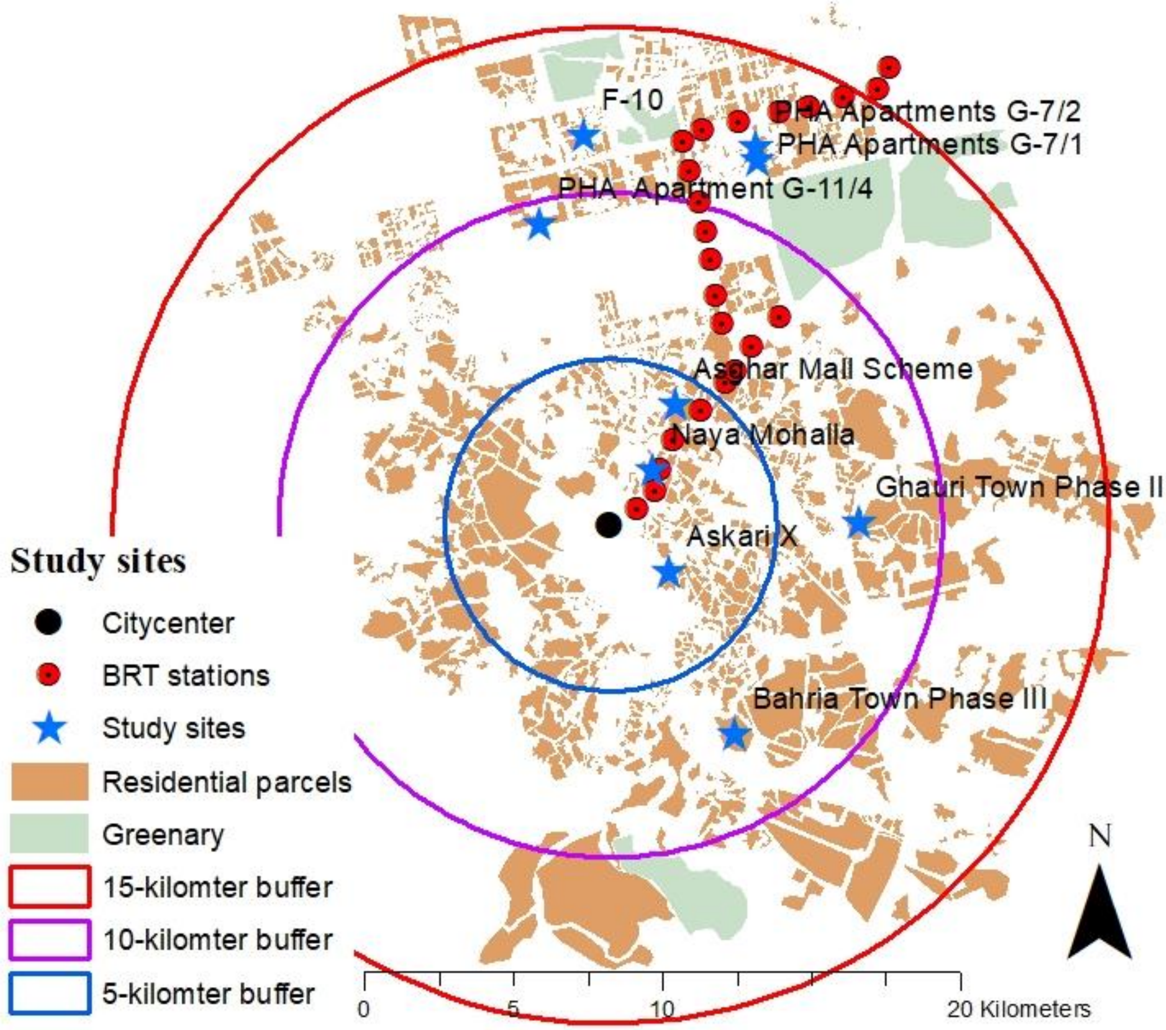

Figure 17 Geographical location of study sites in Rawalpindi-Islamabad

The five service facilities within the same dimensions were also divided into lower-, medium- and high-level. The lower-level facilities are usually located within the neighborhoods that facilitate daily needs (e.g., utility stores, clinics, and schools). Whereas the higher-level facilities traditionally located away from the residential areas provide better and somewhat expensive services such as supermarkets, hospitals, and universities, see Figure 18 for the spatial distribution of these facilities. The service facilities and their divided levels are as follows;

- *Education*: Higher-level= Universities, Medium-level= Colleges, Lower-level= Schools
- *Health*: Higher-level= Hospitals, Lower level= Clinics
- *Shopping*: Higher-level= Supermarkets, Lower level= Grocery stores
- *Drinking water*: Stays as it is
- *RIBRT*: Stays as it is

The level of a particular service facility that satisfies the residents' needs depends entirely on the households' characteristics and preferences. For instance, in RIMA, people living near the city center could easily access small-scale shopping stores and use them more than travel a long distance to buy groceries in bulk at the supermarkets. The same is the case with health facilities. On the other hand, suburbanites visit malls, supermarkets, and well-developed hospitals more often located outside gated communities. Though these facilities may be expensive, they provide high-quality services compared to lower-level facilities. Nevertheless, ultimately people are free to choose their desired level of service facilities. Therefore, city planners in RIMA must consider equal opportunity to access the facilities at all levels regardless of whether residents choose a certain level of service more than others.

Table 13 Correspondence between distance range, walking time and accessibility scores

Accessibility measures	**Level of accessibility**				
	Very Good	**Good**	**Normal**	**Bad**	**Very Bad**
Euclidean distance to facilities (meters)	≤ 300	300-600	600-1200	1200-1800	> 1800
Walking time (min)	≤ 5	5 to 10	10 to 20	20 to 30	> 30
Accessibility score to each facility	100	80	60	40	20

Source: Su et al., 2017; Zeng et al., 2019

7.3.2. Household access satisfaction

In addition to spatial analysis, this study employed quantitative statistical analysis to examine household access satisfaction and the attachment to the residence location. This analysis was further divided into two main parts. Firstly, *access satisfaction* with drinking water, shopping stores, BRT, education, and health facilities was calculated using a dichotomous category, 0 for

“Not satisfied” and 1 for “Satisfied,” to examine the extent to which 435 respondents were satisfied when accessing these facilities. Then, the descriptives were calculated for the *location attachment* using a 5-point Likert scale of “1=Very dissatisfied, 2= Dissatisfied, 3= Do not feel anything, 4= Satisfied, and 5= Very satisfied”.

7.4. Access capacity to services in RIMA

The accessibility scores of service facilities were calculated in RIMA and were divided based on three groups—city center, mid-urban, and suburban. Table 14 shows the descriptive summary of accessibility mean scores of service facilities. Except for universities, schools, hospitals, and grocery stores, all service facilities’ access scores and sub-types were higher within the city core region than in other groups. The mean accessibility score of the main types across all the groups ranged from 25.24 (BRT) to 65.31 (shopping) and from 36.98 (universities) to 79.39 (grocery stores) for sub-types. University access scores (41.26) and hospitals (51.37) were highest within suburban areas. The mean scores for schools (69.52) and grocery stores (79.36) were highest among the mid-urban group. BRT service showed the lowest because it is a single corridor line that provides access to only 8% of the population within ten minutes of walking distance (Adeel et al., 2014). The remaining population who desires to use the BRT must take another travel mode to reach the nearest BRT stations. The poor access to other services indicates the relative accessibility deprivation for such groups.

Furthermore, Figure 19 shows the accessibility score by the residential parcel for all the sub-types, except BRT, since this service is not spread across RIMA. The color-grading from “Red to Dark Blue” indicates “Poor to Very Good”, representing accessibility scores. The figure shows that the red color across RIMA indicates less well-equipped services in such areas, meaning low access to such facilities, than dark blue areas showing high proximity to several service facilities. Notably, each service facility indicates a unique pattern within RIMA. For example, universities show low access in several parcels of all three groups, hospitals and supermarkets show low access in the southern region of RIMA and drinking water plants are less in number within the outlying suburban residential parcels. In other words, the straight-line distance of the facilities from the nearest residential parcel is more than 1200 meters, making it difficult for the residents to walk to them. On the contrary, most parcels in all three groups are well equipped with schools, grocery stores, and clinics, indicating that such services are within the range of 600 meters and easy to walk to.

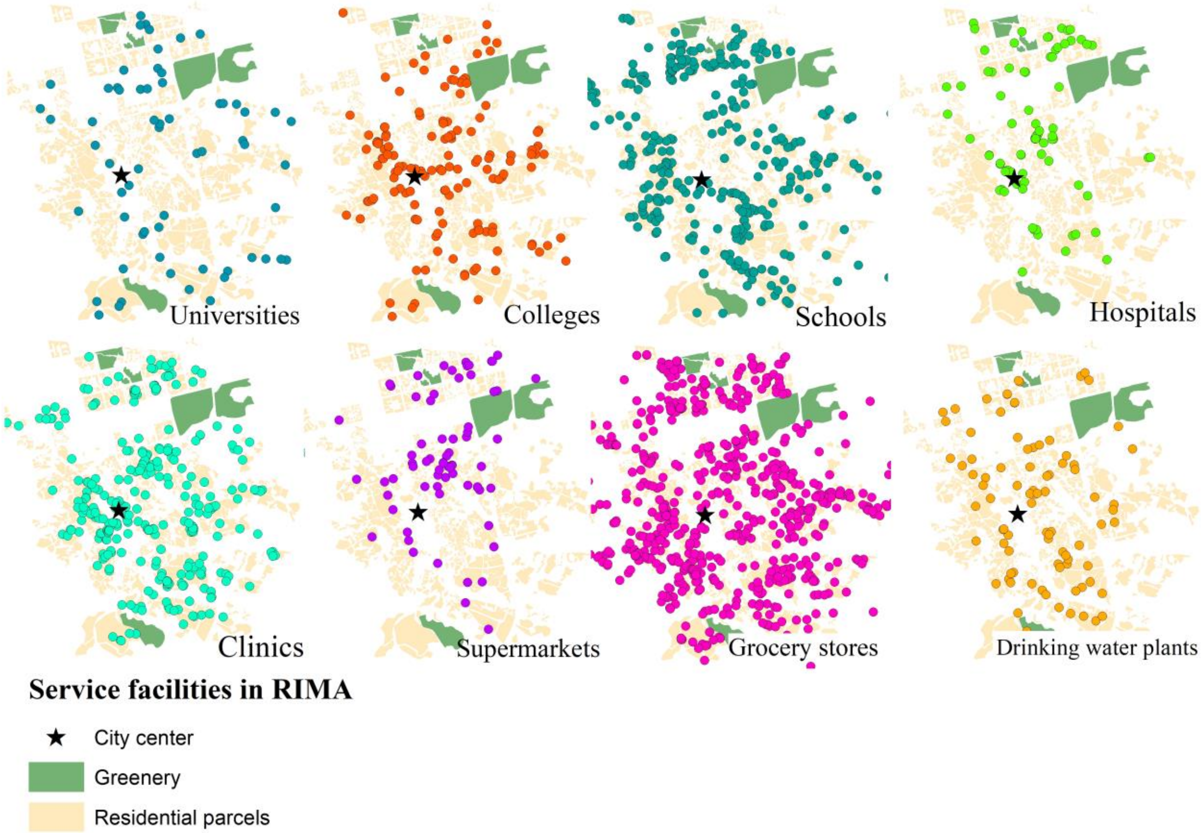

Figure 18 Spatial distribution of service facilities in RIMA

Table 14 Mean accessibility scores of service facilities in RIMA

Service facilities	**City Core**		**Mid-urban**		**Suburban**	
	Mean	**St. D.**	**Mean**	**St. D.**	**Mean**	**St. D.**
Education	**56.57**		**54.01**		**50.25**	
Universities	36.98	19.60	38.02	22.00	41.26	22.63
Colleges	68.04	21.04	54.49	22.47	42.61	25.12
Schools	64.69	18.97	69.52	20.22	66.88	22.63
Health	**64.19**		**50.08**		**58.27**	
Hospitals	49.94	22.47	38.82	21.29	51.37	24.29
Clinics	78.44	17.41	61.34	23.83	65.17	23.08
Shopping	**65.31**		**61.44**		**63.75**	
Supermarkets	52.63	25.69	43.53	24.86	49.12	24.94
Grocery stores	77.99	16.02	79.36	17.19	78.38	17.89
Drinking water	**63.13**	18.82	**53.80**	22.92	**41.62**	24.66
BRT	**35.42**	20.53	**25.24**	13.98	**28.90**	17.40

Note:

1. St. D. = Standard deviation.

2. The bold numbers for education, health, and shopping indicate the mean values of the mean accessibility score of sub-types of the respective facility.

