QATAR UNIVERSITY

COLLEGE OF ENGINEERING

IMPACT ASSESSMENT OF LAND USE PLANNING ON TRAVEL BEHAVIOUR IN DOHA, QATAR

BY

SAMAR ZAINA

A Thesis Submitted to the Faculty of the

College of Engineering

in Partial Fulfillment

of the Requirements for the Degree of

Masters of Science in Urban Planning and Design

January 2017

COMMITTEE PAGE

The members of the Committee approve the Thesis of Samar Zaina defended on 27/12/2016.

Dr. Fodil Fadli
Thesis/ Dissertation Supervisor

Prof. Yacine Rezgui
Committee Member

Prof.Vian Ahmed
Committee Member

Dr. Shaibu Bala Garba
Committee Member

Dr. Djamel Ouahrani
Committee Member

Approved:

Khalifa Al-Khalifa, Dean, College of Engineering

ABSTRACT

ZAINA, SAMAR, M., Masters : Jan: 2017,

Masters of Science in Urban Planning and Design

Title: Impact Assessment of Land Use Planning on Travel Behavior in Doha, Qatar

Supervisor ofThesis: Dr. Fadli, Fodil.

In the last decade Qatar has witnessed a rapid growth in its economic and industrial sector as a result of oil and gas economies. This transformed small port cities to large sprawling metropolitan and increased the population. Infrastructure and transportation projects began to develop and the city began to witness down falls in its urban fabric. This is due to the lack of implementation of master plans, poor land use planning and lack of systematic processes, as a consequence to the fast economic and industrial growth. Urban communities in Qatar depend highly on motorized movement and private transport. Therefore, cities like Doha became uninviting and poorly designed.

Land use planning and travel behavior are closely associated and influence one another. Land use planning impacts the transportation network, generates travel distance and time, and influence people's behavior. Hence, direct implications of land use planning decisions are imposed and reflected on travel behavior. Land use planning decisions increase sprawl into dispersed, automobile dependent development. While other land use planning decisions are useful for supporting the ability of smart growth.

The thesis aims to examine and investigate the influence of land use factors on travel behavior within old and new urban contexts. In doing so, it introduces the way Qatar spatially organized its city over the years and examines the land use impact on travel behavior. The factors investigated in this thesis include density, regional accessibility, land use mix and roadway connectivity. Using the Qatar Strategic Transport Model data, we observe the relationship between land use attributes and travel behavior. The social economic characteristic and the residential self-selection are considered for home-based work and non-work trips.

As an overall, Fereej Abdul Aziz generates a higher density, mixed use and complete planning than Al Messila, and has the potential to achieve a high regenerative symbiotic district. On the other hand, Al Messila has potential to reduce green house gas emission and reduce resource use to assist in decreasing the environmental footprint of the city and urban sprawl.

The results indicate the following; density is considered to be the most influential factor of built environment, residential characteristics effect traveler's decisions, socioeconomic elements are in agreement with the cultural prospect, and the more distant the work place is, the greater the travel distance and travel trips.

The study focuses on developing land use policies and recommendations through the assessment of Doha's current land use conditions and their impact on travel behavior. They look at three dimensions of the urban form including density, diversity and design. The guidelines include; consolidation of urban context via increased density and mixed use planning to enforce stronger design control and increase the security, vitality, and transit system use. It is essential to establish policies that balance household from settling in high density areas, foster location of major traffic, limit new developments and balance jobs and housing. Finally guidelines need to be in place to encourage the use of public transport and cater for pedestrian friendly neighborhoods.

Key Words: Land use, travel behavior, sustainable development.

DEDICATION

Every challenging work needs self effort and guidance from those close to our heart. I would like to dedicate my humble efforts to my loving mother, father, siblings and supportive partner, whose affection, love, encouragement and pray enabled me to gain such success and honor.

ACKNOWLEDGMENTS

I would like to acknowledge the support of Qatar University for creating an environment that encourages scientific research. This research study was developed for the Masters of Science in Urban Planning and Design Program (MUPD) at Qatar University. I would like to express my gratitude to my supervisor Dr. Fodil Fadli and fellow work colleagues at AECOM Middle East for their continuous support. Credit also goes to leading planners and architects from Qatar's Government Agencies and Ministries, namely to the Ministry of Municipality and Urban Planning (MMUP), Ministry of Transportation and Communications (MoTC), Qatar National Council for Culture, Arts and Heritage, Qatar Rail and Ashghal-Public Works Authority for their collaboration, for participating in the meetings, handling relevant visual data and cardinal documents to the research aims. I would like to thank the reviewers for their comments, which contributed to an improvement of this thesis. Finally, I would like to thank my family and partner for their continuous support throughout the course of my research. The author is solely responsible for the statements made herein.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: SCOPE OF STUDY

Chapter 1, Scope of Study defines the thesis topic of land use planning, travel behavior and their relationship from different perspectives as the introduction section of the thesis. This chapter also covers the problem statement, research questions, main aim and objectives and the overall structure of the thesis.

1.1 Introduction

The relationship between land use and transportation are closely connected. Every land use decision has direct implication on transportation. The distribution of land use influences the plan of the transportation network and generates travel. Hence, this affects and impacts the overall travel behavior (Hanson, 1999). The generated travel increases the demand for new amenities, which promotes developments and increases accessibility. The combined land use and transport policies improve accessibility and the ability for people to transport. It contributes towards activities, and the transit of goods and services. There are many forces that have influence the urban form and context. One of these influential elements includes planners and decision makers. They have the ability and authority to control and monitor the planning of land developments, regulations, management programs and other systems (Hanson, 1999). The implementation of land use policies is critical at a neighborhood level to help and guide in reducing driving (Aditjandra, 2012). It is found in North East of England, UK, that land use organization influences travel behavior after controlling self-selection. Areas with accessible public transport encourage residents to derive away from driving and use sustainable means of

transport. An environment with social vitality and vibrant community reduce the car travel distance (Hanly, 2013).

Self-selection is found to be an influential indicator in controlling the relationship between land use and travel behavior (Tiwari, 2016). The current literature put forward states that assessing the neighborhood characteristics of travel behavior is another approach to explore the different approaches provoked in self-selection (Aditjandra, 2012). It is crucial to indicate that self-selection has an important role and degree of influence towards impacting travel behavior of people (Esmaeili, 2011). For instance households in favor of sustainable modes of transport are likely to reduce driving and transit through sustainable means.

However, this thesis is concerned with the land use planning as the mean of influencing travel behaviors within neighborhoods and urban development's. It focuses on an enduring question within the land use impact on transportation which is as follow: to what level and extend does the urban form influence dependency on vehicular travel and travel behaviors.

A few studies (Brownstone, 2013; Cervero, 2010) have learned about the correlation between the urban form and travel behavior. In many growing and developed countries, sprawl has been mainly a consequence of automobile dependence (Cao, 2014). Policymakers and decision makers have implemented various concepts including Transit Oriented Development (TOD) and smart growth to respond and mitigate sprawl. Previous studies illustrate that land use and transportation policies in force to control sprawl. This

is via the introduction of alternative means of transport to assist in reducing automobile dependence (Litman, 2016).

This thesis aims to deliver policies in Doha, Qatar. It aspires to enhance and improve land use planning. Such implementation of land use policies will ease roads and impact on travel behavior; creating more sustainable inviting urban centers that encourage and promote a healthier means of living. Figure 1 below illustrates the structure of the thesis in order to reach achieve aim and objectives of the thesis.

1.2 Problem Statement

Over the years Qatar's land use planning has developed communities and spaces around car and contributed to unpredictable travel behaviors. This phenomenon has put strain on the roads infrastructure, increased traffic, impacted accessibility and influenced people's travel behavior. Land use patterns have different accessibility features and impacts on roads. These factors are also recognized to add load towards transportation. The impacts include the movement of jobs in and to suburbs, same use commercial in one area, labor shortages by jobs and or housing mismatches, and finally the infrastructure and housing planning. To address these issues of land use and transportation, a set of measures are needed in to be put in place (Hanson, 1999).

Qatar's land use planning results to detached destinations and long travel distant destination (shops, school etc.), impacting patterns of trips, choice of route, and time(Furlan ; Faggion, 2015).

Travel behavior is concerned with the study of how people use transport and space. The criteria for travel behavior are wide and are related to time use and activity observation. It looks at the trips people make, household location and destination, mode of transport, accompany, time of the trip and travel, time loss due to congestion, pattern of trips, choice of route, and the reason behind travel (Wee, 2016). The collection of such data allows tracking people and estimate transport trips to insert into a strategic model. The model assists transport analysts make predictions and forecast traffic on future road networks, land use patterns and policies. However, some argue that these factors ignore other useful categories of indicators including a transportation segment, land use segment, a temporal segment, and individual segment. Focusing on passenger transport, the study uses the definition of travel behavior provided by Geurs and van Wee (Wee, 2004a): "the extent to which land use and transport systems enable (groups of) individuals to reach activities or destinations by means of a (combination of) transport mode(s)."

It has been clear that researchers view travel behavior by utilizing specific measures. Travel researches examine travel behavior by focusing on where people travel, how people travel and how far people travel (Joy, 2003). This allows interpreting the dynamics of reporting travel behavior and patterns.

Thereby the expansions of land use planning introduce facilities that experience longer driving times.This raises the concern about the role land use planning plays in exacerbating or combating the problems of congestion, jobs/housing destinations (household location and destination), time of the trip and mode of travel. The efforts to

respond to the planning decisions are through the introduction of planning policies which contribute to respond to this phenomenon.

The main research question put forth for this study is; what is the land use impact on travel behavior in relation to activity analysis and time use to work and non- work trips. This is studied to deliver innovative policies and methods that aim to enhance land use planning. This is followed with three consecutive questions that help support achieve the main research question including how has land use impacted travel behavior, what differences are evident in close compact urban fabric development and non-compact urban developments in respect to travel behavior to work and non-work trips, and what land use and transportation measures are needed to address the combating problems of congestion, household location and destination, and time of trip. Those questions are in support of responding to the aim and objective of this research amplified in the section below.

1.3 Main Aim and Objective

This thesis aims to provide recommendation of innovative policies and methods to enhance and improve land use planning for Doha Qatar via the enhanced smart growth and sustainable solutions to promote transportation and travel behavior for work and non-work trips. It looks at creating planning objectives and recommendations for land use planning to achieve self-contained urban centers that improve travel behavior. This will be achieved by utilizing the VISUM software to access Qatar's Strategic Transportation Model which has an embedded platform of traffic data. The data includes the number of

trips, travel patterns and movements. The data will be evaluated based on a number of objectives and in response to generating mitigation strategies that enhance sustainable environments and creates smart cities.

The three supporting objective include evaluating and studying the way Qatar spatially organized its city and evaluating the impact of land use planning on travel behavior for work and non-work trips. The thesis will also explore efficient land use patterns that enhance commuting and create sustainable means of travel behavior through transportation systems, modes and networks. This will be tackled via analyzing two varied study areas with different urban characteristic. The analysis will assist in synthesizing and making a judgment towards informed planning policies and guidelines. The thesis attempts to respond to the objective and questions in the chapters to follow.

