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Planning for Accessibility Towards more Integration between Land-Use and Transportation; Ramallah City as a case study

التخطيط لإمكانية الوصول بالتنسيق التكاملي بين استخدام الأراضي والمواصلات؛ مدينة رام الله كحالة دراسية

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Words cannot express my gratitude to my university and my professors, who encouraged me and generously provided me with invaluable knowledge. They broadened my mind to new practices and experiences. They put me before the doors of an attractive field that combines sustainability, accessibility, land use, and transportation to meet the higher human being goal: Better Quality of Life. Thanks for giving me the opportunity to learn and research in different fields in civil engineering sciences.

My family, friends, and colleagues thank you of being around thank you for your generous moral support. Your belief in me has kept my spirits and motivation high to accomplish my thesis in "Planning for accessibility toward more integration between land use and transportation" that contribute to more sustainable development and better quality of life on our planet. My steps in this research are a catalyst and a motivation to more efforts to discover our needs, priorities, and opportunities for a better and more beautiful Palestine.

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Abstract

Planning for accessibility is a dynamic approach that aims to enhance the well-being of people and open horizons for a wide range of opportunities for them. Planning for accessibility bonds land-use planning objectives with transportation planning objectives, to ease the reach to the desired destinations from any point in origin through physical connections, travel options, and proximity. Sustainable transportation in Ramallah City is fraught with many challenges and problems same as the whole system in Palestine mainly due to the ongoing Israeli arbitrary measures in the exploitation of lands and resources that made both land use and transportation planning a challenging topic to address. Ramallah city is a dynamic city where citizens enjoy diversity in almost all development sectors. A range of initiatives is in place in Ramallah City to achieve more sustainable land use and transportation outcomes. This research studies the land-use transportation integration at the neighborhood level to search for the practical potential strategy of planning for accessibility. This search is guided by viable, equitable, and bearable sustainability dimensions. Measuring accessibility takes different forms; one of the methods used in the research is the cumulative opportunities measure which counts the number of opportunities reached within a given distance. Also, the effect of land use on transportation can be measured by the 5Ds or Density, Diversity, Design, Destination Accessibility, and Distance to Transit. To achieve more integration between land use and transportation, a wide range of strategies could be implemented, i.e. New Urbanism, Transit Oriented Development, Complete Streets, and Complete Communities.

This research makes use of Ramallah Municipality Data and the Palestinian Central Bureau of Statistics data (PCBS), observed data, in addition to a survey conducted for the study area. The methodology of the research followed three consecutive stages. The first stage was the study area analysis, data gathering, and survey data analysis. The second stage was an analysis of the effect of land-use factors and socio-demographic characteristics on travel mode choice for work trips for Ramallah City residents, this was done by generating land-use factors maps and socio-demographic attribute table and then, generating five regression models. The third stage was a summary descriptive analysis of related national and local plans and frameworks to search for practical potential strategies. The Geographic information system (GIS) was used to present and interpret the spatial information and relationships among variables.

The research demonstrated the effect of land use and socio-demographic characteristics on the mode of travel chosen by residents for their work trips. The results showed that higher density, land use mix, shorter distances to transit, and destination accessibility will give people opportunities to choose different modes of travel for their work trips, the 5Ds are associated with less car dependency and more walking, cycling, and using the public transport. The research also found that the most suitable land-use management strategy is the Smart Growth. That promotes but is not limited to compact development, land use mix development, higher road connectivity, multi-modal transportation, pedestrian environment, and green public spaces. This research has the opportunity to be expanded for further complementary analysis and could be part of the whole plan for achieving the

vision of Ramallah City since it complies with the majority of national and local plans.

الملخص

التخطيط لإمكانية الوصول هو نهج يهدف إلى تعزيز رفاهية المجتمع، ويفتح آفاقاً للعديد من الفرص المتنوعة للمجتمعات. يدمج التخطيط لإمكانية الوصول بين أهداف التخطيط لاستخدامات الأراضي وأهداف التخطيط للمواصلات وذلك من أجل تسهيل الوصول للوجهات الموغوب الوصول إليها من نقطة الإنطلاق عبر الطرق، ووسائل النقل وتوزيع مواقع هذه الوجهات. يتعرض النقل المستدام في فلسطين بشكل عام وفي مدينة رام الله بشكل خاص للعديد من المعيقات والمشكلات أهمها الاجراءات التعسفية التي يمارسها الاحتلال بشكل مستمر من مصادرة الأراضي، واستغلال الموارد مما يجعل التخطيط لاستخدام الأراضي والمواصلات أمراً معقداً. تعتبر مدينة رام الله مدينة ديناميكية يتمتع المواطنين فيها بتنوع في غالبية قطاعات التنمية. هناك العديد من المبادرات في مدينة رام الله تسعى لتحقيق استدامة أكثر في العلاقة التكاملية بين استخدام الأراضي والمواصلات. يدرس هذا البحث العلاقة التكاملية بين استخدام الأراضي والمواصلات على مستوى الأحياء للبحث عن الإمكانات العملية لتطبيق استراتيجيات التخطيط للوصول مع الأخذ بعين الاعتبار عناصر الاستدامة النمو الاقتصادي، الإدماج الاجتماعي، وحماية البيئة.

يتخذ قياس إمكانية الوصول أشكالًا مختلفة، ومن الطرق المستخدمة في البحث مقياس الفرص التراكمية الذي يحسب عدد الفرص التي تم الوصول إليها ضمن مسافة معينة. كما يمكن قياس تأثير استخدام الأراضي على النقل من خلال ما يسمى بـ (5Ds) أو الكثافة، والتنوع، والتصميم، وإمكانية الوصول إلى الوُجهات، وبعد أو قرب المسافات عن وسائل المواصلات العامة. هناك مجموعة واسعة من الاستراتيجيات التي يمكن تطبيقها لتحقيق المزيد من التكامل بين استخدام الأراضي والمواصلات مثل العمران الجديد، التنمية الموجهة نحو استخدام النقل العام (TOD)، والشوارع الكاملة، والمجتمعات الكاملة.

يستخدم هذا البحث بيانات من بلدية رام الله والجهاز المركزي للإحصاء الفلسطيني، وبيانات تم جمعها من منطقة الدراسة، بالإضافة إلى استبيان تم إجراؤه لمنطقة الدراسة. اتبعت منهجية البحث ثلاث مراحل متتالية: المرحلة الأولى؛ تحليل منطقة الدراسة وجمع البيانات وتحليل الاستبيان، المرحلة الثانية؛ تحليل تأثير عوامل استخدامات الأراضي والخصائص الاجتماعية والديموغرافية على اختيار وسيلة النقل لرحلات العمل لسكان مدينة رام الله، تم ذلك عن طريق إنشاء خرائط لعوامل استخدامات الأراضي وجدول للخصائص الاجتماعية والديموغرافية، ثم تم إنشاء خمسة نماذج انحدار. أما المرحلة الثالثة؛ تحليل وصفي موجز للخطط والأطر الوطنية والمحلية ذات الصلة. تم استخدام نظام المعلومات الجغرافية (GIS) لتقديم وتفسير المعلومات المكانية والعلاقات بين المتغيرات.

أظهر البحث تأثير استخدام الأراضي والخصائص الاجتماعية والديموغرافية على اختيار وسيلة النقل لرحلات العمل، حيث أظهرت النتائج أن الكثافة المرتفعة، والمزج باستخدامات الأراضي، واقتراب المسافات عن المواصلات العامة، وإمكانية الوصول إلى الوجهات ستمنح الناس فرصاً لاختيار وسائل نقل مختلفة لرحلات العمل، وترتبط هذه العوامل باستخدام أقل للسيارة واستخدام أكثر لوسائل المواصلات العامة، والمشي وركوب الدراجات. وجد البحث أيضاً أن الاستراتيجية العملية الملائمة هي Smart Growth. هذه الاستراتيجية تعزز المدن المدمجة، وزيادة المزج في استخدامات الأراضي، واتصال أعلى في الطرق، والنقل متعدد الوسائط، بالإضافة إلى بيئة ملائمة للمشاة، وأماكن عامة خضراء. هذا البحث لديه فرصة للتوسع لمزيد من التحليل التكميلي ويمكن أن يكون جزءاً من الخطة الكاملة لتحقيق رؤية مدينة رام الله كونه يتوافق مع غالبية الخطط الوطنية والمحلية.

1. Chapter One: Introduction

1.1. Introduction

"*Ramallah & Al-Bireh urban area will/can become 'Smart Moving' with a good balance between walking and cycling, the car and public transit*" is the vision of Ramallah City (MoLG and MDLF 2021). Generally, cities are the most generative part of the country all national and international planning sectors are directed to sustainable development to hosting strategies that do-no-harm for present and future generations. Planning for accessibility opens the doors for a better quality of life by creating more equitable; healthier; more convenient; more efficient places for present and future generations (MoLG and MDLF 2021) (Susan 2018) Planning for accessibility is dedicated to taking action for concerns raised by increasing population growth, climate change, changes in land use patterns, travel behavior and economic development since it is a function of both transportation and land use (Blanton 2000)

Today's framework on sustainable development is quite strong, for instance, in 2015 the U.S. Department of Housing and Urban Development (HUD) issued an executed order for Strategic Sustainability Performance. Also In 2015, the UN adopted an agenda for 2030 with 17 sustainable goals (SDGs) as a course of action for people and the planet to be able to prosper in a peaceful and wealthy world (Nations 2015). In addition, the U.S Green Housing Council (USGBC) developed the Leadership in Energy and Environmental Design for Neighborhood

Development (LEED-ND) certificate as an integral part of the solution to the environmental challenges facing the planet. Many world governments incorporate sustainable development policies in their agendas, and there are plenty of regulations and laws concerning this topic. The Palestinian National Authority (PNA) in its National Development Plan 2021 - 2023 adopted sustainable development priorities and policies to be achieved by 2030, it is driven by the need to restructure the Palestinian economy, and change the tools and driving forces of development (PNA 2021).

Sustainable Transport in Palestine is fraught with uncertainties and problems. Road congestion, air pollution, and traffic noise are projected to worsen in densely populated areas as income levels and automobile ownership rise. While major road construction in Israel has followed trends in other developed countries, Palestine's transportation infrastructure has been ignored for decades. The Apartheid Wall, the bypass roads built to connect Israeli settlements, the checkpoints, the limitation of Palestinians' land control according to the Oslo Accord II, as well as the limitations on Palestinian movement isolated the Palestinian cities, aggravated problems of inequity in mobility and adversely affected all life aspects of the Palestinians (Fürst et al. 2001). Palestine's political situation experiences dynamic changes continuously, the ongoing Israeli control and exploitation of lands and natural resources made sustainable transport planning and implementation a complex issue especially since it is linked to sensitive substances such as security, Israeli settlements, checkpoints, and by-pass roads (Fürst et al. 2001). Land-use change and planning are considered to be significant sources in achieving sustainable transport development (Carlos Loures 2019). Studying the synchronization of transportation and land use will support both transport planning objectives and land use planning objectives (Litman 2008). Integration of land use and transportation influenced researchers years ago as ways of shaping travel demand to meet three common transportation objectives: reduce the number of motorized trips; increase the share of non-motorized trips, reduce travel distances and increase vehicle occupancy levels (Cervero and Kockelman 1997). Meeting the mentioned objectives will lead to degenerating trips, improving air quality, increasing levels of walking and bicycling, and transit use (Blanton 2000).

Integrating land use and transportation into a single focus brings balance between mobility – the movement between places – and accessibility – the ease with which desired activities can be reached from any particular location – Planning for Accessibility can lead to a reduction in car dependency; improvements in environment quality; encourages walking, bicycling, and transit environments; revitalize economic and community; preserve neighborhood character (Blanton 2000). Based on the current circumstances of Palestine, researchers claimed that it is difficult to keep up with demands for road expansion and other transportation facilities on the West Bank (Abu-Eisheh, Kuckshinrichs, and Dwaikat 2020). Despite these challenges, still there are many opportunities to adopt and implement planning for accessibility strategies and approaches, to help achieve sustainable development outcomes and results.

This research reviews different studies into Planning for Accessibility to find a practical potential of planning for accessibility for Ramallah City towards more integration between land use and transportation taking into consideration the three pillars of sustainable development, the social, the economic, and the environmental. This research makes use of Ramallah Municipality Data and the Palestinian Central Bureau of Statistics data (PCBS), observed data, in addition to a survey conducted for the study area. The research also uses the analytical power of geographic information systems (GIS) through ArcMap 10.3 software to measure geographical aspects of urban form at the parcel level. Several land use and urban form indices will be used including density, land use mix, accessibility, connectivity and distance. Finally, conclusions and future research directions are recommended.

1.2. Research Gap

Planning for accessibility has been a major undertaking recently; it gives priority to people, and focuses on "*the ends rather than the means*". The concentration on the traveler instead of the transportation system reduces the need to drive, although they do not reduce the actual driving (Handy 2005). The majority of studies in this field measure accessibility to forecast land-use changes and growth patterns and their relation to the transportation system (Arafat, Srinivasan, and Steiner 2010). Some other studies focused on the urban fabric and its relation to travel behavior (Ewing and Cervero 2001). Those studies examine what is known as the 5D's, or density, diversity, and design, destinations accessibility, and distance (distance to major transit stops) and their impact on travel behavior. Those studies were conducted on aggregated and/or disaggregated levels of analysis (Arafat, Srinivasan, and Steiner 2010).

As mentioned in the introduction, Palestine incorporated sustainable development priorities and policies to be achieved by 2030 in the PNA National Development Plan (NDP) for (2018 – 2021) & (2021 – 2023) (PNA 2021). Since then, many efforts have been made toward the formulation of strategies and frameworks to achieve the NDP objectives. Furthermore, Spatial Development Strategic Frameworks (SDSFs) were developed for each of the Palestinian governorates. Ramallah and Al-Bireh SDSF was developed in March 2020. The SDSF is also known as the city-region plan where it combines strategic development dimensions with spatial consideration at the governorate level. Smaller-scale analysis – at parcel level – is extremely needed to better interpret those plans, and to better perform programs and projects that are directly related to the needs of individuals within Ramallah City.

1.3. Research Significance

The mentioned SDSFs are based on a general comprehensive approach and can be considered as the base of the National Urban Policy for Palestine that is under formulation (Arabtech Jardaneh and UN-HABITAT 2020). Those plans have been prepared at the governorate level, and each municipality and/or council will develop related programs and projects at a smaller scale. This research is significant at this stage of strategic governance planning since it studies the travel behavior of individuals and their relation to land use patterns considering the sustainability development dimensions at the parcel level.

1.4. Research Questions

The followings are the questions that the research aims to answer:

1. Do land-use factors and residents' socio-demographic characteristics affect the travel mode choice for work trips in Ramallah City?
2. What is the potential of achieving planning for accessibility objectives in Ramallah City considering the integrated land-use transportation policies to provide better sustainable development outcomes?
3. What gaps in knowledge and/or resources prevent PNA from attaining the desired outcomes?

1.5. Research Purpose and Objectives

The main objective of this research is to find a practical potential of planning for accessibility in Ramallah City considering the integration between land use and transportation to meet the needs of the future. Specifically:

1. To study the effect of land-use factors and residents' socio-demographic characteristics on travel mode choice for work trips in Ramallah City.

2. To study the potential of achieving planning for accessibility objectives in Ramallah City considering the integrated transportation land-use policies.

1.6. Research hypotheses

The research assumes the following hypotheses: (1) Higher densities, land use mix, higher connectivity, destination accessibility, and shorter distances to transit will give people the opportunity of choosing different mode choices for their work trips. (2) The 5Ds (Density, Diversity, Design, Distance, and Destination accessibility) are positively associated with choices of non-motorized modes. (3) There are potential strategies and practices for planning for accessibility in Ramallah City.

1.7. Research Limitations

The main determinant input in this research is to have accurate and up-to-date data. The feasibility of conducting this research is based upon access to information that can be effectively acquired, gathered, interpreted, synthesized, and understood at both aggregate and disaggregate data levels. This research faced challenges and limited access to data for multiple reasons:

1. Individual level of data: Detailed data concerning individuals were not authorized to be given to anyone, even for academic studies.
2. Humble cooperation: Several visits were conducted to the concerned authorities to get the minimum data required for the analysis.
3. Concerns regarding security: The research encounters difficulties to obtain the required number of responses to the survey since it contains details at the individual level.

Additionally, since the data is obtained from different sources, it was required to synchronize, map, and match the available data to one source and to be projected to one coordinate system.

1.8. Thesis Structure

Including this introductory chapter outlining, an introduction, research gap, significance, questions, purpose, and limitations, the thesis comprises five chapters. Chapter 2 covers the literature review, followed by the methodology and data analysis in Chapter 3. Results and discussions are described in chapter 4. The last chapter (chapter 5) is dedicated to the conclusions and recommendations for future research.

2. Chapter Two: Literature Review

2.1. Chapter Overview

This chapter gives an overview of the literature on Planning for Accessibility. First, the definition of accessibility is presented, and the second section overviews the accessibility measures and land use factors along with the literature review matrix. The third section presents the concept of planning for accessibility strategies. The forth section overviews the transportation context in Palestine and the public transport in Ramallah City. The fifth section summaries the related policy agendas. Finally, a literature of the Geographic Information System is highlighted.

2.2. Definition of Accessibility

In recent decades, there has been an increase in the attention of Planning for Accessibility, planners and researchers studied and published plenty of literature addressing the concept of accessibility and its relation to land use and transportation coordination, accessibility measures and its wide applications, how it affects decision making and polices, its effect on economic development, social inclusion, and the environment. Consequently planning for accessibility makes a major contribution to the whole built environment of societies. Access to opportunities and sustaining the vitality of cities and neighborhoods is the role of high–quality planning for accessibility (Stanley, Stanley, and Hansen 2017), (Keller et al. 2012).

Accessibility is derived from two directions; the first focused on mobility *"increase in the territory that can be reached for a given investment of time and money"* (Levine, Grengs, and Merlin 2019) for its goal of having faster vehicle-operating speed by reducing delays, traffic waiting times, and improving levels of service. To achieve the mentioned indicators, planners focused on fast and wide highways as well as land-use regulations that aim to prevent congestion through increasing travel distances and increasing the spread between origins and destinations (Levine, Grengs, and Merlin 2019). Since the Industrial Revolution, the global has faced serious risks to the survival of the ecological system due to the rapid population growth, depletion of natural resources, energy consumption, environmental degradation, climate change, and insufficient resources to preserve the ecological balance. In the year 1987 – when the idea of sustainable development evolved – remedial actions were taken to overcome the mentioned challenges and to find new approaches to sustain the ecological system and meet the demands of present and future generation development (Hajian and Jangchi Kashani 2021).

From here the other direction of accessibility arises which is the ability and the ease of people to access destination (Handy 2005), *"increase in the value of destinations that can be reached for a given investment of time and money"* as Jonathan Levine and others stated in their book "From Mobility to Accessibility" (Levine, Grengs, and Merlin 2019). Accessibility is to connect people and businesses so that they can physically engage in spatially and temporally distributed activities of all kinds and physically exchange information, goods, and services (Miller 2020). Furthermore, *"Accessibility is an attribute of people (and goods) rather than transport modes or service provision and describes integrated systems from a user viewpoint"* (Halden, Jones, and Wixey 2005).

2.3. Accessibility Measures

In planning for accessibility literature, there is a plenitude of methods and approaches used for accessibility measures since accessibility planning differs between countries at macro and micro scales, i.e. the country topography, available resources, geopolitical situation, social and cultural contexts, peoples' behavior, the spatial distribution of origins and destinations, type cities and communities (historical or new urbanization) and many other aspects. Also Planning for accessibility varies by travel mode, relevant to auto drivers, public-transport riders, pedestrians, and cyclists (Levine, Grengs, and Merlin 2019).

Accessibility is the potential for interaction. Planning for accessibility measures the easiness to reach the desired destinations from any point of origin through physical connections, travel options, and development proximity. I.e. accessibility is better where there are more destinations available within a specific travel time (Blanton 2000). Planning for accessibility is a common way of planning strategies that many countries are adopting in recent years. Accessibility planning is an organized method that measures accessibility-related information, including origins, destinations, and transportation routes, and develops a set of indicators using the available data and tools such as the geographic information systems (GIS). This allows actual accessibility to be compared to the indicators, allowing accessibility issues to be recognized, remedied, and tracked. Accessibility planning is a continual process that shows how accessibility has changed over time (Chapman and Weir 2008). The components used in modeling accessibility varied among researchers; Handy and Niemeier described accessibility measures components as: *"Accessibility is determined by the spatial distribution of potential destinations, the ease of reaching each destination, and the magnitude, quality, and character of the activities found there"* (Handy and Niemeier 1997). While Geurs and Wee divided accessibility measures components as land use, transport, temporal and individual (Geurs and van Wee 2004). Figure 1 shows major accessibility measures components.

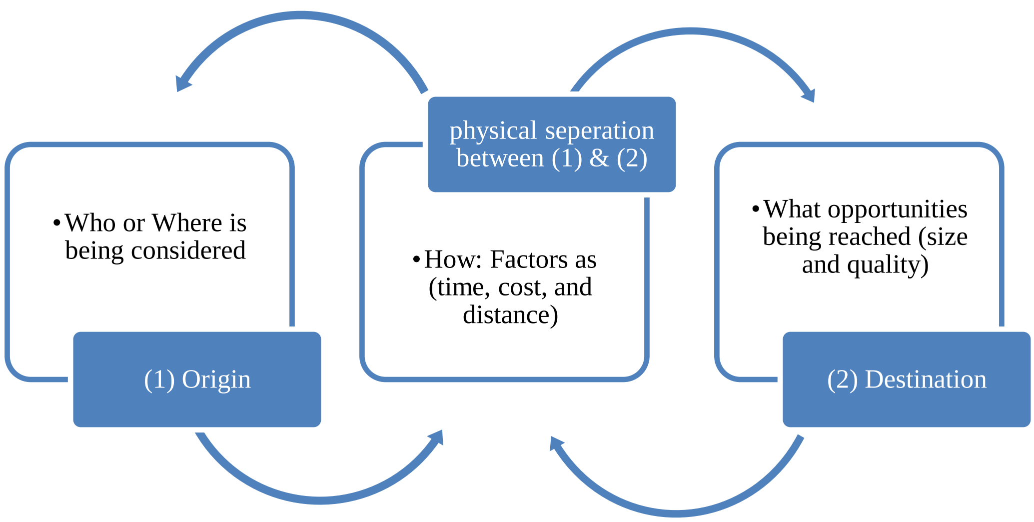


Figure 1: Accessibility measures components (Halden, Jones, and Wixey 2005)

As mentioned, measuring accessibility has many indicators that make such a study extremely flexible. It is difficult to evaluate land-use change over short periods, there has been a lack of research that attempts to capture this influence (Arafat, Srinivasan, and Steiner 2010). Eric Miller in his discussion paper "Measuring Accessibility Methods and Issues" in 2018 stated that Academics and practitioners generally agree on a group of intuitive principles of accessibility: (1) accessibility varies from one point in space to another it could be a parcel or a building, or a zone; (2) it is activity-specific, i.e a specific location may have good accessibility for shopping but poor for another trip purpose; (3) it joins the measure of easy/difficulty in traveling between points in space with the measure of attractiveness and/or the magnitude of opportunities at different spatial locations; (4) and finally, accessibility measurement includes integration or summation of opportunities over space, weighted by the ease of interaction, i.e. closer opportunities will have higher weights than further away points (Miller 2020). Accessibility measures require further assumptions in the fields of travel impedance; location attractiveness; person-level diverseness; and location choice set (Miller 2020). Handy and Niemeier emphasize that travel cost and destination choice and travel choice are all crucial to accessibility. As a result, accessibility is controlled by both land-use patterns and the nature of the transportation system i.e. two people in the same location may rate their accessibility differently due to differences in their demands and tastes (Handy and Niemeier 1997).

Accessibility measures can be categorized into four groups: First, according to Geurs and Wee, Infrastructure-based accessibility measures; analyze the performance or level of service of transport infrastructures. It is the mobility measure. It measures the performance of the transportation system by travel times, congestion, and operating speed. This measurement ignores land-use transportation strategies. Second, Location-based accessibility measures; analyze accessibility to spatially distributed activities (Geurs and van Wee 2004). Types of measures:

- Distance measures: (connectivity measures): the 'relative accessibility' measure is the degree to which two places or points on the same surface are connected. The simplest measure is the straight line between two points, i.e. the travel times or distances to a given location or transport utility (Geurs and van Wee 2004).
- Handy and Niemeier identified the cumulative opportunities measures: *"counts the number of opportunities reached within a given travel time (or distance). And since all potential destinations within the cutoff time are weighted equally, regardless of the differences in travel time"* (Handy and Niemeier 1997).
- Gravity-based measures: Handy and Neimeir identified this measure: *"It is derived from the denominator of the gravity model for trip distribution. This measure weights opportunities, usually the quantity of an activity as measured by employment, by impedance, generally a function of travel cost or time"* (Handy and Niemeier 1997).

Accessibility, A_i for residents of zone i is then measured as shown in Equation 1 below:

$$A_i = \sum_j a_j f(t_{ij}) \, , \qquad \text{... Equation 1}$$

where a_j is the activity in zone j, t_{ij} is travel time, distance, or cost from zone i to zone j, and $f(t_{ij})$ is an impedance function (Handy and Niemeier 1997). The impedance factor used in this research is Distance.

- Balancing factor (double constrained spatial interaction model): ensures that the magnitude of flow originating at zone i and destined at zone j equals the number of activities in zones i and j. The balancing factors are dependent and estimated in an iterative procedure (Geurs and van Wee 2004).

Third, Person-based measures: analysis at the individual level, measures spatially limitations on an individual's freedom of action in the environment. It captures activity-based contextual effects. This measure is sensitive to the transport and land-use components and takes individual needs, abilities, and opportunities into account. Despite advances in GIS and spatial modeling, the operationalization of this measure still faces many difficulties. This measure requires large data availability (Geurs and van Wee 2004). Fourth, Utility-based measures: analyze the economic benefits that people drive from access to spatially distributed activities. This measure interprets accessibility as the outcome of a set of transport choices (Geurs and van Wee 2004). This measure has literature beyond the scope of this research. Table 1 presents a summary of accessibility measures in the Matrix.