7.5. Relative accessibility deprivation and location attachment

Day (2016) and Su et al. (2017) argued that the built environment of the residential area affects the way people feel, behave, and go about their daily lives. The way service facilities are spread in a built environment also impacts the residents' satisfaction level when accessing such facilities. Therefore, as a sub-analysis, this study examined the respondents' access satisfaction with five service facilities. The descriptive summary is given in Table 15.

Overall, this cross-analysis indicates disparities in all services across the groups. The city core residents showed the highest satisfaction with health (51.2%) and BRT (59.2%) services compared to other groups, and suburban residents showed the highest satisfaction with education (42.0%), shopping (43.1%), and drinking water plants (45.9%) compared to the city core and mid-urban residents. Notably, residents of all three groups did not show significant satisfaction differences with education, shopping, and health facilities, with low satisfaction with the sample's health facilities.

This result could be because small-scale neighborhood clinics might not provide good quality services, even though they are accessible within walking distance, forcing urbanites to visit large-scale hospitals in remote areas. Similarly, city core residents were dissatisfied when accessing education facilities, maybe because they did not prefer such facilities near the neighborhoods due to poor quality and instead commuted to the institutions with higher standards away from the residential area. Surprisingly, the city core residents indicated low satisfaction with shopping compared to other groups. Although spatial analysis showed a "Very Good" accessibility score for grocery stores within the residential areas throughout RIMA, it appears that the local government did not equip neighborhoods with large-scale supermarkets as per residents' demand. Moreover, compared to a low satisfaction level with drinking water among city core residents and higher among other groups, the spatial accessibility score among city core residents was higher than other groups (63.13 for city core vs. 53.80 for mid-urban and 41.62 for suburban). The reason for low access satisfaction among the city core could be three-fold: (1) the timings of the drinking water availability might be unpredictable, (2) the drinking water plants located within the residential area are always crowded at the time of available water, or (3) the structure of water plants exists but does not provide clean water, forcing residents to visit other facilities away from home. Lastly, mid-urban residents reported the lowest satisfaction with BRT service compared to other services, possibly because of BRT's low coverage area in RIMA.

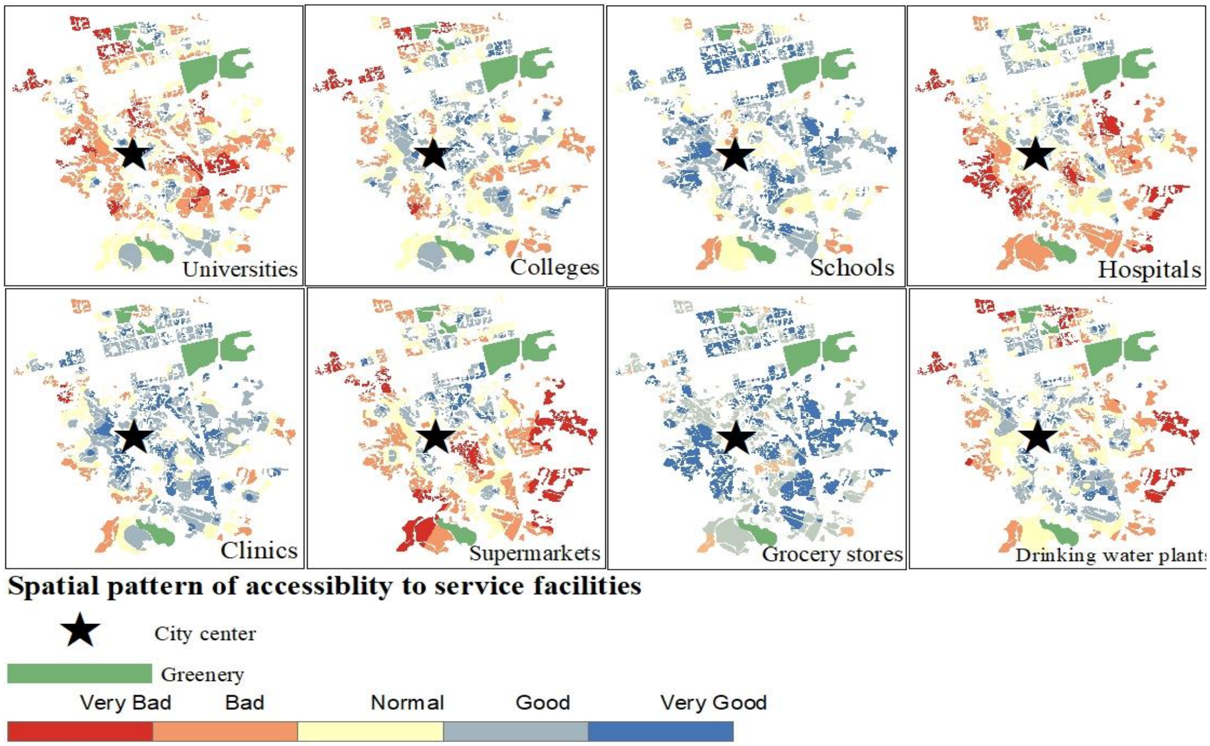

Figure 19 Spatial distribution of accessibility score of service facilities in RIMA

The degree of dissatisfaction with access to service facilities significantly impacts the level of attachment to the location of the residential area that residents were currently living in. The descriptives of the degree of location attachment are given in Table 16. Out of the total sample, around 55% of the city core residents felt "worse" or "much worse" with attachment to the residential location. This result is surprising because this group reported the highest access satisfaction to RIBRT compared to the low access satisfaction among other groups. However, despite being well-equipped with service facilities, it was worth mentioning that city core respondents did not report a "Much better" degree of location attachment level.

Mid-urban and suburban groups show almost 100% car ownership. Also, all three groups showed a high percentage of working adults in the households. If working adults in the city core use private vehicles to commute to work, other households would have to depend on other modes to access desired destinations. Hence, they preferred the location that provides better access to BRT.

Table 15 Descriptives of access satisfaction to service facilities

Satisfaction with service facilities	City center		Mid-urban		Suburban		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Education								
Satisfied	40	23.0	61	35.1	73	42.0	174	-
Not satisfied	70	41.4	62	36.7	37	21.9	169	-
Total	110	32.1	123	35.9	110	32.1	343	-
Health								
Satisfied	43	51.2	24	28.6	17	20.2	84	-
Not satisfied	104	29.6	119	33.9	128	36.5	351	-
Total	147	33.8	143	32.9	145	33.3	435	-
Shopping								
Satisfied	75	26.0	89	30.9	124	43.1	288	-
Not satisfied	72	49.0	54	36.7	21	14.3	147	-
Total	147	33.8	143	32.9	145	33.3	435	-
Drinking water								
Satisfied	56	18.9	104	35.1	136	45.9	296	-
Not satisfied	91	65.5	39	28.1	9	6.5	139	-
Total	147	33.8	143	32.9	145	33.3	435	-
RIBRT								
Satisfied	132	59.2	3	1.3	88	39.5	223	-
Not satisfied	15	15.3	77	78.6	6	6.1	98	-
Total	147	45.8	80	24.9	94	29.3	321	-

Note: The Chi-square tests for all the facilities indicate 99% significant level.

Table 16 Descriptives of satisfaction with built environment and desire to live near BRT

Attributes	City core		Mid-urban		Suburban		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Location attachment								
Much worse	24	16.3	14	9.8	6	4.1	44	10.1
Worse	57	38.8	12	8.4	5	3.4	74	17.0
Neutral	44	29.9	28	19.6	45	31.0	117	26.9
Better	22	15.0	86	60.1	83	57.2	191	43.9
Much better	-	-	3	2.1	6	4.1	9	2.1

Thus, the result of the access capacity to service facilities in RIMA and satisfaction/attitude towards the access to service facilities and the overall residential location can assist the local government when establishing policies to construct low-cost housing for disadvantaged groups. Usually, local governments in many cities develop affordable housing projects near the peripheral regions where accessing health, shopping, recreational, and educational facilities becomes time-consuming and expensive. This low access to services significantly impacts the residents' quality of life. For example, no access to large-scale shopping facilities could prevent residents from obtaining good quality food; no access to health facilities would worsen the health of disadvantaged groups; and no access to high-quality education could jeopardize the children's future, making it difficult to mobilize in the upper social class. However, this study did not directly analyze the correlation between spatial accessibility analysis and health status and children's possible bright future. Additionally, this study did not ask respondents how lack of access to the service facilities in question affects their quality of life.

7.6. Discussion

Many urban planners believe that developing affordable housing can help low-income groups solve their residential problems. Ball (2016) and Varady and Matos (2017) stated that developed cities had neglected to provide Affordable Housing Communities to subsidize households. On the contrary, Woo and Kim (2016) have argued that relocating the residents from centrally located residential areas to newly built affordable housing at urban fringes leads to low proximity to urban facilities. This relocation is common in many developing economies such as Mexico, Brazil, and China which are rapidly urbanizing and causing urban inequalities (Ma et al., 2018; Wei and Chiu, 2018). Even though disadvantaged groups are provided with affordable housing units, their locations are markedly inaccessible. Zeng et al. (2019) have identified that the peripheral location of Affordable Housing Communities causes several social-spatial issues of low or no access to service facilities that, in turn, cause accessibility deprivation.

This study in RIMA spatially analyzed the accessibility score from residential parcels to service facilities. It concluded that the city core region is relatively well-equipped with various service facilities, providing better access to mixed-income groups. Low-income households in the city core may feel deprived of opportunities away from a convenient distance because low access to frequently used service facilities impacts poor people more than the well-off group due to a significant increase in transportation costs. Although some service facilities are less in number in one region while in abundance in other areas, well-off residents have relatively better resources to access the desired service than low-income residents, offsetting the influence of low access to quality of life. For instance, the household characteristics in this study's survey showed that a large proportion of respondents in the city core are low-income, with three to five adult travelers in one family. This survey category implies that they are highly dependent on public transportation such as BRT for their mobility. Since BRT is a single corridor without the integration of feeder buses, commuters usually take multiple travel modes to access BRT stations (Khan and Shiki, 2018). Subsequently, around 53% of the mid-urban and 48.3% of the suburban group earn more than PKR 150,000, making it affordable to bear the daily transportation expenses. Therefore, service facilities must be located near BRT or neighborhoods of low-income people with no car ownership.

After the first phase of BRT in RIMA, the Punjab government established phase 2 to transport passengers directly to Islamabad International Airport. The spatial analysis in Figure 19 should dictate new policies for extending the BRT corridor towards suburban study sites. However, as Haque and Rizwan (2020) have argued, BRT can facilitate low-income groups and benefit the economy to some extent, yet it cannot mitigate traffic congestion, as the primary transportation mode is still private vehicles.

Furthermore, the Government of Pakistan 2018 launched an affordable housing scheme known as the *Naya (New) Pakistan Housing Program* to provide affordable housing to low-income families across the Punjab province (see https://phata.punjab.gov.pk/). The size of the houses ranges from 817 square feet to 1361 square feet. The official web page indicates that several affordable housing societies provide facilities such as utilities, roads, schools, mosques, commercial areas, fast internet, and other facilities, but they are not located in Islamabad and inner Rawalpindi. Also, no access to BRT or different transportation modes may impact the mobility of low-income groups, leading to accessibility deprivation.

This case study employs spatial accessibility to quantify the access capacity of RIMA residents with five service facilities and a statistical housing survey to examine the accessibility issues of the residents at three geographical locations—city core, mid-urban, and suburban. Though this dual method has been used in a handful of studies (Zeng et al., 2019), it is an effective tool to identify and highlight the socio-spatial difficulties faced by disadvantaged groups. This study's findings helped us understand the multiple accessibility issues faced by the residents of all three locations. Therefore, the planners must focus on these deprived locations for suitable housing and facility development. This mixed method can deepen the research in the context of accessibility deprivation when aiming to provide affordable housing units in other cities.

The research results have led to three valuable policy recommendations when planning future housing or service development projects.

Social and economic opportunities: Public and private developers must not only aim to ensure adequate housing units but also focus on providing social and economic opportunities, such as education, health, transportation, clear water, and jobs, to disadvantaged groups. The Rawalpindi and Islamabad development authorities can simultaneously establish housing units and service facilities. This idea applies to all cities, not limited to developing states; although this type of development plan is not new (Woo and Kim, 2016), it is often ignored (Zeng et al., 2019).