1.4 Thesis Structure

Thesis is organized into nine chapters and is as follow:

Chapter 1 Scope of Study defines the thesis topic of land use planning, travel behavior and their relationship. It covers the structure of the thesis, its problem statement, research questions and main aim and objectives.

Chapter 2 Theoretical Background and Context investigates the Land Use Impact on Travel Behavior to deliver policies and guidelines that improve urban planning. The theoretical background of the research initiates with providing context to Land Use, Land Use factors and Travel Behavior. Then the Background section studies literatures and

their correlation regarding the influence and impact of the urban form on travel behavior. Upon setting a high level of literature review for the topic undertaken, management strategies for sustainable developments and smart growth urban planning is covered. The management strategy is covered to assist in delivering innovative policies and methods to enhance land use planning in Doha, Qatar.

Chapter 3 Historical Background of Qatar realizes the land use impact on travel behavior through the urban form evolution of Qatar and its road network. It covers the three urban phases of Qatar including pre-oil settlements, urbanization and oil boom and megaprojects.

Chapter 4 covers the research methodology of the dissertation. It initiates with the study area and justification. Followed by the conceptual framework of study and concludes with the data collection method of the study covering the literature review, build environment factors, primary data, secondary data and adapted QSTM, and data analysis process and tools.

Chapter 5 covers the Data collected as per the research methodology outlined in the previous chapter. It covers the study area content, land use factors, and travel behavior within the scope of study.

Chapter 6 presents major findings of research interpretation and discussion in response to the land use planning impact on travel behavior. It illustrates how land use factors have direct correlation and implication to one another. This chapter is also focused on the relationship between built environment and travel behavior including vehicle ownership, mode of transport and home based trips, particularly between work

and non-work trips. Among this other finding have been made on home based trips, self-selection, travel behavior & impact from land use and finally planning issues.

Chapter 7 of the research includes three sections including limitation and future research opportunities, policies and guidelines, and conclusion. Section one covers the limitations and future research opportunities underpinned for this thesis. Section one contains the various limitation and restraint obstructed throughout the course of preparing the research. It also covers future research opportunities underpinned for this thesis.

It has become evident throughout the course of research that land use planning carries great impact on travel behavior. Many forces come in perspective when influencing the urban fabric and form of a city. For that reason it is critical to control and put constraints on the way our cities grow and mature. Therefore, a number of policies and guidelines are then proposed in section two, as an instrument to shed light to the main research question, aim and supporting objectives. Finally the last section is the conclusion, which draws a conclusion to the thesis representing the contribution towards knowledge. Figure 1 illustrates the thesis structure of all thesis chapters and their relevant content.

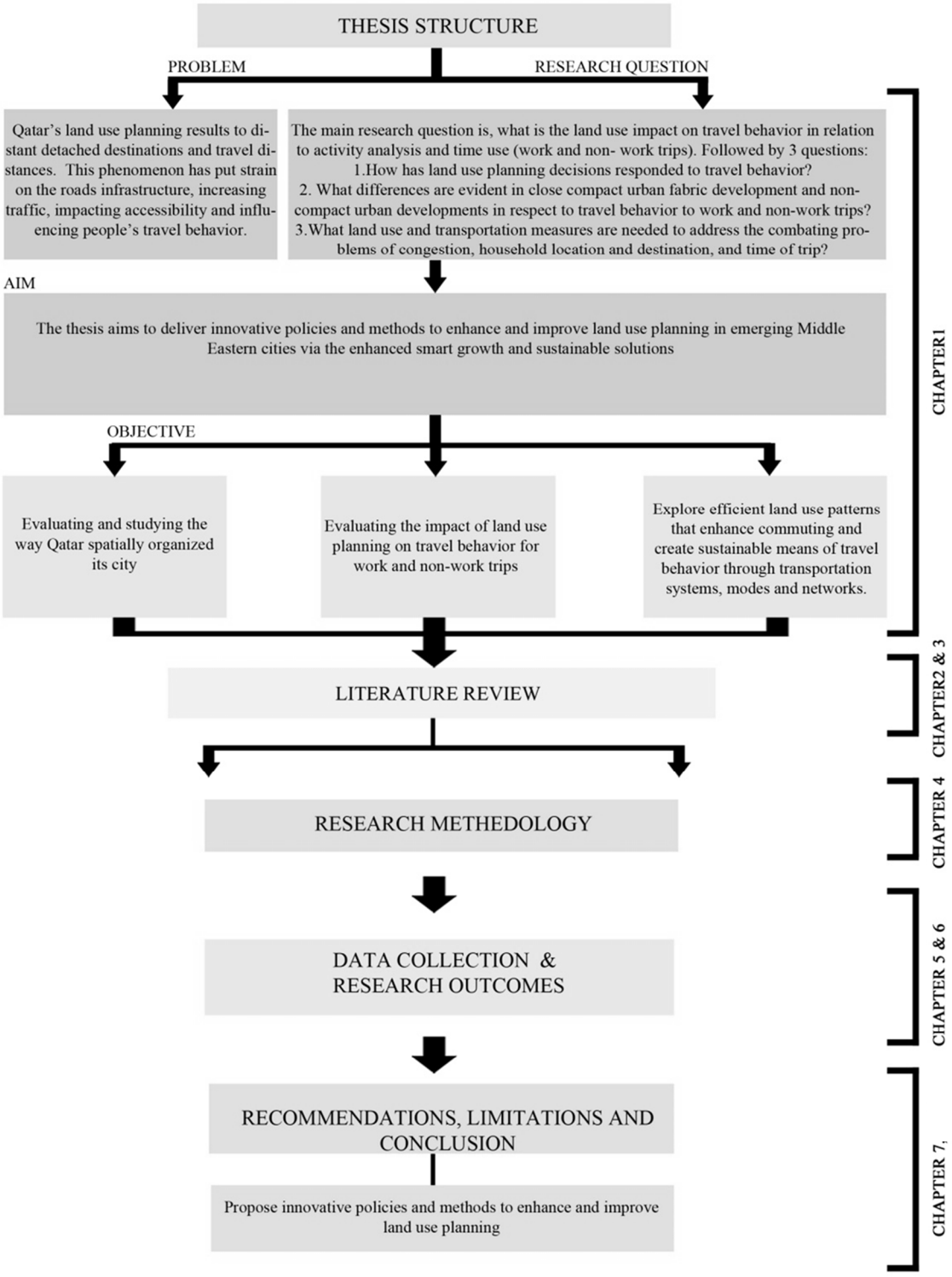

Figure 1. Structure of Thesis (source: developed by author)

CHAPTER 2: THEORETICAL BACKGROUND AND CONTEXT

The research study investigates the Land Use Impact on Travel Behavior to deliver policies and guidelines that improve urban planning. As such theoretical background of the research initiates with providing context to Land Use, Land Use factors and Travel Behavior. Then the Background section studies literatures and their correlation regarding the influence and impact of the urban form on travel behavior. Upon setting a high level of literature review for the topic undertaken, management strategies for sustainable developments and smart growth urban planning is covered. The management strategy is covered to assist in delivering innovative policies and methods to enhance land use planning in Doha, Qatar.

2.1 Land Use

Land use planning and travel behavior correlate. Land use circumstances effects transport modes and activity. It is critical to understand the factors of planning and their impact on transport activity, this relationship influences and guides decisions to achieve strategic goals.

Land use patterns are defined as people's use on earth's surface. This includes the location of the development, type of development, and the design of infrastructure such as road network and buildings (Litman, 2016). The land use development patterns reflect the urban form and correspond directly to diverse economic, social and environmental results.

Some of the built environment requires less impervious surfaces including buildings and pavement per capita and thereby domain more open space of gardens, natural habitat or farmland, while other are accessible and reduce the dependency on transportation for the business and consumer.

The land use patterns also influence accessibility, the capacity to reach preferred destinations and services, which affect mobility, the type of travel activity and duration of travel (Litman, 2003). The level of urban access and mobility is different based on different urban form environments. In urban areas accessibility is higher with more diverse transport system, but slower and higher mobility cost. Whereas, in rural areas land use accessibility is lower and transportation options are less. However, the speed of automobile is faster and more economical per mile (State, 2007). It is significant to control the land use planning through enabling legislative authorities; which may be addressed through growth policy, sub-division laws and permitting regulations.

2.2 Land Use Factors

The land use planned for the different purposes change based on multiple factors. These factors influence land use in its physical, economic and social elements. The Land use patterns refer to various factors that contribute to travel behavior including density, regional accessibility, land use mix and connectivity (Cao, 2014). The Land Use factors affect travel behavior which is dependent on vehicle ownership, travel (vehicle miles of travel and vehicle trips), transportation mode, and active transport (walking and cycling).

2.2.1 Density

Density is a factor recognized by many as the dominating attribute to travel impacts and is related with additional factors (land use mix, accessibility, transport diversity) often named compact development as it includes other associated attributes. The understanding of density is defined as the number of people, jobs, or homes per unit of land area (acre, hectare, square mile or kilometers) (MacLean, 2004). It can affect travel behavior through increased proximity of reduced travel distance to destinations and reduced automobile travel, provide mobility options of increased cost efficiency through the provision of walkways, paths and public transit options, reduced automobile travel speeds and conveniences by increased traffic friction, congestion and parking costs. The increase of density is associated with reducing vehicle ownership and travel, better transport options, reduced parking supply and increased parking prices.

Research signifies that when density increase per capita automobile travel declines, and other transportation modes increase (Handy, 2010); (Cervero, 2010); (JICA, 2011). That is twice the increase of urban density per capita reduces the vehicle travel by almost 25-30% (Cervero, 2010).

Density contributes to travel activity through increased proximity (geographically), mobility options, reduced automobile travel speeds and convenience. It also impacts historical conditions, self-selection and complementary factors. While increased proximity is achieved as travel distances to destinations are reduced; this results to an achievable walking and cycling distances. Increased density increase the cost efficiency to provide sidewalk, public transportation, and transport options as per capita

costs decline with increased density. Many of the denser neighborhoods built before 1950s were built around multi model transportation, whereas newer neighborhoods are designed for one mode of automobile access.

It is evident that density is also positively linked to many other urban land use factors such as regional accessibility, land use mix, connectivity, improved transport options, and reduced parking supply.

There is synthesis amond (Kolko, 2011), (Hamida, 2014), (Liu, 2007) that density is measured as the number of workers, people or housing unit per unit of area in kilometer, square mile, hectare or acre. This method usually includes large areas of undeveloped and vacant land; thereby many use weighted density which weights these densities by each block's share of that factor. Meaning that census data for population, census data for employment and land area are required to carry out a weighted density. This represents weighted density of the occupied areas. Another approach is using the net density which marks out undeveloped land. To achieve this, detailed land use information is necessary to identify developed land.

Density analysis has a few limitations regarding the data collection; most density analysis is measured for large geographic areas which may deceive in the important differences in the neighborhood density (Eidlen, 2010). For instance, a city may be relatively dense but lack employment concentrated centers and the type of transit services to support the neighborhood, leading to high levels of per capita vehicle travel.