Table 1: Accessibility measures literature review matrix

<table>
<tr><th>Accessibility Measures type</th><th>Measure</th><th>Strengths</th><th>Weaknesses</th></tr>
<tr><td rowspan="2">1. Infrastructure based</td><td>Analyze performance or level of service of transport infrastructure i.e. travel times, congestion, operating speed</td><td>Easy to interpret and the necessary data are often available</td><td>It ignores the coordination between land use and transportation.</td></tr>
<tr><td colspan="3">Examples of applications according to Geurs, K.T., and Wee, B. Van, 2004 (Geurs and van Wee 2004) :
AVV, 2000; DETR, 2000; Linneker and Spence, 1992</td></tr>
<tr><td>2. Location-based</td><td colspan="3">analyze accessibility to spatially distributed activities</td></tr>
<tr><td rowspan="2">2.a. Cumulative opportunities</td><td>Counts the number of opportunities reached within a given travel time (or distance).</td><td>Easy to interpret and relatively undemanding of data.</td><td>all opportunities are equally weighted regardless of the difference in travel time</td></tr>
<tr><td colspan="3">Examples of applications: Handy and Niemeier, 1997 (Handy and Niemeier 1997) :
Ingram, 1971; Wickstorm, 1971; Wachs and Kumagai, 1973; Black and Conroy, 1977; Guy, 1983. McKenzie, 1984; Sherman et. al, 1974; Wachs and Kumagai, 1973; Wickstrom, 1971</td></tr>
<tr><td rowspan="2">2.b. Gravity-based</td><td>It is derived from the denominator of the gravity model for trip distribution. This measure weights opportunities, usually the quantity of an activity as measured by employment, by impedance, generally a function of travel cost or time</td><td>Weights opportunities. Evaluate the combined effect of land use and transport, incorporate assumptions to individual's perception, and is appropriate for analyzing the level of access to social and economic opportunities. It can be easily interpreted using existing data and models.</td><td></td></tr>
<tr><td colspan="3">Examples of applications according to Geurs, K.T. and Wee, B. Van, 2004 & Handy and Niemeier, 1997 (Geurs and van Wee 2004) (Handy and Niemeier 1997) :
Stewart, 1947; Hansen, 1959; Ingram, 1971; Wilson, 1971; Vickerman, 1974; Patton, 1967; Linneker and Spence, 1992; Handy, 1994.</td></tr>
<tr><td rowspan="2">3. Person-based</td><td>Analysis at the individual level measures spatially limitations on an individual's freedom of action in the environment. It captures the activity-based contextual effect.</td><td>This measure takes individual needs, abilities, and opportunities into account</td><td>This measure requires large data availability</td></tr>
<tr><td colspan="3">Examples of applications according to Geurs, K.T., and Wee, B. Van, 2004 (Geurs and van Wee 2004):
Miller, 1991; Kwn, 1998, Recker et al., 2001</td></tr>
<tr><td>4. Utility-based</td><td colspan="3">Analyze the economic benefits that people drive from access to spatially distributed activities. This measure interprets accessibility as the outcome of a set of transport choices. This measure has literature beyond the scope of this research</td></tr>
</table>

Easy access to destinations determines people's choice of residence and the behavior of their movement in the city. Therefore, numerous literature covers the coordination between land use and transportation through studying the urban form and its relation to travel behavior. Ewing and Cervero (2001) summarized more than 50 empirical studies on the effect of land use on transportation. They also derived elasticities of travel demand concerning density, diversity, design, and regional accessibility (Ewing and Cervero 2001). The land-use transportation coordination studies are conducted on an aggregate level of analysis using Traffic Analysis Zones (TAZ) or urban form neighborhoods as defined areal units (Arafat, Srinivasan, and Steiner 2010). It is also performed on the disaggregated level of analysis using the individual trip-maker analysis to properly capture the diversity of behavioral responses among different types of people (Badoe and Miller 2000). Reilly and Landis (2003) mentioned that aggregate analysis investigates how travel patterns vary as a function of area-wide or zonal averages. Aggregate analysis has ecological fallacy issues, while disaggregating analysis seeks to circumvent these issues by considering behavior at the individual level (Reilly and Landis 2003).

Most research in the field of the impact of land use on transportation examines what is known as the 3D's, or density, diversity, and design, and their impact on travel behavior (Arafat, Srinivasan, and Steiner 2010). Ewing and Cervero 2001 added to the 3D's two more variables: destinations (accessibility) and distance (distance to major transit stops). Cervero and Kockelman (1997) analyzed the 1990 travel diary data and land-use records for the San Francisco Bay Area to estimate the related features of the built environment to variations in Vehicles Miles Traveled (VMT) per household and modal choice for non-work trips. They found that density, land use diversity, or land use mix as well as pedestrian-oriented design reduce trip rates and boost walking and transit use in a statistically significant way. They also pointed out that compact development has an impact on modal choice (Cervero and Kockelman 1997). The grid network and restricted parking, according to their research, minimize automobile use and boost the use of transit and walking (Arafat, Srinivasan, and Steiner 2010). Frank and Pivo 1994 investigate the effects of land use mix, population density, and employment density on the usage of Single Occupant Vehicles (SOV), transit use, and walking for both work trips and shopping trips in addition to the modal choice. They found that both work and shopping trips, density, and land use mix are related to mode choice, even when controlling non-urban form factors. Transit usage and walking increase as density and land-use mix increase, whereas SOV decreases (D. Frank and Pivo 1994).

Cervero and Radisch (1996) investigate the effects of New Urbanism design principles on both non-work and commuting travel by comparing modal splits between two different neighborhoods in the San Francisco Bay Area and found that in transit-oriented neighborhoods the modal choices for bike and pedestrian increase (Cervero and Radisch 1996). Handy came to the same conclusion, the urban form influences the mode choice and increasing local accessibility will increase people’s choices of where to go locally by walking, biking, transit, or driving resulting in increasing the modal choices of individuals (Arafat, Srinivasan, and Steiner 2010).

Litman (2008) investigates the effects of land use factors on travel behavior, and the ability of land use management strategies to achieve transportation planning objectives. He found that increasing population and employment densities reduce automobile travel. Increasing land-use mix reduces automobile travel. Areas with attractive, safe, and connected street networks reduce automobile travel. In addition, the presence of a strong, competitive transit system reduces automobile travel (Litman 2008). Litman also found that accessibility increases when population density increases, and that, reduces travel distance and the need for automobiles, thus, decreasing the modal choice of driving. However, the increase in density will increase the transportation options while simultaneously will reduce speed and will increase congestion (Arafat, Srinivasan, and Steiner 2010). Ewing and Cervero 2010 published a meta-analysis that summarizes empirical results on the relationship between the built environment and travel. They defined the 5Ds of the land-use factors and how they affect Vehicle Kilometers of Travel (VMT) (Ewing and Cervero 2010):

1. Density is measured as the variable of interest per unit area, higher densities are related more to local activity opportunities, and higher service levels for walking and public transportation.
2. Diversity is measured by the number of different land uses in a given area, entropy index measures diversity, where low values represent a single land use environment, while higher values represent a more mixed uses environment.
3. Design is measured by street network characteristics within an area. It includes measures of the proportion of four-way intersections, street density,

number of intersections per area, sidewalk coverage, and physical variables that increase the pedestrian environment.

4. Destination accessibility measures the ease of access to trip attractions. It includes measures of distance to the central business district, and the number of jobs reachable within a given travel time.
5. Distance to transit measures the average of the shortest street routes from the residences or workplaces in an area to the nearest rail station or bus stop. It includes also the distances between transit stops or the number of stops per unit area.

Litman 2011 also described the methods for valuing the effect of land use impact on travel behavior; Table 2 presents the major definitions and measures (Litman 2021):

Table 2: Land use Factors definition (Litman 2021)

Factor	*Definition/ measure*
Density	*"Population or number of jobs per unit area (m, km)"*
Land use Mix/ Diversity	*"Degree that related land uses are located together, the ratio of jobs and residents in an area."*
Regional accessibility	*"Location of development relative to the regional urban center, the number of jobs accessible within a certain travel time, distance."*
Centeredness	*"Portion of commercial, employment, and other activities in major activity centers"*
Connectivity	*"Degree that roads and paths are connected and allow direct travel between destinations"*
Roadway design and management	*"Scale and design of streets to control traffic speeds and favor different modes and activities"*
Parking supply and management	*"Number of parking spaces per building unit of km, and the degree to which they are priced and regulated for efficiency."*
Walking and Cycling conditions	*"Quality of walking and cycling transport conditions, including the quantity and quality of sidewalks, crosswalks, paths, and bike lanes, and the level of pedestrian security"*
Transit accessibility	*"The degree to which destinations are accessible by high-quality public transit"*
Site Design	*"The layout and design of buildings and parking facilities"*
Mobility Management	*"Programs and strategies that encourage more efficient travel patterns."*

As mentioned, there are substantial researches that measure the effect of land use factors on travel behavior, and since land uses and peoples' travel behavior differs from one region to another, the studies vary in scale, scope, methodology, type of data, and the degree they account for land-use factors, therefore Table 3 show an overview of the measuring methods and their results for the Density, Diversity and Design factors depending on the regions urban characteristics and the data collected and at what level the data were analyzed.

Table 3: An overview of Land use factors (Density, Design, and Diversity) effect on travel behavior

Density		
Studies found density as a strong predictor of travel behavior.		
Levinson and wynn	1963	*"neighborhood density substantially reduces vehicle trip frequency"* (Levinson and Wynn 1963)
Pushkarev and Zupan	1977	*"Population density is a decisive factor in justifying investments in heavy rail transit systems"* (Badoe and Miller 2000)
Pushkarev and Smith	1984	*"Transit usage was influenced very significantly by residential density"* (Badoe and Miller 2000)
Holtzclaw	1994	*"Measures the influence of neighborhood characteristics on auto use. The reported regression coefficient on density in his study was 0.25, suggesting that doubling the density will reduce both the number of cars per household and the VMT per household by about 25 percent"* (Cervero and Radisch 1996)
Dunphy and Fisher	1996	There was a general tendency for less driving in higher-density regions. And there is a positive relationship between density and transit usage. In addition, household travel as measured in miles per household was found to increase with income (Badoe and Miller 2000)
Studies found the impact of density on travel is fairly weak		
Marwick & Mitchell Levinson and Kumar Burby	1975 1993 1974	*"Density and urban design did not explain much of the variation observed in transit usage or VMT"* (Badoe and Miller 2000)
Schimek	1996	*"Density matters but not by much. A 10 percent increase in density was projected to lead to only a 0.7 percent reduction in household automobile travel. By comparison, a 10 percent increase in household income was projected to contribute to a 3 percent increase in automobile travel"* (Badoe and Miller 2000)
Cervero and Kockelman	1997	*"Density has a modest and only a local effect on travel. Higher densities only marginally reduced the probability of commuting by car and slightly increased the probability of walking and riding transit"* (Cervero and Kockelman 1997)
Diversity		
Studies found that land use mix has a significant impact on the travel choices of individuals		
Cervero	2002	*"Mixed land use exerts a strong influence on travel behavior. His study shows that intensities and mixtures of land use significantly influence decisions to drive alone, share a ride, or patronize transit"* (Cervero 2002)

Cervero	1996	*"Finds that having grocery stores and other consumer services within 300 feet of one's residence tends to encourage commuting by mass transit, walking, and bicycling while controlling for such factors as residential density and vehicle ownership*" (Cervero and Radisch 1996)
Studies found that the impact of diversity on travel is fairly weak		
Crane and Crepeau	1998	*"Find a little role for land use mixture in explaining travel behavior. Mixed-use settings were not found to be significantly correlated with fewer car trips or lower car mode splits*" (Boarnet 2011)
Leck	2011	*"The influence of land use mix on travel tends to be subject to much larger variation because there is neither a simple way to define "mixed-use" nor a clear-cut method of how to quantify it*" (Leck 2011)
Design		
Studies found that design has a significant impact on the travel choices of individuals		
Kulash	1990	*"Traditional grid circulation patterns reduce VMT by 57 percent as compared to VMT in other street networks*" (Leck 2011)
McNally and Ryan	1992	*"Report less driving in a rectilinear grid street system"* (Leck 2011)
Cervero	2002	*"Finds that neighborhoods with fairly well-developed sidewalk infrastructure appear to have influenced mode choice to some degree, seemingly by providing more attractive settings for taking a bus or joining a vanpool*" (Cervero 2002)
Studies found that the impact of design on travel is fairly weak		
Crane	1996	*"Crane sharply criticized the simulation studies conducted by Kulash et al. (1990) and McNally and Ryan (1992). He claims that the evidence concerning the transportation benefits of the grid pattern is weak at best, and contradictory at worst. He argues that those studies supportive of the proposition that "grid patterns reduce car use" tend to have serious flaws, such as assuming that trip frequencies do not vary from one design to another or failing to isolate the independent influence of the street pattern on travel behavior"* (Boarnet 2011)
Rodriguez and Joo	2004	*"He examined the relationship between travel mode choice and the attributes of the street pattern (sidewalk availability, presence of walking and cycling paths) and found the influence of these attributes on mode choice to be fairly weak*" (Boarnet 2011)

To give a wider view of how the measure is performed, Cervero and Kockelman in 1997 studied the effect of land use factors on Vehicle Miles traveled (VMT) per household and mode choice for non-work trips to 50 neighborhoods in the San Fransisco Bay Area. The analysis was performed at the disaggregated data level – the individual trip maker –. The explanatory variables were divided into the built environment variables (land use factors) are listed in the Figure 2 and the control variables (other factors) are listed in Figure 3 (Cervero and Kockelman 1997).

1. Density
- Population density: population per developed acre
- Employment density: employment per developed acre
- Accessibility to jobs: expressed in a gravity model form; for zone i, Accessibility Index = $\{\sum_j (\text{jobs})_j \exp[\lambda\, t_{ij}]\}$, where i = origin (residential) traffic analysis zone, j = destination traffic analysis zone, t_{ij} = travel time between zones i and j, and λ = empirically derived impedance coefficient. The accessibility index serves as a proxy of relative proximity and compactness of land uses

2. Diversity
- Dissimilarity index: proportion of dissimilar land uses among hectare grid cells within a tract. For each tract, computed as: $\{[\sum_j^k \sum_l^8 (X_l/8)]/K\}$, where K = number of actively developed hectare grid-cells in tract, and X_1 = 1 if land-use category of neighboring (i.e. abutting or caddy-corner) hectare grid-cell differs from hectare grid-cell j (0 otherwise). (See Fig. 2)
- Entropy: mean entropy for land-use categories among hectare grid cells within a half mile radius of each hectare grid cell within a tract. For each tract, computed as: $\{\sum_k [\sum_j P_{jk} \ln(p_{jk})]/\ln(J)\}/K$, where: p_{jk} = proportion of land-use category j within a half-mile radius of the developed area surrounding hectare grid-cell k; j = number of land-use categories; and K = number of actively developed hectares in tract. The mean entropy ranges between 0 (homogeneity, wherein all land uses are of a single type) and 1 (heterogeneity, wherein developed area is evenly distributed among all land use categories)
- Vertical mixture: proportion of commercial/retail parcels with more than one land-use category on the site
- Per developed acre intensities of land uses classified as: residential; commercial; office; industrial; institutional; parks and recreation
- Activity center mixture: (1) entropy of commercial land-use categories computed across all activity centers within a zone; (2) proportion of activity centers with more than one category of commercial-retail uses; (3) proportion of activity centers with stores classified as: convenience; auto-oriented; entertainment/recreational; offices; institutional; supermarkets; service-oriented
- Commercial intensities, measured as per developed acre rates of: convenience stores; retail services; supermarkets; eateries; entertainment and recreational uses; auto-oriented services; mixed parcels
- Proximities to commercial-retail uses: (1) proportion of developed acres within 1/4 mile of: convenience store; retail-service use; (2) proportion of residential acres within 1/4 mile of: convenience store; retail-service use

3. Design
- Streets: (1) predominant pattern (e.g. regular grid, curvilinear grid); (2) proportion of intersections that are: four-way (proxy of grid pattern); (3) per developed acre rates of: freeway miles within or abutting tract; number of freeway under- and over-passes; number of blocks (proxy for the grain of road net); number of dead ends and cul-de-sacs; (4) averages of: arterial speed limits; street widths
- Pedestrian and cycling provisions: (1) proportion of blocks with: sidewalks; planting strips; street trees; overhead street lights; quadrilateral (i.e. rectangular or square) shape; bicycle lanes; mid-block crossings; (2) proportion of intersections with: signalized controls; (3) averages of: block length; sidewalk width; distance between overhead street lights; slope; pedestrian green lights at signalized intersections; (4) bicycle lanes per developed acre
- Site design: proportion of commercial–retail and service parcels with: off-street parking; off-street parking between the store and curb; on-street front or side parking; on-site drive-ins or drive-throughs

Figure 2: Built environment variables

1. Socio-demographics of trip-maker
- Age
- Gender: male status
- Employment: full-time or part-time status; professional occupation
- Race and ethnicity: racial-ethnic category; Caucasian status
- Possession of driver's license

2. Household of trip-maker
- Size: number of members; number of persons under 5 years of age (proxy for pre-school child dependency); number of persons 5 years of age and over (proxy for active household members)
- Vehicle ownership: number of automobiles, trucks, vans, and motorcycles per household
- Income
- Housing tenure (own or rent)

3. Transportation supply and services
- Transit service intensity: route miles of peak-hour revenue service divided by developed area of tract
- Distance to: nearest freeway-on ramp; nearest BART station; nearest commuter rail station; nearest light rail station; and nearest ferry landing
- Proportion of commercial–retail parcels with: paid on-street parking; paid off-street parking

4. Distance
- Euclidean distance between centroids of trip's origin and destination traffic analysis zones
- Euclidean distance: to downtown San Francisco; downtown Oakland; downtown San Jose.

Figure 3: Control variables

The dependent variables were vehicle miles traveled (VMT) by personal vehicles and mode choice (person vehicle or not, and single occupant vehicles (SOV) or not. The analysis uses multiple regression models to predict VMT and bionomial logit analysis to predict the probability of a person travelling by a non-personal-vehicle or non-SOV mode. They found that density, diversity and pedestrian-oriented design reduce personal VMT and boost walking and transit use. Following Figure 4 is one of their regression model results (Cervero and Kockelman 1997):

Dependent variable: Vehicle miles traveled in personal vehicles by all household members for all trips*	Base model		Built environment model	
	Coefficient	Probability	Coefficient	Probability
Explanatory variables				
No. of workers in household (full- and part-time, non-students)	5.316	0.000	5.919	0.000
No. of automobiles and vans in household	7.795	0.000	6.184	0.000
Annual household income, in $1000	0.033	0.294	0.041	0.185
Transit service intensity†	−9.682	0.487	−23.377	0.117
Proportion of commercial parcels with paid parking	−0.049	0.991	−6.141	0.162
Accessibility index‡	—	—	−0.079	0.000
Proportion of neighborhood blocks that are quadrilaterals (i.e. with four straight sides, either square or rectangular)	—	—	9.861	0.003
Constant	14.82	0.112	9.758	0.003
Summary statistics	Base model		Built environment model	
No. of cases	896		896	
R squared	0.141		0.171	
F statistic (probability) of model differences = 14.43 (0.000)				

Figure 4: Predictive models of daily personal VMT per household, all trips

Based on the above-mentioned literature, researchers' debated that changing the built environment dimensions such as the 5Ds (Density, Diversity, Design and Destination Accessibility and Distance to Transit) will lead to achieving the land use transportation objectives (Cervero and Kockelman 1997). *"If cities can be planned not simply to be more transit - and pedestrian-friendly, but to get people out of their cars, then the impact of urban form on travel behavior must be found* *to be consistent and strong for the widest possible range of travelers and trip types"* (Reilly and Landis 2003).

Land-use transportation studies demonstrate that land-use factors influence not only travel distance but also affect the number of generated trips (Ewing and Cervero 2001). Crane emphasizes that research on the impact of urban form on travel behavior can be grouped in a useful way. First, development of compact and dense residences and businesses; second, specify trip chaining and purposes; third, conduct analytical methods such as regression and simulations; fourth; choose the independent variables; fifth, natural and level of data analysis i.e. aggregated or disaggregated; sixth, classification and measure urban forms (Leck 2011). Litman accentuates that land use impacts can be evaluated at four levels: (1) Analysis of a single land-use factor; (2) Regression analysis of multiple land-use factors, which will determine the relative magnitude of each factor; (3) regression analysis of land use demographic factors; (4) and finally regression analysis of land use, demographic and preference factors (Litman 2021).

2.4. Planning for Accessibility

Accessibility planning has a variety of advantages as a tool for transportation and land use planning. These include: coordinating transportation with other public policy objectives (i.e., housing, education, health, and social services); assessing access equity by taking into account the needs of all groups in society; identifying the social implications of land-use projects or transportation service changes; and assisting in the delivery of positive social, economic, and environmental community outcomes (Chapman and Weir 2008). Accessibility is used in planning in different ways; (1) The effect of changes in the transport system on people's access to opportunities; (2) Distribution of transport impacts; (3) Available travel options; (4) Consistency of transport; (5) linkages with other public policies; (6) impacts of new developments; (7) Community planning and business travel planning (Halden, Jones, and Wixey 2005). Tables 4 and 5 present planning objectives and land use management strategies as described by Litman. Those strategies differ in scale, perspective and emphasis, but overlap to various degrees (Litman 2021):

Table 4: Land use Management Strategies Effectiveness (Litman 2021)

Planning objective	*Impacts of land use management strategies*
Reduce congestion	*"can reduce the amount of congestion experienced for a given density"*
Roads and parking savings	*"Some strategies increase facility design and construction costs, but reduce the amount of road and parking facilities required and so reduce total costs"*
Consumer savings	*"May increase some development costs and reduce others, and can reduce total household transportation costs."*
Transport choice	*"Significantly improve walking, cycling, and public transit service."*
Road safety	*"Traffic density increases crash frequency but reduces severity. Tends to reduce per capita traffic fatalities."*
Environmental protection	*"Reduced per capita energy consumption, pollution emissions, and land consumption"*
Physical fitness	*"Tends to significantly increase walking and cycling activity"*
Community livability	*"Tends to increase community aesthetics, social integration, and community cohesion"*

Table 5: Land use management strategies (Litman 2021)

Strategy	*Scale*	*Description*
Smart Growth	*Regional and local*	*"More compact, mixed, multi-modal development"*
New Urbanism	*Local, street, and site*	*"More compact, mixed, multi-modal, walkable development"*
Transit-Oriented Development	*Local, neighborhood, and site*	*"More compact, mixed, development designed around quality transit service"*
Location Efficient Development	*Local and site*	*"Residential and commercial development located and designed for reduced automobile ownership and use."*
Access management	*Local, street, and*	*"Coordination between roadway design and land*

Strategy	*Scale*	*Description*
	site	*use to improve transport"*
Streetscaping	*Street and site*	*"Creating more attractive, walkable, and transit-oriented streets"*
Traffic Calming	*Street*	*"Roadway redesign to reduce traffic volumes and speeds"*
Parking management	*Local and site*	*"Various strategies for encouraging more efficient use of parking facilities and reducing parking requirements."*

The mentioned land use management strategies can be implemented in a wide range of conditions and scales: i.e. infilling existing urban areas, creating compact downtowns in suburban areas, creating more connected roads in new development areas, and creating walking facilities and transit services in rural areas (Litman 2021).

Furthermore, planning for accessibility management strategies can also be guided by several perspectives such as: Provide access to all public policy sectors; Contain the spread of urban sprawl; Increase green areas; Retain agricultural lands and historical areas; Encourage public transit usage; Accessibility to open spaces and recreational areas within neighborhoods; Improve social interactions and connections within the communities; Plan to maximize energy and water efficiency and minimize urban heat impacts; and Link economic productivity into planning for accessibility (Stanley, Stanley, and Hansen 2017).

2.5. Transportation context in Palestine

The effect of transportation and land-use policies vary across people, place, and time. Geographic, social, and economic context shapes the outcomes of transportation policies and influences the relationships between urban form, transportation infrastructure, and travel behavior (Guerra and Li 2021). Land use and transportation coordination in Palestine will have a different peculiarity since it is under occupation. The restrictions on available land use due to the limitation of Palestinian Control over lands according to the Oslo II Accord where the West Bank was divided into areas A, B, and C. The by-pass roads built by the Israeli authorities to link Israeli settlements and the restrictions on travel by Palestinians aggravate the problems of inequity in mobility. Palestine suffers from several challenges along the three dimensions of sustainability; the rise of car ownership, road congestion, air pollution, and traffic noise is increasing day after day, especially in the high densely populated regions (Fürst et al. 2001). Lack of accessibility quality, high rate of accidents and deaths, inequity, unaffordability, decreasing opportunities, and the participatory role of communities all are limitations of sustainable transportation. Road-based vehicles are the sole means of transportation in Palestine, and the road networks have been modestly expanded to accommodate the rapid increase in the number of vehicles. The average annual car growth rate for Palestine has reached 5% from the 1990 to 2015 period. However, the rate is increasing year after year and reached 14.7% in 2016 (Abu-Eisheh, Kuckshinrichs, and Dwaikat 2020).

Public transit context in Ramallah city: The private sector owns and operates public transport services and vehicles, roads are generally narrow and congested especially in the CBDs areas with almost no parking control in most streets. The public transit in Ramallah City comprises (1) buses: carry from 20 to 50 passengers and plays minor role in the public transport within the governorate, buses do not operate to schedule. (2) Shared – taxis (service): the predominant type of public transit, and (3) private taxis. The public transport vehicles have no schedules for leaving their terminals; the drivers decide when to leave based on the demand on the transit route per day or once they have a full load of passengers. There are no regular stops along the routes, vehicle stops as required by the passengers. The frequency varies during the day, and there is no specific time to expect the arrival of vehicles at a terminal. The fare is basic and flat regardless of the trip length and if passengers want to reach a specific destination that is not on the transit route, they pay an additional charge (MoLG and MDLF 2021).

There are four public transport stations within the study area, their physical conditions vary, and they are all located within the "City Center" neighborhood of Ramallah City. The stations service the New City, Al-Tireh, Al-Masyoun, and Al-Itha'a neighborhoods, while Baten El-Hawa neighborhood has no transit route. People living in Baten El-Hawa use both the surrounding villages' buses that pass through the neighborhood and/or ask for private taxis to reach their destinations. The existence of the terminals inside the "City Center" neighborhood has advantages in terms of vicinity and proximity to people and disadvantages in terms of inadequate space for all operating vehicles, severe congestion, and restriction of the movement of all traffic (MoLG and MDLF 2021).

2.6. Summary of related policy agendas

Two kinds of policy agendas that have a relation in defining potential strategies in Planning for accessibility for Ramallah City are summarized in this section:

1. The "Spatial Development Strategic Framework for Ramallah and Al-Bireh Governorate, 2030" that is prepared in 2020 by Arabtech Jardaneh Consultative Company (AJPAL) in a participatory approach and with substantial inputs from many local and national stakeholders, with the assistance of the European Union Under the framework of the project "Fostering Tenure Security and Resilience of Palestinian Communities through Spatial-Economic Planning Interventions in Area C", managed by the United Nations Human Settlements Programme (UN-HABITAT) (Arabtech Jardaneh and UN-HABITAT 2020).
2. The "Comprehensive Public Transportation Master Plan for the Urban Center of Ramallah and Al-Bireh" which is prepared under the "Integrated Cities and Urban Development Project (ICUD)" implemented by the Ministry of Local Government (MoLG) and the Municipal Development and Lending Fund (MDLF) Funded by the World Bank in May 2021 prepared by: CDG, MOVE Mobility, and NCD (MoLG and MDLF 2021).