Regular financial aid: The lack of stable funding from the provincial or local governments causes significant challenges to developing and maintaining affordable housing units with better proximity to service facilities (Cai et al., 2017). Wu (2015) argued that local governments acquire substantial fees for land leasing and improved economic activities when dealing with urban redevelopment and gentrification. That is why city officials maintain good locations in metropolitan areas for heavy commercial activities and high-class residential areas, pushing affordable housing and related activities nearer to the city periphery (Fenton et al., 2013). Therefore, diversified financial resources and a partnership with private enterprises can encourage the development of affordable housing and associated services at appropriate locations. Subsequently, local officials must provide attractive incentives to encourage social workers and property developers to establish education, shopping, and health facilities at low and high orders for the relocated residents to the newly built affordable residential units.

Consulting residents' opinions: After identifying the residents who want to relocate to affordable housing units, it is essential to understand their views and attitudes. This consultation could help improve the quality of housing units. Organizations such as the Rawalpindi Development Authority and Islamabad Development Authority deal with planning and constructing residential and commercial properties. Ouyang et al. (2017) emphasized that an adequate developing strategy ensures equity when distributing the service facilities around the affordable housing units. Therefore, public opinion is one of the critical elements for future planning processes.

7.7. Conclusion

This case study of RIMA, Pakistan, attempted to explore the city-wide accessibility of the residents towards several frequently used service facilities based on spatial analysis for distance from residential parcels to service facilities and statistical analysis for household access satisfaction. The findings have revealed that spatial analysis of certain service facilities (Table 14) differs from what residents feel (Table 15). Even though the city-wide accessibility was high for certain facilities, residents living near such facilities stated low access satisfaction. This result indicates that residents do not want to use inferior quality services within the neighborhood and instead visit superior quality services in remote areas, especially health and education facilities, which eventually affects their quality of life.

Low-income and extremely low-income groups living in the city core feel inconvenienced by the daily, long commuting time to access high-quality education and health services. This feeling affects their dissatisfaction with the residential location and failing to form a community attachment. Thus, local government and the associated private partners must consider the location and residents' accessibility when planning to establish service facilities within a community to enhance equity amongst all income groups. Also, paying attention to public opinion and maintaining regard for disadvantaged groups is essential to ensure justice in metropolitan cities.

The analysis presented in this chapter did not consider whether the respondents visited the services closer to a residential area. Urbanites might choose service facilities such as universities or large-scale hospitals in remote areas depending on the quality of the service. Therefore, aspiring researchers in this field can focus on household satisfaction with the quality-of-service facilities that residents from the city core to a suburban region often visit.

This study has concluded that residents in different geographical areas suffer from accessibility deprivation depending on the type of service. However, further case studies should include more service facilities and target the population living in affordable housing units in different Pakistani cities to examine the significant differences and recommend suitable policies. Additionally, the frequent travel to several service facilities on the daily basis reflects the transportation costs, especially with large the number of active travelers in one household. The next chapter reflects on the households' housing and transportation costs to determine the affordability of the location that residents are currently living in.

Chapter 8: Location Affordability Index and Transportation Costs in Rawalpindi-Islamabad, Pakistan.

" 'I can't afford it' shuts down your brain. 'How can I afford it?' open up possibilities, excitement and dreams". (Robert T. Kiyosaki)

8.1. Introduction

The previous chapter discussed the respondents' access capacity and travel satisfaction with five service facilities in RIMA. Since travel satisfaction can be influenced by the number of times trip is being made to a certain destination, and the cost associated with that travel, this chapter will focus on such matters. It attempts to answer the thirs and final sub-research question, i.e., "To what extent LAI determines location affordability in RIMA context? What factors influence househod's transportation costs?". It will also determine whether a certain location of the residence is affordable for a family when considering both housing and transportation costs.

Large cities in Pakistan have reported rapid population growth resulting in extreme suburbanization (Khalil and Nadeem, 2019) and high vehicle ownership. This suburbanization in the RIMA has led to an acute shortage of affordable housing for disadvantaged groups in the central city. Though Pakistan's NHP in 2001 dictated several land development features to meet housing demand (Salman et al., 2018), transportation and urban form indicators that can impact affordability were absent in such policies. With this policy gap, public and private developers have struggled to meet the affordable housing demand with proximity to service facilities, especially transit. Further, the high correlation of vehicle ownership with its usage validated the development of suburban private gated communities for the high-income population, leaving behind the disadvantaged groups.

Urbanization in developing nations has restructured economic and spatial development away from the city center, leading to an acute shortage of affordable housing for low-income people. This resulted in low proximity to service facilities, increased car usage, and decreased BRT access when living in suburban regions. Cunningham and MacDonald (2012) stated that housing could provide social and economic opportunities to households when located in a proper neighborhood, making it considerably affordable for low-income groups. In Chapter 3, we have learned that measuring housing costs to determine housing affordability is not enough, and transportation costs must be incorporated in the analysis since this expenditure takes the second most extensive portion of the household income. The housing costs measuring approach has been criticized in the housing and transportation literature as this approach does not involve transportation and accessibility costs (CNT, 2012; Isalou et al., 2014; Mattingly and Morrissey, 2014; ITF, 2017).

The LAI designed by the CNT is a standardized affordability measure of residential location based on H+T costs (HUD, 2017), i.e., the 45% benchmark comprises 30% housing costs plus 15% transportation costs (HUD, 2017; 2019). Transportation costs are associated with income and residential location, affecting most low-income households. This index is popular in both developed and developing cities. Recently, it has been argued that H+T costs measurement must consider other indicators, such as economic (Sean and Hong, 2014; Thaker and Sakaran, 2016), location (Olanrewaju et al., 2018), urban form (Źróbek et al., 2015), and housing structure (Teck-Hong, 2012) that can influence buyers' and renters' decisions to choose a resident. It may seem affordable when living in the city periphery with low rent or housing prices. However, due to a lack of access to urban amenities, the average long distances and car dependence for accessibility may burden households with transportation costs (Currie, 2010; Mattingly and Morrissey, 2014), making it less affordable for low-income families.

Previous studies empirically identified housing structural attributes as essential indicators for buyers or renters in decision-making. These attributes include housing size, number of bedrooms/bathrooms, and a house garden (Teck-Hong, 2012). Hurtubia et al. (2010), Sundrani (2018), Opoku and Abdul-Muhmin (2010), and Chia et al. (2016) concluded that the number of bedrooms and bathrooms are significant parameters in buying a house due to privacy issues. These attributes mentioned above substantially share the H+T costs to construct the overall LA. Though this model is well-practiced in the northern part of the globe, no attention has been given to it in South Asian countries. This RIMA study fills this gap by incorporating urban form and household travel indicators to comprehensively determine the affordability of the residential location, which is quite different from the trade-off comparison of Western societies.

8.2. Data collection

Other than the explanatory variables mentioned in data collection section in Chapter 7, this chapter analyzed additional variables to predict transporation costs. *Urban form* variables include city-core, mid-urban and suburban, and distance from city center to BRT in meters. *Socioeconomic and demographic characteristics* include number of children in one household, active travelers in one household, monthly income, and car ownership. *Travel behavior* was measured using three sub-variables: Usage (never, seldom, often, and frequently), Time taken in minutes (0-14, 15-29, 30-44, 45-60, and > 60), and Mode choice (walk, motorbike, car, and public transportation). Public transportation (PT) mode includes BRT, taxi-like services, and other informal low-quality services. The *density* estimation was taken the same as calculated by Dewita et al. (2014), i.e., > 40 dwellings = high, 30-40 dwellings = medium, and < 40 = low.

8.3. Household characteristics

Out of the total sample, 44% of the household heads were between 40 and 54 years, followed by 25% between 25 and 39 years. Furthermore, male respondents constituted 90% of the household heads compared to their counterparts. This number is quite understandable as Pakistan is a gender-segregated society. Since age and gender are not significantly associated with LA analysis, they are not included. Table 17 summarizes the variations among descriptive socioeconomic and demographic characteristics across the urban forms.

Three socio-demographic characteristics were considered for this research. Household size was the largest among the respondents living in the mid-urban area, with a mean value of 5.4 household members, compared to the other groups. Both mid-urban and suburban respondents had their houses built with an average of around five rooms (number of rooms) compared to 3-room homes of city core residents. In the same capacity, mid-urban residents, on average, had more children (approximately three children) than residents of the city core and suburban areas. Household size and the number of children positively impact transportation costs (Makarewicz et al., 2020). High number of active travelers (4) and children (3.2) were reported among mid-urban households compared to other groups.

Similarly, I adopted three socioeconomic characteristics in this study. Mid-urban residents showed the highest mean monthly income of Pakistani Rupees (PKR) 178,822, with the highest mean housing costs of PKR 57,252, compared to the lowest mean income among the city core respondents, PKR 46,490. It was also worth noticing that the city core respondents showed the lowest housing costs and transportation costs among other groups, but when compared with the shared income, the housing costs and transportation costs percentages were the highest compared to other groups, i.e., 48.3% and 11%, respectively. These percentages significantly contradict Makarewicz et al. (2020), Dewita et al. (2019), and Isalou et al. (2014) findings.