2.2.2 Land Use Mix

Land use mix refers to the allocation of complementary land uses located closer together in a balanced mix. These land uses include residential, commercial, recreational and institutional. This makes forms of transport within an accessible, viable walking and cycling distance. It can also improve the perceived security of and area and the economic development of an area. Mixed land use can contain a mix of residential types. These types of mixes prices housing for diverse income groups. Land use mix is critical to achieve smart growth and New Urbanism (Wee, 2016). It reduces commute distance and allows for walking and cycling in areas that provide affordable housing (Modarres, 1993; Pratt, 2003; Ewing, 2010). Generally, they are located within close proximity to job-rich areas and greater alternatives of transport modes.

Multiples methods are in place to measure land use mix including entropy indices, dissimilarity indices, job/housing ratio. Both the entropy indices and dissimilarity indices are measured with a score from 0 (least mixed) to 1.0 (most mixed) (Brownstone, 2013). The entropy indices looks at the variety of land use in an area and the dissimilarity indices looks at the number of neighboring parcels with different land use (Weitz, 2003). The job/housing ratio should measure at a balance of 1.0 to minimize average vehicle travel (Guerra, 2011). Wang, Khattak and (Zhang, 2013) found that mixed land use neighborhoods with central services, activities and a good network connections have a lower emission by 9% than other neighborhoods.

Table 1 summarizes the finding of study created to how numerous land use elements influence automobile commute rates. Another study by (Davidson, 1994) found that amenities for banking service, gym, post, childcare and cafeteria could potentially decrease average weekday automobile commuting by 14% due to reduced trips and improved ridership (Crane, 2000).

Table 1. Bus Worksite Drive Alone Share (source: R. Crane, 2000)

Land Use Characteristics	Without	With	Difference
Mix and Land Uses	71.7	70.8	-0.9
Accessibility to Services	72.1	70.5	-1.6
Preponderance of Convenient Services	72.4	69.6	-2.8
Perception of Safety	73.2	70.6	-2.6
Aesthetic Urban Setting	72.3	66.6	-5.7

2.2.3 Centricity

Centricity refers to the area that employs entertainment, commercial, employment, and supplementary zones in a multi-modal center. These centers reduce the amount of vehicle travel, and provide alternative means of transport apart from automobiles, as illustrated in Figure 2.

The dissertations explored exemplify the different point of views at which the land use factor of centricity influence private automobile, public transport use, automobile share and travel behavior.

(Kuzmyak, 2012) found that street network connectivity and grain, employment density, transportation facility quality, job/population balance, and regional accessibility have a great effect on vehicle travel and trip. The study found that workplace density that

reaches 50-75 employees per gross acre reduces automobile use. (Davis, 2001) and (Chen, 2002) established that centricity affects trips made at a local and regional level and encourages ridesharing.

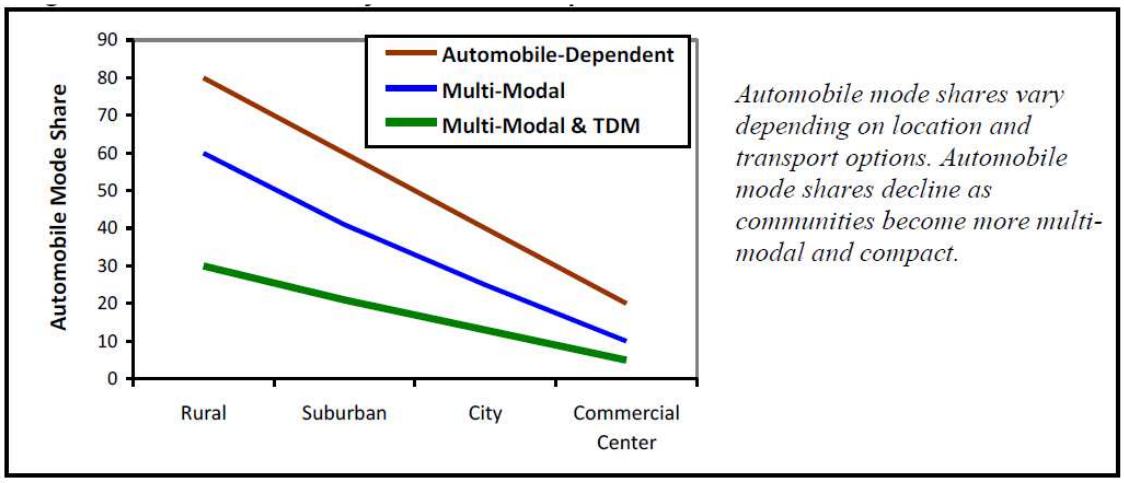

Figure 2.Economically Automobile Optiomal Mode Shares (source: Litman, 2016)

The study conducted by (Kahn, 2012) found that centers with vibrant towns dependent less on private vehicles and rely more on public transit services and walking. This results to a reduction of fuel consumption, vehicle emission in comparison to urban regions with less vibrant towns. The study also suggests that urban centers with more vibrant towns experience less sprawl; suggesting that vibrant centers influence land use patterns, and as a result patterns of land use affect people's driving and public transportation.

2.2.4 Regional Accessibility

Regional accessibility can generally be defined as the level to which a good or service is available to as many people within a region as possible (Pratt, 2003); (Ewing, 1995). A method of assessing accessibility is to determine where the centre of the region is in relation to the distribution of regional population.

It is found that regional accessibility has the slightest influence on the trip generation but major implications on the mode of choice, trip length and per capita vehicle travel (SACOG, 2008). (Cervero, 2010) found that per capita vehicle travel has the greatest impact from regional accessibility, the elasticity of vehicle travel in response to downtown distance is -0.22 and in response to vehicle job accessibility -0.20. This indicates that a decrease of 10% measured distance to downtown decreases vehicles travel by 2.2% and an increase of 10% neighboring jobs decreases vehicle travel by 2%.

(Kockelman, 1997) established that scattering employment to suburb can reduce travel length but increases non-commute vehicle travel. A 5% growth in regional employment reduces the average commute distance by 1.5% but increases total per capita vehicle travel (Chatman, 2003).

Another critical element that supports connectivity is pedestrian accessibility and its associated safety measures. Pedestrian spaces play a major role in the urban fabric from a physical and social point of view. Scholar and planners question the use and safety of pedestrian accessibility, and the level of support it provides the urban context.

The distribution and allocation of pedestrian walkways must meet the needs of everyday use and shall be considered within the planning and design regime. The sidewalks shall allow for circulation space away from automobiles and other forms of transportation. In the dissertation (Deacon, 2013; Environment, 2017) it suggest that sidewalks provide a platform for social interaction, circulation, political activities and expression. Sidewalks are an important typology of the overall public space usually undervalued. They are used daily for different purposes, intentions and or destinations. Therefore, it is important to design and plan sidewalks and address how they are to be used.

2.2.5 Connectivity

Connectivity is defined as the level at which a road system is linked, and the direct connection level of travel connecting journeys (VTPI, 2008). A road network with many dead end streets reduces the accessibility within a neighborhood. While a network with increased connectivity, accessibility and reduces the travel distance of automobile and other forms of transportation.

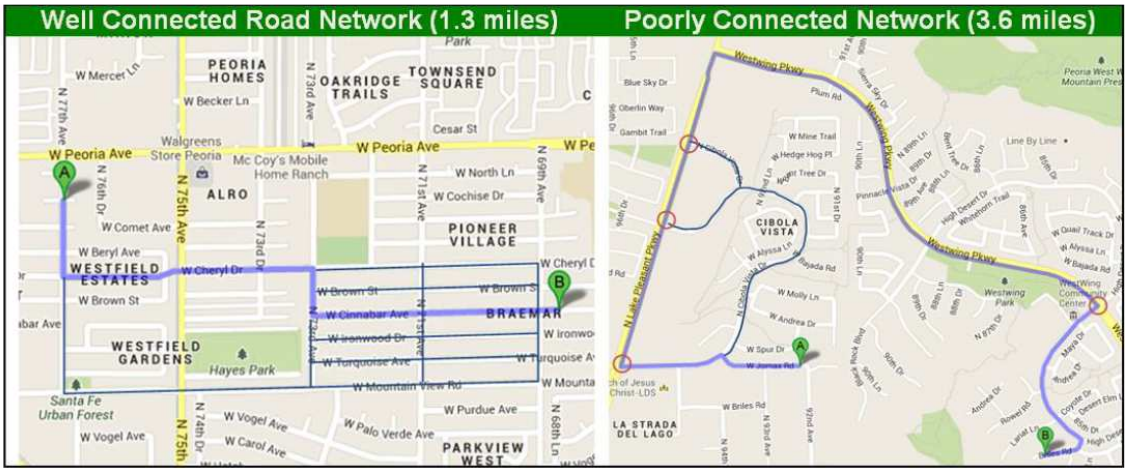

Figure 3. Roadway Connectivity Impacts on Accessibility and Saferty (source: Frank, 2008)

Various indicators may be utilized to measure the level of connectivity for different modes of transport comprising; road density, junction density, an area of dead end street, and an area of four way intersections (Butler, 2004); (Dill, 2005). Both street connectivity and intersection density are classified as the second highest impact on travel activity; having a vehicle travel elasticity of -0.12 with respect to connectivity. So an increase of 10% in street density reduces vehicle travel by 1.2%. Therefore the study concluded that increased street connectivity reduces the vehicle travel and increased public transport and walking. So with a 10 % growth in street intersection density reduces travel of vehicle by 0.5%. The project Atlanta, Georgia SMARTRAQ also found that multiplying regional average intersection density by two, directly impacts reductions in the average per capita weekday vehicle travel by 1.6% (Frank, 2008).

Mixed land use with good network connectivity has also other advantages. (Zhang, 2013) found that emissions and vehicle travel reduce by 9%, and (Larco, 2010) found that alternative modes are increased. Residents were twice as likely to travel to

local amenities by walking or biking, and safety has improved (Hawkins, 2007). This is considered as the greatest barrier to walking or biking. Another element that improved pedestrian walking or cycling is relative to the alteration from a small block grid to a modified grid; a grid that allowed cycling and pedestrian circulation and blocked automobile traffic at major intersections. This increased connectivity for pedestrians by 10%, improved physical activity by 26%, and decreased vehicle travel by 23%.

2.3 Travel Behavior

Travel behavior is concerned with the study of how individuals use space and transportation. The criteria for travel behavior are large and have direct correlation to time use and activity analysis. It looks at the trips people make, the household location and destination, the mode of transport, the accompany, the time of the trip and travel, the time lost due to congestion, the pattern of trips, the choice of route, and the reason behind travel (Wee, 2016). The collection of such data allows tracking people and inserting the transportation planning data into a model to assist transport analysts make predictions and forecast traffic on future road networks, land use patterns and policies. However, Geurs and Wee (Wee, 2004) argue that these factors ignore other useful categories of indicators including land use element, a transportation element, a temporal element, and individual element. Focusing on passenger transport, the study uses the definition of travel behavior provided by (Wee, 2004): "the extent to which land use and transport systems enable (groups of) individuals to reach activities or destinations by means of a (combination of) transport mode(s)."

It has been clear that researchers view travel behavior by utilizing specific measures. Travel researches examine travel behavior by focusing on where people travel, how people travel and how far people travel (Sharp, 2003). This allows interpretation of the dynamics of reporting travel behavior and patterns.

2.4 Influence of Urban Form on Travel Behavior

In this section, a variety of case studies from around the world are undertaken as a mean to illustrate and assess the extent of influence urban form has on travel behavior.