Spatial Development Strategic Framework

The Spatial Development Strategic Framework (SDSF) for Ramallah and Al-Bireh Governorate is considered a base in Palestine's sustainable development; it integrates the planning practices related to the preparation of the strategic development plans with those related to the preparation of the physical plans. The unique component of this plan is the spatial dimension. This plan introduced a matrix analysis of priorities, goals, indicators, and development programs and projects for Ramallah and Al-Bireh Governorate, the matrix was also developed into an action plan, and monitoring & evaluation plan. The action plan's total implementing cost is US$590,619 million to be distributed over eleven years to all development sectors. One of the major outputs of this plan is a recommendation for the provision of development centers and services in Ramallah and Al-Bireh Governorate to ease access to citizens and to improve the quality of services to provide better opportunities for the communities (Arabtech Jardaneh and UN-HABITAT 2020). Table 6 shows the goals, indicators, and development programs for the Environment and Infrastructure – Roads and Transportation sector, this table and was extracted from the SDSF matrix which is annexed in Appendix (C).

Table 6: Roads and transportation priority issues, goals, indicators, and development programs & projects for Ramallah and Al-Bireh Governorate in relation to the National Policy Agenda (2017-2022) and the Sustainable Development Goals (2030) (Arabtech Jardaneh and UN-HABITAT 2020)

Environment and Infrastructure – Roads and Transportation		
Priority Development issue	Weakness of the Road Network's Capacity to Keep up with the Increasing in Traffic, and the Weakness of the Public Transportation	
Objectives	1. Expanding and Developing the Road Network	2. Developing the Public Transport System and Meet its needs
Indicators	- Density of paved roads - (km / km2)	- Number of public Transportation Complexes (Number)
	- Level of periodic maintenance of roads (Descriptive)	- Public Transportation Coverage level (Descriptive)
	- The level of Conductivity of Different Roads (Descriptive)	
Proposed Programs / Projects	Program of Development, Maintenance, and Rehabilitation of the Road Network	Program of Development of Public Transport Systems and Facilities
National Policy Agenda (2017-2022)	8. Improving Services to Citizens.	27. Meeting the Basic Needs of Our Communities
Sustainable Development Goals (2030)	DG 3: Good Health and WellBeing (3.6) SDG 9: Industry, Innovation, and Infrastructure (9.1) SDG11: Sustainable Cities and Communities (11.2)	

The indicators used to measure the development objectives of the environment and Infrastructure – Roads and Transportation sector are: Density of Paved roads (km/km^2), level of Periodic Maintenance of Roads (Descriptive); the level of

Conductivity of Different Roads (Descriptive); Number of Public Transportation Complexes (Number); and Public Transportation Coverage Level (Descriptive).

The SDSF was based on a general comprehensive approach to identifying the spatial dimension and locations of each program and project. The SDSF also took into consideration the available capacities and the needs of different communities. As a result, the SDSF includes the proposed programs and projects with the framework for Ramallah & Al-Bireh Governorate for the different development sectors with its spatial dimension as shown in Figure 5 (Arabtech Jardaneh and UN-HABITAT 2020).

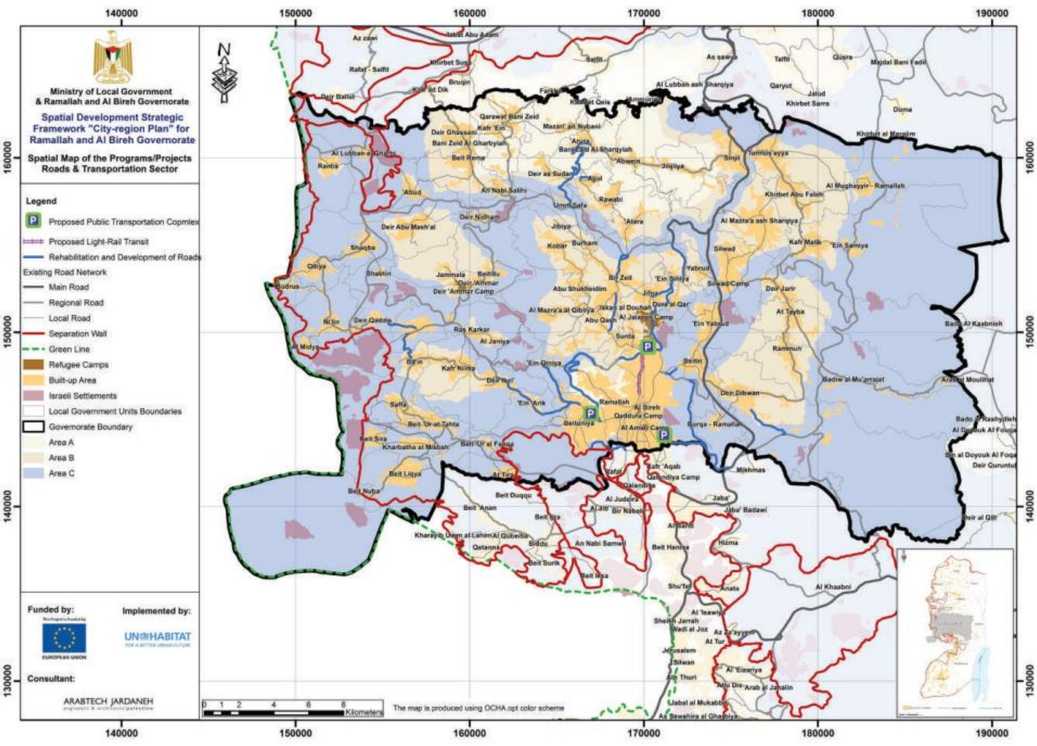


Figure 5: The Spatial Dimension of Programs and Projects Proposed in the Roads and Transportation sector (Arabtech Jardaneh and UN-HABITAT 2020)

The SDSF as mentioned identified sixteen service centers in Ramallah and Al-Bireh Governorate within four levels (regional center, two sub-regional centers, six local centers, and seven neighborhood centers). The service center that complies with this research is the regional center located in the Middle Development Region (Ramallah and Al-Bireh) as shown in Figure 6. (Arabtech Jardaneh and UN-HABITAT 2020).

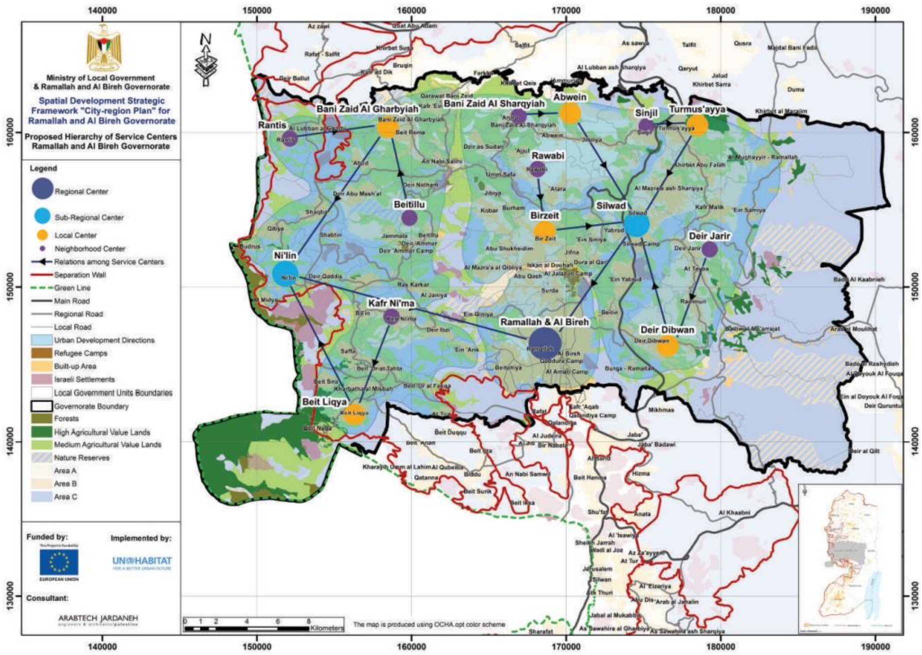


Figure 6: The suggested hierarchy of service centers in Ramallah and Al-Bireh Governorate (Arabtech Jardaneh and UN-HABITAT 2020)

Figure 7 shows the strategic framework plan for the spatial development of roads and the transportation sector in Ramallah & Al-Bireh

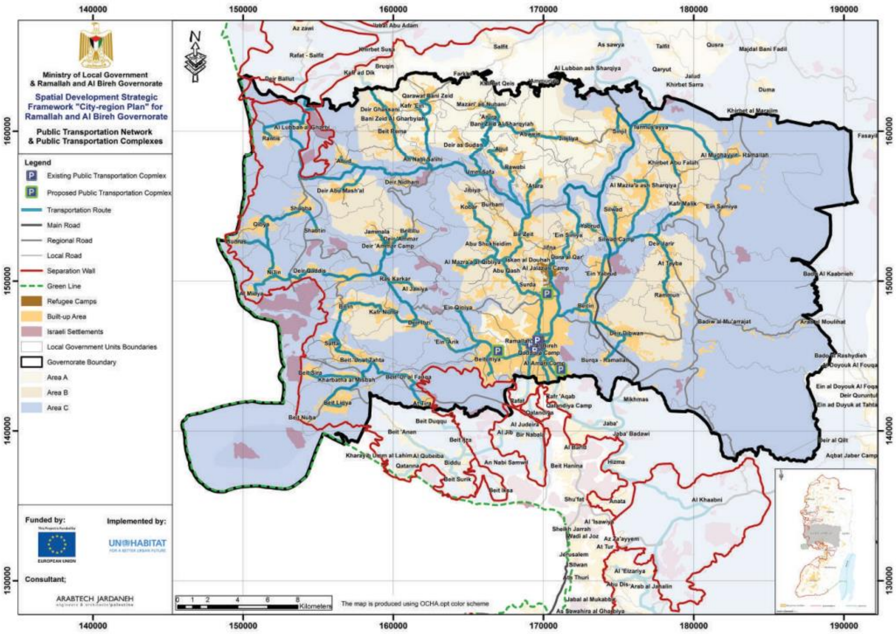


Figure 7: Public Transportation Routes and Stations in Ramallah and Al-Bireh Governorate (Arabtech Jardaneh and UN-HABITAT 2020)

Public Transportation Master Plan.

The Comprehensive Public Transportation Master Plan for the Urban Center of Ramallah and Al-Bireh (Appendix D) was formulated based on an assessment of the existing national and regional transport network. Covers Ramallah, Al-Bireh, Surda, and Abu-Qush areas with a major goal of: *"A public transport system should be a system that is continuously developing in a sustainable way, and that contributes to improving livability and accessibility"* (MoLG and MDLF 2021). The Master Plan vision is "*Ramallah & Al-Bireh urban area will/can become 'Smart Moving' with a good balance between walking and cycling, the car and public transit*". The Model of this Plan was developed using TransCAD software up to the year 2036 (MoLG and MDLF 2021).

The assumption for this plan is that *the best scenario is the scenario which has a low cycle time, higher max load, low interval time, high frequency, low fleet* *number, and high boarding numbers*. Developing the scenarios was based on the central corridors; the terminals; the connection between external and internal lines; the mode of travel; and the total coverage of the urban area. The Master Plan suggested four scenarios, and each scenario was assessed according to a Feasibility study based on financial analysis, environmental impacts, and social feasibility. (MoLG and MDLF 2021) The preferred scenario is shown in Figure 8 which includes three main corridors that connect the three terminals (North, South, and West); the different urban areas are connected with the existing bus lines; the feeder systems operate towards the terminals and to some stops in the bus lines; and finally, high quality of public space for pedestrians will be key as shown in Figure 9 (MoLG and MDLF 2021).

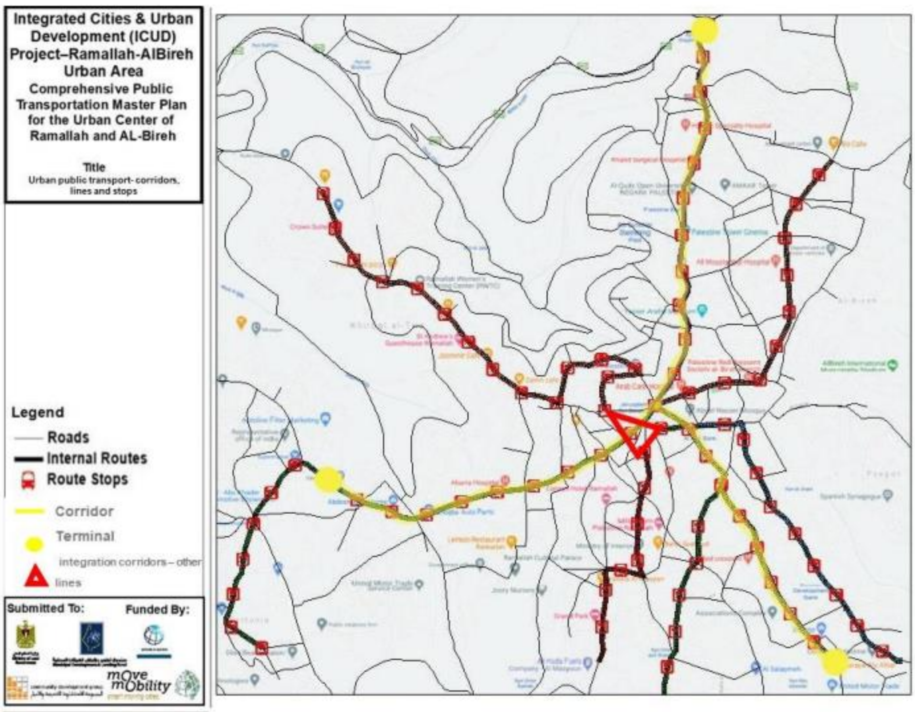


Figure 8: Urban public transport corridors, lines, and stops (MoLG and MDLF 2021)

Figure 9: Integration between corridor line & other internal lines (MoLG and MDLF 2021)

Figure 10 illustrates all Master Plan elements; the Multi-modal Hubs (terminals) are the places where passengers can shift from internal public transportation within Ramallah and Al-Bireh Governorate to external public transportation (MoLG and MDLF 2021).

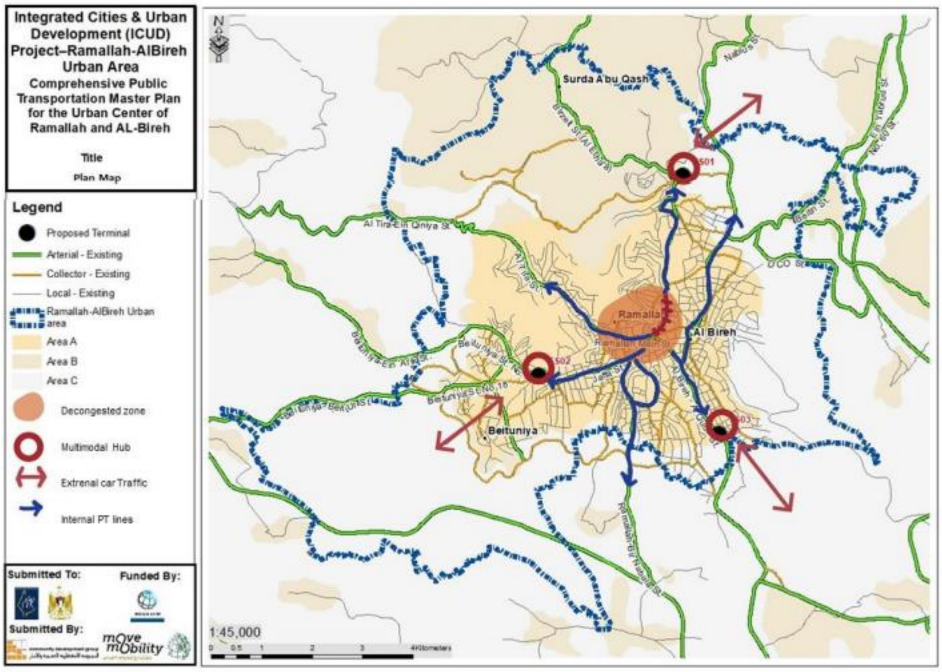


Figure 10: Master Plan Map (MoLG and MDLF 2021)

The Master Plan also gives in detail the planning strategies and measures (MoLG and MDLF 2021): First: The parking strategy focuses on increasing off-street parking and Park + Ride facilities and aims at encouraging the use of public transportation. Second: Pedestrian Strategy proposes no car zone in the central area and a domain for only pedestrians and public transport. The plan focuses on establishing a pedestrian strategy and pedestrian infrastructure and design. Third: legislation, since the public transportation sector suffers from different inefficiencies and difficulties, the local government has a central role to play in the development and implementation of legislation activities such as the legal relationship between transport operators and passengers and between operators and public administration bodies. In addition, the existence of official bodies and committees responsible for making decisions, controlling, and managing the public transportation system is very crucial to the success and the development of this sector. Therefore, the plan aims at establishing the strategy and establishing an integrated urban transport committee and a Public Transport body (MoLG and MDLF 2021). Fourth: The role of taxis, improve the taxis' contributions through modernizing vehicle fleets, ensure effective regulation of services, and support improvements in the vehicle standards. The plan aims to establish a responsible body to ensure the mentioned measures. Fifth: Technical and operational measures, the plan aims to establish technical and operational design strategies and design; terminal, lines, feeders, and modes; fleet needed; bus stop and coverage; flow measures; central station and urban accelerator; information system; ticketing and fare collection. Finally, other studies shall be conducted such as a feasibility study; a detailed design of the Master Plan; a parking study, and a study of the impact of the public transport measures on the car circulation. The timeframe and an estimated cost along with the responsibilities are detailed in the Master plan in short term and long term starting from 2021 to 2036 with a total cost of USD 96.4 million (MoLG and MDLF 2021).

2.7. The Geographic Information System

This research uses Geographic Information Systems (GIS) to perform the data analysis. The GIS is a comprehensive tool designed for spatial analysis which captures, stores, query, analyze, display and output geographic information. GIS tools have a significant influence on the spatial decision-making process (Rikalovic, Cosic, and Lazarevic 2014). Through the GIS, a Multi-Criteria analysis method can be used to contribute to the efficiency and quality of spatial analysis for the study. Multi-Criteria analysis methods such as Index Overlay, Fuzzy Logic, Probabilities Logic, Regression Logic, Analytical Hierarchical Process, Boolean Algebra, and Neural Artificial Networks can be used in accessibility planning (Fataei et al. 2015). ArcMap 10.3 software was used to map, analyze and visualize the data. In accessibility measures, the results of GIS outputs can be presented in plots, graphs, tables and spatial maps. GIS enables speedy appraisal of the effect of land use factors on mode choice for work trips, and the comparison between types of travel modes, it also enables visual interpretation of results. GIS supports transport and land use planning by analyzing spatial patterns i.e. shortest distances; measures accessibility by different modes and to various destinations; walking times; transit frequencies; service areas and travel times (Ford et al. 2015).

In GIS accessibility can be measured by Euclidean distance, Manhaten distance, and/or network distance. This research uses network distance *"The network distance is the distance travelled between two locations using the road network"*. It measures the length of street segments as a percentage of the whole street network, or by measuring the actual distance travelled, it includes barriers for more accurate indication of travel distance. Estimation of accessibility can be topological or opportunity measurement or both. Topological *"estimates the physical proximity from origin to destinations and includes measurement of distance i.e. distance to the nearest location"*. Opportunity models *"measures a density or attraction of accessible places*" (Arafat, Srinivasan, and Steiner 2010). Those measurements can be performed on aggregate level of analysis i.e. Traffic

Analysis Zones or urban form neighborhoods, or disaggregate level of analysis i.e. using dynamic zoning such as parcel level analysis (Arafat, Srinivasan, and Steiner 2010). Parcel level of analysis is a way to overcome the modifiable areal unit problem (MAUP) in GIS analysis, since the 5Ds could have widely different results based on shape and scale chosen for analysis. In terms of GIS language, the parcel level analysis reduces the differentiation of neighborhood sizes, measured distance (Euclidean, grid, Manhaten, Netwrok), boundaries, and configuration. Therefore, this research uses Parcel-level opportunity indicators using network distance. Major strengths of GIS in planning for accessibility are it has interactive data, spatial analysis, network analysis, visualization tool, rapid testing scenarios, dynamic zoning and applicability to other cities and localities (Ford et al. 2015).

3. Chapter Three: Research Methods and Data Analysis

3.1. Chapter overview

This chapter represents the research methodology and data analysis. Section 3.2 gives an overview of the methodology used, while section 3.3 gives a detailed methodology for each research stage and analysis of the data.

3.2. General Methodology and Research Stages

The potential planning for accessibility strategy for Ramallah City was developed by implementing three consecutive stages. The first stage was the study area analysis and data gathering; the second stage was an analysis of land use factors and socio-demographic characteristics that affect – the study area residents' – the reason for choosing a certain mode of travel for work trips; the last stage was assessing to what extend do Ramallah City incorporates planning for accessibility into its policy agenda. The first two stages were done by using mainly the tools in the ArcMap 10.3 software, while the last stage was done by determining the priorities of planning for accessibility in the plans and policy agendas for Ramallah City. This research uses Parcel-level opportunity indicators using network distance. The general methodology of the research is shown in Figure 11 below.

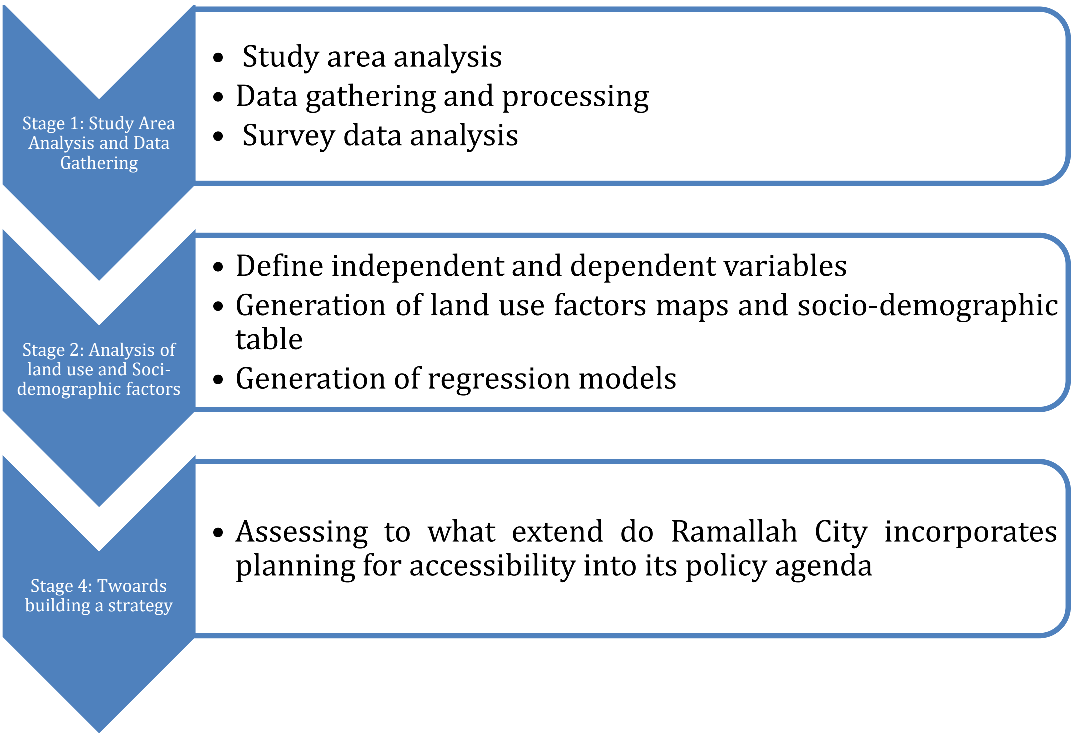


Figure 11: The general methodology of the research

3.3. Research stages methodologies and data analysis

Stage 1: Study Area Analysis and Data Gathering:

First: Study area analysis

Planning for accessibility in Palestine as well as all other planning sectors has a different peculiarity since Palestine is under the Occupation. The analysis of the Transport context in Palestine and the public transit in Ramallah City in the literature review emphasizes the need to plan for accessibility, taking into account the various development sectors, the available opportunities, the obstacles facing it, the sustainability pillars, and the geopolitical situation to *"counteract the hostile planning system that aims to marginalize and end the physical presence of* *our people on their land"* – as Eng. Majdi Al-Saleh said concerning the development of the "Spatial Development Strategic Framework for Ramallah and Al-Bireh Governorate, 2030" (Arabtech Jardaneh and UN-HABITAT 2020)

The methodology used to perform the study area analysis is based on previous literature on the study area in addition to data analysis using ArcMap 10.3 software.

Ramallah and Al-Bireh governorate (refer to Figure 13) is located in the middle of the West Bank (refer to Figure 12) of Palestine with an area of 855 km^2 and a population of 355,202 according to PCBS forecasting in 2021 based on the 2017 census (PCBS 2021a). The climate in Ramallah & Al-Bireh Governorate is the same as the West Bank which is mostly Mediterranean, temperature and humidity vary according to altitude, hot and dry in summer, cold and rainy in winter. The annual rain precipitation rate is about 500 mm, and temperatures range from zero ^oC in winter to 35 ^oC in summer (Arabtech Jardaneh and UN-HABITAT 2020). The terrain of Ramallah & Al-Bireh Governorate is mountainous and most of the governorate elevation ranges between 830 and 880 meters above Mean Sea Level (PCBS 2021b).

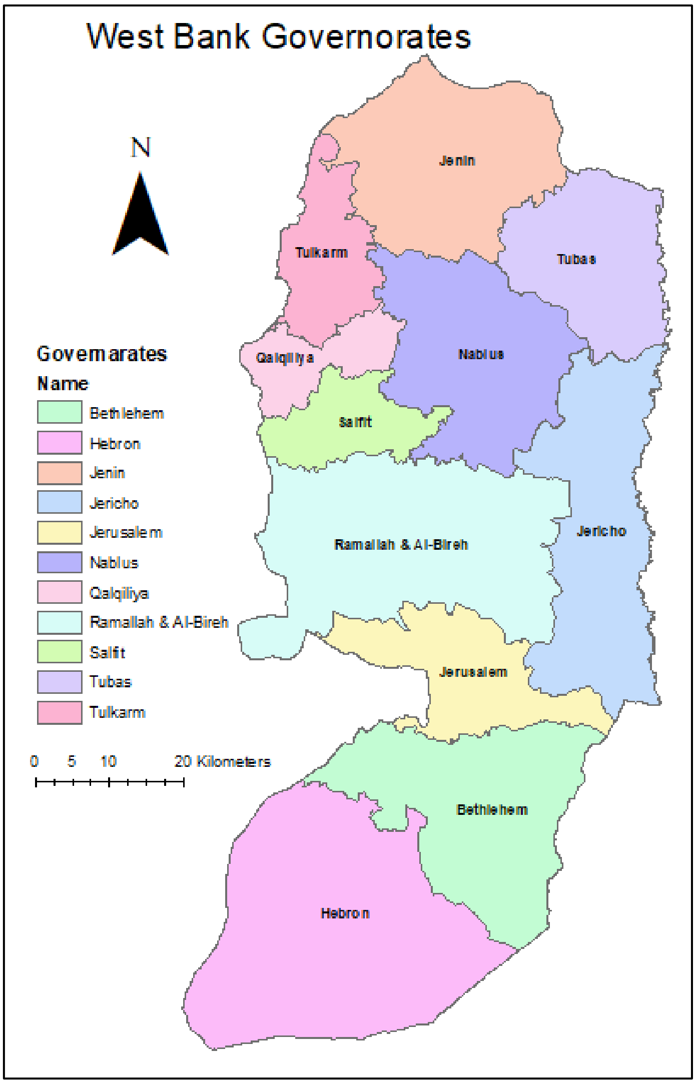


Figure 12: The West Bank Governorates

The study area of this research is only "Ramallah City" which is located in the mid-south of Ramallah and Al-Bireh Governorate with an area of 19.28 km^2 and a population of 42,122 according to PCBS forecasting in 2021 based on the 2017 Census (PCBS 2021a), (Ramallah Municipality 2018).