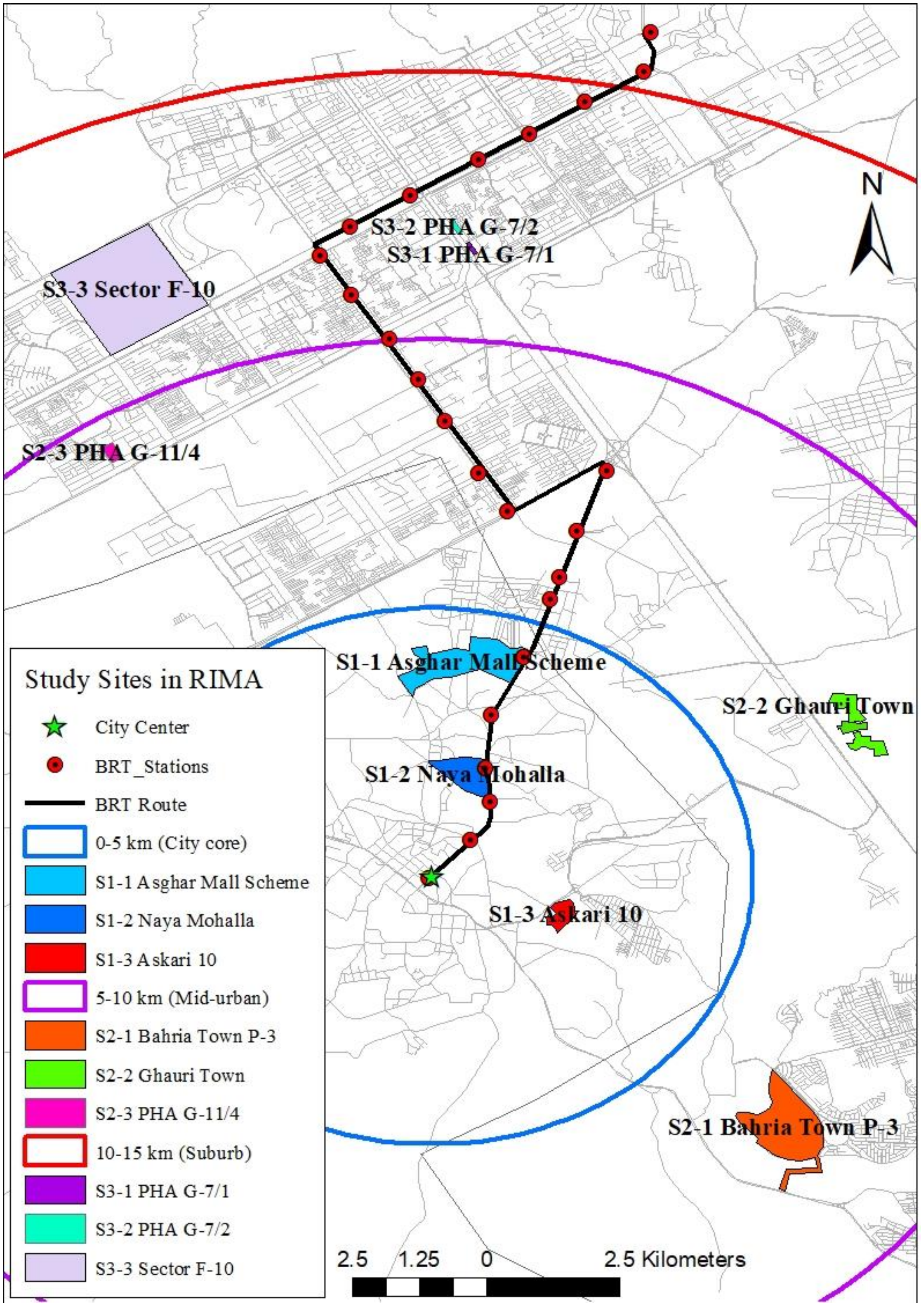

Figure 20 Spatial distribution of nine selected study sites in RIMA

Table 17 Descriptives of households' characteristics across urban forms

Household characteristics	**City core (n=147)**	**Mid-urban (n=143)**	**Suburban (n=145)**	**Total (n=435)**
Socioeconomic characteristics				
Total income (m)	PKR 46,490	PKR 178,822	PKR 167,467	PKR 130,317
Number of vehicles (m)	0.8	0.7	0.9	0.8
Active travelers (m)	3.2	4.0	3.1	3.4
Number of children	3.1	3.2	2.6	3.0
Motorbike ownership[a] (%)	71.4	30.8	13.1	38.6
Car ownership[a] (%)	51.7	97.9	97.9	82.3
Housing ownership (%) (Owner/Renter)	39/28.2	38.6/27.2	22.4/44.6	1
Housing ownership (frequency) (Owner/Renter)	(87/60)	(86/58)	(50/95)	1
Household expenditure				
Housing costs (m)	PKR 21,173	PKR 57,252	PKR 45,338	PKR 41,089
Transportation costs (m)	PKR 4,615	PKR 14,706	PKR 11,693	PKR 10,291
H+T costs (m)	PKR 25,788	PKR 71,958	PKR 57,031	PKR 51,380
Housing costs (%)	48.3	34.8	29.2	37.1
Transportation costs (%)	11	9.3	7.8	9.4
H+T costs[b] (%)	59.4	43	37	46.6

Notes: In 2020, one US dollar was equivalent to 160 Pakistani rupees (PKR).
m = mean values.
% = mean percentage values.
[a] motorbike and car ownership mean percentages for those respondents who chose "YES" in a survey.
[b] H+T costs = Housing and Transportation costs.

The vehicle ownership variable was calculated based on the number of motorbikes and cars owned by one household family. Since Pakistan culture includes extended family members in one house, some respondents owned multiple vehicles in one family. Households in the city core mostly owned motorbikes (71.4%), compared to around 31% of mid-urban and about 13.1% of suburban families. On the contrary, respondents living in mid-urban and suburban areas owned cars (about 98% each) more than city-core households (51.7%). It is clear that well-off families mostly own cars.

Additionally, respondents were asked about housing ownership for the property that they were living in at the survey time. Surprisingly, the data revealed that around 40% of the respondents residing in the city core reported being house owners compared to 22.4% of the suburbanites. Even though city core residents had low incomes, their housing ownership was the highest amongst the three groups.This could be because Rawalpindi has an ancient history long before the partition from India. The houses built in the city center were more than 100 years ago during the Hindu regime. Since then, generations of families have lived there and owned the properties, and passed these houses on to the next generations. Therefore, despite the expensive location, low-income families owned houses. In case of housing renters, respondents in suburban region showed the highest percentage of renting houses at 44.6% compared to around 29% of renters among mid-urban renters. The city core group also showed low renting percentage, i.e., 28.2%. This percentage is also surprising because suburban region in RIMA context hosts well-off people who tend to own the housing rather than renting it.

8.4. Housing and transportation costs measures

Previous studies focused on analyzing the data for a household-level mortgage for house owners and rent payments for house renters (Li et al., 2018; Saberi et al., 2017; Aljoufie and Tiwari, 2020). One study analyzed only monthly housing rent payments (Mattingly and Morrissey, 2014). Aljoufie and Tiwari (2020) also included utility costs such as water, electricity, and sanitation bills as monthly housing costs because these costs also share the household income. In RIMA's case study, households were asked to include rent payments, utility bills such as electricity, gas, water, and garbage bills, and monthly housing maintenance under housing costs. The mortgage concept is not common in Pakistani cities; therefore, it was excluded from the RIMA case study.

For transportation costs, some studies used technical tools to measure the mean commuting costs for a certain distance traveled, provided the data's availability. Besides fuel, operational costs, and taxi bills, vehicle-owning costs were also included in determining overall household transportation expenses (Aljoufie and Tiwari, 2020). PT costs were excluded from the analysis in Jeddah due to a significantly low mode share percentage (Aljoufie and Tiwari, 2020). However, both private and PT costs were calculated in RIMA's study. The costs for public services include ride fares to frequently used service facilities in question. Occasional visits to relatives, recreational parks, and other places were excluded from the study. The costs for private vehicles include fuel, parking costs, vehicle maintenance, and yearly tax. The vehicle purchase cost was excluded from the study to avoid bias because more well-off households can afford a car.

Table 18 demonstrates the descriptives of housing costs, transportation costs, and H+T costs across city core, mid-urban, and suburban groups in RIMA. The analysis shows that mid-urban respondents spent more than PKR 50,000, which is the highest mean amount compared to the residents of other regions. However, the mean percentage of housing costs with income share was significantly high amongst the city core respondents, reflecting the influence of low income.

Regarding transportation costs, the mid-urban households spent PKR 14,706 on transportation, the highest mean among the groups. However, city core residents reported the highest mean percentage of transportation expense, considering income share, among the groups. Additionally, the combined H+T costs were also substantially high (> 45%) among the dense city core residents, making this area extremely hard to afford. This proves that transportation costs affect overall H+T costs, as shown in Bandung, Indonesia (Dewita et al., 2019). The residents with minimum income and higher expenses in the inner-city reported high unaffordability (Dewita et al., 2019). Additionally, since RIMA is a developing region, small economical motorbikes are extremely popular. One point worth mentioning is that motorbike ownership, and its usage is observed more among city-core households in the RIMA context than in other groups where car ownership is high. This pattern is quite similar to other developing cities but different than Western culture.

8.5. Data analysis

The research analysis is divided into two parts using primary data. First, we looked at significant differences in household expenditures between house owners and renters by performing a one-way analysis of variance (ANOVA) test. Then, three boxplots of housing, transportation, and combined H+T costs across nine study sites were designed to illustrate which site exceeds the H+T affordability threshold and which can be considered affordable. After that, the Cross-tabulation and Chi-square analysis of travel pattern indicators from the city center to suburban groups determined the significant differences in household travel behavior across the three groups. Second, we designed the multivariate linear regression model to predict the impact of travel pattern measures on H+T costs.

8.5.1. Urban form and travel behavior

Besides the household characteristics, it was also essential to determine the travel patterns to service facilities in a built environment that directly impacts transportation costs. Therefore, cross-tabulation of travel patterns, that is, travel frequency, travel time, and travel mode, across three groups (city core, mid-urban and suburban) was conducted to determine the difference in the travel patterns among families in different geographical locations. Though recent studies primarily focused on travel distance, travel time, and travel mode as travel characteristics (Mouratidis et al., 2019; Næssa et al., 2018), this study adds travel frequency to have a comprehensive assessment of the transportation costs. Additionally, the chi-square test provides the significance of travel pattern differences.

8.5.2. Linear regression model for transportation costs estimation

Three Ordinary Least Square (OLS) regression models were designed to predict the transportation costs for RIMA families to determine the impact of urban household characteristics and travel patterns. The robust standard error test and multicollinearity for mean variances were calculated.

Model 1 included urban form and socioeconomic and demographic characteristics controlling for travel behavior indicators. These models help predict the strength of the impact of the explanatory variables on travel costs in the context of household characteristics. Model 2 includes all the predictors, whereas Model 3 adds car ownership at the end.

Upon including the dummy variables in the regression model, the analysis represents the relationship of dummy variables with the dependent variable, controlling for the reference variable (Alkharusi, 2012). The dummy variables are valued as "1" and other variables as "0". The nominal variables in the dataset were converted into dummy and reference variable before regressing them with transportation costs. For urban form indicators, dummies were created for city core and mid-urban variables with suburban group as reference. For travel behavior, dummies were created for Usage categories, i.e., "seldom, often and frequently" with "never" as reference variable. Similarly, dummies for Mode choice categories consist of "motorbike, walk and public transportation" with "car" as reference. This method is preferred when performing linear regression having independent variables as categorical (Myers and Well, 2003). Whereas the rest of the variables were interval-ratio and were included in the analysis as they were. After testing for multicollinearity and non-significant results among the travel pattern indicators, travel mode and travel time were excluded from the analysis. DWP and health facilities were excluded from the final regression model. Similarly, the homoscedasticity test suggested the removal of several mode choice dummy variables as their tolerance value was nearly 1, indicating heteroscedasticity (Klein et al., 2016). Furthermore, for "Travel frequency" categories, frequently use PT, often use PT, frequently use utility store, seldom use utility store, and frequently use education were included in the OLS analysis.

8.6. Location affordability across study sites

The element of urban form clarifies the variation in H+T costs among the mixed-income groups in the context of urban form. For that purpose, another descriptive analysis was conducted to calculate housing, transportation, and combined H+T cost among house owners and renters.

Using one-way ANOVA, the significant differences were tested for housing expenditure across urban forms for each household type, i.e., owner and renter (see Table 18).

The differences in the H+T expenditure between house owners and renters were not significant. However, the data indicates that, regardless of the housing tenure, respondents living in the city core spent a large amount of monthly income on H+T expenditure compared to other groups. Table 14 indicates that the percentage difference among the house owners and renters is more negligible within the city core and mid-urban samples than in suburban samples (where renters are overrepresented). Also, housing expenditures show complications among house owners such as inherited properties, maintenance, and mortgages. Therefore, the interpretation focuses on the housing expenditure pattern among renters since the housing expense among such households includes monthly rent, utilities, and other commodities.

Table 18 Mean differences in housing and transportation expenditure by urban form for house owners and renters

Housing ownership	**Household expenditure**	**City core (n=147)**	**Mid-urban (n=143)**	**Suburban (n=14)**	**Total (n=435)**	***p***
Owners	Housing costs	PKR 21,960	PKR 59,640	PKR 44,455	PKR 41,599	***
	Transportation costs	PKR 4,778	PKR 15,116	PKR 11,900	PKR 10,396	***
	H+T costs	PKR 26,738	PKR 74,756	PKR 56,355	PKR 51,994	***
	Housing costs %	47.3	34.0	27.2	37.4	***
	Transportation costs (%)	10.4	9.0	7.8	9.3	***
	H+T cost (%)	57.7	43.0	35.0	46.7	***
Renters	Housing costs	PKR 20,033	PKR 53,649	PKR 45,877	PKR 40,526	***
	Transportation costs	PKR 4,378	PKR 14,088	PKR 11,567	PKR 10,177	***
	H+T costs	PKR 24,412	PKR 67,737	PKR 57,444	PKR 50,704	***
	Housing costs (%)	49.9	33.5	30.4	36.9	***
	Transportation costs (%)	11.9	9.6	7.8	9.5	***
	H+T costs (%)	61.8	43.1	38.2	46.4	***

Notes: H+T costs = Housing and Transportation costs.
One US dollar is equivalent to 160 Pakistani rupees (PKR).
*** $p < 0.001$

The differences in the range of housing (H) costs, transportation (T) costs and the combined H+T costs among home renters were much higher between the city core and mid-urban households, i.e., for H costs; PKR 20,033 - PKR 53,649 = PKR 33,616, for T costs; PKR 4,378 - PKR 14,088 = PKR 9,710, and for combined H+T costs; PKR 24,412 - PKR 67,737 = PKR 43,325, as compared to the differences between mid-urban and suburban households, i.e., for H costs; PKR 53,649 - PKR 45,8777 = PKR 7,772, for T costs; PKR 14,088 – PKR 11,567 = PKR 2,521, and for combined H+T costs; PKR 67,737- PKR 57,444 = PKR 10,293. However, in the context of shared income, the differences in the expenditure are less significant (i.e., for H costs: 49.9% in the city core, 33.5% in mid-urban, and 30.4% in suburban). It was worth noting that the mean H costs among renters was lower than that for the owners, except among the suburban group. This difference could be because of the low rent with small housing size. On the contrary, in other developing cities such as Qom, Iran, the average family income decreased when moving from the central district to suburban New Town (Isalou et al., 2014).