(Aditjandra, 2012) studies show that different neighborhood characteristics including safety factors, accessibility and social factors have important influences on car ownership, driving behavior and travel behavior. These studies suggest that neighborhood planning is critical to control travel behavior among different geographical dimensions despite the different planning contexts. However, some factors may have different determining factors for travel behavior like in the case between the US and Britain. Where in the US residents are concerned with yard size and off-street parking and Britain's are concerned with facility accessibility and safety perspective of the neighborhood.

In Europe (Narayan, 2003) studied that stronger design controls and urban planning led to compact, dense urban form and high dependency on public transport. While a dissertation by (Perkins, 2002) studied the implication of location on travel behavior for 408 households in Townsville and Cairns and found that fuel consumption and distance travelled are the two main concerns. Fuel consumption was found to be

three times more for urban dwellers than central city dwellers which formed a challenge on policy makers, city planners and developers. In the US and Britain the travel behavior from land use patters reinforced vehicle dependency particularly in cities and sprawling suburbs. These cases have been studied as they demonstrate and withstand similar characters and context as that of Qatar. Qatar's planning is highly dependent on vehicles and existing concerns appear around fuel consumption and long travel distances.

In Adelaide, (Primerano, 2005) studied 9000 households to determine urban form influence on travel behavior. It has been concluded that urban environments with high quality urban design and dense mixed land use would decrease the number of car use and increase context with environmentally sustainable transport modes. However, the authors determined that the results are based on a limited selection of suburbs of uniform size and density thereby may be misleading to infer to the results for the wider country context.

Agreement between (Narayan, 2003) and (Primerano, 2005) found that proximity to service centers and local shopping within local network encouraged sustainable choice of travel modes. And large area zoning of suburban development distant from centre's encouraged private vehicle transportation and decreased choice of travel modes. In another study carried in Maryland by (Duncan, 2002), the dissertation looked at the impact of new urban areas on travel, particularly how compact mixed use developments could significantly influence travel modes. The study looked at three dimensions of the urban form including density, diversity and design. It found that density and mixed land use influence public transport use, car-pooling or solo-commuting. An increase in density resulted to lower dependency on solo-commuting and an increased use of public

transport. The author amplifies that the element of side walk plays a significant role in encouraging traveler to use the bus, or engage in car-pooling.

(Crane, 2001) studies to determine the travel behavior from land use patterns of Orange Country and San Diego. The study found that land use design affects the price of travel and trip taken. However, it is worth noting that during the non-work car trips the land use variables had little impact on the travel behavior.

In the case of German governance, the response to increased congestion, pollution and other concerns as a consequence of automobile use has introduced other modes of travel via land use planning. In the year 1993, the German guidelines passed down the theory of 'decentralized concentration' which influenced the adoption of compact developments of spatial planning including residential, commercial and recreational to reduce dependency on vehicles (Brownstone, 2013; Hedel, 2007).

The question remains whether land use planning has a significant impact on mobility behavior? Based on the 'new urbanism' school advocates, land use planning of high density, mixed land use and choices of public transportation enhance compact neighborhoods and thereby reduce automobile travel. However, despite previous support for this scheme (Kenworthy, 2006; Holtzclaw, 1990) cited in (Handy, 1998), several other studies cast skepticism ex. (Greenwald, 1999; Hedel, 2007) read the references and support it with examples; those in favor and those opposing the proposition.

However, research illustrates that in countries with a growing urbanization contributed by European scholar (Dyck, 2011; Witlox., 2011; Cao, 2014) land use planning and transportation intervention can be an effective means to manage automobile use and travel.

(Peter, 2005) studied the urban form impact on travel behavior in India. Particularly the study amplified on the transport mode of choice and travel behavior using two variables for assessment; accessibility to the employment opportunity and transport mode to reach it. People in the centre of the city used non-motorized modes including walking and cycling as opportunities are located in the central city of India. The dissertation proposes that employment opportunities should be considered for low earning households to decrease distances and travel times.

The dissertation by (Naess, 2003) and (Jensen, 2004), focused on the factor of housing location and its distance from the city. Particularly Norway and Denmark's urban forms have been examined to realize the influence residential land use location has on travel behavior (Sadhu, 2016). It has been found that the nearer the household is to the centre of the city the higher the likelihood of people walking and cycling. In India various transportation studies have been carried which take into account the informal settlement. It is found that travel times negatively impact choice of travel and destinations. It is also found that the disadvantaged are affected by the city policies which distances them from employment opportunities and creates different travel characteristics from higher income households.

(Ardeshiri, 2016) studied the built environment attributes for travel behaviors in Iran. The results indicate that households in high residential and job densities, short distances to centers use non-motorized and transit modes. Also, individuals in a mixed land use neighborhood use non-motorized and transit modes to non-work destinations. Particularly, the design measurements and criteria that influenced the study included street density and internal connectivity. Higher internal connectivity leads to further tendency than utilized non-motorized and transit modes.

It is viewed that urban form significantly impacts travel behavior and patterns. The literature review illustrates that low density, single land use creates lengthier travels and higher reliance on automobile use. Whereas, in higher density mixed land use with the provision of multi transport modes, sustainable travel behaviors are promoted and used. Overall, it is observed that land use planning influences travel behavior with a consistent effect in spite of different planning and political context. Therefore, land use policies need to be tailored for specific contexts.

2.5 Management Strategy

Upon setting a high level of literature review for the topic undertaken management strategies for sustainable developments and smart growth urban planning is covered. The management strategy is covered to assist in delivering innovative policies and methods to enhance land use planning in Doha, Qatar.

2.5.1 Sustainable Development and Smart Growth

Diverse land use management strategies may be utilized to obtain planning objectives and enhance accessibility and modes of transport. Land use Management strategies can be employed to help change travel behavior and various planning issues. These influence in a number of ways, reduces number of vehicle ownership and use, and vehicle travel. Particularly for this study the strategy utilized will be sustainable development to achieve planning objective amplified in Table 2. It looks at planning objective of how congestion can be reduced, savings on road & parking cost and area, consumer savings, transport choice, road safety, environment protection, physical fitness, and community livability. These potential planning objectives assist in creating spaces and transport systems that are efficient, cost effective, and sustainable.

Table 2. Land Use Management Strategies Effectiveness (source: Litman, 2016)

Planning objective	Impacts of Land use Management Strategies
Congestion Reduction	Strategies that increase density increase local congestion intensity, but by reducing per capita vehicle travel they reduce total regional congestion costs. Land use management can reduce the amount of congestion experience for a given density.
Road & Parking Savings	Some strategies increase facility design and construction costs, but reduce the amount of road and parking facilities requires and so reduces total costs.
Consumer Savings	May increase some development costs and reduce others, and can reduce total household transportation costs.
Transport Choice	Significantly improves 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	Reduces 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.

The literature defines the most accepted definition of sustainable development to be: 'Humanity has the ability to make development sustainable-to ensure that it meets the needs of the present without compromising the ability of future generations' (Li & Lai, 2014).

Sustainable developments are built upon key criteria including increased density, design of friendly accessible scheme and diversity of land use mix, housing and commuting choices as depicted in Figure 4. It illustrates a conceptual diagram of the sustainability elements and how they can be adapted into a new urban context.

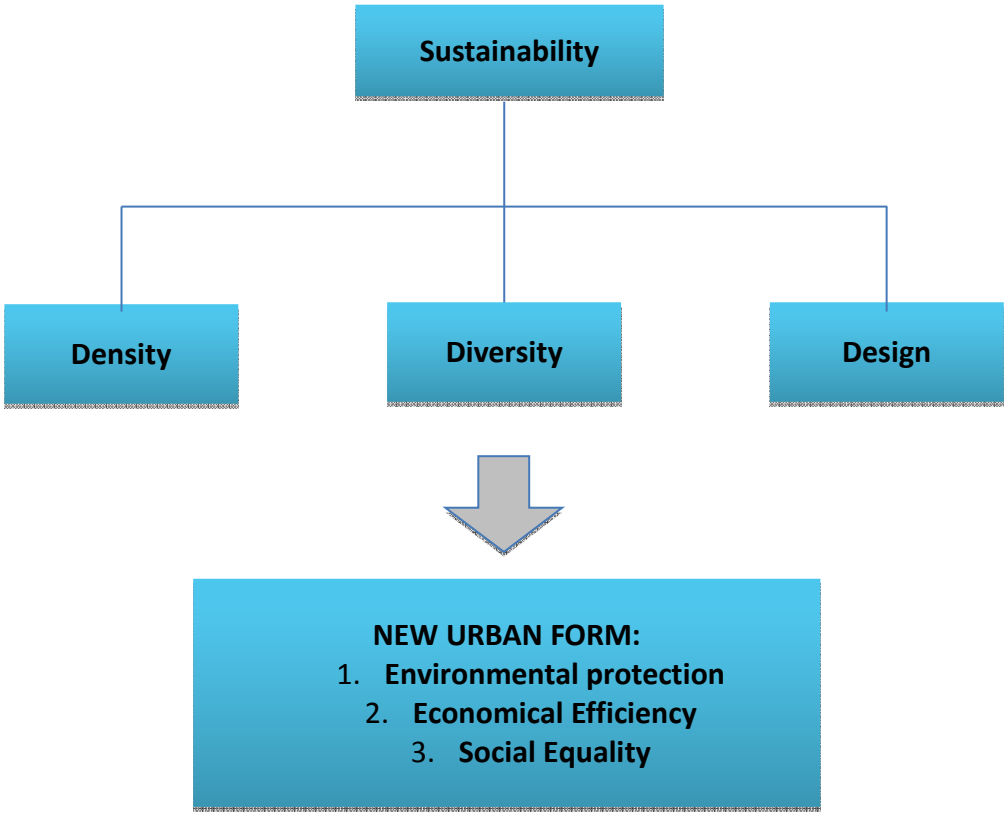

Figure 4. Urban Sustainability (source:developed by author)

Density, diversity, and design components are used to attain environmental protection, economical efficiency and social equality. It is with these three strategies that an urban development can become sustainable. Initially, environmental protection guards land development in environmental protected areas. It secures accessible transport means to protect the sensitive environment. Economic efficiency refers to higher transit ridership, economic development and location efficiency. Efficiency is achieved via planning for missed land use with high density developments. Finally, social equality means is met as affordable and diverse housing is made available to the people. It is also met with increased choice of transit modes to ensure and secure social justice. By

achieving the above mentioned elements sustainable developments emerge (Lai, 2014). And through the implementation of sustainable urbanism principles, smart growth developments are achieved.

Table 3 illustrates the different land use management strategies, their description and the relevant scale of development fit for each. The strategies identified in the table allows to enforce and assist in developing land use planning recommendation as a response to the change in accessibility, travel behavior and various transport systems.

Table 3. Land Use Management Strategies (source: VTPI 2008)

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, often designed around transit villages.
Location-Efficient Development	Local and site	Residential and commercial development located and designed for reduced automobile ownership and use.
Access management	Local, street and site	Coordination between roadway design and land 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.

In response to proposing policies that are economically sustainable this dissertation investigates sustainable management strategies including “Smart Growth”.