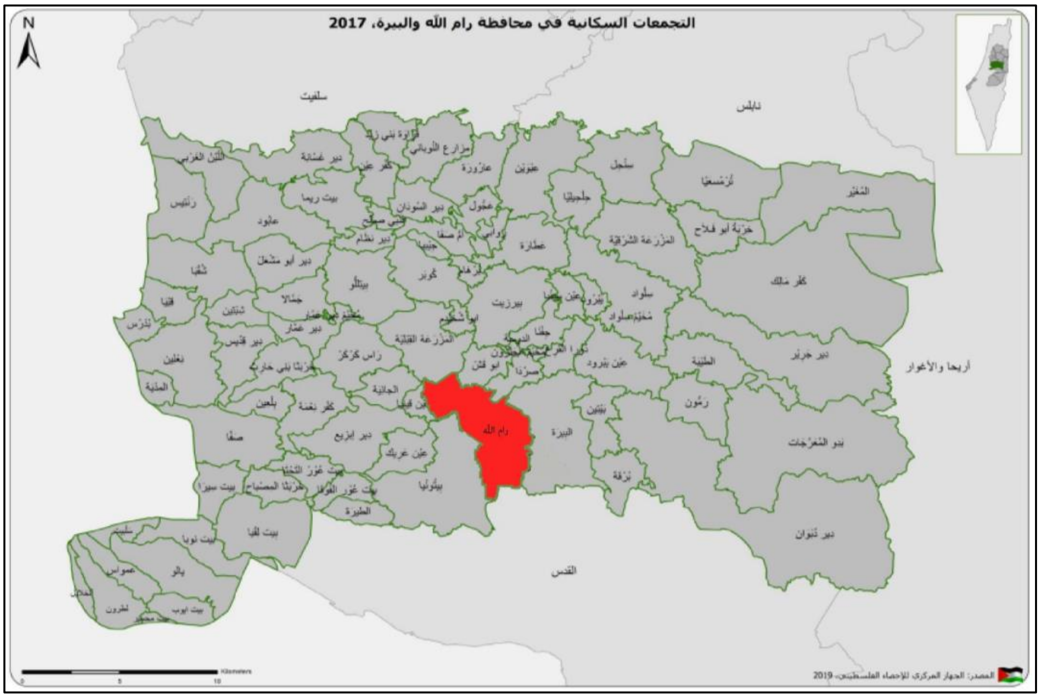


Figure 13: Ramallah and Al-Bireh Governorate [34]

Ramallah city is considered the economic and administrative capital of the Palestinian National Authority (PNA), it comprises the District Headquarters, the legislative Council building in addition to most of the authority's ministries and offices. Moreover, Ramallah city has several, diverse and attractive services; health, financial, education, governmental, commercial, industrial, cultural, and entertainment. These services attract residents from all over the Palestinian cities and therefore increase the number of the settled population (Ramallah Municipality 2018). Figure 14 shows Ramallah City's nine neighborhoods as defined by Ramallah Municipality (Al-Tireh, The Old City, Baten El-Hawa, Al-Itha'a, Al-Masyoun, The Industrial Area, Al-Wad, The City Center, and The New City).

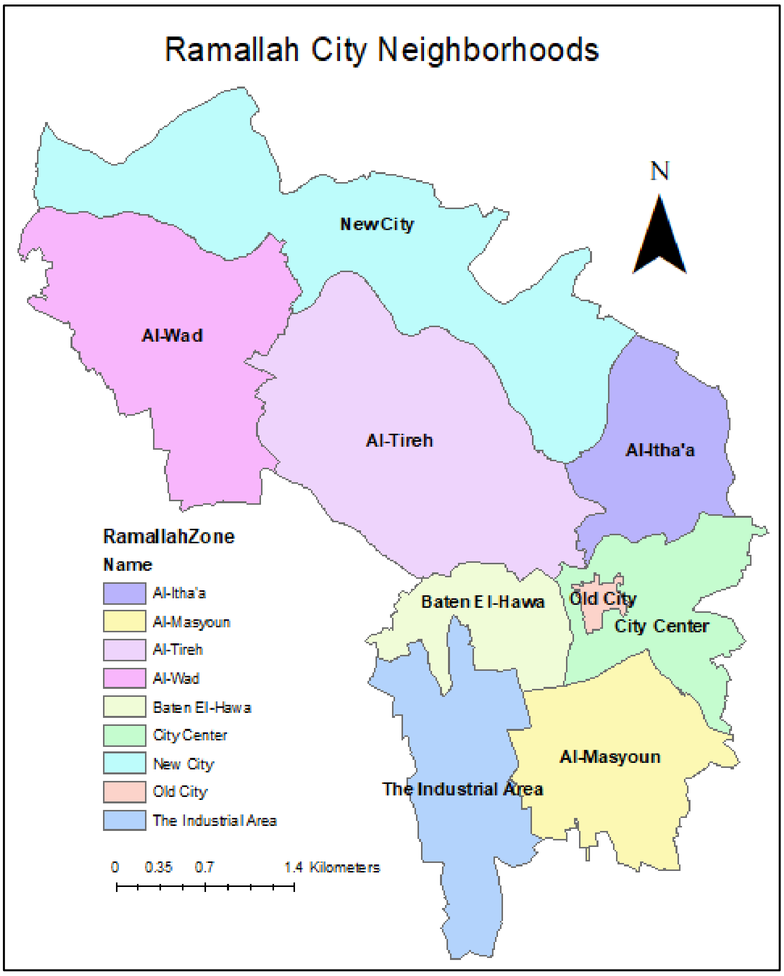


Figure 14: Map for the study area (Ramallah City)

Since Oslo Accords of 1993, and 1995 and the establishment of the PNA, Ramallah City experienced fast increase in the population parallel with the fact of its role as the Palestinian administrative seat. The establishment of PNA's administrative/political institutions and international aid organizations in Ramallah spawned an economic boom that was coupled with the return of members of the American Diaspora and the internal migration of West Bank Palestinians to the city (Al-Houdalieh and Sauders 2009). As mentioned, After the Oslo Accord II, the areas in the West Bank of Palestine that are a total of (5,660) km^2, with a total population of 3.1 million Palestinians (PCBS 2021b) were divided into Areas A, B, and C. The PNA has full control only over Area A, while the majority of the West Bank falls under Area C (60% of the West Bank area), which is fully controlled by Israel and contains all the Israeli settlements.

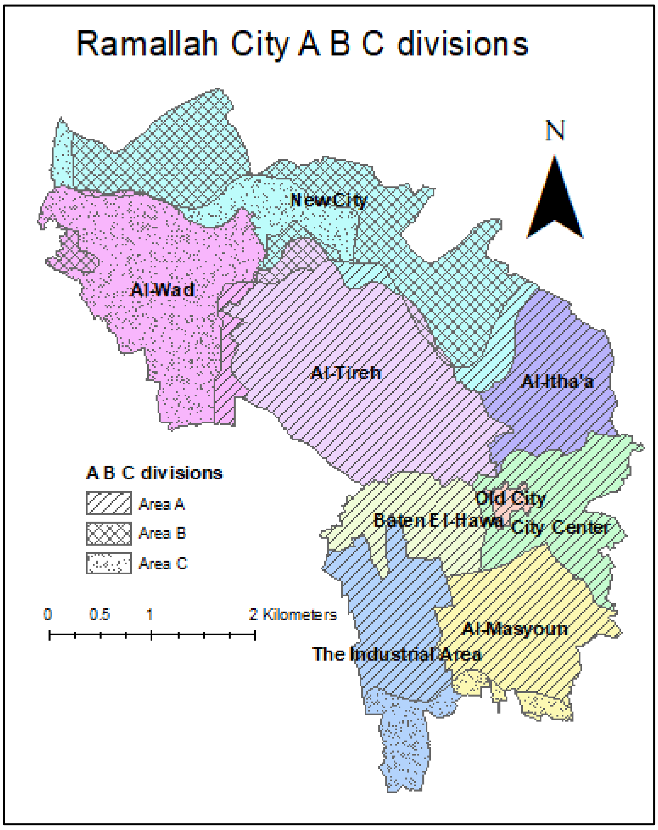


Figure 15: A, B, and C divisions for Ramallah City

Figure 15 above shows how Ramallah City is divided into Areas A, B, and C. Al-Wad and parts of Ramallah New City neighborhoods in addition to small parts of the Industrial area and Al-Masyoun neighborhoods are considered Area C. Another Part of Ramallah New City neighborhood is considered Area B while the rest neighborhoods are considered Area A. This reflects why – due to the geopolitical situation of Palestine – the urban development process in Al-Wad neighborhood is slow and requires several approvals from the concerned parties.

The Apartheid wall – constructed in 2022 – serves for the Israeli takeover of almost 10% of the West Bank. About 85% of the wall's meandering route winds through the West Bank. In other words, it runs through the occupied territory and is not located along with the Green Line or in Israel proper. An area that is equal to 9.4% of the West Bank and includes the territories that Israel annexed to the municipal boundaries of Jerusalem, was cut off from the West Bank, and consequently was cut off from Ramallah governorate land (B'Tselem 2017) as shown in Figure 16.

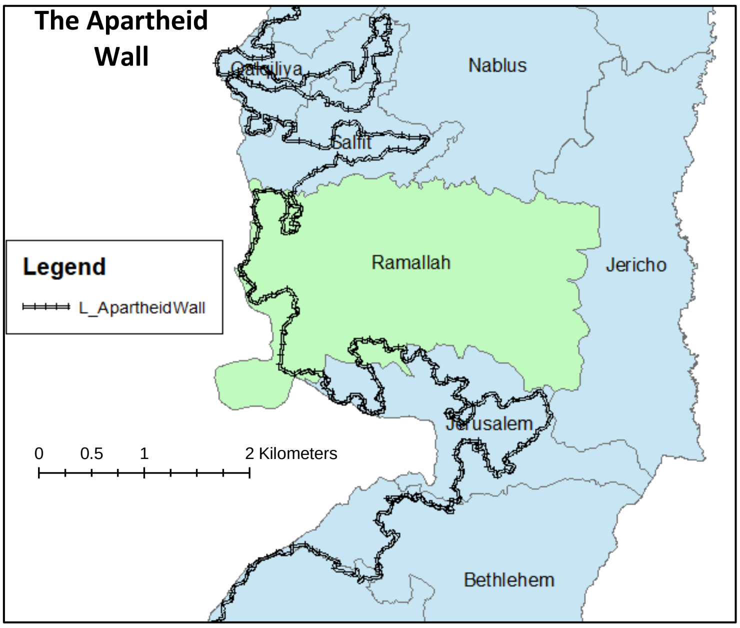


Figure 16: The Apartheid Wall takeover of Ramallah & Al-Bireh Governorate land

On the other hand, and in terms of infrastructure, Ramallah city, same as the rest of the West Bank, suffers from a lack of quality and quantity of infrastructure.

However, all types of infrastructure were negatively affected by the policies of the Israeli occupation from restriction and resource access limitations to lack of production materials and restrictions on the use of available land (Salah and Rizeq 2008).

The following Figures 17, 18, and 19 show a general overview of the study area, where, Ramallah City is divided into 25 blocks, 173.89 kilometers of road lengths and 8,789 parcels of which 5,411 residential parcels, 2,776 of them are occupant. Land uses in Ramallah City mainly vary between residential, commercial, industrial, and agricultural uses.

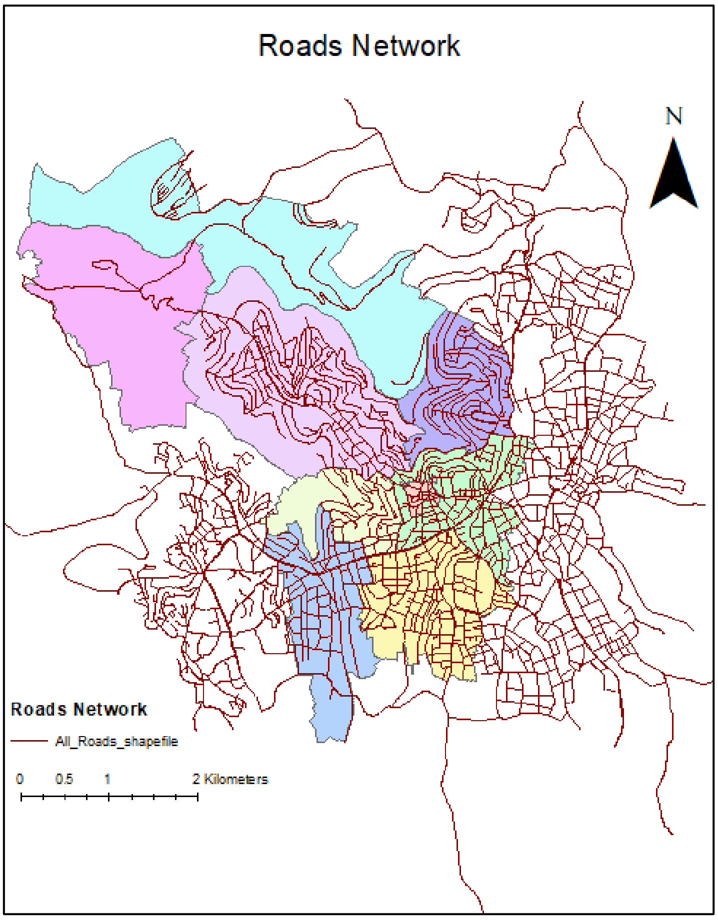


Figure 17: Roads Network for Ramallah City

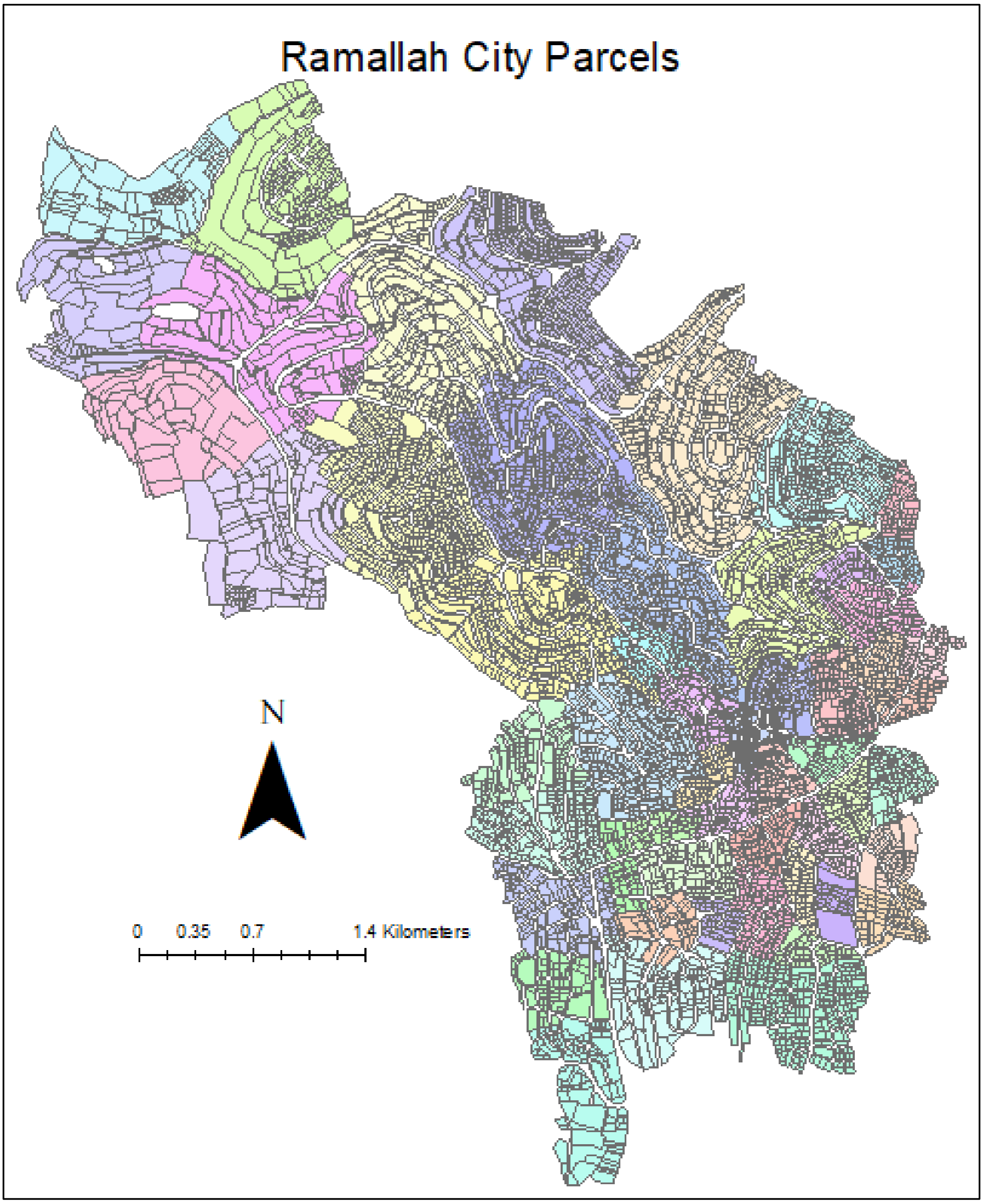


Figure 18: Ramallah City Parcels

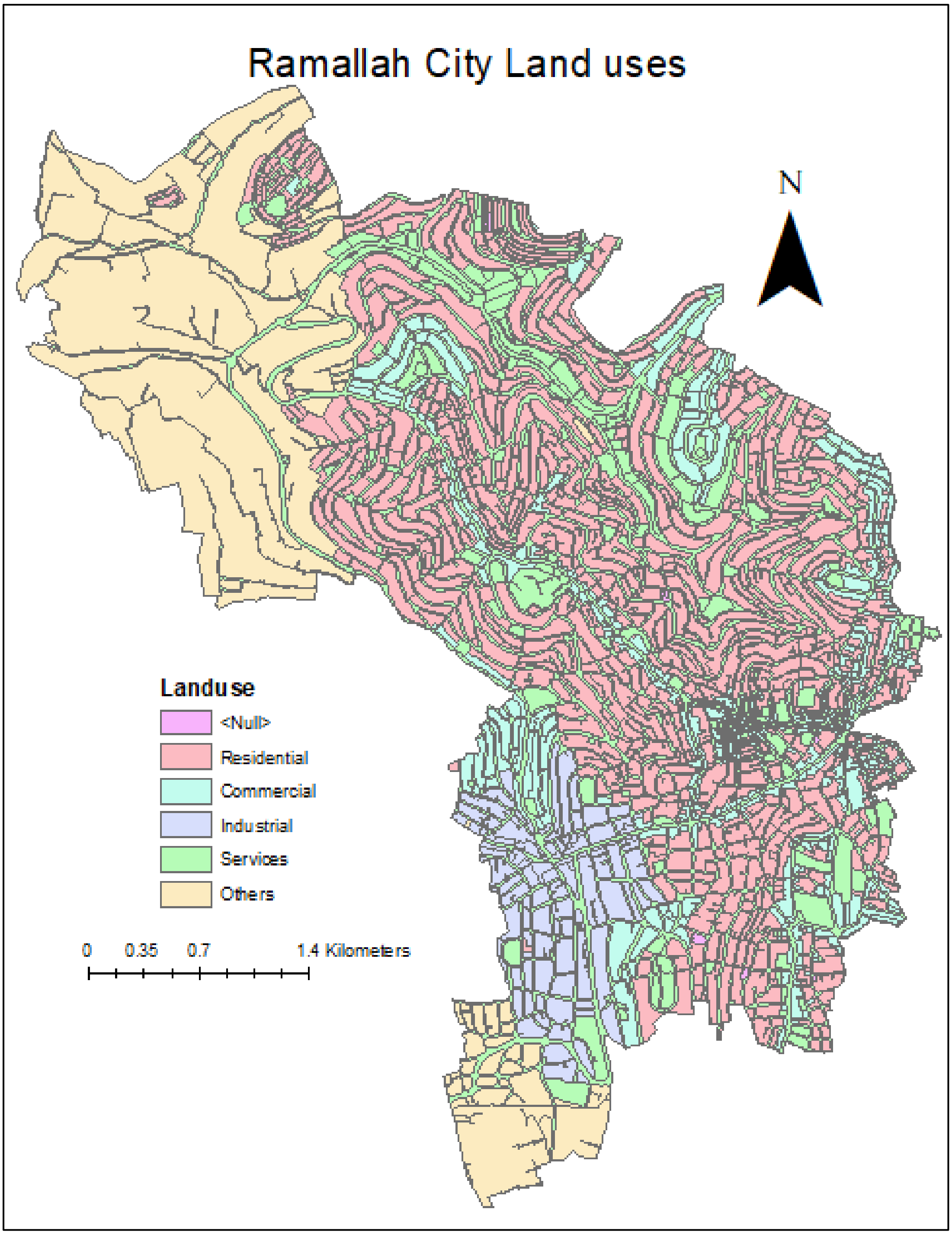


Figure 19: Ramallah City Land uses

Second: Data gathering and processing

Data sources:

The first source of the study data is from Ramallah Municipality which has a GIS department that updates spatially all planning elements (Residential, retail, industrial, services) according to the approved Ramallah Master Plan. The available data are GIS layers for only localities that are directly related to the Municipality. Ramallah neighborhoods included in the study are Al-Tireh, The Old City, Baten Al-Hawa, Al-Itha'a, Al-Masyoun, The Industrial Area, Al-Wad, The City Center, and The New City. The available layers are the streets, shapes of buildings, landmarks, neighborhoods, land uses, parcels, quarters, and blocks. All the above-mentioned layers are updated to the year 2021, except the landmark layer. Those layers were used to generate results for stages one, and two. Another type of data was obtained from Ramallah Municipality is the "Comprehensive Public Transportation Master Plan for the Urban Center of Ramallah and Al-Bireh" and a summary of the "Spatial Development Strategic Framework for Ramallah and Al-Bireh Governorate, 2030". Both documents were considered as the base of stage three results.

The second source of data is from The Palestinian Central Bureau of Statistics (PCBS) which implements the Population, Housing, and Establishments census every 10 years. The data collected for this research was based on the 2017 census. The available data is GIS layers for census neighborhoods that differ from the neighborhoods specified by Ramallah Municipality. The available layers for each neighborhood are only totals of the number of residents, the average family size, the number of operating establishments, the education status, the ownership of a dwelling, the number of employees, and the number of car ownership. Those layers were used to generate results for stages one, and two.

The third source is the direct observations of transit routes, and discussions with different transit drivers, the information gathered were mainly used in stage two to capture the required indicators to perform the analysis. The observed data are the public transit routes, number of transit vehicles per terminal, the major stops per route, the frequency in peak hours, the number of drivers per station, and the number of passengers.

The fourth data source is the survey; which was prepared to study the behavior of the study area residents at the individual level. An Arabic survey was prepared and contained three parts. The first is intended to document general socioeconomic information about the study area residents; the second, is intended to document general information about the work details of the study area residents'; the third is used to assess the relationship between the percentage of people using a specific mode of travel and the socio-demographic characteristic indicators. The template of the survey is annexed in Appendix (A).

Data processing

Two kinds of data processing have been conducted, the first concerning the Geographic Information Systems (GIS) through the ArcMap 10.3 software, data was mapped, analyzed, and visualized using different GIS tools. In later stages of the analysis, GIS tools were used to spatially analyze, capture and display geographic accessibility indicators at parcel-level opportunity measure using network distance and dynamic zoning. Hence, follows are the main data processing steps in ArcMap software:

- Data from PCBS was mapped, matched, and synchronized to Ramallah Municipality data. All were projected to the "Palestine_1923_Palestine_Grid" coordinate system.
- Data check and cleanup: Any data outside "Ramallah Zone" boundaries were considered as outliers and adjustments have been made accordingly to the needed attribute tables.
- Since the official bodies consider the individual level of data as confidential data, and only totals of the study area residents were obtained for each census block from the PCBS, then, to find the number of residents in each residential parcel, the population rate per parcel was calculated and then spatially projected to the residential parcels after multiplying it by the number of units in each parcel. A similar procedure was done for the number of employees in each job location specified within the study area.
- Types of Land uses were re-categorized from 120 categories into 5 categories (1 was assigned to residential land uses, 2 for commercial land uses, 3 for industrial land uses, 4 for services, and 5 for other land uses).
- Ramallah and Al-Bireh are considered twin cities, and there are so many overlaps between both cities in the different services and infrastructure facilities, for instance, the major roads to the New City neighborhood are located within the power of Al-Bireh Municipality, hence, all related routes

were taken into consideration in the network analysis for measuring the distance to transit land-use factor.

It is worth mentioning that the Environmental System Research Institute (ESRI) website is the main reference in GIS tools tutorials and helps in understanding how the ArcMap 10.3 software works, and what each tool stands for.

The second kind of data processing is the analysis of the survey sample size, using Yamane Formula (Equation 2 below) for calculating the sample size of the study area population. The total study area population according to the analysis using the software is 41,679 while according to the census obtained from the PCBS the total Ramallah City population is 42,122, the difference in values is because of what is stated above concerning the prediction of the number of residents in each parcel. Therefore, all the subsequent stages of analysis are based on the 41,679 population.