Theoretically, when moving from suburban areas to the city center, housing expenditure increases with the decrease in T costs as an H+T trade-off, as Makarewicz et al. (2020) confirmed using PSID data. However, in the RIMA context, combined H+T costs were significantly higher among mid-urban households and were reported lowest among city core families. This gap is because of the income distribution among families in different geographical locations and other household characteristics that may influence the overall expenditure. Though the city core sample indicated a larger family size and more children than the suburb, their car ownership was significantly low. Additionally, travel behavior to access facilities have the potential to explain the differences in T costs.

Table 19 summarizes the location affordability, households' family income, percentages of H costs, T costs and combined H+T costs across nine study sites. It clearly shows that households residing in study sites within city core, i.e., S1-1 to S1-3, have reported the highest unaffordability compared to other groups. H costs, T costs and H+T costs percentages across the study sites indicate a gradual decline from city core to suburban sites. This could be because it reflects the low-income factor among city center demographics. Respondents in mid-urban and suburban groups have high mean income which reflects low associated costs, resulting in high percentage of location affordability. Therefore, it is not surprising to have high mean H+T cost percentages within city core sites.

Figures 21, 22, and 23 demonstrate boxplot visuals for a percentage of H costs, T costs, and H+T costs, respectively, across nine study sides to show the differences in the range, median and interquartile range boxes of household expenditure. The cost percentages are shown on the x-axis and the study sites are on the y-axis of the three plots. The H costs percentage in Figure 21 shows a steady decline from the first site, which is closest to the city center, to the ninth site away from the city center. Recalling the 30% housing costs benchmark, sites from S1-1 to S2-2 were reported markedly beyond the 30% threshold, having S1-1 reaching the H costs above 50% of the monthly income. On the other hand, households living at sites S2-3 to S3-3 had housing costs below the 30% benchmark, with sites S3-3 at the lowest housing costs, making these sites affordable for households with certain demographics.

Additionally, T costs across nine sites revealed that the median T costs percentages in all the sites were below the 15% threshold, with site S3-3 having the lowest (around 6%) and Site S1-1 having the highest (around 12%). This low T costs percentage reflects household income and maybe the travel mode they chose. Generally, PT such as BRT and informal services, are very economical. Also, students are sometimes compensated with a free ride when commuting in a school/college uniform. However, mid-urban residents usually use private vehicles or ride expensive taxi-like Careem due to a lack of other transportation options.

Furthermore, the H+T costs percentage boxplot includes location affordability across the study sites (Figure 23). The study sites are divided into two groups, i.e., Affordable and NOT Affordable, based on the percentage of the H+T cost out of the shared income of households living in those sites. The Blue cluster is those with H+T costs <45% (Affordable), and the Red ones have H+T costs >45% (NOT Affordable).

The analysis showed that median values of H+T costs percentage for site S1-1 was the highest (around 65%) and lowest (approximately 46%) in S3-2 among the "NOT Affordable" group. In contrast, sites in suburban region have the lowest median H+T costs percentages among the "Affordable" group. These sites are comprised of publicly developed housing where government officers reside. Though they are located 10 kilometers away from the city center, they are relatively closer to the BRT; hence, they reported low H+T costs. However, it is not clear whether the households used PT to commute everyday.

Table 19 Households' cost percentages across nine study sites

Household costs (%)	**S1-1**	**S1-2**	**S1-3**	**S2-1**	**S2-2**	**S2-3**	**S3-1**	**S3-2**	**S3-3**
Affordable (<45%)	6.3	8.2	8.0	47.1	50.0	72.5	81.7	77.5	82.2
NOT Affordable (>45%)	93.8	91.8	92.0	52.9	50.0	27.5	18.3	22.5	17.8
Income in PKR	37,770	45,383	55,944	241,137	140,413	149,300	162,783	133,030	204,322
H costs	51.03	48.60	45.50	35.33	34.82	30.48	28.96	30.30	28.54
T costs	12.41	10.40	10.30	8.10	10.48	9.19	8.02	8.64	6.84
H+T costs	63.45	59.00	55.80	43.43	45.29	39.66	36.97	38.93	35.37
Sample size	48	49	50	51	52	40	60	40	45

PKR = Pakistani Rupees
H+T = Housing and Transportation
H = Housing
T= Transportation

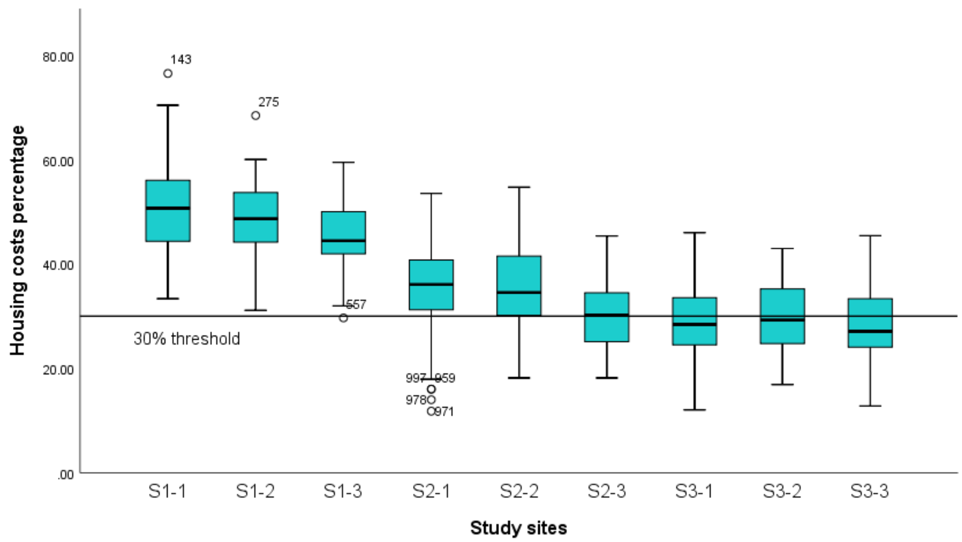

Figure 21 Summary of housing costs as a percentage of income across nine selected sites

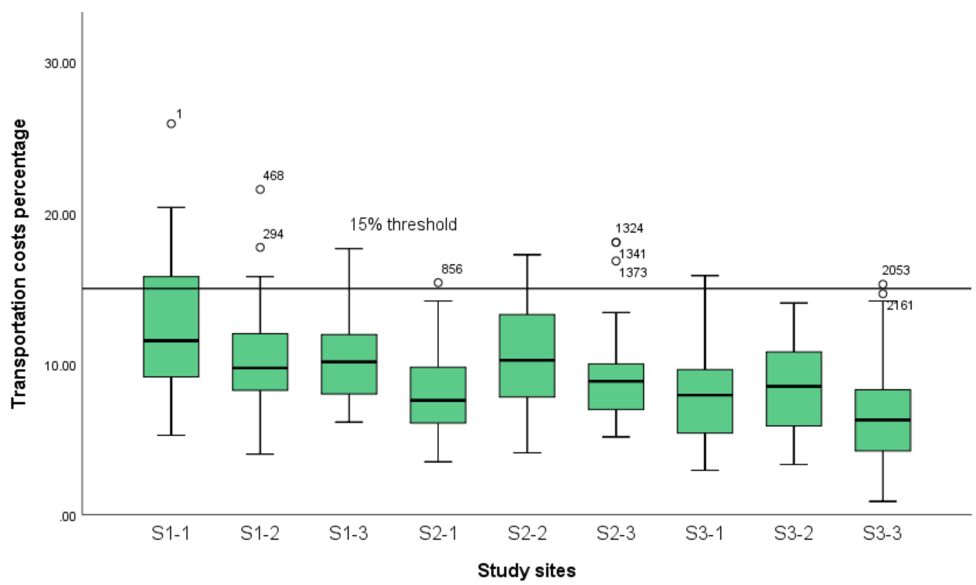

Figure 22 Summary of transportation cost as a percentage of income across nine selected sites

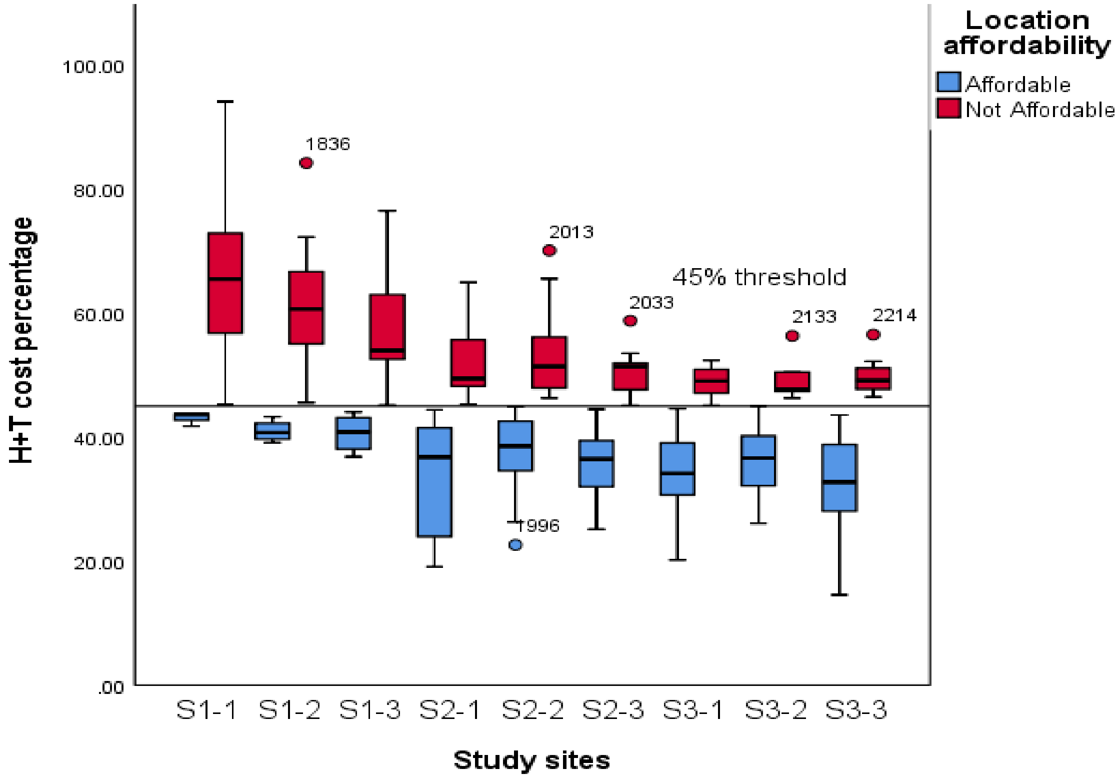

Figure 23 Clustered boxplot of combined H+T costs compared with location affordability
Note: H+T = Housing and Transportation.

8.7. Urban form and travel patterns

This section examines the travel pattern differences in accessing public facilities from the city core to the suburban region. The cross-tabulation and chi-square test indicate significant differences in the travel patterns between the highly dense city core areas and mid-and low-density mid-urban and suburban areas. Table 20 provides a descriptive summary.

8.7.1. Travel frequency

The whole sample "Frequently" used the DWP; clean water is necessary when living in a community. The majority visited Utility stores and PT "Often" (206, versus 147 respondents). The city core respondents were dominant visitors for both facilities among the three groups. Out of the total sample, 114 households "Never" used PT; those living away from the city center "Never" or "Seldom" used this facility. Additionally, 343 respondents "Frequently" visited Education facilities, having a mid-urban sample as the dominant group (around 36%). Further, 40.2% of the city core residents "Never" sent their children to schools outside the neighborhood. Lastly, most of the sample "Seldomly" visited Health facilities, whereas only 80 respondents used such facilities "Often". Those living in suburban regions visited such facilities the least.

8.7.2. Travel Time

The time taken to access various facilities also varied significantly depending on the residents' location. All three groups did not report a significant difference in travel time to reach the DWP, indicating better proximity to residential areas. Most suburban households took "15 to 29 minutes" to reach Utility stores, compared to the other groups that spent "< 15 minutes". The city core groups had educational and health facilities within 15 minutes of walking distance compared to those living in suburban areas, mainly low-density gated communities. High-density city center neighborhoods could provide easy access to schools, colleges, or universities to 82.4% of households compared to the children of only 40 households of the suburban group who traveled more than an hour.

8.7.3. Travel mode

Like travel time, people prioritize a particular travel mode depending on their geographical locations. Those living in the city core mainly "Walked" or rode "Motorbikes" to reach most of the facilities, compared to mid-urban or suburban samples who mainly used "Cars." Also, 119 households could access any PT service within walking distance. This could be why 46.7% of the city core children used PT to go to Education facilities.