Smart growth is a planned economic and community development that challenges to restrain urban sprawl and deterioration of environmental conditions. It concentrates employment within existing urban areas to increase transport efficiency" (Zaina, 2016).The occurrence of increased congestion, sprawl, air pollution, loss of spaces, and carbon dioxide emission call upon the implementation of smart growth policies. The policies encourage provision for walking, transport option and mixed use developments. Another element that leads to smart growth is the increased rise in housing pricing in central cities leading to inadequate residential choices and homeownership opportunities for most of the population (Litman, 2016b). As such the introduction of smart growth creates communities that are productive, hospitable and environmentally responsible. It also supports multiple discipline including developers, environmentalists, public officials, residents, citizens etc. to house growth (Lai, 2014). Smart growth and sustainable developments aim to meet the demand of the present with compromising the ability of future generations. "Despite the general thought that land use management communities evolve to become highly urbanized, these strategies have flexibility and can be manipulated" (Zaina, 2016).

Table 4 illustrates the elements of TOD and their response in terms of smart growth principles. The third column of the table is representative of the new day plan of current practices that may be in place to achieve the elements of a TOD in urban centers. These elements and their response to smart growth can be used as means to assist in developing land use planning policies in Qatar.

Table 4. TOD, Smart Growth Principles and Sustainable Developments (source: Growth, 2008)

Elements	Smart Growth Principles	Sustainable Developments
Concentrate development near transit to avoid growth of low-density neighborhoods.	Preserve open space, farmland, natural beauty and critical environmental areas.	Protecting the Environment and Promoting Local Food Production.
Concentrate development near existing transit-served communities.	Strength and direct development towards existing communalities.	Improving the Economy and Advancing Education. Promoting Energy Independence. Protecting the Environment and Promoting Local Food Production. Meeting the Needs of Older Adults. Ensuring Access to Affordable Housing and Human Services.
Provide robust regional transit access and a well-connected local street network comfortable for pedestrians and cyclists.	Provide a variety of transportation choices.	Promoting Energy Independence. Ensuring the Health people. Meeting the Needs of Older Adults. Ensuring Access to Affordable Housing and Human Services.
Plan for and incentivize development near transit stations.	Make development decisions predictable, fair and cost effective.	Improving the Economy and Advancing Education.
Engage communities to ensure appropriate character and mix of uses in transit station areas.	Encourage community and stakeholder collaboration in development decisions.	Restoring Public Confidence in Government.

The literature review carried out in chapter 2 builds the foundation of the study scope and creates a synthesis among the investigated topics. It establishes the definition of land use, its corresponding factors, and travel behavior. Varied case studies have been taken to understand correlation of urban form and its impact on travel behavior. This is then followed by a management strategy review of sustainable developments and smart growth.

The literature allows to establish a base line to assess the selected study areas against. It also enables the generation of proposed policies and guidelines to improve land use planning in Qatar.

2.6 Literature Methodologies

The literature methodology section reviews two studies with focus on their methodology and the transition from conception to data and analysis. The first case looks at the impact of built environment attribute on travel behavior in Shiraz, Iran. It collected data for 22 neighborhoods through surveying daily activities for home based work and non work trips. A structural equation model is used to inspect the relationship between land use factors and travel behavior. The results of the equation provide an indication to the density, accessibility and land use mix. (Ardeshiri, 2016). The second case conducted an analysis of the built travel. It quantified affect sizes, updated earlier works and added outcome measures. This is achieved through computing elasticity's for individual studies and pooled them to produce weighted averages. (Cervero, 2010).

CHAPTER 3: HISTORICAL BACKGROUND OF QATAR

To realize the implication of land use and its impact on travel behavior it is critical to understand the evolution of urban form in Qatar and its road network. Qatar Underwent three major urban phases including pre-oil settlements, urbanization and oil boom and megaprojects. During the phase of urbanity of transition of the pre oil period Doha witnessed settlements of Al Khalifa tribes on the eastern coast of the peninsula in 1847 to access the sea and water sources. The settlements where build on fishing, later the findings and expansion of the pearl trade arose, leading to conflicts. The British power was concerned about its trade routes and recognized Qatar as an official ruler in 1868. The space created at that time is the result of the cultural and economic interactions of a civilization as a response to its environment.

Urbanization and Oil Boom in Qatar (Rizzo, 2013) categorized the phase into 'modernization' and 'globalization' also referred to as 'abstract space'; the conceived space of intellect driven by a capital economy as noted by (Wiedmann, 2013). The developments of this phase are administered and controlled by political sectors and rulers to improve the functionality of spaces and places. In this section, the planning and urban development's in Qatar are discussed since their independence from the British Empire by the diverse influential decision makers and stakeholders.

In 1972, Qatar was declared as an independent country with an efficient administration which included several ministries; Ministry of Municipal Affairs and Agriculture 1974(MMAA) took control of the town planning, and Ministry of Public Works (MPW) took charge of infrastructure.

During that time, in 1974 British consultant Llewelyn Davis was appointed by MMAA to design Doha's master plan for 1990. The concept was to develop a ring concept with clear land use distribution with new areas called Al-corniche, West Bay and Al Dafna (Rizzo, 2013). A decade later the country began to witness rapid economic growth as a result of oil revenues. Thereby, new plans had to be initiated to compensate and provide more space for expatriates. During 1970s the nationals moved to new developed areas (Al Rayyan, Medinat Khalifa or Al Gharrafa located North West of the city) promoted by land policies. The implementation of the master plan was crucial to allow the carrying of public administration. During this same time in 1967 road systems began to appear in Qatar.

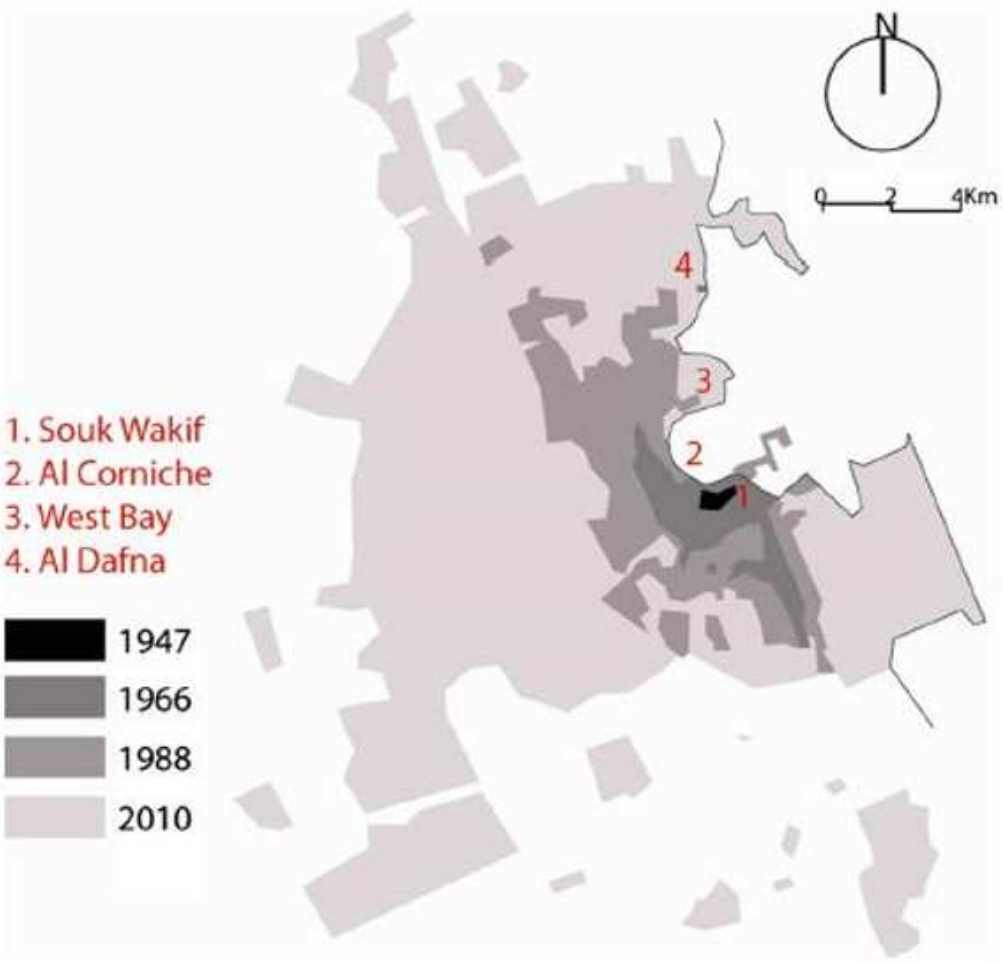

Figure 5. Urban Growth Phases in Doha: 1947 – Urban Development Prior to Oil Exploitation; 1966- Modernization Phase; 1988- Petro-Urbanism Phase; 2010- Megaprojects Phase (source: Rizzo, 2014)

In 1991 the Department of MMAA had responsibilities while other ministries held different responsibilities leading to coordination problems, which were further intensified because high-profile projects where carried by Emiri Diwan, thus not part of the ministries legislation (Adham, 2008). Doha continued engaging with western consultant for projects between 1980s and 1990s including Doha Landscape master plan

by American planning firm HOK in 1983, planning study of Doha's city centre by Lebanese Dar Al-Handasah consultant in 1985, and the Physical Development Plan by Louis Berger & HOK in 1993-1997. However, none of the proposed plans have been implemented due to economic and political instability and the first Gulf War in 1990s.

The mega project phase is defined and highlighted as the government will to develop large, themed urban projects to compete with other mega projects in the gulf. Over the past two decades Qatar witnessed a rapid urban growth that transformed small port cities to large sprawling metropolitan as a result of the export of oil and gas. In 2002, there were 1230 km of highway, 145,280 passenger cars and 75000 commercial vehicles registered. (Zaina, 2015).During this time Qatar engaged large megaproject campaigns to attract global firms, professionals and tourists. These mega projects where controlled by the governance focus was on multiple themes as its foundation for prospect developments, establishing state-owned and semi-privatized institutions that are owned by very powerful stakeholders. This led to initiations by government investments for new infrastructure, including new airports, highways, ports, stadiums and hotels to accommodate for the expansion and resulted to a new built environment. However, with poor planning and lack of democratic processes the city witnessed down falls in the physical and social equity within Doha (Rizzo, 2014; Radwan, 2014; Faggion, 2015). During this period the population grew to 2.2 million, an increase of 0.81% from 2015. Accordingly the present population of 2.2 million people is anticipated to multiply by 2030.

Recently, new planning strategies are envisioned to promote non-motorized transportation modes, reduce carbon dioxide emission and create healthy environments through land use planning. This is described in the National Vision manifesto – 'Qatar National Vision (QNV) 2030 builds a bridge between the present and the future. It envisages a vibrant and prosperous country in which there is economic and social justice for all, and in which nature and man are in harmony' (Vision, 2008).

Qatar is undergoing a major milestone towards the implementation of a public transport system of the Doha Metro. It is a rapid transportation system that will be operational in 2019. The Doha metro is composed of 4 metro lines; Red, Green, Gold and Blue Line with an overall length of 300km and 100 stations. Figure 6 shows The Red, Green and Gold Lines departing from Msheireb central interchange in Doha town (Rail, 2016). The Blue Line however, functions as a semi-orbital service (Faggion, 2015; Radwan, 2014).