To find the Study area Sample Size: n = the sample size, N = 41,679 population of Ramallah City, e = 0.05 the level of significance or limit of tolerable error, 1 = constant.

$$n = N / [1 + N (e)^2] \quad \ldots \text{Equation 2}$$

$$n = 41{,}679 / [1 + 41{,}679 (0.05)^2]$$

$$n = 396$$

The sample size collected for the study area population is 399. The Sample survey was stratified and randomly distributed via an online survey tool, a QR printed code. Respondents were randomly selected, taking into consideration to select the representative percentage of the respondents in each neighborhood based on the total population and targeting mainly the workers. Those percentages are shown in Table 7:

Table 7: percentages of each neighborhood sample size

Neighborhood	Population	% of pop. size	Sample size	% of sample	difference
Al-Ithaa	6,159	14.78%	64	16.04%	-1.26%
Al-Masyoun	8,375	20.09%	80	20.05%	0.04%
Al-Tireh	12,303	29.52%	116	29.07%	0.45%
Baten Al-Hawa	3,500	8.40%	30	7.52%	0.88%
City Center	6,943	16.66%	63	15.79%	0.87%
Industrial Area	1,845	4.43%	18	4.51%	-0.08%
New City	1,269	3.04%	14	3.51%	-0.46%
Old City	1,285	3.08%	14	3.51%	-0.43%
	41,679		399		

Third: Survey Data Analysis

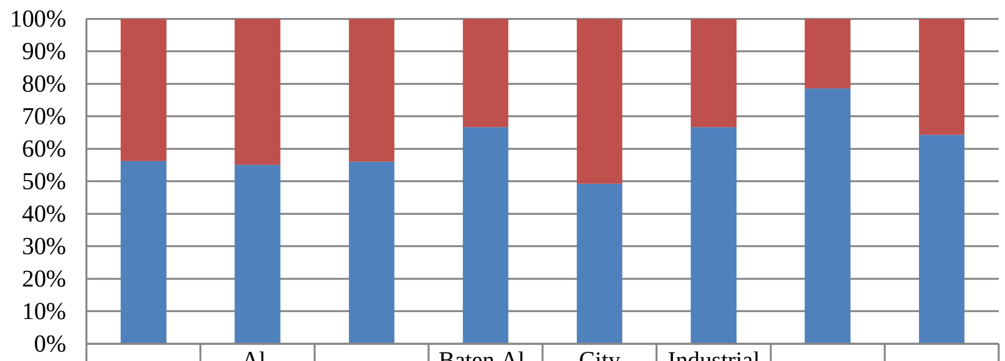
To consider the socio-demographic characteristics in the analysis, as mentioned, a sample survey was conducted to know the mode choice used by Ramallah residents to get to their workplace and the frequency of using those modes. In addition, to study the effect of their location, income, gender, age… etc. on the mode they choose to get to their workplaces. The survey included a total of 439 respondents. 40 out of 439 lives outside the study area, therefore, those were considered outliers and removed from the analysis. Thus, the total number of eligible respondents is 399. The survey included but was not limited to the following questions:

1. Regularity of work (full time, partially…etc).
2. The number of working days.
3. The number of daily working hours.
4. Home and work location.
5. Distance and time to the work.
6. Travel mode of choice from home to work.
7. The frequency of choosing the travel mode.

Overview of the Study area data analysis:

1. Gender:

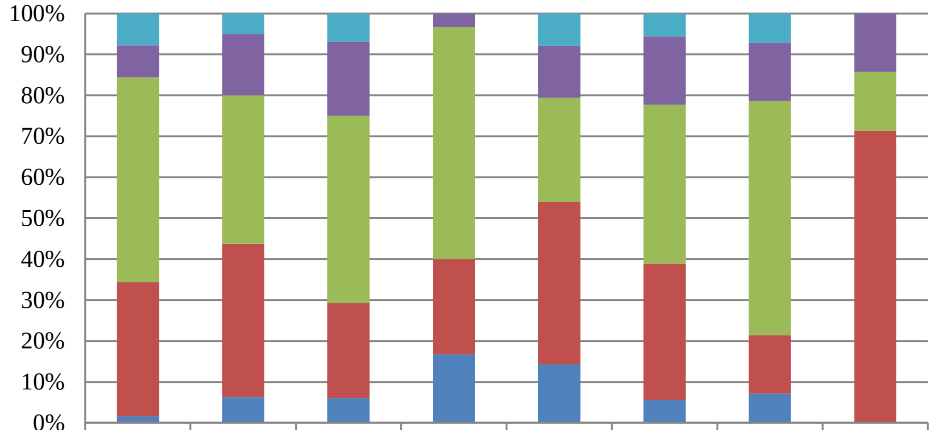
Figure 20 shows that the percentage of female respondents is close to the males' respondents in Al-Itha'a, Al-Masyoun, Al-Tireh, and the City Center neighborhoods and ranges from (43% to 51%), while the rest neighborhoods have higher male survey respondents.



	Al-Ithaa	Al-Masyoun	Al-Tireh	Baten Al-Hawa	City Center	Industrial Area	New City	Old City
Male	43.75%	45.00%	43.97%	33.33%	50.79%	33.33%	21.43%	35.71%
Female	56.25%	55.00%	56.03%	66.67%	49.21%	66.67%	78.57%	64.29%

Figure 20: Respondents per gender in each neighborhood

2. Age



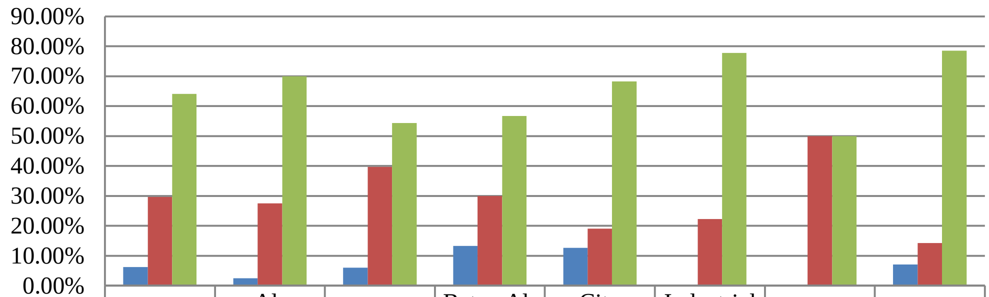
	Al-Ithaa	Al-Masyoun	Al-Tireh	Baten Al-Hawa	City Center	Industrial Area	New City	Old City
51 and above	7.81%	5.00%	6.90%	0.00%	7.94%	5.56%	7.14%	0.00%
41 - 50	7.81%	15.00%	18.10%	3.33%	12.70%	16.67%	14.29%	14.29%
31 - 40	50.00%	36.25%	45.69%	56.67%	25.40%	38.89%	57.14%	14.29%
23 - 30	32.81%	37.50%	23.28%	23.33%	39.68%	33.33%	14.29%	71.43%
22 or less	1.56%	6.25%	6.03%	16.67%	14.29%	5.56%	7.14%	0.00%

Figure 21: Respondents per age group in each neighborhood

Figure 21 shows that the majority of respondents fall under the typical age group who uses travel modes for work trips between 23 and 50.

3. Level of education:

Figure 22 shows that the majority of respondents are residents who have an undergraduate or postgraduate level of education.



	Al-Ithaa	Al-Masyoun	Al-Tireh	Baten Al-Hawa	City Center	Industrial Area	New City	Old City
High School	6.25%	2.50%	6.03%	13.33%	12.70%	0.00%	0.00%	7.14%
Postgraduate	29.69%	27.50%	39.66%	30.00%	19.05%	22.22%	50.00%	14.29%
Undergraduate	64.06%	70.00%	54.31%	56.67%	68.25%	77.78%	50.00%	78.57%

Figure 22: Respondents per level of education in each neighborhood

4. The average income in each neighborhood:

Figure 23 below shows the average monthly income for Al-Itha'a, Al-Tireh, Baten El-Hawa, the New City, and Al-Masyoun neighborhoods ranges between (1,535 $/month and 2,264 $/Month). The Old City, the City Center, and Industrial Area neighborhoods have an average monthly income range between (829 $/Month and 1,309 $/Month).

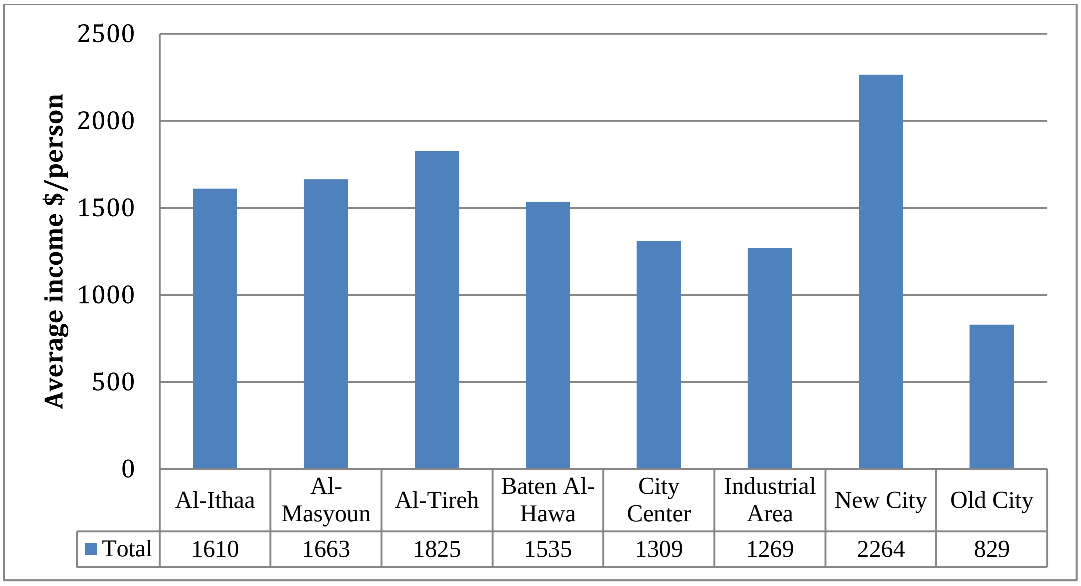


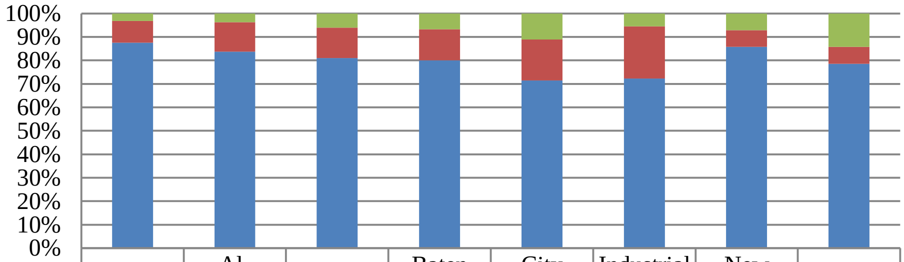
Figure 23: Average income in each neighborhood

5. Income vs. education

Figure 24: Monthly income mean vs. education level in each neighborhood

Figure 24 shows that the higher the education level the higher the average income, in addition, it shows that people who have higher average income prefer new development areas i.e. the New City and Al-Tireh neighborhoods.

6. Regularity of Work:

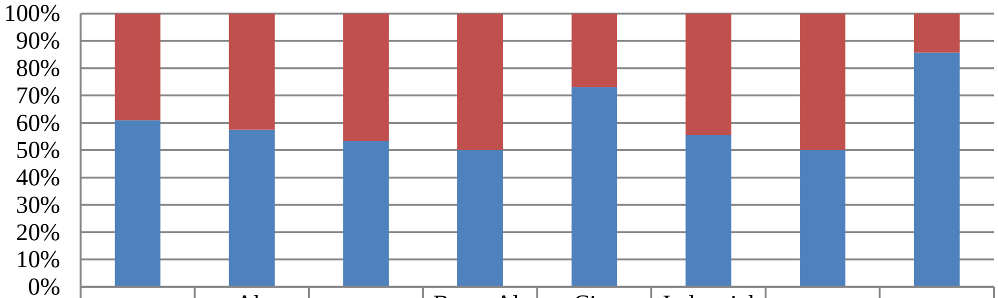


	Al-Ithaa	Al-Masyoun	Al-Tireh	Baten Al-Hawa	City Center	Industrial Area	New City	Old City
Unemployed	3.13%	3.75%	6.03%	6.67%	11.11%	5.56%	7.14%	14.29%
Part Time	9.38%	12.50%	12.93%	13.33%	17.46%	22.22%	7.14%	7.14%
Full Time	87.50%	83.75%	81.03%	80.00%	71.43%	72.22%	85.71%	78.57%

Figure 25: Regularity of work in each neighborhood

Figure 25 shows that 93.73% of the respondents are workers, which is the data needed for the study as we are studying the percentages of choosing a mode of travel for work trips.

7. Work trip track

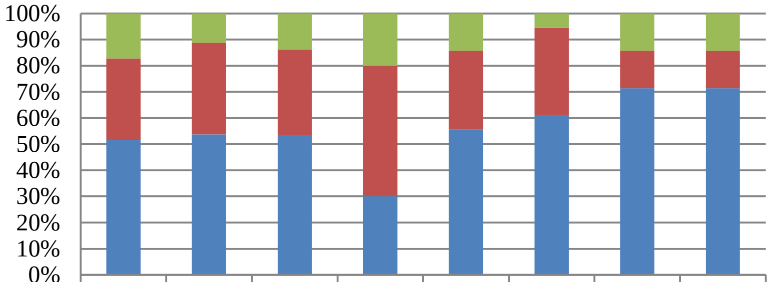


	Al-Ithaa	Al-Masyoun	Al-Tireh	Baten Al-Hawa	City Center	Industrial Area	New City	Old City
Indirect	39.06%	42.50%	46.55%	50.00%	26.98%	44.44%	50.00%	14.29%
Direct	60.94%	57.50%	53.45%	50.00%	73.02%	55.56%	50.00%	85.71%

Figure 26: Work Trip Track in each neighborhood

The survey questioned respondents to specify if they go to work directly or if they do an activity before reaching their jobs. Figure 26 shows that almost half of the respondents go directly to work. This question was only for a one-way trip (from home to work), the survey did not cover the return back trip (from work to home).

8. The number of working hours in each neighborhood:



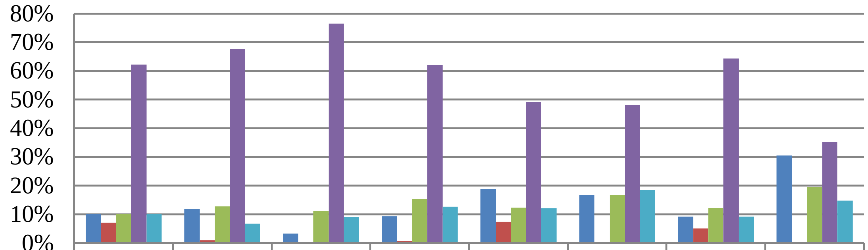
	Al-Ithaa	Al-Masyoun	Al-Tireh	Baten Al-Hawa	City Center	Industrial Area	New City	Old City
Others (less than 6 or More than 10)	17.19%	11.25%	13.79%	20.00%	14.29%	5.56%	14.29%	14.29%
8 to 10 hrs	31.25%	35.00%	32.76%	50.00%	30.16%	33.33%	14.29%	14.29%
6 to 8 hrs	51.56%	53.75%	53.45%	30.00%	55.56%	61.11%	71.43%	71.43%

Figure 27: The number of working hours in each neighborhood

Figure 27 shows that in all neighborhoods, the majority of people work for 6 to 10 hours per day.

9. Mode Choices used for work trips in each neighborhood:

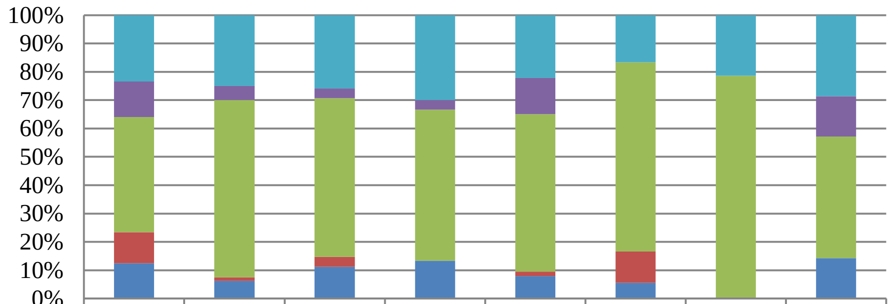
In all neighborhoods, the majority of people use the private cars as a mode choice for their work trips but the Old City uses also walking in addition to private cars as the main mode choices for work trips as shown in Figure 28.



	Al-Itha'a	Al-Masyoun	Al-Tireh	Baten El-Hawa	City Center	The Industrial Area	New City	Old City
Walking	10%	12%	3%	9%	19%	17%	9%	31%
Bike	7%	1%	0%	1%	7%	0%	5%	0%
Carpool	10%	13%	11%	15%	12%	17%	12%	19%
Private Car	62%	68%	77%	62%	49%	48%	64%	35%
Public Transit	10%	7%	9%	13%	12%	19%	9%	15%

Figure 28: Mode choices used for work trips in each neighborhood

10. Preferable Mode Choice:

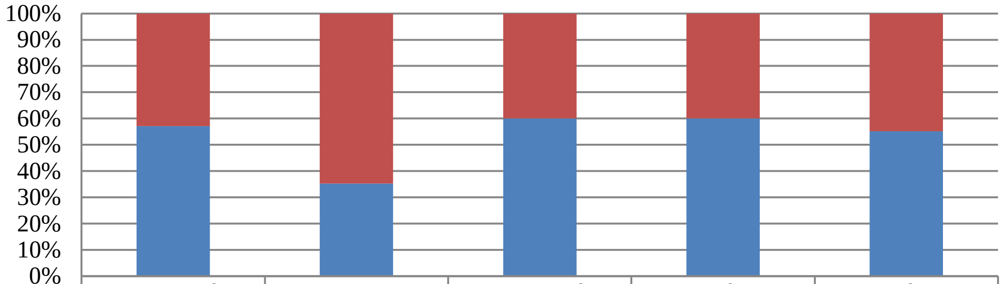


	Al-Ithaa	Al-Masyoun	Al-Tireh	Baten Al-Hawa	City Center	Industrial Area	New City	Old City
Time efficient	23.44%	25.00%	25.86%	30.00%	22.22%	16.67%	21.43%	28.57%
Healthy	12.50%	5.00%	3.45%	3.33%	12.70%	0.00%	0.00%	14.29%
Convenience	40.63%	62.50%	56.03%	53.33%	55.56%	66.67%	78.57%	42.86%
Cheaper	10.94%	1.25%	3.45%	0.00%	1.59%	11.11%	0.00%	0.00%
Available	12.50%	6.25%	11.21%	13.33%	7.94%	5.56%	0.00%	14.29%

Figure 29: Preferable Mode choice

Figure 29 shows that people choose a specific mode of travel that is convenient and time-efficient for their work trips.

11. Mode Choices used by gender type for work trips:

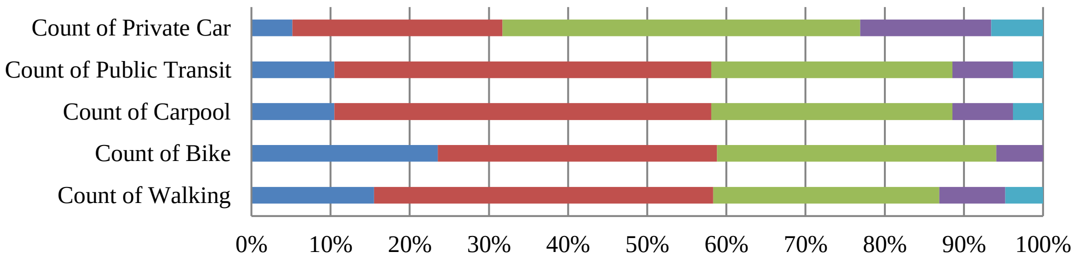


	Count of Walking	Count of Bike	Count of Carpool	Count of Public Transit	Count of Private Car
Male	42.86%	64.71%	40.00%	40.00%	44.83%
Female	57.14%	35.29%	60.00%	60.00%	55.17%

Figure 30: Mode choice used by gender type for work trips

Figure 30 shows that females use the public transit and the carpooling as mode of travel for their work trips more than males.

12. Mode Choices preferred by age group for work trips:

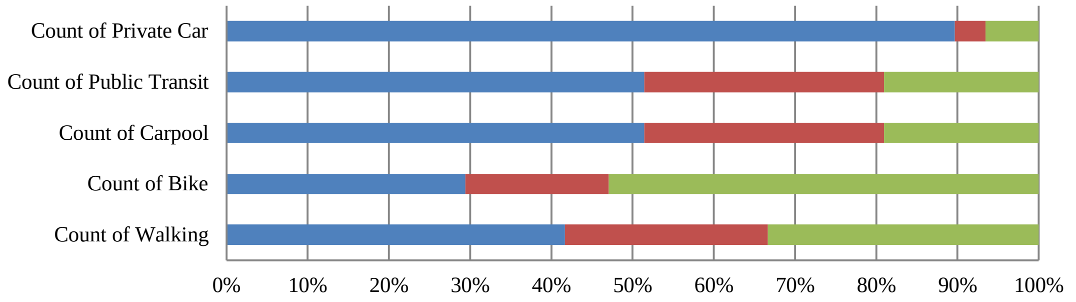


	Count of Walking	Count of Bike	Count of Carpool	Count of Public Transit	Count of Private Car
22 or less	15.48%	23.53%	10.48%	10.48%	5.17%
23 - 30	42.86%	35.29%	47.62%	47.62%	26.55%
31 - 40	28.57%	35.29%	30.48%	30.48%	45.17%
41 - 50	8.33%	5.88%	7.62%	7.62%	16.55%
51 and above	4.76%	0.00%	3.81%	3.81%	6.55%

Figure 31: Mode choice preferred by age group for work trips

Figure 31 highlights the differences between age groups in choosing the mode of travel for their work trips.

13. Mode Choices for Work Trips vs. Shopping Trips (S):



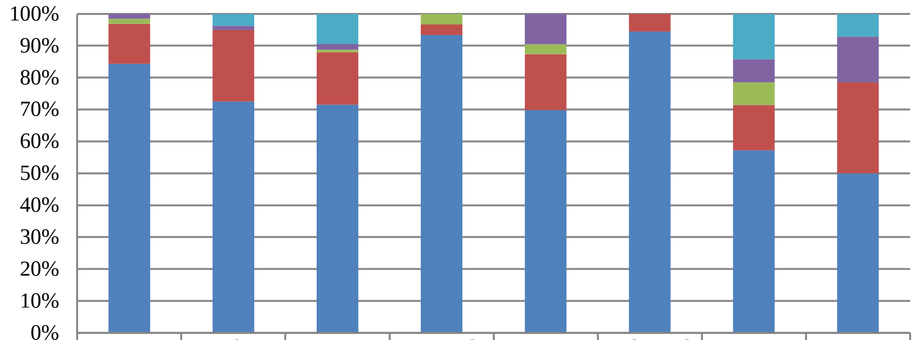
	Count of Walking	Count of Bike	Count of Carpool	Count of Public Transit	Count of Private Car
S-Private Car	41.67%	29.41%	51.43%	51.43%	89.66%
S-Public Transit	25.00%	17.65%	29.52%	29.52%	3.79%
S-Walking	33.33%	52.94%	19.05%	19.05%	6.55%

Figure 32: Mode choice for work trips vs. shopping trips

The survey questioned respondents to specify what mode of travel they choose for shopping trips, Figure 32 above compares the mode of travel chosen for work trips vs. the mode of travel chosen for shopping trips. For instance, 89.66% of people who use the private car as a mode of travel for their work trips also use the private car for shopping trips.

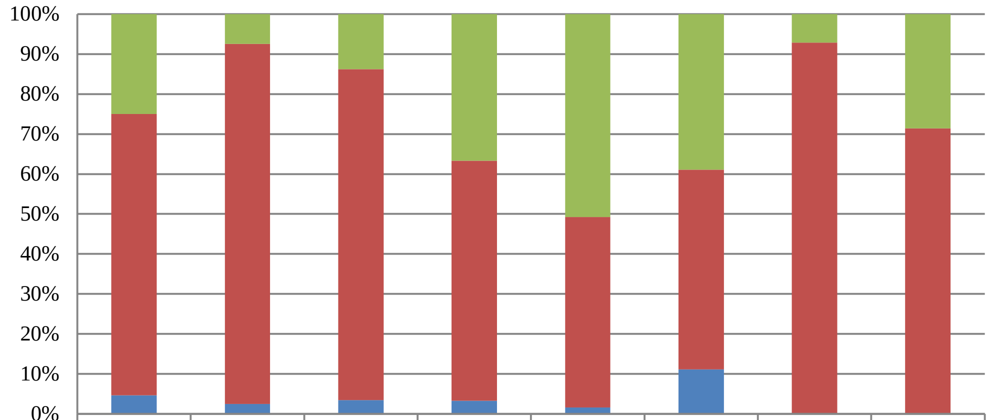
14. Housing Type and Ownership in each neighborhood.

Figure 33 hereafter shows that the majority of respondents live in apartments. Moreover Figure 34 shows that the majority of respondents own the houses they live in.



	Al-Ithaa	Al-Masyoun	Al-Tireh	Baten Al-Hawa	City Center	Industrial Area	New City	Old City
Villa	0.00%	3.75%	9.48%	0.00%	0.00%	0.00%	14.29%	7.14%
Shared Appartment	1.56%	1.25%	1.72%	0.00%	9.52%	0.00%	7.14%	14.29%
Others	1.56%	0.00%	0.86%	3.33%	3.17%	0.00%	7.14%	0.00%
Individual House	12.50%	22.50%	16.38%	3.33%	17.46%	5.56%	14.29%	28.57%
Appartment	84.38%	72.50%	71.55%	93.33%	69.84%	94.44%	57.14%	50.00%

Figure 33: Housing type in each neighborhood

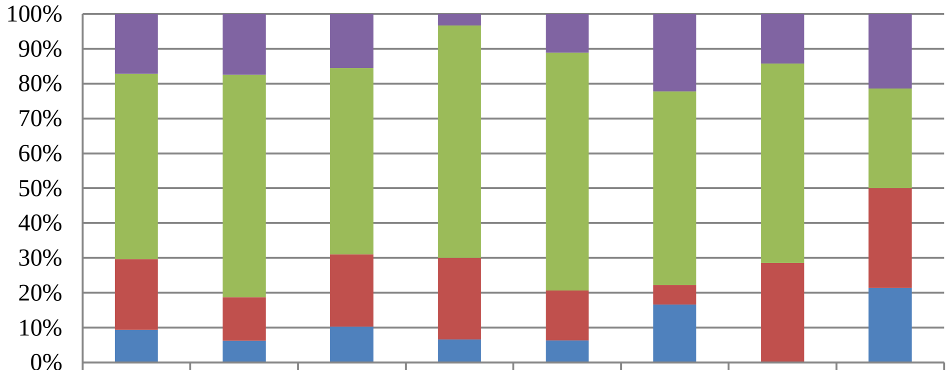


	Al-Ithaa	Al-Masyoun	Al-Tireh	Baten Al-Hawa	City Center	Industrial Area	New City	Old City
Tenant	25.00%	7.50%	13.79%	36.67%	50.79%	38.89%	7.14%	28.57%
Owner	70.31%	90.00%	82.76%	60.00%	47.62%	50.00%	92.86%	71.43%
Others	4.69%	2.50%	3.45%	3.33%	1.59%	11.11%	0.00%	0.00%

Figure 34: Ownership in each neighborhood

15. Work Sectors:

Figure 35 shows that the majority of respondents work in private sector.



	Al-Ithaa	Al-Masyoun	Al-Tireh	Baten Al-Hawa	City Center	Industrial Area	New City	Old City
Public Sector	17.19%	17.50%	15.52%	3.33%	11.11%	22.22%	14.29%	21.43%
Private Sector	53.13%	63.75%	53.45%	66.67%	68.25%	55.56%	57.14%	28.57%
Others	20.31%	12.50%	20.69%	23.33%	14.29%	5.56%	28.57%	28.57%
Freelance	9.38%	6.25%	10.34%	6.67%	6.35%	16.67%	0.00%	21.43%

Figure 35: Percentage of working sectors in each neighborhood

Stage 2: Analysis of land use factors and socio-demographic factors

The methodology used to generate land-use factor maps is based on previous literature to define land-use factor indicators, analysis of the survey responses to define socio-demographic indicators, in addition to data analysis using ArcMap 10.3 software. Each GIS tool used has its unique input field, cell size, the radius of analysis, areal unit, and environments. For the study area analysis, all land-use factor maps share the following tools and input fields:

1. Environments: All data tools were assigned to "Ramallah Zone" as Mask raster analysis and processing Extent.
2. All land-use factor maps (Raster Values) were extracted to the actual residential parcel layer.
3. Cell size: all data tools were assigned to 30 meters cell size.