Additionally, the frequent visits to the said facilities, long travel distances, and travel mode choices would substantially impact the household transportation costs among urban form groups. Walking or taking BRT would result in low transportation costs. Whereas frequent car usage to visit all the facilities would result in high transportation costs. Therefore, these differences in travel characteristics and their impact on household H+T costs make multivariate analysis compulsory to determine the association's significance in the RIMA context.

In sum, it is evident that the city core group traveled less and walked to their destinations due to the highly dense, compact, and mixed settlement of this location than those living in low- to mildly dense residential areas. Another significant difference in commuting patterns between urban form groups is the travel mode choice; city core residents walk or ride motorbikes more than suburban residents, who use their cars.

8.8. Transportation costs using multivariate analysis

Similar to the previous studies, urban form and household transportation (T) costs are statistically significant in RIMA. These associations are robust after including a variety of household and travel pattern indicators. Three OLS regression models are presented in Table 21.

The R-squared values indicate the explained variance in T costs, i.e., 63.4%, 66.0%, and 66.1% in Models 1, 2, and 3, respectively. comprises urban form indicators, including mid urban and suburban dummies representing the kilometers to the city center as well as the population density of the study sites and socioeconomic characteristics. Besides the primary finding of the OLS analysis that geographical location has a substantial impact on household transportation costs, I attempted to provide the principal findings of the relationship between geographical location, travel behavior, and transportation costs in the RIMA context.

8.8.1. Relationship of urban form and household indicators with transportation costs

The results indicate that all the urban form predictors were significantly associated with T costs in Model 1 while controlling for travel indicators. When moving from a suburban to a city core region, T costs are likely to decrease by PKR 3,555. This association was significant at a 99% confidence interval. On the contrary, the T costs increase by PKR 1,622 when moving towards the mid-urban region. This association was statistically significant at a 95% confidence interval. Similarly, the T costs increase by PKR 264 at a 90% confidence interval with one unit increase in the distance from the city center to RIBRT. It was worth noticing that the statistical significance of the distance variable disappeared when controlled variables were added in Models 2 and 3.

In the case of socioeconomic and demographic characteristics, the number of children were significantly associated with low T costs. This could be because child expenses, such as education and health, does not substantially affect high incomes. The significance of this association increased to a 95% confidence interval after adding travel behavior indicators in Models 2 and 3. Active travelers was significantly associated with high T costs by PKR 264. This is understandable because the number of people who travel on the daily basis would result in higher T costs. Also, wealthy households tend to choose neighborhoods away from the city center with low proximity to local markets and other amenities, which contradicts the Mexico City dynamics (Guerra, 2014; 2015) but agrees with such studies that car owners tend to drive more. Monthly income was significantly associated with high T costs at a 99% confidence interval.

8.8.2. Travel indicators matter to T costs despite a complicated relationship

Other than the traditional travel behavior indicators used in travel satisfaction studies, i.e., travel time and travel mode, after adding the travel frequency variable in Model 2, I found that frequent and often use of PT was positively associated with high T costs by PKR 2,826 and PKR 1,850, respectively. This could be true for the households living away from the city center who use uber like service called Careem (See Chapter 6 for details). Furthermore, frequent and seldom use of utility stores are negatively associated with T costs at a 95% confidence interval. This association is understandable because utility stores are abundantly available in RIMA (as shown in Chapter 7, Table 14) which enables households to access such facilities at walking distance, reducing the T costs substantially. Lastly, frequent use of education facilities indicates a positive statistical association at a 95% confidence interval. It means that T costs increase with one unit increase in

In the RIMA context, the central households tend to use PT services such as formal BRT and other PT more, thus, having high transportation costs. Guerra (2017) also indicated that diverse land use helps households accomplish more daily activities without traveling long distances. However, our study shows high PT usage among city core residents, which is the opposite of what Guerra (2017) argued in his study in Mexico City.

The point worth noticing in Models 2 and 3 is that, after adding travel indicators, the effect sizes of the city core and mid-urban dummies significantly increased. This marked increase is directly related to frequent travel using public transportation services and visiting education facilities. Similar to other developing cities, households usually hire private transportation services that act as mini school buses to send their children to schools away from the residential zones.

8.8.3. Insignificant association of car ownership with transportation costs

Car ownership was added to Model 3 and showed an insignificant association with T costs in the RIMA context. This is the most surprising result in RIMA context and is contradictory to the study in the U.S. by Makarewicz et al. (2020) in which this variable showed strong significance with high T costs by USD 5,584. However, in the RIMA context, the inconsistency could be because the rich households with high car ownership and low T costs burden on family income dominated the study sample. If the analysis is done on a large sample, car ownership would appear significant because no vehicle ownership and high usage of RIBRT might reduce the T costs to a large extent.

Additionally, unlike Model 1, the association of vehicle ownership became statistically significant with H+T costs in Model 2; however, the relationship is negative. It means that having a car and its frequent usage is not a burden to overall household H+T costs, which is theoretically possible amongst wealthy families. The central low-income households tend to walk several facilities as they live in a densely populated area. Also, it takes less time to access any transportation service, especially BRT, than in less densely populated regions. Households may also drive less in congested areas to avoid long traffic jams, long travel times, and parking constraints. In RIMA, car owners are cautious about theft, even in the daytime.

From the perspective of policymaking, higher usage of PT is not undesirable in developing cities. Frequent travel using PT indicates active economic and social participation along with less environmental pollution and road accidents. Since RIMA is facing rapid urbanization, developers should focus on diversifying the service facilities and residential areas by improving the land-use policies. This change could increase the modal split to transit services, even amongst high-income groups, and encourage green travel modes.

8.9. Discussion

8.9.1. Overall results discussion

The study initially proposed the assessment of H+T costs across the study sites, and the factors effecting the T costs. Consistent with the LA studies, household characteristics remain the most significant indicator affecting the T costs when controlling travel characteristics (Table 21). The urban form dummies, representing kilometers to the city center, also showed a direct relationship. The T costs significantly decreased when moving from city suburbs to densely populated city core regions but would increase when moving towards mid-urban areas around ten kilometers away from the city center. This reflects the difference in the residential selection and household characteristics. Since many central households do not own cars in RIMA, dependence on PT is quite common. Additionally, the city center provides highly diverse mixed land opportunities, and low-income households tend to keep their trips short. This is a unique finding in a developing city context. Other studies indicate that high-income households choose to live near the city center, a transit-friendly neighborhood, but whether they are pro-transit compared to cars is different.

The box plot analyses of housing costs, transportation costs, and combined H+T costs examined across the study sites (see Figures 21, 22, and 23) indicate that city core residents spent more than 45% of their shared income on H+T costs, showing a higher unaffordability pattern than other groups. Due to BRT stations' proximity, households do not necessarily need to own a car to travel. However, site S1-2 can be a suitable option for low-income groups regarding their economic and travel conditions. Thus, specific housing development is essential around site S1-2 near the city center with better proximity to BRT to accommodate low-income and extremely low-income families. though locations near S3-1 and S3-2 can also be considered optimal for affordable housing development, such locations are suitable for households with characteristics better than those in city core regions in RIMA. Families with moderate income living in mid-urban areas are likely to find a suitable place to rent in those areas; however, these sites will be further away from BRT. Such areas need attention to extend the BRT corridor for better transit access, employment and education opportunities, and recreation facilities to avoid lengthy travel time and usage of private cars.

The findings of high household income and low H+T costs concerning the shared income when moving away from the city center contradict the results highlighted in the Qom, Iran study (Isalou et al., 2014), where the H+T cost differences between the central district and suburban town were investigated. They concluded that similar to Western societies, the housing costs are much higher among the city center households who earn more than those living in suburban regions. Further, H+T costs are much higher among suburbanites due to high transportation costs (Isalou et al., 2014). Though RIMA and Qom are developing areas, this interesting result indicates significant variance in the urban paradigms, reflecting unique household characteristics and travel behavior. That is why the households' trade-off associated with the higher housing costs and low transportation costs in urban areas and low housing costs and high transportation costs in suburban areas among Western countries is different from the trade-off among households in the city center of RIMA.

The study further investigates the influence of urban form on travel patterns. Here, travel patterns can be used as a mediator. The cross-tabulation suggests that people often use private vehicles to reach most public facilities when living away from the city core. Such groups also never used BRT due to inadequate access (Khan and Shiki, 2018; Khan, 2021), resulting in longer travel times. In RIMA's case, the central residents helplessly send their children to schools within 5 km of the neighborhood, reflecting the household income or concerns about poor education quality. These residents usually visit small-scale health clinics located within an unplanned and scattered area at walking distance compared to the well-off car users. However, neighborhoods near the city center could easily access BRT and other PTs to visit various frequently used facilities.

Some facilities such as hospitals, supermarkets, or universities away from the neighborhoods tend to increase car usage and trip duration. Again, consistent with the travel behavior studies, both living in the city center and the high-density facilities available in a neighborhood result in short distances and usage of green services. The research in the Oslo metropolitan area (Mouratidis et al., 2019) also indicated that 30% of the compact city residents walked to reach the main destination, compared to 50% of suburban car users. The substantial differences in the current study call for city densification policies—having more public facilities to increase densities and control the urban sprawl by limiting the travel distances, thus resulting in the modal split to green services and overall, less transportation expenditure.

After housing costs, transportation is the second-largest expense, as Makarewicz et al. (2020) stated, but it did not appear significant in the RIMA context. Though low-income households living in the city core spent extensively on transportation, the overall share in income does not exceed the 15% threshold. This means that, regardless of the geographical location, the average transportation costs cannot determine location-efficient sites so that families could save more money from transportation costs by relocating.

8.9.2. Future research

The limitations in this study can be addressed by future research for housing development near the city center and transit to reduce H+T costs. Though this research used only five facilities and three travel indicators to mediate household expenditure, future studies can add other urban facilities, such as the desire to relocate near transit, trip satisfaction, and other growing numbers of walkability measures. These indicators are already established but not yet comprehensively utilized as mediators in LA studies. Also, the said indicators can be incorporated into this study's model as well as previous studies that showed the improvement in the LA context (e.g., Dewita et al., 2019; Guerra et al., 2016; Makarewicz et al., 2020).

8.10. Conclusion

Similar to the studies were done by Isalou et al. (2014) and Dewita et al. (2019) among developing cities, this research also supports the thesis that LAI can determine housing affordability to some extent, and transportation costs must be incorporated into the housing costs analysis to determine affordable locations comprehensively. Most studies have not adequately synergized the urban form indicators and travel behavior to examine T costs. Using individual-based samples from RIMA households, this study contributes to both LA and travel behavior literature by 1) using travel patterns as a mediator to associate an urban form with T costs, and 2) adding travel frequency, which is often ignored, to the travel pattern indicators. This input of travel behavior clarified the causal mechanism with a detailed explanation of the impact of neighborhood structure on transportation costs.

The research in this chapter presented several essential findings. First, the clustered boxplot analysis indicated that compared to mid-urban and suburban regions, a major proportion of households in two sites within the city core reported the highest unaffordability. This could be because of low income and high cost, as Dewita et al. (2019) indicated in the Indonesian context. Second, the multivariate analysis showed that neighborhoods near the city core result in low T costs as families in such areas do not use cars to travel daily compared to severely car-dependent mid-urban and suburban regions. Lastly, travel frequency substantially explained the variance in T costs because frequent and often usage of PT and frequent trips to education facilities greatly impact househols' T costs. This case is the same with suburbanites who tend to drive more to enjoy the city facilities.

This study attempted to improve the single variable approach of Smart and Klein (2018) by including three groups ranging from the city core to the suburban, based on the distance to the city center, and contributed to the model used by Makarewicz et al. (2020) by adding multiple accessibility predictors as well as travel frequency. Though the study tried its best to collect a sample representing RIMA households, it was limited to a relatively small sample size due to the residents' time constraints and privacy concerns. Therefore, including more sites with unique geographical features as well as rural areas in the city outskirts and slum settlements could give insight into the influence of location and household characteristics on H+T costs.

RIMA is facing urbanization at the city core and sub-urbanization at the outer skirts, encouraging the developers to provide all the necessary facilities to the households of the suburban gated communities, leaving low-income group densities behind. That is why national housing policies in Pakistan must consider LAI integrated with compact city policies so that the policymakers will guide the development of housing and service facilities for the needy.

Table 20 Travel behavior with urban form to access public facilities.