Figure 6. Doha Metro (source: Rail,2016)

For many years planning has been developed around the vision of catering urban communities with cars. This has contributed to developing poor and uninviting urban centers (Bernick, 1997; Cervero, 2000; Kockelman, 1997). This case has taken place in Qatar which is evident in its cities within Doha and outside of Doha (Heaton, 2015). “Many of the new districts have underwent a fast urban regeneration and built environment characterized by its contemporary architecture. However, the introduction of the rail system in Qatar has the potential to prompt the construction of compact transit

villages along the railway" (Zaina, 2016; Fromherz, 2012); "Home Sweet Home: A Growing Population is Driving Demand for More Affordable Housing". These centers have great potential to enhance transport interface, revive and generate underused spaces and create affordable housing options and employment opportunities and cut on the road infrastructure strain through the introduction of land use policies.

Appreciating the historical background and evolution of urban form in Qatar is critical. It allows realizing the implication of land use and its impact on travel behavior analysis in the following chapters to follow.

CHAPTER 4: RESEARCH METHODOLOGY

Chapter 4 covers the research methodology of the dissertation. It initiates with the study area and justification. This is then followed by the conceptual framework of study.

This chapter concludes with the method of data collection for the study covering five sub-sections. These include the literature review, built environment factors, primary data, secondary data and adapted QSTM, and data analysis process and tools.

4.1 Study Area and Justification

The methodology chapter discusses the theoretical framework for the study undertaken. Doha is the capital city of Qatar and is located on the coast of the Persian Gulf, east of the city. The thesis assesses two district areas in the city of Doha, Qatar, namely Fereej Abdul Aziz located in zone 14 and Al Messila District located in zone 36 illustrated in Figure 7 below.

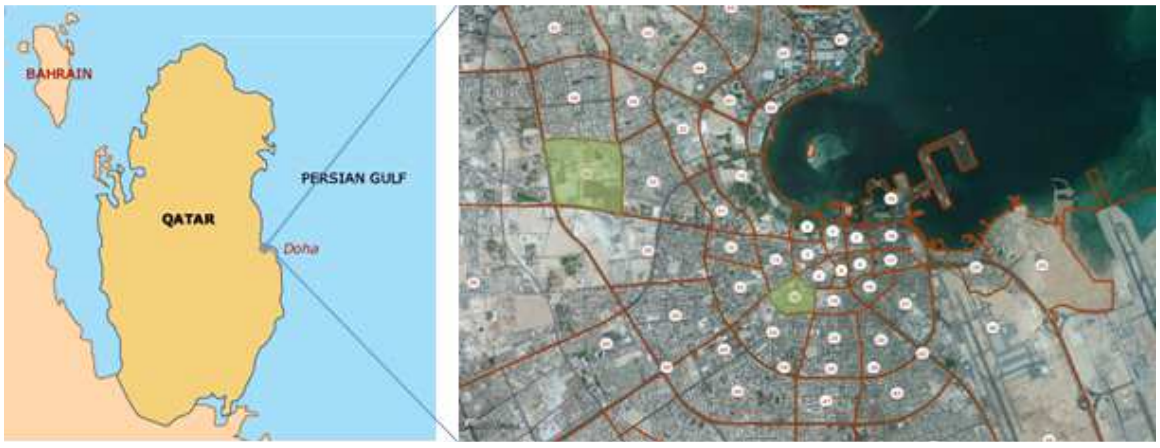

Figure 7. Doha Metro (source: developed by author)

Fereej Abdul Aziz area is located in Inner Doha, almost 0.5km away from Doha Bay as per Figure 8. The area acts as a strategic gateway for the city from the West, lying between two main routes of the city; A ring and B-ring which penetrate past the oldest part of Doha and onto the airport. The area includes great strips of commercial use, residential use and is home to historical significance.

Fereej Abdul Aziz district is selected as the study area as it sits strategically in the heart of Doha, attracting many and becoming one of the busiest centers in the country. Most significantly the area is among the main economic hubs in Doha and among the prominent centers of historical tourism that has attracted large numbers of expats in recent years. This area requires critical attention and study to enable it to become a more sustainable, inviting district that is easily accessible.

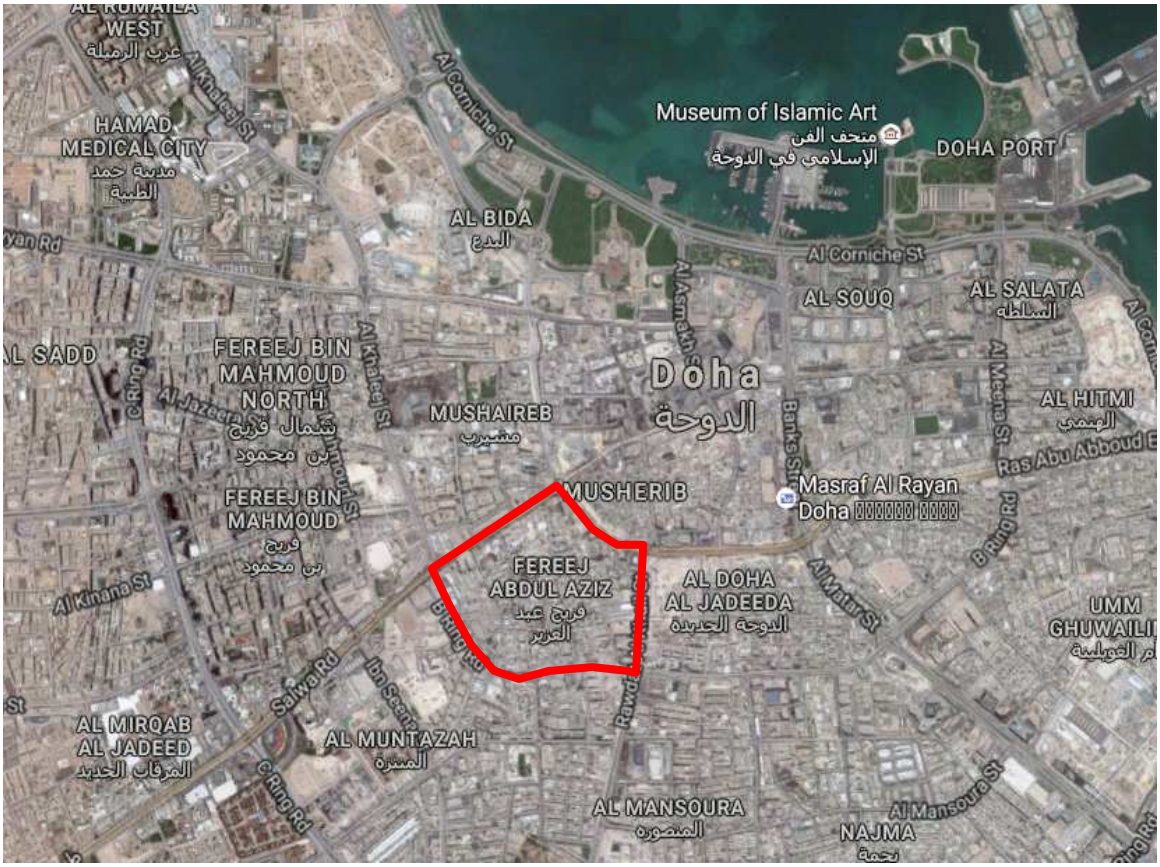

Figure 8. Fereej Abdul Aziz Location Plan (source: developed by author)

The second area is Al-Messila district which lies in the municipality of Doha. Tremendous growth began to appear in this part of Doha in the early 2000s, including settlements of residential compounds to house expatriates, villas, commercial and medical developments.

Figure 9. Al Messila Location Plan (source: Google Earth)

The housing typologies in Qatar are varied; ranging from gated communities including compounds, to standalone villas, and apartment buildings. For the purpose of this study 2 centralized differentiated housing typology districts have been selected; Fereej Abdul Aziz which consists of mainly condensed apartment building and Al Messila which reflects the gated communities and standalone villas. Both of which are representative of the wider Qatar urban fabric.

They have also been selecting for their varied urban forms. Fereej Abdul Aziz is distinguished for its organic traditional neighborhoods and Al Messila is recognized for its rigid modern developments each accommodating different economic elements. Doha

4.2 Conceptual Framework

The scope of research covered under this thesis includes the assessment of the four identified land use criteria's. The land use criteria's include density, regional accessibility, land use mix and connectivity. They are evaluated to examine their impact on travel behavior elements. The travel behavior element includes Vehicle Ownership, Travel (Trips, Mode of Transport shared) and Active transport illustrated in Figure 10. The assessment of land use impact on travel behavior results to identifying planning issues of Qatar. A major factor that led to planning issues is the rapid growth of the state of Qatar. Implementation of master plans and policies have not been enforced as per the Ministry of Municipality and Environment statement. This led to a number of planning issues including the social quality, physical fitness, accident costs, consumer costs, infrastructure costs, and traffic congestion. This took place in response to the travel behavior decisions the society and people make.

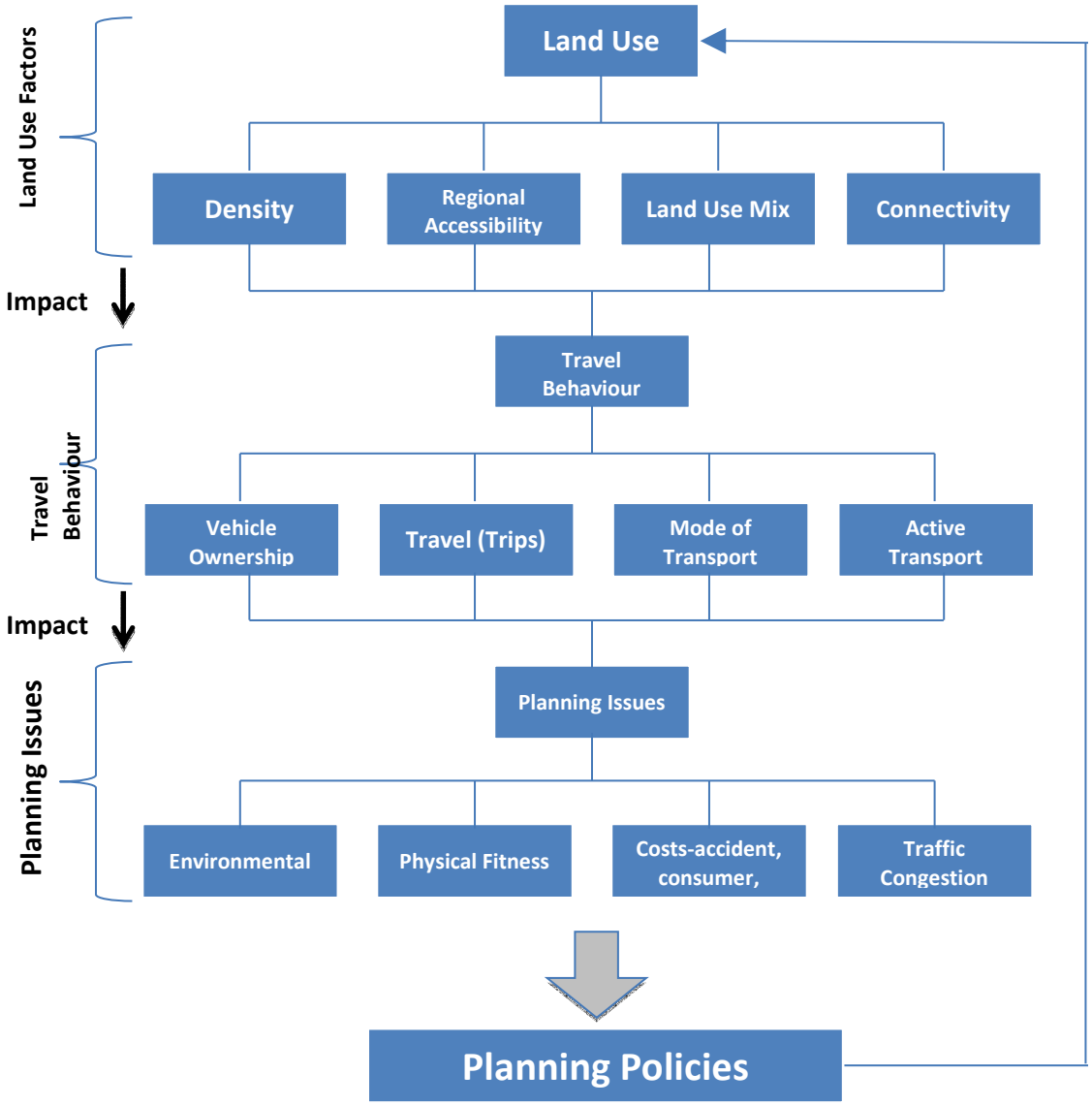

Figure 10. Conceptual Framework (source: developed by author)