4. The Radii of the circles used in the analysis are assigned to either 400 meters for density, diversity, distance to transit, and destination accessibility or to 196 meters since the study is performed at the parcel level.
5. The area unit was assigned to either square kilometers or square meters to study the effect of the favorable walking distances.
6. All socio-demographic indicators values were joined to the actual residential parcel layer.

First: Define dependent and independent variables

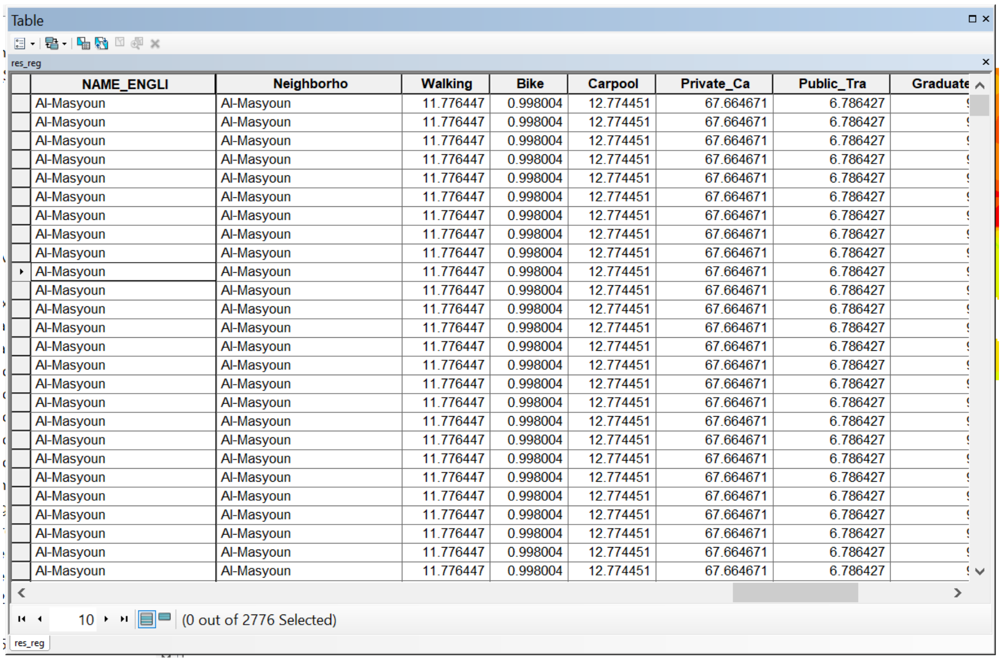
Selecting the proper indicators requires significant knowledge of the obtained data and the level of data analysis. The dependent variables used in the analysis are the percentage of choosing a particular mode of travel for work trips, the data were obtained from the survey where each respondent specified the frequency of using a particular mode of travel during the week, and the values were extracted to the actual residential parcels attribute table. The modes used are the available modes used in Palestine and they are walking, public transit, carpooling, and private cars, the biking was excluded from the analysis since its percentage is very low compared to the other modes. The independent variables are divided into, socio-demographic independent variables differentiated from the survey and land use factors independent variables that were based on the literature review and the available data from the mentioned sources. Variables are shown in the following Table 8.

Table 8: Dependent and independent variables

Factor	Independent variables (indicators)
Density	Actual residential density (Person /Area)
Diversity	Actual residential parcel area (Area/Area)
	Commercial parcel area (Area/Area)
	Industrial parcel area (Area/Area)
	Services parcel area (Area/Area)
Design	Roads line density (Meters/Area)
	Number of four-way intersections (Number/Area)
Distance to transit	Transit frequency per stop (Frequency/Area)
	Euclidean Distance from residential parcels to the nearest stop (Distance)
	Near frequency, proximity between residential parcels, and stops (Distance)
Destination Accessibility	Accessibility to jobs (Person/Distance)
Socio-demographic	Percentage of the graduated population from universities (%)
	Percentage of residents living in apartments (%)
	Percentage of housing units' owners (%)
	Percentage of residents' full-time jobs (%)
	Average monthly income ($)
	Average age (Number)
Mode of Choice	Dependent variable
Walk	Percentage of using walking as a mode of travel to work trips (%)
Public Transit	Percentage of using public transit as a mode of travel to work trips (%)
Carpool	Percentage of using carpooling as a mode of travel to work trips (%)
Private Car	Percentage of using private cars as a mode of travel to work trips (%)

Second: Generation of land use factors maps and socio-demographic table

Spatial land use and socio-demographic indicators were measured; outputs resulted in different forms; attribute tables and maps. Those indicators were used as independent variables in performing regression models. The socio-demographic data were presented in the attribute table of the actual residential parcels, where beside each parcel a value of the socio-demographic indicator is shown. Figure 36 is a screenshot of how it is performed in ArcMap software:



NAME_ENGLI	Neighborho	Walking	Bike	Carpool	Private_Ca	Public_Tra	Graduate
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	
Al-Masyoun	Al-Masyoun	11.776447	0.998004	12.774451	67.664671	6.786427	

Figure 36: Socio-demographic indicators in the attribute table

Land use factor maps were generated first as shown in Figures 37 to 41, and then the raster values were extracted to the actual residential parcels attribute table.

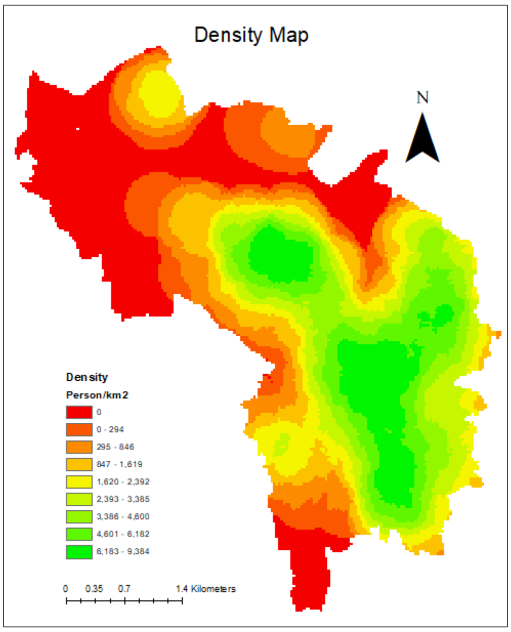
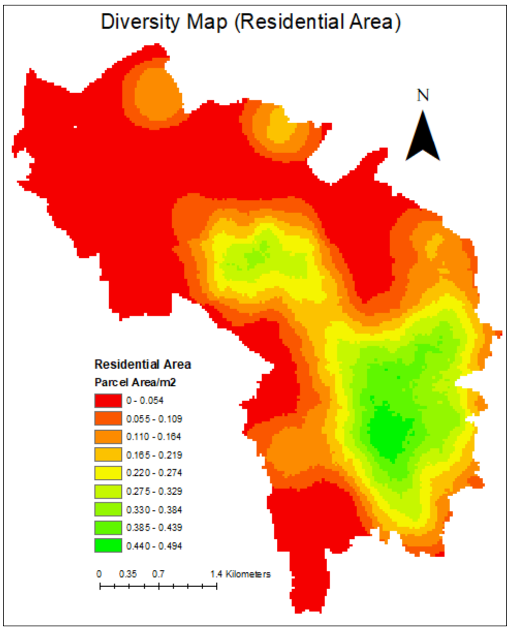
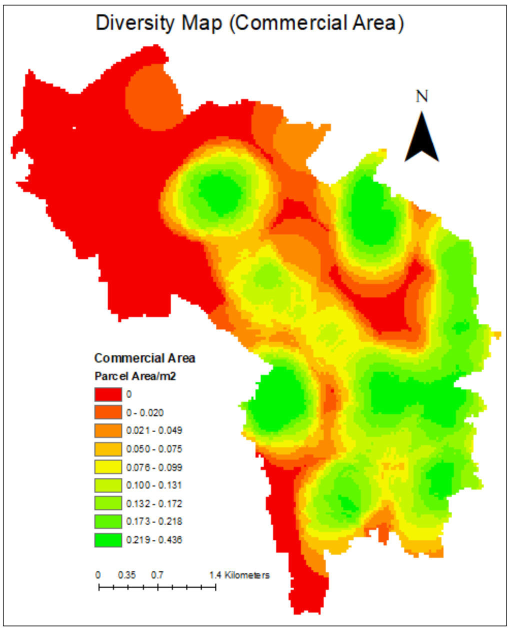


Figure 37: Density Map

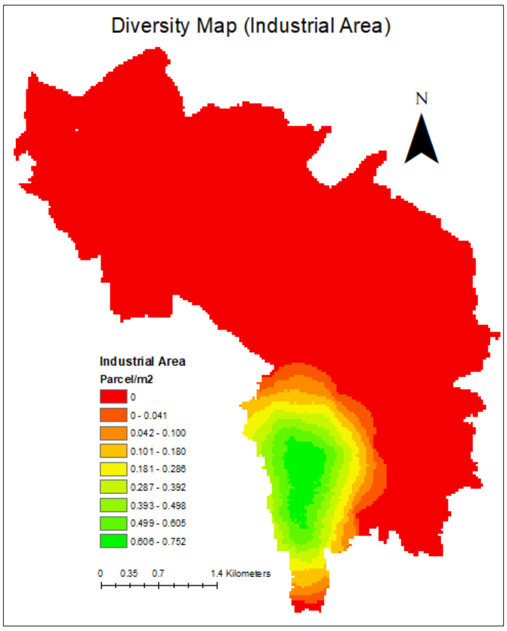
Figure 37 above shows the Density Map; the population density reaches its higher value of 9,384 persons in kilometers square which represents the green color locations in the map.



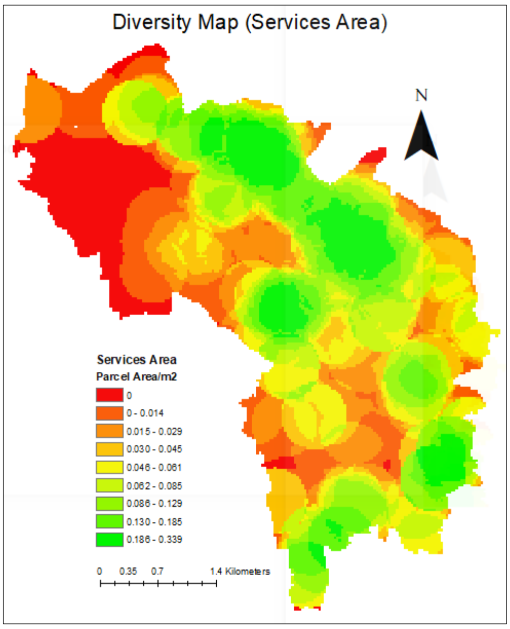
Diversity Map (Residential Area)



Diversity Map (Commercial Area)



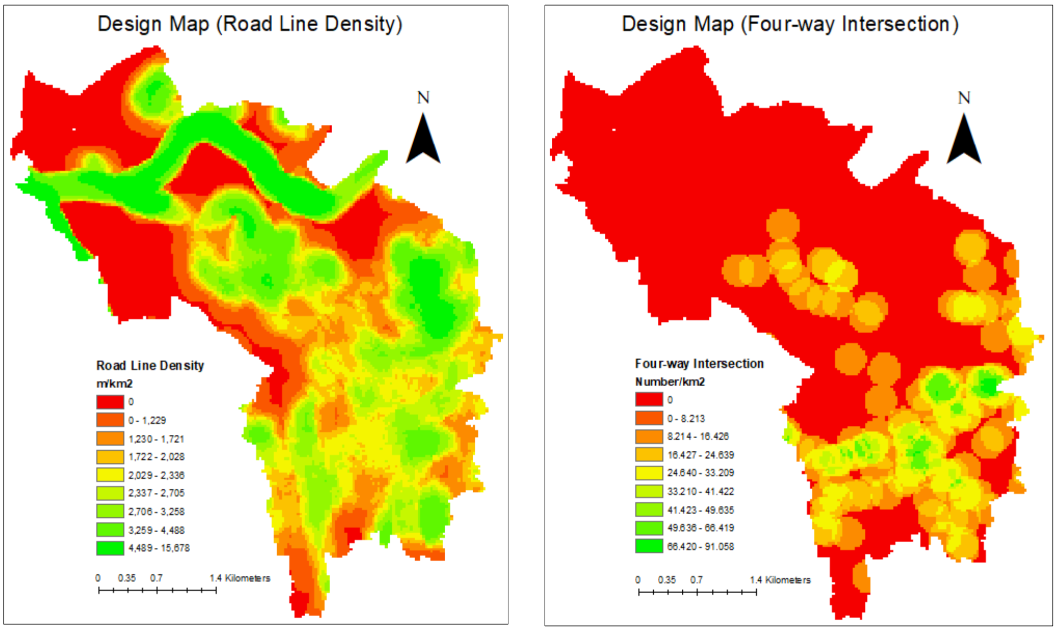
Diversity Map (Industrial Area)



Diversity Map (Service Area)

Figure 38: Diversity Maps

Figure 38 presents the share of each land use (residential, commercial, industrial and service) to the parcel area



Road line density | Number of four-way intersections

Figure 39: Design Maps

Figure 39 represents the analysis of two design factors; the road line density is distributed over all neighborhoods, and the number of four-way intersections is concentrated in the Old city, City Center Al-Masyoun and The Industrial Area.

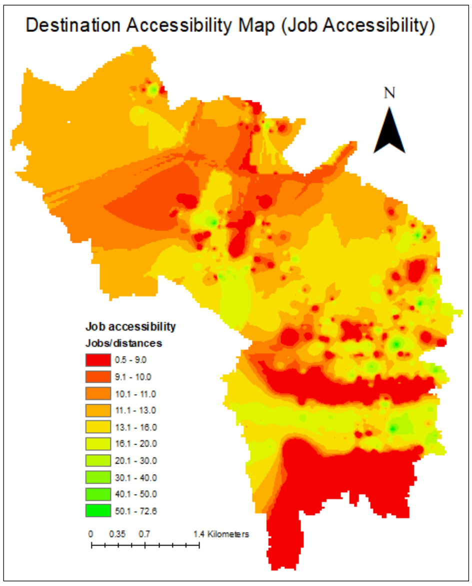
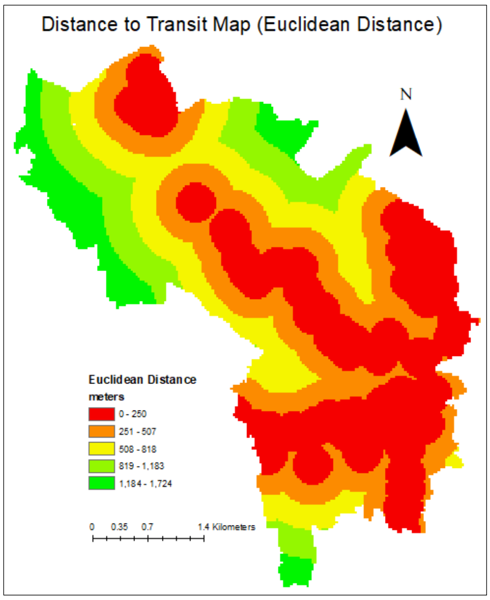
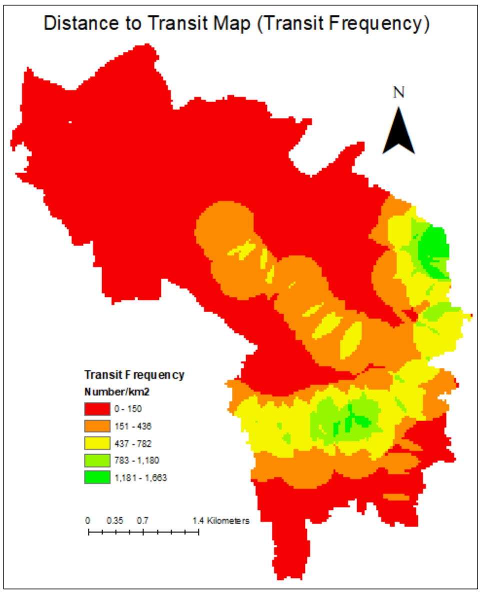


Figure 40: Job Accessibility Map

Figure 40 above shows the distribution of Job Accessibility in the study area; the neighborhoods that have the higher job accessibility are Al-Tireh, the Old City, City Center, Al-Ithaa and Al-Masyoun.





Euclidean Distance Transit Frequency

Figure 41: Distance to Transit Maps

According to the literature there are no regular stops along the routes, therefore, stops were assumed based on direct observations and interviews with the head of drivers in each station. The Network analysis was performed to generate the Euclidean Distance map from origins to the nearest transit stop and to generate transit frequency at each stop as shown in Figure 41. All land use factor maps results (as independent variables) were extracted to the residential layer to get to generation of regression models as shown in the Figure 42 below.

Table

res_reg

NAME_ENGLI	near_freq	Design_lin	Design_4wa	Diversity_	Density_Re	Job_Access	Transit_Fr	EucD
Al-Masyoun	71.298932	754.855774	9.472389	0.085483	1225.918091	2.396458	39.788734	7
Al-Masyoun	37.789342	846.359192	16.556105	0.085558	1187.865234	2.396181	39.788734	5
Al-Masyoun	123.06648	831.27594	12.845068	0.10705	1681.702393	2.398703	39.788734	13
Al-Masyoun	156.178564	1526.518188	22.906509	0.134153	2050.584961	2.410818	51.364655	15
Al-Masyoun	235.456033	2225.509277	4.7819	0.11247	1361.380249	2.375464	59.683105	23
Al-Masyoun	143.330469	1677.891235	24.834158	0.143181	2173.971924	2.41377	59.683105	13
Al-Masyoun	158.061618	1862.178101	24.834158	0.154546	2407.807129	2.402671	59.683105	15
Al-Masyoun	184.006474	1855.39563	20.668642	0.158192	2665.363037	2.397727	59.683105	18
Al-Masyoun	207.213141	1875.61438	13.656662	0.158988	2744.982178	2.393825	57.043156	20
Al-Masyoun	226.677541	2655.021729	0	0.1219	1627.262329	2.373749	59.683105	22
Al-Masyoun	103.862931	2024.661255	24.834158	0.163739	2364.546631	2.405322	59.683105	9
Al-Masyoun	243.980592	1998.06604	8.278052	0.164376	2782.272461	2.386951	48.652943	24
Al-Masyoun	181.75571	2037.079834	16.88372	0.180613	3227.275879	2.393838	59.683105	1
Al-Masyoun	121.778731	2103.768555	24.834158	0.179145	2859.656494	2.399947	59.683105	11
Al-Masyoun	68.883055	2228.286865	24.834158	0.185103	2646.655762	2.39891	59.683105	6
Al-Masyoun	191.281201	3481.87793	1.042673	0.135862	1813.857056	2.369205	59.683105	19
Al-Masyoun	234.454912	2378.008301	8.278052	0.185821	3223.101074	2.375232	59.683105	23
Al-Masyoun	263.428231	2345.420898	8.278052	0.186277	3343.577148	2.373504	59.683105	26
Al-Masyoun	311.971476	2325.438232	8.278052	0.181633	3367.978516	2.376785	33.162251	31
Al-Masyoun	250.798871	3360.443115	0	0.114084	1674.002441	2.373853	49.794437	24
Al-Masyoun	114.059438	2482.151611	23.095146	0.217169	3687.679443	2.392014	63.852665	1
Al-Masyoun	66.07138	2412.755615	30.233967	0.21568	3291.847168	2.393042	73.690132	6
Al-Masyoun	235.310791	2534.564209	8.278052	0.20217	3652.413574	2.371942	59.683105	23
Al-Masyoun	155.905596	2442.986084	21.725832	0.21009	3767.236816	2.387871	59.683105	15
Al-Masyoun	314.21121	2465.620605	8.278052	0.193089	3739.86792	2.375147	32.095318	31
Al-Masyoun	136.858891	3985.57373	8.292887	0.176721	2283.575684	2.375479	79.577469	13

5 (0 out of 2776 Selected)

res_reg

Figure 42: Land use factors values in the attribute table

Third: Generation of regression models equations

Conducting Ordinary Least Squares (OLS) tool, to find if there are relationships among the 17 independent variables and the five dependent variables mentioned above. Six regression model reports were generated, attached in Appendix (B) showing the effect of the independent variables in reducing or increasing the choice of a particular mode of travel. Insignificant variables were excluded from the analysis as will be mentioned in the results and discussion section. All data were processed relative to 2,776 residential units in Ramallah City. Descriptive statistics of independent and dependent variables are shown in Table 9 below.

Table 9: Descriptive statistics of independent and dependent variables

Factor			Mean	SD	Min	Max
Independent variables	Near frequency	X1	153.914	102.089	-1.000	398.966
	Line Density	X2	2606.816	879.638	0.000	6409.480
	4 way intersections	X3	14.720	16.016	0.000	87.111
	Residential Area	X4	0.271	0.109	0.004	0.487
	Residential Density	X5	4578.571	2321.176	121.556	9351.659
	Jobs accessibility	X6	12.429	5.179	1.705	69.285
	Transit Frequency	X7	187.228	155.973	0.000	831.585
	Euclidean Distance	X8	251.854	277.296	7.728	1614.549
	Commercial Area	X9	0.118	0.075	0.000	0.324
	Industrial Area	X10	0.022	0.096	0.000	0.734
	Services Area	X11	0.067	0.050	0.000	0.285
	Graduated pop	X12	93.302	4.733	0.000	100.000
	Apartments	X13	76.430	8.212	0.000	94.444
	Age	X14	33.863	1.814	0.000	36.071
	Ownership	X15	72.611	16.844	0.000	92.857
	Full time job	X16	79.871	5.672	0.000	87.500
	Monthly income	X17	1593.681	341.727	0.000	2264.286
Dependent variables	Private Cars	Model 1	61.704	12.375	0.000	76.543
	Public Transit	Model 2	10.371	2.757	0.000	18.519
	Walking	Model 3	12.133	7.462	0.000	30.556
	Carpooling	Model 4	12.732	2.299	0.000	19.444

Stage 3: Towards building a strategy

The Methodology used to find potential to achieving planning for accessibility objectives and to define the gaps in knowledge and /or resources is by assessing the relevancy of the related policy agenda to planning for accessibility:

<u>“The Spatial Development Strategic Framework (SDSF) for Ramallah and Al-Bireh Governorate”</u> uses the spatial dimension at aggregate level of analysis to

perform the results of the framework. It includes the social dimension through studying the available capacities and the needs of different communities. The related indicators are indicators applicable to the “Land use Design factor” only. And finally the framework recommends the provision of development centers and services to ease the access to residents and improve the quality of services for better opportunities to people. The “Comprehensive Public Transportation Master Plan for the Urban Center of Ramallah and Al-Bireh” is directly intertwined with the goals of the SDSF and complies with planning for accessibility objectives. The plan vision looks at the city as a smart moving city to enhance the well-being of Ramallah City residents through a good balance between walking, cycling, the car and public transit. The plan aims to reduce the need for travel, promote for competitive transit system and pedestrian environment addressing different community needs. This is evident in *“A public transport system should be a system that is continuously developing in a sustainable way, and that contributes to improving livability and accessibility”*. The plan resulted in “Public Transportation Master Plan” and in “Planning strategies and measures”, results are developed using the spatial analysis tool “TransCAD” up to the year 2036.

4. Chapter 4: Results and Discussions

4.1. Chapter overview

This chapter covers the results of the three stages of the analysis with a discussion of them. The first section presents the results of the regression models and the second section discusses the potential of achieving planning for accessibility objectives in Ramallah City by considering land-use transportation policies and suggests a proposed strategy.

4.2. Results of Stage One and Two

As described in the methodology and data analysis, regression models are used to study the effect of land use factors and socio-demographic characteristics on the travel mode choice for work trips for Ramallah City residents as follows: first, a regression model to study the effect of land use factors on choosing the private car as a mode of travel for work trips; second, a refined regression model for the private cars with only seven land-use factors; and finally four regression models to study the effect of land use factors and socio-demographic characteristics on choosing a particular mode of travel for work trips. The biking was excluded from the analysis since the percentage of people using the biking as a mode of travel for their work trips is only 3%.

It is worth nothing that the regression models used are multiple linear regression models that follow the formula of (Equation 3):

$Y = B_0 + B_1X_1 + \ldots + B_nX_n + \varepsilon$ … Equation 3

Where; Y is the predicted value of the dependent variable; B_0 is the Y-intercept – the value of Y when all other variables are set to zero; B_1X_1 is the regression coefficient of B_1 of the first explanatory variable (X_1); ε is the model error.

First: Regression model to study the effect of land use factors on choosing the private car as a mode of travel for work trips: the dependent variable used in this model is the percentage of using private cars as a mode of travel for work trips, and the independent variables used are 11 variables as shown in Table 10:

Table 10: Independent variables

Factor	Independent variable	Symbols
Density	Residential Density	X5
Diversity	Residential Area	X4
	Commercial Area	X9
	Industrial Area	X10
	Services Area	X11
Design	Line Density	X2
	4-way intersections	X3
Distance to transit	Transit Frequency	X7
	Distance to the nearest stop	X8
	Near frequency	X1
Destination Accessibility	Jobs accessibility	X6

The t-test results show that all the above-mentioned independent variables are significant except the service area variable (X11). Therefore, the model was repeated without this independent variable, the results are shown in Figure 43 in a GIS table format.