Travel indicators	City core	Mid-urban	Suburban	Total	Travel indicators	City core	Mid-urban	Suburban	Total
DWP					**Education**				
Usage					*Usage***				
Frequently	147 (33.8)	143 (32.9)	145 (33.3)	435 (-)	Never	37 (40.2)	20(21.7)	35(38)	92(-)
Time Taken					Frequently	110 (32.1)	123(35.9)	110 (32.1)	343 (-)
0-14 min	144(34.0)	136 (32.20)	142 (33.60)	422 (-)	*Time Taken*** (n=343)*				
15-29 min	3 (23.1)	7 (53.8)	3 (23.1)	13 (-)	0-14 min	84 (82.4)	18 (17.6)	0 (0)	102 (-)
*Mode****					15-29 min	26 (49.1)	27 (50.9)	0 (0)	53 (-)
Walk	19 (100)	0 (0)	0 (0)	19 (-)	30-44 min	0 (0)	50 (96.2)	2 (3.8)	52 (-)
Motorbike	75 (84.3)	11 (12.4)	3 (3.4)	89 (-)	45-60 min	0 (0)	25 (26.9)	68 (73.1)	93 (-)
Car	53 (16.2)	132 (40.4)	142 (41.2)	327(-)	> 60 min	0 (0)	3 (9)	40 (93)	43 (-)
Utility store					*Mode*** (n=343)*				
*Usage****					Walk	3 (-)	0 (0)	0 (0)	3 (-)
Seldom	34 (51.5)	20 (30.3)	12 (18.2)	66 (-)	Motorbike	27 (-)	0 (0)	0 (0)	27 (-)
Often	77 (37.4)	74 (35.9)	55 (26.7)	206 (-)	Car	37 (16.7)	84 (38)	100 (45.2)	221 (-)
Frequently	36 (22.1)	49 (30.1)	78 (47.9)	163 (-)	PT	43 (46.7)	39 (42.4)	10 (10.9)	92 (-)
*Time Taken****					**Health unit**				
0-14 min	147 (51.8)	78 (27.5)	59 (20.8)	284 (-)	*Usage*				
15-29 min	0 (0)	65 (43)	86 (57)	151 (-)	Seldom	123 (34.6)	119 (33.5)	113 (31.8)	355 (-)
*Mode****					Often	24 (30)	24 (30)	32(40)	80 (-)
Walk	51 (77.3)	15 (22.7)	0 (0)	66 (-)	*Time Taken****				
Motorbike	63 (86.3)	7 (9.6)	3 (4.1)	73 (-)	0-14 min	121 (59.6)	89 (29.1)	23(11.3)	203 (-)
Car	33 (11.1)	121 (40.9)	142 (48)	296 (-)	15-29 min	26 (11.2)	84(36.2)	122 (52.6)	232 (-)
PT					*Mode****				
*Usage****					Motorbike	55 (90.2)	3 (4.9)	3 (4.9)	61 (-)
Never	0 (0)	63 (55.3)	51 (44.7)	114 (-)	Car	67 (19.2)	140(40.1)	142 (40.7)	349 (-)
Seldom	2 (2)	39 (38.6)	60 (59.4)	101 (-)	PT	25 (100)	0 (0)	0 (0)	25 (-)
Often	81 (55.1)	36 (24.5)	30 (20.4)	147 (-)					
Frequently	64 (87.7)	5(6.8)	4 (5.5)	73 (-)					
*Time Taken*** (n=321)*									
0-14 min	147 (49.5)	61 (20.5)	89 (30)	297 (-)					
15-29 min	0 (0)	19 (79.2)	5 (20.8)	24 (-)					
*Mode*** (n=321)*									
Walk	119 (56.7)	0 (0)	91 (43.3)	210 (-)					
Motorbike	27 (90)	3 (10)	0 (0)	30 (-)					
Car	1 (1.2)	77(95.1)	3 (3.7)	81 (-)					

Notes: Chi-square for DWP usage could not be calculated because 100% of the sample used this facility.
DWP = Drinking water plants
PT = Public transportation.
**p < 0.05. ***p < 0.001.
Source: Author's analysis

Table 21 OLS models of household housing and transportation expenditures

Predictors	***b***	**Std. Error**	***b***	**Std. Error**	***b***	**Std. Error**
			Urban Form			
City core *(Reference: Suburban region)*	-3555.670***	519.901	-5627.816***	689.228	-5433.292***	732.635
Midurban *(Reference: Suburban region)*	1622.000**	674.996	2075.228**	665.570	2099.091**	666.564
Distance from city center to BRT (meters)	264.732*	140.820	69.627	142.477	65.379	142.644
			Socioeconomic and demographic characteristics			
Number of children	-259.554*	141.069	-366.584**	145.447	-371.941**	145.672
Active travelers	263.886*	159.701	213.386	156.143	205.339	156.549
Monthly income	.028***	.002	.027***	.002	.027***	.002
Car ownership					440.194	560.224
			Travel behavior (Reference: Never use)			
Frequently use PT			2809.998***	693.961	2826.433***	694.590
Often use PT			1858.681***	509.900	1850.242***	510.244
Frequently use utility store			-1087.695**	394.891	-1094.485**	395.164
Seldom use utility store			-1092.321**	511.673	-1052.131**	514.454
Frequently use education			1114.482**	473.413	1097.828**	474.101
(Constant)	5379.912***	904.512	6386.024***	940.768	6027.483***	1045.975
R^2	63.4		66.0		66.1	

Notes: b = unstandardized coefficients. Beta = standardize coefficients.
PT = Public transportation.
*p<0.1.**p < 0.05. ***p < 0.001.
Source: Author’s analysis

Chapter 9: Dissertation Conclusion

9.1. Overall conclusion

Being a developing and growing economy, Pakistan has been facing rapid urbanization and suburbanization for a long time. Higher education and employment seekers migrating from remote, underdeveloped small cities and rural regions to metropolitan cities like Islamabad, Lahore, Karachi, and Faisalabad act as catalysts in the urbanization phenomenon. Consequently, the Pakistani government at all levels, i.e., national, provincial, regional, and local, must provide housing and transportation infrastructure and service facilities to cater to the needs of households with moderate and low-income families. Pakistan launched the official NHP in 2001 to develop housing schemes across the country. This set of policies includes various measuring indicators, as indicated by Malik et al. (2019), to build housing in urban areas; it excluded the indicators of transportation costs, access to PT, and other service facilities to determine the affordability of residence location. At the same time, land use and built environment indicators that can optimally identify suitable locations to establish housing projects were also excluded from the housing policies.

Pakistan significantly lacks studies that explored the transportation issues among daily commuters, focusing on the comprehensive analysis of the factors affecting travel behavior and the travel mode choice to access RIBRT. This dissertation attempts to fill the gaps in the existing literature of housing and transportation studies, especially in South Asian countries. After discussing the key concepts, theories, and policies in Chapters 2, 3, 4, and 5, this dissertation performs multiple empirical analysis based on the primary and secondary data using statistical and empirical analysis, as shown from Chapter 6 to Chapter 8.

Using a survey-based approach, first empirical analysis in Chapter 6 of this dissertation attempts to fill the gap by exploring the factors such as urban form, commuter characteristics and travel behavior, that influence the choice of travel mode to access RIBRT. Similarly, the urban form indicators that affect the households' access capacity to frequently used service facilities, and the transportation costs associated with the travel to such facilities also demands extensive investigation. The impact of access to service facilities in a neighborhood on residents' satisfaction with the built environment is also not empirically discussed in a Pakistani context. The second empirical analysis in Chapter 7 measures the city-wide accessibility towards five frequently used service facilities in RIMA and compared it with the access satisfaction of households in various geographical location to determine whether the satisfaction varies in different urban setting. The accessibility analysis was performed using ArcGIS, whereas the access satisfaction of households was performed with statistical tools. Furthermore, this dissertation argues that location affordability must be examined using not only household characteristics and housing costs, but should also include transportation costs, urban form, and service facility indicators to achieve a vivid understanding of location affordability and accessibility deprivation, especially among low-income households. The third analysis in Chapter 8 of this project contributed to determining whether LAI can reveal the affordable location across urban forms and the factors impacting the T costs in RIMA. Multivariate regression analysis was performed to identify the influencing factors.

9.2. Main findings

As stated above, this dissertation took RIMA as a case study to explore the the influence of urban forms on travel behavior and location affordability. The main objectives were 1) to examine the impacts on travel mode choice when reaching RIBRT to determine the accessibility towards RIRBT, 2) to measure the accessibility towards five service facilities inclusing RIBRT and compare it with the satisfaction of the households when accessing those facilities, and 3) to determine the location affordability using LAI across urban forms and the factors affecting T costs in RIMA context..

Chapter 6 highlights the impacts of socio-economic characteristics, travel patterns, and satisfaction levels on feeder mode choice to reach the nearest RIBRT station. The robust findings in Table 10 revealed that no vehicle owners and daily RIBRT users were more likely to use paratransit services maybe because of low fare rates and abundant availability.

As far as the satisfaction with service attributes of travel modes is concerned, the bar analysis (Figures 13 and 14) showed low satisfaction with waiting time, travel time, and safety among paratransit users, and this result is consistent with the previous transportation studies (Tangphaisankun et al., 2010; Mahmoud and Hine, 2016). Overall, the findings show that though commuters from remote areas show loyalty to paratransit service due to the sufficient availability in RIMA, their formal integration into the RIBRT network is still too complicated. Transportation operators in RIMA must stress modifying the vehicles to potentially enhance their service quality.

From the policy perspective, strict monitoring of vehicle maintenance, safety, timetable of arrival and departure from designated stops, and route completion is essential. The local government must regularly fund paratransit operators to install surveillance cameras inside vehicles to prevent possible criminal activities, especially harassment against women. Additionally, the operators should collaborate with the local government to construct a plan for dedicated lanes that could substantially increase travel speed, reducing travel time. When doing so, paratransit service quality may improve to an acceptable level. It may be considered for the formal integration into the RIBRT network as feeders, stimulating land development, especially for housing near RIBRT stations.

Chapter 7 demonstrates the spatial analysis to determine the citywide accessibility to service facilities from residential areas in RIMA. Then, a sub-analysis using a statistical model of household surveys was conducted to examine the household characteristics and access satisfaction with service facilities. Woo and Kim (2016) stated that residents relocating to affordable housing at urban fringes leads to low proximity to urban facilities. Zeng et al. (2019) have identified that the peripheral location of Affordable Housing Communities causes several social-spatial issues of low or no access to service facilities that, in turn, cause accessibility deprivation. Similar to Zeng et al. (2019), the findings of this dissertation showed that the city core region is relatively well-equipped with various service facilities, providing better access to mixed-income groups (Figure 19; Table 14). It was worth noticing that although some service facilities were less in number in one region while in abundance in other areas, well-off residents had relatively better resources to access the services than low-income residents, offsetting the influence of low access to quality of life. For instance, the household characteristics in this study's survey showed that many respondents in the city core are low-income, with three to five adult travelers in one family. This survey category implies that they are highly dependent on PT such as BRT for their mobility.

It is discussed in detail in Chapter 6 that since BRT is a single corridor without the integration of the feeder buses, commuters usually take multiple travel modes to access BRT stations (Khan and Shiki, 2018; Khan, 2021). Therefore, service facilities must be located near BRT or neighborhoods of low-income people with no car ownership. The spatial analysis in Figure 19 should dictate new policies for extending the BRT corridor towards suburban study sites in Table 11. In comparison with the spatial analysis of city-wide accessibility, the sub-analysis of households' access satisfaction showed that depending on the type and level of service facility, almost all the respondents across three groups reported dissatisfaction with poor access to service facilities (Table 15). Low-income households living in the city core felt inconvenienced by the daily, long commuting time to access high-quality education and health services. This dissatisfaction highly correlates with low attachment to residential location attachment (Table 16).

From a policy perspective, public and private developers must ensure housing development in a neighborhood with well-equipped service facilities such as education, health, transportation, and clean water for disadvantaged groups. Diversified financial resources and a partnership with private enterprises can encourage the development of affordable housing and associated services at appropriate locations. Subsequently, local officials must provide attractive incentives to encourage social workers and property developers to establish education, shopping, and health facilities at low and high orders for the relocated residents to the new affordable housing units. Furthermore, organizations such as Rawalpindi and Islamabad development authorities dealing with planning and constructing residential and commercial properties must consider equity when distributing the service facilities around the affordable housing units. Therefore, public opinion is one of the critical elements for future planning processes.