4.3 Data Collection Method

4.3.1 Literature Review

The literature review covers key definitions of the study concepts and focuses on the research problem, question, aim and objective, and its associated method and techniques in order to adapt the methodology. The literature review will initiate a synthesis among the reviewed case studies and abstract land use criteria to utilize and assess their impact on travel behavior implications in Doha. The urban form is reviewed in respect to its density, regional accessibility, land use mix, and connectivity factors. These factors are assessed to evaluate the impact of land use factors on people's travel behavior in the neighborhood. The study will also investigate the trips assignment, and analyze the origin and destination patterns of all modes of transport including automobiles, public transportation and walkability.

Within the theoretical framework of this study; the literature review is the initial step taken to assess case studies and establish the methodological and conceptual framework of the research criteria. The case studies range from an international scale of assessment to local case studies. All case studies presented in this research contain similar conditions and characteristics to that of Doha. This will guide in extracting guidelines from case studies fit to assess the existing conditions of land use and its impact on travel behavior in Doha, Qatar.

4.3.2 Built Environment Factors

The factors of density, land use mix, street density, design and connectivity, and regional accessibility are assessed to evaluate their impact on land use factors and people's travel behavior in a neighborhood. These factors are calculated at trip origins to comprehend land use influence on travel behavior specifically to understand the effect on home-based work and non-work trips.

This section amplifies and explains the employment undertaken for each of the variables of land use. Firstly, we examine density, there are two variables used to calculate density including job density and residential density. The residential density is defined as the number of residents per net area of each zone/study area while job density is to be measured as the number of commercial service activities (jobs) per square kilometers of total buffer area.

Secondly, the land use mix factor of built environment is calculated by the entropy index. Entropy index refers to the measurement of solo land use as low values and more varied land uses as higher values (R. E. R. Cervero, 2010) to cater for the balance of multiple land uses illustrated in Figure 11. In this equation, Pj refers to the ratio of each of the land uses in buffer areas and J is the sum of various kinds of land uses (Wu, 2016)

Areas with a high Entropy index are considered for the evaluation while case studies that score low in Entropy index are usually excluded from the analysis by other studies. Thereby, this study ensures that both selected areas have a high Entropy Index.

Information is extracted from land use plans and calculated at the scale of zones in accordance to the equation below.

$$EI_i = -\left(\sum_{j=1}^{J} Pj \cdot \ln Pj\right) / lnJ$$

Figure 11. Entropy Index Equation : In this equation, Pj refers to the ratio of each of the land uses in buffer areas and J is the sum of various kinds of land uses (source: Wu, 2016)

The design and accessibility factor is defined at the street density and internal connectivity of the built environment. Street density is defined as the division of total street length over unit of area by the area to calculate number of linear miles of road per square mile of territory. The value of street density reveals one of two; the higher the value the indication of more streets and additional connectivity and the lower the value the indication of less streets and poor connectivity in road network (Wu, 2016).

Internal connectivity is an indication of intersection density measured as the number of street intersections divided by the number of intersections plus cal-de-sacs. A value higher than 1.0 cannot be achieved, where higher values indicate a higher level of connectivity. It has been found through research (Ewing, 2010) that that walking trips increase as connectivity levels are higher.

Finally the factor of built environment is regional accessibility for the purpose of transport within the urban fabric. This is measured as the distance from home to the nearest public transport including bus stop or intersection point. Regional accessibility

can also be interpreted for an individual travel behavior via measuring the distance to closer employment sub-center and distance to Central Business District. (Witlox., 2011)

4.3.3 Primary Data

Upon taking a logical approach of literature review, the study is followed by data collection. Using the Built environment factors identified above, both Fereej Abdul Aziz and Al Messila case studies have been measured through primary data collection. The primary methods used include site observation and analysis, photographs and mapping information.

The data have been captured through Doha's Ministries including Ministry of Municipality and Environment, Ministry of Transportation and Communications, Ministry of Development Planning and Statistics. The observations are first hand data collected that captures car movements and trips. By observing the collected data, analyzing it and creating a synthesis among it a holistic perspective can be developed.

The site observation and mapping of data has been collected over a two month study duration from September (one week of the month) and October (one week of the month). It was carried three times within the week days and over weekends at three intervals; AM peak (6.30am -8.30am), MD peak (12pm – 2pm) and PM Peak (5.30pm – 7.30pm).

The research primary data instruments also include direct interviews and consultation with Duncan Fox (Director of Urban Planning-AECOM) and Ahmed Seyam (Director of Transportation – AECOM) regarding the planning issues as a consequence of land use planning on the transportation sector in Doha Qatar.

4.3.4 Secondary Data and Adapted QSTM

The research also investigates secondary data including Atlas, maps, and censuses data to obtain demographic statistics of those areas and households. This information is collected by government departments and Municipality. Demographic statistics will provide an appreciation of status, class, race and age group of the occupants of study area. In turn a relationship of travel behaviors versus demographics statistics can be drawn.

Alongside to that the Qatar Strategic Transport Model (updates QSTM 1.0 Sept 2013) will be utilized to extract the traffic volumes for the identified area of this study. The Qatar Strategic Transportation Model VISUM model is an important strategic planning tool that is currently used for many transportation projects in Qatar. The Ministry of Municipality and Economics continuously updates this model to ensure robust forecasts for assessment of any transportation or development in Qatar.

This Model takes into account, the base year, current year and ultimate year. The base year 2011 has a total population of 1.7 million, the current year 2016 has a total 2.6 million inhabitants, and the ultimate year 2031 has an anticipated population of 3.6 million. It has also been updated with the latest available data, land uses and road

network of the State of Qatar. Moreover the Qatar Strategic Transportation Model is updated to reflect the private and public transport model. Fundamentally the Qatar Strategic Transportation Model will be utilized to quantify the trips generated to work and non-work trips.

The secondary data depends on two types of software's; GIS (Geographic information System) Application and VISUM. The GIS Application is used via the Ministry of Municipality and Environment online portal to generate maps and access Atlas's. These include Qatar Socio-Economic Atlas, Digital Atlas of Qatar, Geo Statistic Application and Qatar Atlas. While the VISUM software will be utilized to access the Qatar Strategic Transportation Model and obtain data that enables an evaluation of the criteria of study. A study of such analysis, recognizes the relationship between the pattern of land use development and transportation. This is achieved via the identification of the point of origin, destination, trips and driving patterns in respect to Doha's urban planning scale.

4.3.5 Data Analysis process and tools

An evaluation of the land use factors on the travel behavior factors is assessed to identify their bearing on generating planning issues. Upon identification of issues an analysis is conducted to generate a set of planning policies that are local to the conditions of the State of Qatar. Thereby this allows the dissertation to conclude with recommendations towards a more inclusive approach through a set of policies that respond to improved sustainable growth and land use planning (travel behavior) in the

State of Qatar, see Figure 10. These policies are aimed to improve city efficiency, reduce travel and pollution and collaborate to enhance a sustainable city.

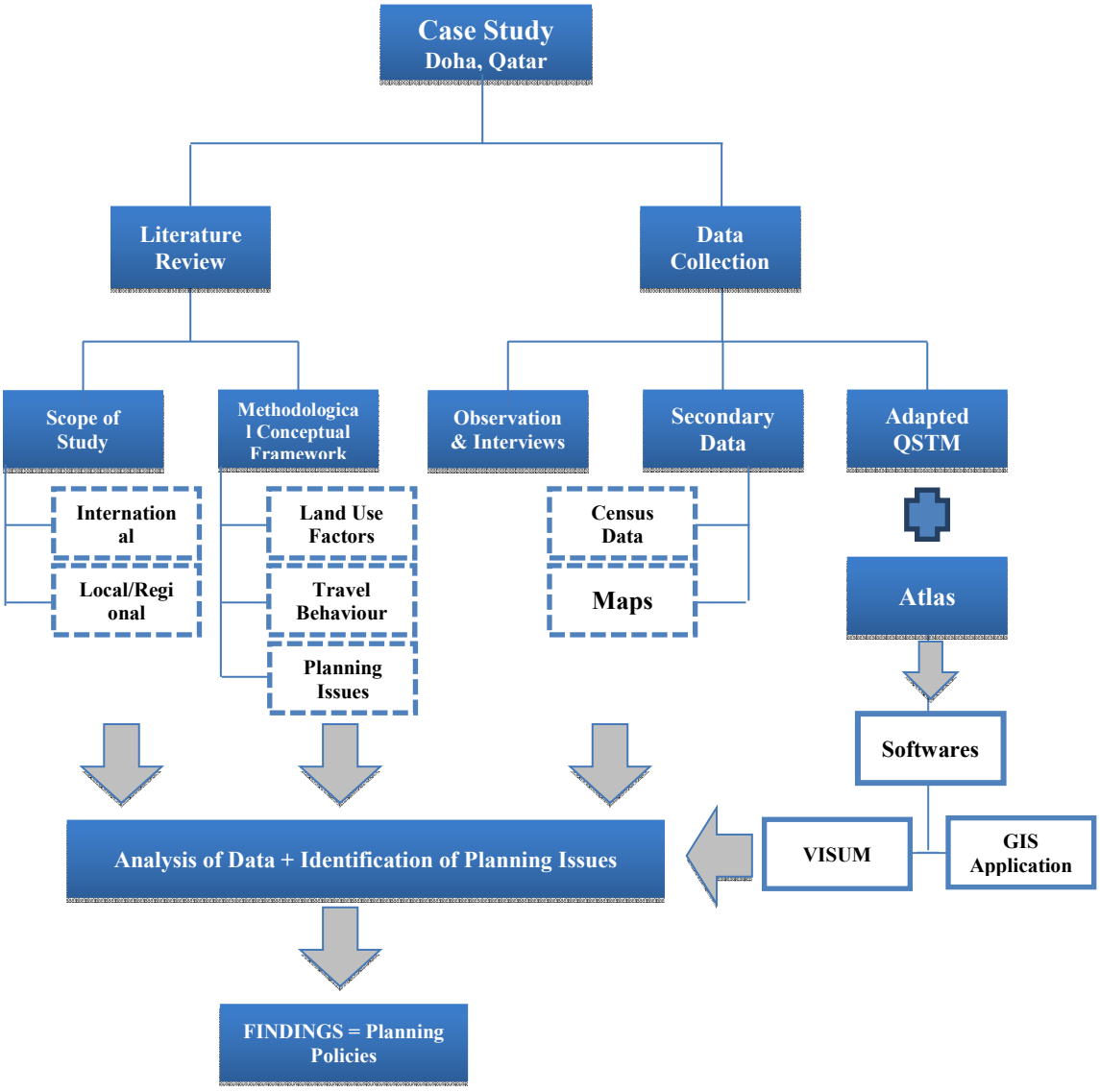

Figure 12. Theoretical Framework (source: developed by author)

The research methodology set out in this chapter covers the study area scope and elaborates on the methods used to collect the data, analyze it in order identify relevant planning policies and guidelines. This is achieved via the criteria identified under the conceptual framework of the study.