OBJECTID *	Variable	Coef	StdError	t_Stat	Prob	Robust_SE	Robust_t	Robust_Pr	StdCoef
1	Intercept	78.603318	0.992358	79.208645	0	1.151455	68.264319	0	0
2	NEAR_FREQ	-0.003694	0.001754	-2.106011	0.03528	0.001766	-2.091849	0.03653	-0.030476
3	DESIGN_LIN	0.000513	0.000206	2.489458	0.01284	0.000269	1.908117	0.056477	0.036458
4	DESIGN_4WA	-0.105816	0.013333	-7.936444	0	0.013624	-7.767004	0	-0.136952
5	DIVERSITY_	-22.632729	3.047359	-7.426999	0	3.07676	-7.356026	0	-0.200077
6	DENSITY_RE	0.000383	0.000133	2.872308	0.004112	0.000127	3.025119	0.00252	0.071914
7	JOB_ACCESS	-0.050726	0.033169	-1.529314	0.126316	0.031558	-1.607367	0.108102	-0.021228
8	TRANSIT_FR	0.012228	0.001311	9.325461	0	0.001186	10.308695	0	0.154118
9	EUCDIST_TR	-0.005952	0.000783	-7.606102	0	0.000695	-8.560914	0	-0.133378
10	COM_DIVE	-93.22817	3.002981	-31.045213	0	2.957833	-31.519076	0	-0.564938
11	IND_DIVE	-39.774928	1.984108	-20.046757	0	1.517531	-26.210294	0	-0.307797

OBJECTID *	Diag_Name	Diag_Value	Definition
1	AIC	20028.695831	Akaike's Information Criterion: A relative measure of performance used to compare models; the smaller AIC indicates the superior model.
2	AICc	20028.808752	Corrected Akaike's Information Criterion: second order correction for small sample sizes.
3	R2	0.484652	R-Squared, Coefficient of Determination: The proportion of variation in the dependent variable that is explained by the model.
4	AdjR2	0.482789	Adjusted R-Squared: R-Squared adjusted for model complexity (number of variables) as it relates to the data.
5	F-Stat	260.031141	Joint F-Statistic Value: Used to assess overall model significance.
6	F-Prob	0	Joint F-Statistic Probability (p-value): The probability that none of the explanatory variables have an effect on the dependent variable.
7	Wald	3051.685528	Wald Statistic: Used to assess overall robust model significance.
8	Wald-Prob	0	Wald Statistic Probability (p-value): The computed probability, using robust standard errors, that none of the explanatory variables have an effect on the dependent variable.
9	K(BP)	148.653473	Koenker's studentized Breusch-Pagan Statistic: Used to test the reliability of standard error values when heteroskedasticity (non-constant variance) is present.
10	K(BP)-Prob	0	Koenker (BP) Statistic Probability (p-value): The probability that heteroskedasticity (non-constant variance) has not made standard errors unreliable.
11	JB	334.752288	Jarque-Bera Statistic: Used to determine whether the residuals deviate from a normal distribution.
12	JB-Prob	0	Jarque-Bera Probability (p-value): The probability that the residuals are normally distributed.
13	Sigma2	79.233237	Sigma-Squared: OLS estimate of the variance of the error term (residuals).

Figure 43: Private Car vs. land-use factors regression model results

Figure 43 also shows that the higher the density, the higher land use mix, the shorter distance to transit, the better the road design, and the higher destination accessibility will lower the use of private cars as a mode of travel to work. The sign of control variables are consistent with prior expectations, e.g. the percentage of using private cars falls with job accessibility.

To investigate if there are differences among neighborhoods, residual statistics is analyzed in Table 11 below:

Table 11: Residual Statistics

Neighborhood	Average of Private Car	Average of Estimated	Average of Residual	Average of StdResid
Al-Itha'a	62.20472441	68.29671465	-6.091990242	-0.684392905
Al-Masyoun	67.66467066	61.31595931	6.34871135	0.713233743
Al-Tireh	76.54320988	67.97241708	8.570792792	0.962869201
Baten El-Hawa	62	60.76774209	1.232257907	0.13843564
City Center	49.21348315	55.39226123	-6.17877808	-0.694142917
New City	64.28571429	69.24077655	-4.955062261	-0.556666922
Old City	35.18518519	46.92953568	-11.74435049	-1.319396426
The Industrial Area	48.14814815	50.92682318	-2.778675035	-0.312164892

Table 11 above shows that all the values of the Average of Standardized Residuals are within one standard deviation and the Old City neighborhood is within two standard deviations. Hence, the model is appropriate in modeling the given data. However our analysis is based on parcel level with radii ranges between 200 and 400 m^2 which reduce the effect of the Modifiable Areal Unit Problem as mentioned in the literature review section 2.7.

Second: a refined regression model for the private cars with only seven land-use factors: Despite that all the above variables have Variance Inflation Factor (VIF) value within the range (less than 7.5) but a refined regression model with only seven land-use factors was performed, Table 12 shows the factors used in the analysis:

Table 12: Independent variables

Factor	Independent variable	Symbols
Density	Residential Area	X2
Diversity	Commercial Area	X4
	Industrial Area	X5
	Services Area	X6
Design	4-way intersections	X1
Distance to transit	Distance to the nearest stop	X3
Destination Accessibility	Jobs accessibility	X7

The t-test results show that all the above-mentioned independent variables are significant except the destination accessibility variable (X7). Therefore, the model was repeated without this independent variable, the results are shown in Figure 44

OBJECTID *	Variable	Coef	StdError	t_Stat	Prob	Robust_SE	Robust_t	Robust_Pr	StdCoef
1	Intercept	81.958753	0.652642	125.580046	0	0.790836	103.635525	0	0
2	DESIGN_4WA	-0.105066	0.013493	-7.78643	0	0.013992	-7.508775	0	-0.135982
3	DIVERSITY_	-14.923636	2.108581	-7.077574	0	2.45187	-6.086633	0	-0.131927
4	EUCDIST_TR	-0.008587	0.000686	-12.522455	0	0.000499	-17.222011	0	-0.19241
5	COM_DIVE	-90.502015	2.90416	-31.162889	0	2.654175	-34.09798	0	-0.548418
6	IND_DIVE	-38.391077	1.999984	-19.195694	0	1.624531	-23.632106	0	-0.297089
7	SERV_DIVE	-14.270523	3.639279	-3.92125	0.000099	3.904744	-3.654663	0.000276	-0.05797

OBJECTID *	Diag_Name	Diag_Value	Definition
1	AIC	20109.110501	Akaike's Information Criterion: A relative measure of performance used to compare models; the smaller AIC indicates the superior model.
2	AICc	20109.162543	Corrected Akaike's Information Criterion: second order correction for small sample sizes.
3	R2	0.467975	R-Squared, Coefficient of Determination: The proportion of variation in the dependent variable that is explained by the model.
4	AdjR2	0.466822	Adjusted R-Squared: R-Squared adjusted for model complexity (number of variables) as it relates to the data.
5	F-Stat	405.939851	Joint F-Statistic Value: Used to assess overall model significance.
6	F-Prob	0	Joint F-Statistic Probability (p-value): The probability that none of the explanatory variables have an effect on the dependent variable.
7	Wald	2422.088501	Wald Statistic: Used to assess overall robust model significance.
8	Wald-Prob	0	Wald Statistic Probability (p-value): The computed probability, using robust standard errors, that none of the explanatory variables have an effect o
9	K(BP)	111.997747	Koenker's studentized Breusch-Pagan Statistic: Used to test the reliability of standard error values when heteroskedasticity (non-constant variance)
10	K(BP)-Prob	0	Koenker (BP) Statistic Probability (p-value): The probability that heteroskedasticity (non-constant variance) has not made standard errors unreliable
11	JB	361.442367	Jarque-Bera Statistic: Used to determine whether the residuals deviate from a normal distribution.
12	JB-Prob	0	Jarque-Bera Probability (p-value): The probability that the residuals are normally distributed.
13	Sigma2	81.679245	Sigma-Squared: OLS estimate of the variance of the error term (residuals).

Figure 44: Private Car vs. six land-use factors regression model results

Figure 44 also shows that the higher the density, the higher land use mix, the shorter distance to transit, and the better the road design will lower the use of private cars as a mode of travel to work. The sign of control variables are consistent with prior expectations, e.g. the percentage of using private cars falls with shorter distances to transit.

Third: Four regression models to study the effect of land use factors and socio-demographic characteristics on choosing a particular mode of travel for work trips: Four models were generated including the eleven land-use variables in addition to six socio-demographic variables. The socio-demographic input data was totals and averages for each neighborhood and extracted to all the residential parcels with the same value. Therefore, the regression models will be generated only to study the direction of the relationships among variables. To study the strength of relationships among variables, the socio-demographic data should be GPS data, not totals and averages, but since this kind of data is not available as mentioned in the methodology and data analysis section, measuring the strength of the relationships will not give a useful interpretation.

Table 13 defines the dependent and independent variables used in the regression models: the table included 17 independent variables, eleven of them representing land-use factors indicators, and six are for socio-demographic characteristics. The same table also includes the four dependent variables.

Table 13: Dependent and Independent variables

Factor	Independent variable	Symbols
Density	Residential Density	X5
Diversity	Residential Area	X4
	Commercial Area	X9
	Industrial Area	X10
	Services Area	X11
Design	Line Density	X2
	4-way intersections	X3
Distance to transit	Transit Frequency	X7
	Distance to the nearest stop	X8
	Near frequency	X1
Destination Accessibility	Jobs accessibility	X6
Socio-demographic	Graduated pop	X12
	Apartments	X13
	Ownership	X15
	Full-time job	X16
	Monthly income	X17
	Age	X14
	Dependent variable	
Mode of travel	Walking	Model 3
	Public Transit	Model 2
	Carpooling	Model 4
	Private Cars	Model 1

Regression Models results: The measure used in this analysis is the decrease/increase in the percentage of people using a specific mode of travel for their work trips in relation to land-use and socio-demographic factors.

Model 1: Private Cars vs. Land use factors and socio-demographic characteristics

Regression model 1 included all independent variables versus the percentage of using private cars as a mode of travel for work trips. The t-test results show that all independent variables are significant except the Four-Way intersection variable (X3). Therefore, the model was repeated without this independent variable, the results are shown in Figure 45 in a GIS table format.

OBJECTID *	Variable	Coef	StdError	t_Stat	Prob	Robust_SE	Robust_t	Robust_Pr	StdCoef
1	Intercept	-3.604272	0.489881	-7.357445	0	2.097534	-1.718338	0.085856	0
2	NEAR_FREQ	0.000764	0.000123	6.192096	0	0.000136	5.635481	0	0.006306
3	DESIGN_LIN	0.000136	0.000015	9.257851	0	0.000022	6.172942	0	0.009685
4	DIVERSITY_	0.695607	0.240957	2.886851	0.003928	0.392376	1.772805	0.076377	0.006149
5	DENSITY_RE	-0.000093	0.000011	-8.51151	0	0.000011	-8.442921	0	-0.017432
6	JOB_ACCES	-0.003804	0.002311	-1.64651	0.099785	0.002282	-1.667343	0.095571	-0.001592
7	TRANSIT_FR	0.001948	0.000106	18.440147	0	0.000136	14.336476	0	0.024554
8	EUCDIST_TR	-0.000417	0.00006	-6.951418	0	0.000061	-6.788244	0	-0.009348
9	COM_DIVE	-0.841664	0.255195	-3.29812	0.001002	0.334993	-2.512483	0.012034	-0.0051
10	IND_DIVE	-7.441981	0.252965	-29.418991	0	0.556275	-13.378243	0	-0.05759
11	SERV_DIVE	1.831407	0.2683	6.825971	0	0.233067	7.857859	0	0.00744
12	GRADUATE	-1.782105	0.007457	-238.970695	0	0.016957	-105.094613	0	-0.681603
13	APPARTMEN	0.943379	0.003212	293.709912	0	0.005961	158.251159	0	0.626046
14	AGE	4.948693	0.017202	287.681538	0	0.033603	147.269685	0	0.725377
15	OWNERS	1.2123	0.002721	445.610601	0	0.003728	325.209569	0	1.650147
16	FULL_TIME	-1.13725	0.00653	-174.159538	0	0.011684	-97.337693	0	-0.521236
17	INCOME	-0.003516	0.000114	-30.781606	0	0.000167	-21.097194	0	-0.097101

OBJECTID *	Diag_Name	Diag_Value	Definition
1	AIC	5044.359446	Akaike's Information Criterion: A relative measure of performance used to compare models; the smaller AIC indicates the superior model.
2	AICc	5044.607542	Corrected Akaike's Information Criterion: second order correction for small sample sizes.
3	R2	0.997677	R-Squared, Coefficient of Determination: The proportion of variation in the dependent variable that is explained by the model.
4	AdjR2	0.997664	Adjusted R-Squared: R-Squared adjusted for model complexity (number of variables) as it relates to the data.
5	F-Stat	74069.695921	Joint F-Statistic Value: Used to assess overall model significance.
6	F-Prob	0	Joint F-Statistic Probability (p-value): The probability that none of the explanatory variables have an effect on the dependent variable.
7	Wald	2076152.420566	Wald Statistic: Used to assess overall robust model significance.
8	Wald-Prob	0	Wald Statistic Probability (p-value): The computed probability, using robust standard errors, that none of the explanatory variables have an effect on the dependent variable.
9	K(BP)	998.46602	Koenker's studentized Breusch-Pagan Statistic: Used to test the reliability of standard error values when heteroskedasticity (non-constant variance) is present.
10	K(BP)-Prob	0	Koenker (BP) Statistic Probability (p-value): The probability that heteroskedasticity (non-constant variance) has not made standard errors unreliable.
11	JB	167.932805	Jarque-Bera Statistic: Used to determine whether the residuals deviate from a normal distribution.
12	JB-Prob	0	Jarque-Bera Probability (p-value): The probability that the residuals are normally distributed.
13	Sigma2	0.357875	Sigma-Squared: OLS estimate of the variance of the error term (residuals).

Figure 45: Model 1 Private Car regression model results

Model 1: The higher density, the higher land use mix, the shorter distance to transit, and the higher destination accessibility will lower the use of private cars as a mode of travel to work. The sign of control variables are consistent with prior expectations, e.g. the percentage of using private cars falls with job accessibility. The socio-demographic characteristics show that it is related to the percentage of using the private cars as a mode of travel for work trips, e.g. the more people own houses the higher they use private cars. The VIF value is less than 7.5 for all values except for the socio-demographic characteristics also, the model showed statistical significance in the Jarque-Bera statistic which confirms the non-normality of the error in the model, both values are normal due to repetition of data as mentioned earlier.

Model 2: Public Transit vs. Land use factors and socio-demographic characteristics

Regression model 2 included all independent variables versus the percentage of using the public transit as a mode of travel for work trips. The t-test results show that all independent variables are significant except the Four-Way Intersection variable (X3). Therefore, the model was repeated without this independent variable, and the results are shown in Figure 46 in a GIS table format.

OBJECTID *	Variable	Coef	StdError	t_Stat	Prob	Robust_SE	Robust_t	Robust_Pr	StdCoef
1	Intercept	6.267475	0.881419	7.110665	0	3.649959	1.717136	0.086076	0
2	NEAR_FREQ	-0.001378	0.000222	-6.204882	0	0.000244	-5.643113	0	-0.051041
3	DESIGN_LIN	-0.000242	0.000026	-9.123813	0	0.000039	-6.209678	0	-0.077094
4	DIVERSITY_	-1.314917	0.433542	-3.032962	0.002456	0.695424	-1.890813	0.058752	-0.052182
5	DENSITY_RE	0.000168	0.00002	8.566228	0	0.00002	8.524502	0	0.141706
6	JOB_ACCES	0.00692	0.004157	1.66451	0.096136	0.004104	1.685911	0.091937	0.013
7	TRANSIT_FR	-0.003486	0.00019	-18.340508	0	0.00024	-14.53755	0	-0.197253
8	EUCDIST_TR	0.000755	0.000108	6.987924	0	0.00011	6.83507	0	0.075898
9	COM_DIVE	1.497713	0.45916	3.261853	0.001136	0.603204	2.482932	0.013078	0.040742
10	IND_DIVE	13.464415	0.455148	29.582498	0	0.998265	13.487819	0	0.467737
11	SERV_DIVE	-3.292227	0.482739	-6.819892	0	0.419512	-7.84776	0	-0.060036
12	GRADUATE	0.049468	0.013418	3.686773	0.000244	0.030241	1.635782	0.102012	0.084935
13	APPARTMEN	-0.135189	0.005779	-23.392817	0	0.010682	-12.65552	0	-0.402736
14	AGE	0.212636	0.030951	6.870141	0	0.058983	3.605045	0.000332	0.139916
15	OWNERS	-0.214834	0.004895	-43.889102	0	0.006608	-32.51222	0	-1.312727
16	FULL_TIME	0.290618	0.011749	24.735556	0	0.021038	13.81383	0	0.597943
17	INCOME	-0.002783	0.000206	-13.540741	0	0.000296	-9.404415	0	-0.345005

OBJECTID *	Diag_Name	Diag_Value	Definition
1	AIC	8305.44195	Akaike's Information Criterion: A relative measure of performance used to compare models; the smaller AIC indicates the superior model.
2	AICc	8305.690046	Corrected Akaike's Information Criterion: second order correction for small sample sizes.
3	R2	0.848476	R-Squared, Coefficient of Determination: The proportion of variation in the dependent variable that is explained by the model.
4	AdjR2	0.847597	Adjusted R-Squared: R-Squared adjusted for model complexity (number of variables) as it relates to the data.
5	F-Stat	965.580134	Joint F-Statistic Value: Used to assess overall model significance.
6	F-Prob	0	Joint F-Statistic Probability (p-value): The probability that none of the explanatory variables have an effect on the dependent variable.
7	Wald	17527.664585	Wald Statistic: Used to assess overall robust model significance.
8	Wald-Prob	0	Wald Statistic Probability (p-value): The computed probability, using robust standard errors, that none of the explanatory variables have an effect on the dependent variable.
9	K(BP)	979.440407	Koenker's studentized Breusch-Pagan Statistic: Used to test the reliability of standard error values when heteroskedasticity (non-constant variance) is present.
10	K(BP)-Prob	0	Koenker (BP) Statistic Probability (p-value): The probability that heteroskedasticity (non-constant variance) has not made standard errors unreliable.
11	JB	172.919459	Jarque-Bera Statistic: Used to determine whether the residuals deviate from a normal distribution.
12	JB-Prob	0	Jarque-Bera Probability (p-value): The probability that the residuals are normally distributed.
13	Sigma2	1.158552	Sigma-Squared: OLS estimate of the variance of the error term (residuals).

Figure 46: Model 2 Public Transit regression model results

Model 2: The higher density, the higher land use mix, the higher destination accessibility and the shorter distance to transit will increase the use of public transit as a mode of travel to work. The sign of control variables are consistent with prior expectations, e.g. the percentage of using public transit increases with job accessibility. The socio-demographic characteristics show that it is related to the percentage of using the public transit as a mode of travel for work trips, e.g. the increase in the monthly income will lower the use of public transit. The VIF value is less than 7.5 for all values except for the socio-demographic characteristics also, the model showed statistical significance in the Jarque-Bera statistic which confirms the non-normality of the error in the model, both values are normal due to repetition of data as mentioned earlier.

Model 3: Walking vs. Land use factors and socio-demographic characteristics

Regression model 3 included all independent variables versus the percentage of using walking as a mode of travel for work trips. The t-test results show that all independent variables are significant except the Four-Way Intersection (X3) and the Service Area (X11) variables. Therefore, the model was repeated without those independent variables, the results are shown in Figure 47 in a GIS table format.

OBJECTID *	Variable	Coef	StdError	t_Stat	Prob	Robust_SE	Robust_t	Robust_Pr	StdCoef
1	Intercept	20.96712	0.58275	35.979633	0	12.521655	1.674469	0.094163	0
2	NEAR_FREQ	0.000467	0.000146	3.203429	0.001389	0.000166	2.811216	0.004974	0.006393
3	DESIGN_LIN	-0.000324	0.000017	-18.665448	0	0.000103	-3.138954	0.001728	-0.038195
4	DIVERSITY_	6.545587	0.286486	22.847826	0	1.700004	3.850338	0.000131	0.09596
5	DENSITY_RE	-0.000132	0.000013	-10.2789	0	0.000025	-5.232347	0	-0.041104
6	JOB_ACCES	-0.00831	0.00273	-3.043545	0.002372	0.002893	-2.871868	0.004118	-0.005767
7	TRANSIT_FR	-0.001438	0.00012	-11.99261	0	0.000605	-2.37753	0.017482	-0.030053
8	EUCDIST_TR	-0.000501	0.000071	-7.025364	0	0.0001	-4.997973	0.000001	-0.018627
9	COM_DIVE	1.485909	0.300559	4.943822	0.000001	0.639611	2.323145	0.020228	0.014932
10	IND_DIVE	-9.349646	0.299319	-31.236375	0	1.739054	-5.376283	0	-0.119986
11	GRADUATE	1.388947	0.008856	156.841735	0	0.06551	21.202045	0	0.880975
12	APPARTMEN	-0.448188	0.003814	-117.517108	0	0.017985	-24.920289	0	-0.493242
13	AGE	-2.720387	0.020463	-132.943133	0	0.172681	-15.753796	0	-0.661278
14	OWNERS	-0.575907	0.003235	-178.031264	0	0.014827	-38.842009	0	-1.300002
15	FULL_TIME	0.445178	0.007765	57.333899	0	0.027055	16.454328	0	0.33837
16	INCOME	-0.003552	0.000136	-26.158887	0	0.00062	-5.729643	0	-0.162651

OBJECTID *	Diag_Name	Diag_Value	Definition
1	AIC	6007.189587	Akaike's Information Criterion: A relative measure of performance used to compare models; the smaller AIC indicates the superior model.
2	AICc	6007.411487	Corrected Akaike's Information Criterion: second order correction for small sample sizes.
3	R2	0.990958	R-Squared, Coefficient of Determination: The proportion of variation in the dependent variable that is explained by the model.
4	AdjR2	0.990908	Adjusted R-Squared: R-Squared adjusted for model complexity (number of variables) as it relates to the data.
5	F-Stat	20164.552967	Joint F-Statistic Value: Used to assess overall model significance.
6	F-Prob	0	Joint F-Statistic Probability (p-value): The probability that none of the explanatory variables have an effect on the dependent variable.
7	Wald	1887472.745331	Wald Statistic: Used to assess overall robust model significance.
8	Wald-Prob	0	Wald Statistic Probability (p-value): The computed probability, using robust standard errors, that none of the explanatory variables have an effect on the dependent variable.
9	K(BP)	1862.245875	Koenker's studentized Breusch-Pagan Statistic: Used to test the reliability of standard error values when heteroskedasticity (non-constant variance) is present.
10	K(BP)-Prob	0	Koenker (BP) Statistic Probability (p-value): The probability that heteroskedasticity (non-constant variance) has not made standard errors unreliable.
11	JB	3447652.972503	Jarque-Bera Statistic: Used to determine whether the residuals deviate from a normal distribution.
12	JB-Prob	0	Jarque-Bera Probability (p-value): The probability that the residuals are normally distributed.
13	Sigma2	0.506429	Sigma-Squared: OLS estimate of the variance of the error term (residuals).

Figure 47: Model 3 Walking regression model results

Model 3: The higher land use mix, and shorter distance to transit will increase the walking as a mode of travel to work. The sign of control variables is consistent with prior expectations, e.g. the percentage of walking people increases with increasing land-use diversity. The higher density and the higher destination accessibility will decrease the walking as a mode of travel for work trips. The socio-demographic characteristics show that it is related to the percentage of using walking as a mode of travel for work trips, e.g. the increase in people's age will lower the probability of walking to work trips. The VIF value is less than 7.5 for all values except for the socio-demographic characteristics also, the model showed statistical significance in the Jarque-Bera statistic which confirms the non-normality of the error in the model, both values are normal due to repetition of data as mentioned earlier.

Model 4: Carpooling vs. Land use factors and socio-demographic characteristics

Regression model 4 included all independent variables versus the percentage of using carpooling as a mode of travel for work trips. The t-test results show that all independent variables are significant except the Four-Way Intersection (X3) and the Job Accessibility (X6) variables. Therefore, the model was repeated without those independent variables, the results are shown in Figure 48 in a GIS table format.

OBJECTID *	Variable	Coef	StdError	t_Stat	Prob	Robust_SE	Robust_t	Robust_Pr	StdCoef
1	Intercept	18.527808	0.863159	21.465119	0	10.853505	1.707081	0.087929	0
2	NEAR_FREQ	-0.001078	0.000218	-4.954971	0.000001	0.00023	-4.686343	0.000004	-0.047861
3	DESIGN_LIN	-0.000428	0.000026	-16.513221	0	0.000093	-4.61525	0.000006	-0.163837
4	DIVERSITY_	2.568216	0.423635	6.062334	0	1.484693	1.729796	0.083787	0.122186
5	DENSITY_RE	0.000088	0.000019	4.585647	0.000007	0.000026	3.403984	0.00069	0.088923
6	TRANSIT_FR	-0.004263	0.000185	-22.987179	0	0.000564	-7.558206	0	-0.289195
7	EUCDIST_TR	0.000448	0.000106	4.23667	0.000028	0.000125	3.591035	0.00035	0.054017
8	COM_DIVE	2.342244	0.449626	5.209318	0	0.638062	3.67087	0.00026	0.076386
9	IND_DIVE	7.802491	0.440869	17.697974	0	1.491957	5.229704	0	0.324952
10	SERV_DIVE	-3.124881	0.469669	-6.653372	0	0.417318	-7.488011	0	-0.068317
11	GRADUATE	0.205464	0.013032	15.765649	0	0.056819	3.61614	0.000318	0.422927
12	APPARTMEN	-0.030858	0.005588	-5.522132	0	0.016245	-1.899516	0.057598	-0.110211
13	AGE	-0.674981	0.029864	-22.601777	0	0.15038	-4.48851	0.00001	-0.532471
14	OWNERS	-0.010039	0.00478	-2.10029	0.035781	0.013569	-0.739856	0.459441	-0.07354
15	FULL_TIME	0.070307	0.011391	6.172202	0	0.02326	3.022674	0.00254	0.173423
16	INCOME	-0.002512	0.0002	-12.531194	0	0.000576	-4.360879	0.000017	-0.373393

OBJECTID *	Diag_Name	Diag_Value	Definition
1	AIC	8189.17033	Akaike's Information Criterion: A relative measure of performance used to compare models; the smaller AIC indicates the superior model.
2	AICc	8189.39223	Corrected Akaike's Information Criterion: second order correction for small sample sizes.
3	R2	0.790999	R-Squared, Coefficient of Determination: The proportion of variation in the dependent variable that is explained by the model.
4	AdjR2	0.789863	Adjusted R-Squared: R-Squared adjusted for model complexity (number of variables) as it relates to the data.
5	F-Stat	696.377934	Joint F-Statistic Value: Used to assess overall model significance.
6	F-Prob	0	Joint F-Statistic Probability (p-value): The probability that none of the explanatory variables have an effect on the dependent variable.
7	Wald	11946.394528	Wald Statistic: Used to assess overall robust model significance.
8	Wald-Prob	0	Wald Statistic Probability (p-value): The computed probability, using robust standard errors, that none of the explanatory variables have an effect on the dependent variable.
9	K(BP)	1957.415687	Koenker's studentized Breusch-Pagan Statistic: Used to test the reliability of standard error values when heteroskedasticity (non-constant variance) is present.
10	K(BP)-Prob	0	Koenker (BP) Statistic Probability (p-value): The probability that heteroskedasticity (non-constant variance) has not made standard errors unreliable.
11	JB	42879.602027	Jarque-Bera Statistic: Used to determine whether the residuals deviate from a normal distribution.
12	JB-Prob	0	Jarque-Bera Probability (p-value): The probability that the residuals are normally distributed.
13	Sigma2	1.111427	Sigma-Squared: OLS estimate of the variance of the error term (residuals).

Figure 48: Model 4 carpooling regression model results

Model 4: The higher the density and the higher the land use mix will increase the carpooling as a mode of travel to work. The sign of control variables is consistent with prior expectations, e.g. the percentage of using carpooling increases with higher densities. The shorter distance to transit will decrease carpooling as a mode of travel for work trips. The socio-demographic characteristics show that it is directly related to the percentage of using carpooling as a mode of travel for work trips, e.g. the increase in people's monthly income will lower the probability of carpooling to work trips. The VIF value is less than 7.5 for all values except for the socio-demographic characteristics also, the model showed statistical significance in the Jarque-Bera statistic which confirms the non-normality of the error in the model, both values are normal due to repetition of data as mentioned earlier.