To further the findings discussed in the preceding paragraph and investigate whether travels to frequently used service facilities impact households' T costs, Chapter 8 explored the housing and transportation costs among RIMA households using LAI, and the impact of urban form, household characteristics, and travel behavior on T costs. Only two studies, i.e., Isalou et al. (2014) and Dewita et al. (2019), in developing cities used this index and were consistent with the results in this dissertation, stressing the incorporation of transportation costs in the housing affordability measures. The main outcomes showed that neighborhoods near the city core result in low T costs as families in such areas do not use cars to travel daily compared to severely car-dependent mid-urban and suburban regions (Table 21). Lastly, travel frequency substantially explained the variance in T costs because frequent and often travel using PT and frequent travel to education facilities greatly impact overall families' T costs.

The findings in Chapter 7 failed to reject the first hypothesis that the households' trade-off associated with the higher housing costs and low transportation costs in urban areas, and low housing costs and high transportation costs in suburban areas in Western countries is different from the trade-off among households in the city center of RIMA. Though the housing costs and transportation costs of the city core sample in RIMA were very low in monetary terms, they became very high out of the shared income. Therefore, this thesis advocates a thorough revision of Pakistan's NHP by incorporating LAI factors. Additionally, indicators such as transportation costs, urban forms, and proximity to service facilities could guide the development of public and social housing near BRT and the development of frequently used service facilities within neighborhoods and near BRT.

Overall, the main findings of this dissertation strongly suggest that urban forms play vital role in influencing the travel mode choice to access service facilities such as mass transit services and other facilities. The availability of the service facilities also vary with the geographical location of the residential areas. Additionally, the travel frequency of the households with certain characteristics can play a mediating role between the urban form and the T costs.

9.3. Academic contribution

First, this study explores the commuters' access capacity when reaching BRT in RIMA using travel behavior characteristics examining the passengers' perception of choosing a particular mode as a feeder when accessing BRT. It aims to identify factors such as commuter attributes, satisfaction with feeder service attributes, and overall trip satisfaction, which could influence decision-making. Also, it contributes to the literature on BRT accessibility performance using informal feeder networks in developing nations.

Second, this study uniquely assesses accessibility deprivation by measuring accessibility scores of service facilities across RIMA and comparing them with households' access satisfaction to identify the constraints faced by the disadvantaged using statistical and spatial models simultaneously. It highlights the association of service facilities with residential areas to measure the degree of location attachment at different geographical locations, focusing on low-income people to determine relative accessibility deprivation. The findings will contribute to the literature on accessibility deprivation in urban areas in terms of methodology and policy perspective

Lastly, this thesis examines the causal relationship of households' housing and transportation costs with urban forms and compares the expenditure of mixed-income households across different geographical regions. It also determines whether the residential location of the household is affordable using the LA Index and addresses the impact of travel behavior to service facilities on households' T costs. It contributes to the literature by adding to the relationship between housing, transit, and urban form by incorporating travel patterns indicators to service facilities. These results can help establish an innovative objective to promote residential-based transit-oriented development (TOD), thus expanding the existing knowledge regarding LA measures and housing choices.

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Appendices

Appendix A: Names of developed housing communities in RIMA

In *Islamabad*;

- AGOCHS (Phases I and II),
- Al-Hamra Avenue,
- Al-Hamra Hills,
- Agro Farming Scheme,
- Al-Makkah City,
- Anza Zephyr Dale Agro Farms,
- Army Welfare Trust,
- Bahria Enclave Housing Scheme (Phases I and II),
- Agro Farming Scheme,
- Bahria Garden City,
- Bahria Town (Phases III, III-E, IV, V, VI, VII, and VII-E),

- Cabinet Division Employees Co-operative Housing Society,
- Capital Enclave,
- CBR Town, Engineers Co-operative,
- Engineers Housing Scheme,
- Federal Government Employees Housing Foundation (FGEHF),
- Federation of Employees,
- FIA Park Enclave Housing Scheme,
- Grace Valley,
- Gulberg Greens Farm Housing Scheme,
- Gulberg Residencia (IBECHS Phase III),
- Gulshan-e-Rabia,
- Gulshan-e-Sehat,
- Islamabad Gardens,
- Islamabad Model Town,
- Jeddah Town,
- Jinnah Garden (Phases I and II),
- Jinnah Town,
- Kashmir Gardens Farming Scheme,
- Khayaban-e-Kashmir (Phases I and II-E),
- Margalla View Housing Scheme,
- Ministry of Interior Employees Co-operative Housing Society,
- Morgah City,
- Multi Gardens (Phases I and II),
- National Assembly Employees Cooperative Housing Society (NAECHS),
- National Police Foundation,
- Naval Anchorage,
- New Islamabad Garden,
- OPF Housing Scheme,
- Pakistan Medical Cooperative Housing Scheme,
- Pakistan Navy Farms,
- Simly Dam Road,
- Paradise City,
- Park View City Housing Scheme,
- Parliamentarians Enclave,
- Rahman Enclave Housing Scheme,
- River Garden Roshan Pakistan Corporation Housing Scheme,
- Senate Avenue,

- Services Co-operative Housing Society,
- Soan Gardens,
- Supreme Court Employees Housing Scheme,
- Tele Gardens Housing Scheme, and
- Zaraj Housing.

In *Rawalpindi*;

- ABAD Cooperative Housing Society,
- Airport Green Garden,
- Army Welfare Housing Scheme (DHA-1),
- Bahria Paradise,
- Bahria Town (Phase-I, II, III-Partially, and VIII-Partially),
- Bostan Avenue Housing Project,
- CBR Cooperative Society,
- Clifton Town,
- Capital Smart City,
- Commoner Sky Gardens Housing Scheme, Murree,
- Doctors Cooperative Housing Society,
- Eastridge Housing Scheme,
- Elite Reverie,
- Faisal Town,
- Fazaia Housing Scheme,
- Federation of Railway Employees and Cooperative Society,
- Foreign Office Employees Cooperative Housing Society,
- Gandhara City,
- Garden Villas,
- Golden Jubilee Cooperative Housing Society,
- Gulshan-e-Fatima,
- Judicial Employees Cooperative Housing Society,
- Kehkashan Town,
- Khudadad City,
- Kohsar View Housing Project,
- Multi Gardens,
- Mumtaz City (Revised),
- Municipal Corporation Cooperative Housing Scheme (Sector A&B),
- Pakistan Atomic Energy Employees Cooperative Housing Society,
- Pakistan Employees Cooperative Housing Society,

- PARC Cooperative Housing Scheme,
- PIA Officers Co-operative Housing Society,
- Rabia Banglows,
- Rawalpindi Railway Employees Cooperate Housing Society,
- Revenue Employees Cooperative Housing Society,
- Safari Enclave II (Land Sub Division),
- Safari Villas (Phases I and II),
- Sanober City,
- Shalimar Town (Extension),
- Shifa Cooperative Housing Scheme,
- T&T Employees Cooperative Housing Society,
- Taj Residencia and its extension,
- Tarnol Housing Scheme,
- Top City (Revised),
- University Town Pvt Ltd, and
- Up-Country Enclosure.

Appendix B: RIBRT Red Line station names

Rawalpindi		*Islamabad*	
Serial. #	Station names	Serial. #	Station names
1	**Saddar**	12	Potohar Road
2	Marrir Chowk	13	Khayaban-e-Road
3	Liaquat Bagh	14	Fayz Ahmed Fayz
4	Committee Chowk	15	Kashmir Highway
5	Waris Khan Road	16	Chaman Highway
6	**Chandni Chowk**	17	Ibn-e-Sina
7	Rehmanabad	18	Katchery
8	6th Road	19	PIMS / Centaurus
9	**Shamsabad**	20	Stock Exchange
10	Faizabad	21	7th Avenue
11	IJP Road	22	Shaheed-e-Milat
		23	Parade Ground
		24	Pakistan Secretariat

Note: Bold station names indicate study sites.
Source: NESPAK, 2015.

Appendix C: Ridership data 2017 of BRT stations in Rawalpindi

Characteristics	Saddar			Marrir Chowk			Liaquat Bagh			Committee Chowk		
	Boarding	Alighting	Total	Boarding	Alighting	Total	Boarding	Alighting	Total	Boarding	Alighting	Total
1-Jan	14545	15864	30409	5031	4030	9061	4531	4150	8681	6676	7049	13725
2-Jan	18760	19745	38505	7495	6201	13696	4933	4733	9666	7312	7731	15043
3-Jan	18627	19493	38120	7373	6287	13660	4882	4972	9854	7585	7813	15398
4-Jan	17372	18251	35623	6999	5929	12928	4739	4293	9032	7042	7309	14351
5-Jan	18810	20372	39182	7408	6192	13600	5367	5015	10382	7836	8296	16132
6-Jan	16170	16855	33025	6435	5491	11926	3952	3951	7903	6227	6346	12573
7-Jan	16463	17712	34175	6015	4695	10710	4907	4551	9458	7912	8075	15987
Total	120747	128292	249039	46756	38825	85581	33311	31665	64976	50590	52619	103209
Descriptives	-	-	-		-	-	-	-	-	-	-	-
Mean	17250	18327	35577	6679	5546	12226	4759	4524	9282	7227	7517	14744
Minimum	14545	15864	30409	5031	4030	9061	3952	3951	7903	6227	6346	12573
Maximum	18810	20372	39182	7495	6287	13696	5367	5015	10382	7912	8296	16132
Standard Deviation	1619.028	1641.618	3246.144	912.658	872.5052	1779.673	436.0056	409.8292	820.6661	620.9295	668.9726	1284.183
Characteristics	Waris Khan Road			Chandni Chowk			Rehmanabad			6th Road		
	Boarding	Alighting	Total	Boarding	Alighting	Total	Boarding	Alighting	Total	Boarding	Alighting	Total
1-Jan	2870	2581	5451	3406	3667	7073	4561	4302	8863	4351	4734	9085
2-Jan	3385	3297	6682	5230	5497	10727	6781	6743	13524	6798	7313	14111
3-Jan	3577	3328	6905	5237	5377	10614	6891	6631	13522	6898	7238	14136
4-Jan	3403	3122	6525	4955	5159	10114	6405	6209	12614	6491	6705	13196
5-Jan	3635	3336	6971	5365	5504	10869	7248	6882	14130	7079	7304	14383
6-Jan	3056	2711	5767	4519	4569	9088	5490	5399	10889	6171	6053	12224
7-Jan	3451	3111	6562	4550	4854	9404	5975	5740	11715	6068	5903	11971
Total	23377	21486	44863	33262	34627	67889	43351	41906	85257	43856	45250	89106
Descriptives	-	-	-	-	-	-	-	-	-	-	-	-
Mean	3340	3069	6409	4752	4947	9698	6193	5987	12180	6265	6464	12729
Minimum	2870	2581	5451	3406	3667	7073	4561	4302	8863	4351	4734	9085
Maximum	3635	3336	6971	5365	5504	10869	7248	6882	14130	7079	7313	14383
Standard Deviation	277.808	305.8414	577.8094	681.6029	662.3853	1341.104	930.5978	920.3765	1847.681	922.8119	962.6439	1868.676

Source: PMA (2018); compiled by the author.

Ridership data 2017 of BRT stations in Rawalpindi (continued)

Characteristics	Shamsabad			Faizabad			IJP Road		
	Boarding	Alighting	Total	Boarding	Alighting	Total	Boarding	Alighting	Total
1-Jan	5029	5175	10204	14222	13148	27370	2274	2048	4322
2-Jan	6976	7257	14233	15050	13590	28640	3124	3046	6170
3-Jan	7468	7502	14970	13566	13725	27291	3119	3157	6276
4-Jan	7064	6978	14042	12213	12723	24936	2809	3080	5889
5-Jan	7482	7499	14981	13247	14324	27571	2984	3165	6149
6-Jan	6477	6085	12562	11969	14389	26358	2762	3089	5851
7-Jan	5475	5275	10750	12418	14003	26421	2473	2490	4963
Total	45971	45771	91742	92685	95902	188587	19545	20075	39620
Descriptives	-	-	-	-	-	-	-	-	-
Mean	6567	6539	13106	13241	13700	26941	2792	2868	5660
Minimum	5029	5175	10204	11969	12723	24936	2274	2048	4322
Maximum	7482	7502	14981	15050	14389	28640	3124	3165	6276
Standard Deviation	968.6179	1018.293	1975.037	1132.299	609.3526	1170.495	322.8237	430.597	735.261

Source: PMA (2018); compiled by the author.