Tables 14 & 15 are summaries of the above figures showing only the significant independent variables:

Table 14: Regression results for Model 1 & 2

Variable		Model 1		Model 2	
		Private Car		Public Transit	
		coefficient	t-stat	coefficient	t-stat
intercept		-3.6043	-7.357	6.2675	7.111
Near frequency	X1	0.0008	6.192	-0.0014	-6.205
Line Density	X2	0.0001	9.258	-0.0002	-9.124
Residential Area	X4	0.6956	2.887	-1.3149	-3.033
Residential Density	X5	-0.0001	-8.512	0.0002	8.566
Jobs accessibility	X6	-0.0038	-1.647	0.0069	1.665
Transit Frequency	X7	0.0019	18.440	-0.0035	-18.341
Euclidean Distance	X8	-0.0004	-6.951	0.0008	6.988
Commercial Area	X9	-0.8417	-3.298	1.4977	3.262
Industrial Area	X10	-7.4420	-29.419	13.4644	29.582
Services Area	X11	1.8314	6.826	-3.2922	-6.820
Graduated pop	X12	-1.7821	-238.971	0.0495	3.687
Apartments	X13	0.9434	293.710	-0.1352	-23.393
Age	X14	4.9487	287.682	0.2126	6.870
Ownership	X15	1.2123	445.611	-0.2148	-43.889
Full time job	X16	-1.1372	-174.160	0.2906	24.736
Monthly income	X17	-0.0035	-30.782	-0.0028	-13.541

Table 15: Regression results for Model 3, 4 & 5

Variable		Model 3		Model 4	
		Walking		Carpool	
		coefficient	t-stat	coefficient	t-stat
intercept		20.9671	35.980	18.5278	21.465
Near frequency	X1	0.0005	3.203	-0.0011	-4.955
Line Density	X2	-0.0003	-18.665	-0.0004	-16.513
Residential Area	X4	6.5456	22.848	2.5682	6.062
Residential Density	X5	-0.0001	-10.279	0.0001	4.586
Jobs accessibility	X6	-0.0083	-3.044		
Transit Frequency	X7	-0.0014	-11.993	-0.0043	-22.987
Euclidean Distance	X8	-0.0005	-7.025	0.0004	4.237
Commercial Area	X9	1.4859	4.944	2.3422	5.209
Industrial Area	X10	-9.3496	-31.236	7.8025	17.698
Services Area	X11			-3.1249	-6.653

Variable		Model 3		Model 4	
Graduated pop	X12	1.3889	156.842	0.2055	15.766
Apartments	X13	-0.4482	-117.517	-0.0309	-5.522
Age	X14	-2.7204	-132.943	-0.6750	-22.602
Ownership	X15	-0.5759	-178.031	-0.0100	-2.100
Full time job	X16	0.4452	57.334	0.0703	6.172
Monthly income	X17	-0.0036	-26.159	-0.0025	-12.531

The explanatory variables show different relationship with the dependent variables, the (+/-) sign of the coefficient reflect the direction of the relationship, as mentioned we are looking for the direction of the relationship more than the amount value of the coefficient which reflects the strength of the relationship. Therefore, tables 14 and 15 above were limited to both positive and negative signs in order to highlight the direction of the relationships between the dependent and independent variables as shown in Table 16.

Table 16: Regression results for all models

Variable		Model 1	Model 2	Model 3	Model 4
		Private Car	**Public Transit**	**Walking**	**Carpool**
Intercept		—	+	+	+
Near frequency	X1	+	—	+	—
Line Density	X2	+	—	—	—
4-way intersections	X3	insignificant	insignificant	insignificant	insignificant
Residential Area	X4	+	—	+	+
Residential Density	X5	—	+	—	+
Jobs accessibility	X6	—	+	—	insignificant
Transit Frequency	X7	+	—	—	—
Euclidean Distance	X8	—	+	—	+
Commercial Area	X9	—	+	+	+
Industrial Area	X10	—	+	—	+
Services Area	X11	+	—		—
Graduated pop	X12	—	+	+	+
Apartments	X13	+	—	—	—
Age	X14	+	+	—	—
Ownership	X15	+	—	—	—
Full-time job	X16	—	+	+	+
Monthly income	X17	—	—	—	—

Where;

— Sign indicates a negative relationship

+ Sign indicates a positive relationship

The above results answer the research question which confirms that the land-use factors and the socio-demographic characteristics affect the mode choice for work trips in Ramallah City. The results also support the assertion of the research's two hypotheses (1) the higher densities, land use mix, more roads connectivity, the shorter distance to transit, and the higher destination accessibility will give people the opportunity of choosing different modes of travel for work trips. (2) The 5Ds are positively associated with choices of non-motorized modes. The following Table 17 shows the results in terms of land use factors:

Table 17: Results of the effect of land use factors on mode choice for work trips

Land use factors/ Mode Choice	Private Car	Public Transit	Walking	Carpool
The higher the Density	—	+	—	+
The more Diversity (land use mix)	—	+	+	+
The more Roads Connectivity (Design)	—	insignificant	insignificant	insignificant
The higher the Destination Accessibility	—	+	—	insignificant
The shorter Distances to Transit	—	+	+	—

All land use factors decrease the percentage of using the private car as a mode of choice for work trips and increases the percentage of using the public transit as a mode of choice for work trips. The design factor was only significant for the effect of land use factors on choosing the private car as a mode of travel for work trips and in its refined regression model. Also, the job accessibility was insignificant for both the carpooling.

4.3. Results of Stage Three

This section answers research questions two and three: what is the potential of achieving planning for accessibility objectives in Ramallah City considering the integrated land-use transportation policies to provide better sustainable development outcomes? What gaps in knowledge and/or resources prevent PNA from attaining the desired outcomes?

"Ramallah City is a dynamic, vibrant, and optimistic city" as the previous Mayor of Ramallah Eng. Mousa Hadid said (Ramallah Municipality 2020). Ramallah City is a member of the global 100 Resilient Cities network. Its vision for a Resilient Ramallah in 2050 is *"We are optimistic, sustainable, inclusive, proud of our own culture and in control of our own destiny"*. Being a member of the network shifts all planning strategies for Ramallah towards tactics to cope, adapt and transform against chronic stresses and shocks (Ramallah Municipality 2020). Planning for accessibility is directly attributed to the vision of Ramallah. However, before getting into strategic land use transportation policies and planning, it is important to highlight some major planning challenges:

1. The rapid growth of the population in Ramallah City increases the burden on infrastructure and services provision; this is applicable in both the New City neighborhood (a new development area with low density, and relatively fewer job opportunities) and the Old City neighborhood (higher in density, higher land use mix, and relatively higher job opportunities).

2. A challenge in creating access to job opportunities due to the rapidly growing population.
3. Weak public transportation services, due to a lack of regional/local bodies that have the authority to make decisions, control, and manage the public transport system. In addition to the lack of land-use transportation strategy.
4. The geopolitical situation poses a major challenge to any development orientation of the people of Ramallah City.
5. Sufficient financial resources to implement related projects and programs.

Towards achieving land-use transportation policies, strategies, planning, and gaps in knowledge/ resources:

The inclusion of sustainable development goals:

A range of initiatives are in place to achieve more sustainable land use and transportation outcomes; the 2030 Agenda for Sustainable Development; Palestine vision 2025 – 2050; National Spatial Plan 2050; National Policy Agenda 2017 – 2022; Urban planning Manual; Spatial Development Strategic Framework; Public Transportation Master Plan, Ramallah Strategic plan, and Ramallah Resilience Strategy 2050. Those plans include a high level of economic, social, and environmental goals and practices. Therefore, for a good strategic land-use and transportation planning, it is recommended to recognize Ramallah City's distinctive qualities when taking into consideration sustainable dimensions to better specify the trade-offs among outcomes. This is can be done through the evaluation of tools, i.e. cost-benefit analysis.

The role of the Built environment and travel:

This research studies the connections between land-use factors and socio-demographic characteristics and their relation to travel mode choice at parcel-level analysis. The research results confirm that higher densities, higher land use mix, more roads connectivity, shorter distance to public transit, and higher access to destinations tend to reduce the dependency on private cars and promote non-motorized modes of travel to work trips. This research – due to the advancement in GIS – has the opportunity to easily perform the analysis to any city in the West Bank once adding the required data into the GIS. It is highly recommended to expand this research for further complementary analysis. Expanding the sample size, the inclusion of more land-use and socio-demographic indicators, measuring other dependent variables, include different kinds of trip purposes would lead to a higher interpretation of the nature of the relationships and their impact on travel behavior.

Land-use management strategies:

Based on the results of stages one and two and the assessment of the relevancy of the SDSF and the Public Transportation Master Plan to planning for accessibility objectives, Ramallah City is going towards a "Smart growth" land use management strategy. Smart growth strategy is also called New Urbanism and Location Efficient Development. This strategy promotes for (VTPI 2019):

1. Density: compact development (infill growth pattern development);
2. Diversity: mixed-use development;

3. Design: high connected roads, allowing direct travel by different modes and streets designed to accommodate different activities (traffic calming);
4. Transport: Travel demand management, Multi-modal transportation, and land-use patterns support non-motorized modes;
5. Destination Accessibility: high level of accessibility to services and jobs;
6. Parking management: Limited supply and efficient management;
7. Planning process: Planned and coordinated between jurisdictions and stakeholders;
8. Public space: Streetscapes, pedestrian environment, and public facilities.

"True Smart Growth requires that all policies to be implemented together to take advantage of their synergies" (VTPI 2019). The scale of this strategy is the local community or neighborhood levels. The Public Transportation master plan included four of the policies mentioned above which are the parking management, the pedestrian environment, public spaces, the planning process, and the multimodal transportation hub. Further analysis is needed to include all the eight policies mentioned above to achieve a Smart Growth land use management strategy.

5. Chapter 5: Conclusions and recommendations

This research used a unique analysis to examine the relationships between land use and work trips. It adds nuances to understanding the travel behavior of people when land use patterns changes. The research uses the analytical power of GIS, where, the analysis depends on dynamic zoning through using the parcel as the level of analysis to overcome the Modifiable Areal Unit Problem resulting in removing the boundaries between neighborhoods and analyze the study area in terms of parcels. The analysis performed is applicable to other cities, and can also be expanded to include additional localities, i.e. Al-Bireh, Betunia, Bethlehem, Nablus due to the automated tools in GIS. Also the analysis is performed using the Network distance, in which the actual distance travelled is measured. This research has a good database for future or further studies in the field of planning for accessibility and can be considered as a first step of Planning for Accessibility strategies in Ramallah City. The findings of this study are informative in examining the effect of land use on the mode chosen for work trips. The analysis showed the higher the density, the more land use mix, the more roads connectivity, the more destinations accessibility and the shorter distances to transit reduce car dependency and promote for more walking, cycling and using the public transit which is consistent with the literature on the effect of land use on travel behavior. The socio-demographic characteristics i.e. income, type of work, number of working days, living location, living situation all affect the mode chosen for work trips. Improvements in the building environment i.e. better transit system, better access to destinations, better pedestrian conditions will by default contribute in reducing the need for cars, and increase the desire of using other modes for work trips. Heading for “Smart Growth” strategy is in place, Ramallah City initiated steps toward Smart strategies, and this research can be considered as a first step in implementing planning for accessibility strategies. Followings are the major conclusions of the research:

First, the research investigated the effects of land-use factors and socio-demographic characteristics on the mode of travel chosen for work trips by residents in Ramallah City. Land-use factors were divided into density, diversity, design, destination accessibility, and distance to transit while the socio-demographic characteristics were divided into people living in apartments, people owning houses, people having a full-time job, the monthly income, the average age, and the level of education, the depended variables were divided according to the percentage of using a particular mode of choice for work trips, four types of modes were suggested using private cars, public transit, walking, and carpooling. All variables were analyzed using regression models. Prior to the analysis, a thorough analysis of the study area and the sample size were conducted to better identify the explanatory variables.

The following implications were derived based on the findings of this research. The effect of land use and socio-demographic factors showed differences based on the mode of travel chosen. All land use factors i.e. higher density, higher land use mix and higher destination accessibility showed decreasing in choosing private cars as a mode of travel for work trips. However, four of the land use factors – higher densities, higher land use mix, higher destination accessibility, and shorter distances to transit showed increasing in choosing public transit as a mode of choice for work trips. On the other hand the design was only significant in the first regression model for the private car. The design factor was expressed by two indicators the number of four-way intersections showed insignificancy in remaining models, and the road line density showed an intangible effect this is due to the type of the roads network in the study area, where the number of one-way roads is limited, and there are no real restrictions on the roads in all neighborhoods, additionally, in some roads the left and the right sides of the roads under different municipality control (in Al-Masyoun, Al-Ithaa, City Center, the Industrial area, the New City neighborhoods). The following points show the effect of land use factors on the travel mode chosen for work trips according to the regression models analysis:

1. Higher densities tend to decrease the use of private cars, and walking, while tend to increase the public transit and the carpooling as modes of choice for work trips
2. Higher land use mix tends to decrease the use of private cars and increases the use of public transit, walking, and carpooling as modes of choice for work trips.
3. The more roads connectivity the less people will use the private car as a mode of travel for their work trips

4. Shorter distances to transit tend to reduce the use of private cars and carpooling while tend to increase the use of public transit, and walking as modes of choice for work trips.
5. Higher job accessibility tends to increase the use of public transit and tend to decrease the use of private cars and walking as modes of choice for work trips.

It worth noting that the 5Ds and the mode of travel chosen are dynamic factors and are related to internal and external dynamic influences i.e. the country GDP; the available resources and capacities; changes in fuel prices; the global interest rate…etc. This dynamic situation needs ongoing research to expand the scope of the analysis by including more SMART indicators. In addition, a wider understanding can be developed by expanding the sample size of the research and including more socio-demographic characteristics and more trip purposes other than work trips only.

Second, the research assessed the related policy agenda to planning for accessibility objectives and based on the results of the effect of land use and socio-demographic factors on mode choice for work trips, the research found that the most suitable land-use management strategy is the "Smart Growth", this strategy promotes compact development, land use mix development, higher connectivity between roads, multi-modal transportation and patterns to encourage non-motorized modes, parking management, pedestrian environment, and green public spaces. On the road to a Smart Growth strategy it is recommended to take into account the link to the economic productivity of Ramallah city and its spatial arrangement; to invest more in *complete neighborhoods* where people can live, work, grow up, and prosper; to boost the government and local authorities in arrangements and funding the implementation plan of the land-use transportation strategy; to enhance communications and coordination between all local authorities since there is an overlap between the Siamese twin Ramallah and Al-Bireh in most urban settings.

<u>Recommendations and Future study</u>

1. Recognize Ramallah City's distinctive qualities when taking into consideration sustainable dimensions to better specify the trade-offs among outcomes.
2. Expand this research for further complementary analysis. Expanding the sample size, the inclusion of more land-use and socio-demographic indicators, measuring other dependent variables, include different kinds of trip purposes would lead to a higher interpretation of the nature of the relationships and their impact on travel behavior. The research could also be expanded to include Betunia and Al-Bireh cities.
3. Include sustainability dimensions indicators; i.e. productivity; unemployment, land prices, houses mix, and affordability, health, and safety, socially disadvantaged people; green gas emissions, natural resources, green cover; place-making; participation, and engagement (percent of local authority budget with decision making developed to local communities). SMART indicators may trigger planners and decision-makers to find more

sustainable solutions taking into consideration the community needs while limiting the negative impacts on the environment and leveraging the economic situation of the society.

4. Further analysis is needed to include all land-use management policies to achieve a Smart Growth land use management strategy.
5. Conduct sessions to change everyone's perspective and understanding of the concept of planning for accessibility.
6. Improve data availability for researchers and academic studies. It is highly recommended that data sources could establish a data bank that can be used for research and development.
7. Enhance the type of data to include more elaborated data at the individual level, i.e. vehicle kilometers travel, vehicle hours travel, chain trips for residents for work, and other trip purposes.
8. Encourage environmentally friendly practices and businesses, i.e. the new startup “Shankaboot” aims to bring the green delivery service to the Palestinian market by using electric bikes only. Planning for more accessibility and taking into consideration the walking and the cycling conditions in addition to the sustainability parameters will for sure lead to more practices such as Shankaboot and other businesses.
9. The political situation, the limitations on resources, and the A, B, and C divisions will always be a burden that prevents the expansion of the Palestinian cities and restricts planning in all development sectors. It is not an easy job for the Palestinian planners and decision-makers to have the

freedom of implementing new strategies and solutions. Finding innovative alternatives will improve Ramallah's resilience toward the Israeli restrictive measures on the ground.

10. This research has an opportunity to be part of the whole plan for achieving the vision of Ramallah City since the findings of this research comply with all national and local plans.

6. Bibliography

Abu-Eisheh, Sameer, Wilhelm Kuckshinrichs, and Abdelnaser Dwaikat. 2020. "Strategic Planning for Sustainable Transportation in Developing Countries: The Role of Vehicles." *Transportation Research Procedia* 48: 3019–36. https://doi.org/10.1016/j.trpro.2020.08.184.

Al-Houdalieh, Salah H., and Robert R. Sauders. 2009. "Building Destruction: The Consequences of Rising Urbanization on Cultural Heritage in the Ramallah Province." *International Journal of Cultural Property* 16 (1): 1–23. https://doi.org/10.1017/S0940739109090043.

Arabtech Jardaneh, and UN-HABITAT. 2020. "Spatial Development Strategic Framework: Ramallah and Al-Bireh Governorate (2030) | UN-Habitat." UN-HABITAT. March 2020. https://unhabitat.org/spatial-development-strategic-framework-ramallah-and-al-bireh-governorate-2030.

Arafat, Abdulnaser, Sivaramakrishnan Srinivasan, and Ruth Steiner. 2010. "The Impacts of Land Use and Urban Form on Travel Behavior. A Parcel-Level Destination-Choice Model for Shopping Travel in South-East Florida." *World Conference on Transport Research Society*.

B'Tselem. 2017. "The Separation Barrier | B'Tselem." The Israeli Information Center for Human Rights in the Occupied Territories. November 11, 2017. https://www.btselem.org/separation_barrier.

Badoe, Daniel A, and Eric J Miller. 2000. "Transportation–Land-Use Interaction: Empirical Findings in North America, and Their Implications for Modeling."

Transportation Research Part D: Transport and Environment 5 (4): 235–63. https://doi.org/10.1016/S1361-9209(99)00036-X.

Blanton, Whit. 2000. "Integrating Land Use & Transportation - PlannersWeb." Planners Web. October 15, 2000. https://plannersweb.com/2000/10/integrating-land-use-transportation/.

Boarnet, Marlon G. 2011. "A Broader Context for Land Use and Travel Behavior, and a Research Agenda." *Journal of the American Planning Association* 77 (3): 197–213. https://doi.org/10.1080/01944363.2011.593483.

Carlos Loures, Luis. 2019. "Introductory Chapter: Land-Use Planning and Land-Use Change as Catalysts of Sustainable Development." In *Land Use - Assessing the Past, Envisioning the Future*, edited by Luís Carlos Loures. IntechOpen. https://doi.org/10.5772/intechopen.84520.

Cervero, Robert, and Kara Kockelman. 1997. "Travel Demand and the 3Ds: Density, Diversity, and Design." *Transportation Research Part D: Transport and Environment* 2 (3): 199–219. https://doi.org/10.1016/S1361-9209(97)00009-6.

Cervero, Robert, and Carolyn Radisch. 1996. "Travel Choices in Pedestrian versus Automobile Oriented Neighborhoods." *Transport Policy* 3 (3): 127–41. https://doi.org/10.1016/0967-070X(96)00016-9.

Cervero, Robert. 2002. "Built Environments and Mode Choice: Toward a Normative Framework." *Transportation Research Part D: Transport and Environment* 7 (4): 265–84. https://doi.org/10.1016/S1361-9209(01)00024-4.

Chapman, Susan, and Doug Weir. 2008. "Accessibility Planning Methods." Research Report 363. NZ Transport Agency.

D. Frank, Lawrence, and Gary Pivo. 1994. “Impacts of Mixed Used and Density on Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, Walking.” *Transportation Research Record Journal of the Transportation Research Board*, January.

Ewing, Reid, and Robert Cervero. 2001. “Travel and the Built Environment: A Synthesis.” *Transportation Research Record: The Journal of the Transportation Research Board* 1780 (1): 87–114. https://doi.org/10.3141/1780-10.

Ewing, Reid, and Robert Cervero. 2010. “Travel and the Built Environment.” Journal of the American Planning Association 76 (3): 265–94. https://doi.org/10.1080/01944361003766766.

Fataei, Ebrahim, Mehdi Aalipour erdi, Habib Farhadi, and Ali Mohammadian. 2015. “Industrial State Site Selection Using MCDM Method and GIS in Germi, Ardabil, Iran.” *Journal of Industrial and Intelligent Information* 3 (4). https://doi.org/10.12720/jiii.3.4.324-329.

Fürst, Franz, Jad Isaac, Isam Ishaq, Jay Kaplan, and Michael Wegener. 2001. “Sustainable Transport Planning for Israel and Palestine.”

Ford, Alistair, Stuart Barr, Richard Dawson, and Philip James. “Transport Accessibility Analysis Using GIS: Assessing Sustainable Transport in London.” ISPRS International Journal of Geo-Information 4, no. 1 (January 20, 2015): 124–49. https://doi.org/10.3390/ijgi4010124.

Geurs, Karst T., and Bert van Wee. 2004. “Accessibility Evaluation of Land-Use and Transport Strategies: Review and Research Directions.” *Journal of Transport Geography* 12 (2): 127–40. https://doi.org/10.1016/j.jtrangeo.2003.10.005.

Guerra, Erick, and Meiqing Li. 2021. “Relationship between Urban Form and Mode Choice in US and Mexican Cities: A Comparative Analysis of Workers’ Commutes.” *Journal of Transport and Land Use* 14 (1): 441–62. https://doi.org/10.5198/jtlu.2021.1789.

Hajian, Mohammadhadi, and Somayeh Jangchi Kashani. 2021. “Evolution of the Concept of Sustainability. From Brundtland Report to Sustainable Development Goals.” In *Sustainable Resource Management,* 1–24. Elsevier. https://doi.org/10.1016/B978-0-12-824342-8.00018-3.

Halden, Derek, Peter Jones, and Sarah Wixey. 2005. “Accessibility Analysis Literature Review’, Measuring Accessibility as Experienced by Different Socially Disadvantage Groups, Working Paper 3.” *Transport Studies Group,* June.

Handy, Susan, and D Niemeier. 1997. “Measuring Accessibility: An Exploration of Issues and Alternatives.” *Environment and Planning A* 29 (7): 1175–94. https://doi.org/10.1068/a291175.

Handy, Susan. 2005. “Planning for Accessibility: In Theory and in Practice.” In *Access to Destinations,* edited by David M. Levinson and Kevin J. Krizek, 131–47. Emerald Group Publishing Limited. https://doi.org/10.1108/9780080460550-007.

Keller, J, R Arce-Ruiz, A Condeço-Melhorado, M Mavridou, and A D Hull. 2012. *(PDF) Accessibility in Planning Practice*.

Leck, Eran. 2011. “The Impact of Urban Form on Travel Behavior: A Meta-Analysis.” *Berkeley Planning Journal* 19 (1). https://doi.org/10.5070/BP319111488.

Levine, Jonathan, Joe Grengs, and Louis A. Merlin. 2019. *From Mobility to Accessibility: Transforming Urban Transportation and Land-Use Planning*. Cornell University Press. https://doi.org/10.7591/9781501716102.

Levinson, Herbert S, and F Houston Wynn. 1963. "EFFECTS OF DENSITY ON URBAN TRANSPORTATION REQUIREMENTS." *Highway Research Record*.

Litman, Todd. 2008. "Land Use Impacts on Transport How Land Use Factors Affect Travel Behavior." *Victoria Transport Policy Institute*, January.

Litman, Todd. 2021. "Land Use Impacts on Transport." Victoria Transport Policy Institue, July.

Miller, Eric. 2020. "Measuring Accessibility: Methods and Issues." *International Transport Forum*, November.

MoLG, Ministry of Local Government, and Municipal Development and Lending Fund MDLF. 2021. "Public Transportation Master Plan for the Urban Center of Ramallah and Al Bireh." Move Mobility. May 2021. https://movemobility.nl/public-transportation-master-plan-for-the-urban-center-of-ramallah-and-al-bireh/.

PCBS. 2021a. " الجهاز المركزي للاحصاء الفلسطيني | عدد السكان المقدر في منتصف العام لمحافظة رام الله والبيرة حسب التجمع 2017-2026." Palestinian Central Bureaux of Statistics. May 30, 2021. https://www.pcbs.gov.ps/statisticsIndicatorsTables.aspx?lang=ar&table_id=701.

PCBS, PCBS. 2021b. "الجهاز المركزي للاحصاء الفلسطيني | المؤشرات." Palestinian Central Bureau of Statistics. 2021. https://www.pcbs.gov.ps/site/lang__ar/881/default.aspx.

PNA, Palestinian National Authority. 2021. *Www.Palgov.Ps/Files/Server/the Mother English Version 10-4.Pdf*. http://www.palgov.ps/article/3939/%D8%A7%D9%84%D8%B3%D9%8A%D8%A7%D8%B3%D8%A7%D8%AA-%D8%A7%D9%84%D8%B9%D8%A7%D9%85%D8%A9-2021-2023.

Ramallah Municipality. 2018. "عن رام الله | بلدية رام الله." Ramallah Municipality. 2018. http://ramallahcity.ramallah.ps/ar_category.aspx?id=BsWK2ma1027893240aBsWK2m.

Ramallah Municipality, Ramallah Municipality. 2020. "رام الله المنيعة 2050_2020." Ramallah Municipality. 2020. https://www.ramallah.ps/ar_page.aspx?id=K26xZva2983745655aK26xZv.

Reilly, Michael K., and J Landis. 2003. "The Influence of Built-Form and Land Use on Mode Choice." *The Influence of Built-Form and Land Use on Mode Choice*.

Rikalovic, Aleksandar, Ilija Cosic, and Djordje Lazarevic. 2014. "GIS-Based Multi-Criteria Analysis for Industrial Site Selection." Procedia Engineering 69: 1054–63. https://doi.org/10.1016/j.proeng.2014.03.090.

Salah, AlAwdeh, and AlSayed Ahmad Rizeq. 2008. "البنية التحتية للاقتصاد الفلسطيني." Chamber of Commerce and Industry.

Stanley, John, Janet Stanley, and Roslynne Hansen. 2017. *How Great Cities Happen: Integrating People, Land Use and Transport (Cities Series)*. Edward Elgar Publishing Limited.

Susan, Handy. 2018. "Enough with the 'D's' Already – Let's Get Back to 'A.'" LJournal. https://doi.org/10.18411/a-2017-023.

VTPI, Victoria Transport Policy Institue. 2019. "Online TDM Encyclopedia - Clustered Land Use." Transportation Demand Management Encyclopedia. September 6, 2019. https://www.vtpi.org/tdm/tdm81.htm?fbclid=IwAR28UcE62gAFGPRS9RuLBj6ivqwT43MqeVR78qPe3uZWHY0HA3i3QN-8cNo.