CHAPTER 5: DATA COLLECTION

This chapter covers the Data collected as per the research methodology outlined in the previous chapter. The scope of the study covers the selected study area content, land use factors and types, and travel behavior.

5.1 Study Area

Qatar witnessed a rapid urban growth that transformed port city to metropolitan area. This was accomplished by the revenue from Qatar's most prominent economic resource; oil and gas. Little consideration had been given to transportation planning and traffic improvement. On the contrary, rather large investments were made in new infrastructure to accommodate for the large expansion (Faggion, 2015). The city of Doha evolved so quickly as a response to the population growth, it was difficult to follow strategic planning techniques. During this period the population grew to 2.2 million. The city began to see urban fabric change from closely planned land parcels to urbanized sprawl developments (Radwan, 2014). For the purpose of this research thesis, the two zones selected for this study is; Zone 14 Fereej Abdel Aziz and Zone 36 Al Messila, as shown in Figure 11.

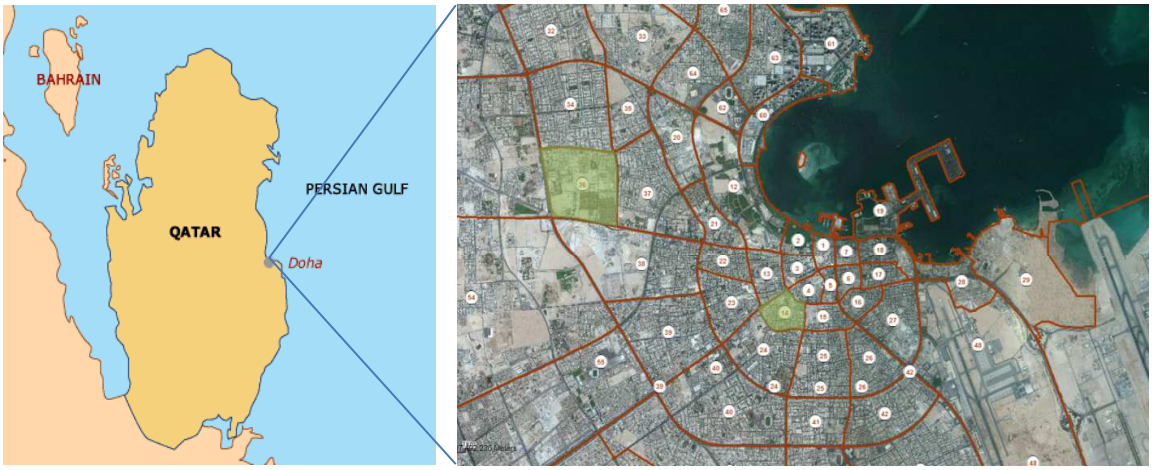

Figure 13. Study Area Location Plan (source: developed by author)

The study areas have been selected as they are representative of the typical urban fabric typology of Doha, Qatar. They both withstand different urban forms and socio-economic elements from one another. Where a compact developments of Fereej Abdul Aziz is analyzed against a non- compact development of Al Messila District, illustrated in Figure 13.

Fereej Abdul Aziz has a compact urban fabric and constitutes an organic traditional form. Strategically Fereej Abdul Aziz district sits in the heart of Doha, Qatar and is home to 15,706 of persons. The area acts as a strategic gateway from the east to the west of Doha. This fact has attracted many expats in the last decade and thus Fereej Abdul Aziz has become one of the busiest congested economic centers of Qatar.

On the other hand Al Messila's urban fabric constitutes a compound organization characterized for its low density. Al Messila district known as a non-compact development lies on the verge of the Doha municipality. Tremendous growth began to

appear in the early 2000s. This includes settlements ranging from residential compounds to house expatriates, villas, commercial and educational developments. The zone features nearby schools including; DeBakery High School for Health Professions and English Modern School. As for the population statistics, Al Messila area holds 6803 inhabitants of which 70% are over the age of 20 years or older and 30% are under 20. As per the Census Population, Housing & Establishments, April 2015 document the literacy rate stood at 98%, of those 55% are employed (Tiwari, 2016).

Table 5. Characteristics of Study Areas (source: developed by author)

Fereej Abdul Aziz – Zone 14	**Al Messila – Zone 36**
Heart of Doha	Lies on the verge of Doha
Compact development	Non-compact development
Organic urban fabric	Compound urban fabric
High Density	Low Density
15,706 persons	6,803 people

Zone 14 Fereej Abdul Aziz has a total population of 15,706, with 10,517 males and 5,189 females. Most of the population are aged between 15-44 (11,335), followed by the age group 45-64 (2,215), then the age group below 15 years of age (1,972) and finally above 65 (184). The percentage of car ownership in the sample population was 91% as per Distribution of Households by Possession of (or Free Access) to Household Appliances & Nationality % 2013 House Expenditure survey (Aditjandra, 2012).

Zone 36 Al Messila has a total population of 6,803, with an approximate 50/50 split; males at 3255 and females at 3548. Most of the population are aged between 15-44 (3,189), followed by the age group below 15 (2,214), then the age group 45-64 (1219) and finally above 65 (181). With regards to the ownership of private vehicles, the mean of car ownership in the sample population is 91%. Results are as per the Household Expenditure and Income Survey, 2013, Ministry of Development and Planning Statistics (Esmaeili, 2011). Table 6 illustrates the socio-economic attributes of the two study areas, Fereej Abdul Aziz and Al Messila zones.

Table 6. Socio-Economic Attributes of Study Area (source: developed by author)

Fereej Abdul Aziz – Zone 14	**Al Messila – Zone 36**
Total Population – 15,706 people	Total Population – 6,803 people
Male Population – 10,517 people	Male Population – 3,325 people
Female Population – 5,189 people	Female Population – 3,548 people
Age group order	Age group order
15- 44 years of age – 11,325 people	15- 44 years of age – 3,189 people
45-64 years of age – 2,215 people	Below 15 years of age – 2,214 people
Below 55 years of age – 1,972 people	45-64 years of age – 1,219 people
Above 65 years of age – 184 people	Above 65 years of age – 181 people
Car Ownership – 91 % of population	Car Ownership – 91 % of population

Figure 14 “Qatar population by broad age groups” shows population aged between 15 and 44 distributed at zone level. The data is based on the Census 2015(X.J Cao, 2014). The higher concentration of this working age population is clearly seen focused in a few Zones, largely dominated with labor gatherings.

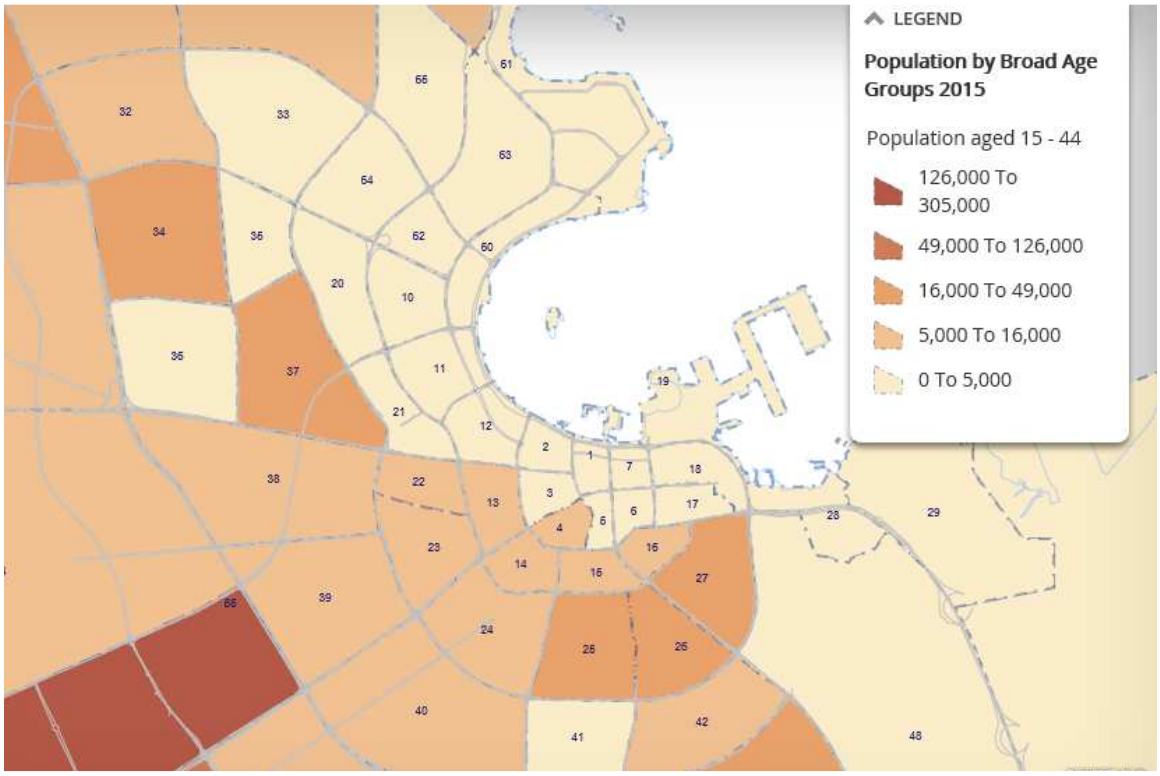

Figure 14. Qatar Population by Broad Age Groups (source: X.J Cao, 2014)

On the other hand, Figure 15 shows the economically active and not active population at zone level through the representation of circles (Planning, 2016). The distribution is based on Census data 2010 for the population aged 15 and above (Litman, 2016).

As per Qatar's Census data 2010 86% of the population is above 15 years of age, of which 87% are economically active and 13% are not economically active. The non-economically active population consists of students, housewives, and unemployed persons. Recognizing the active and non-active population helps determine the employment status and labor force of the country. According to the employment status of the first case study at Zone 14 Fereej Abdul Aziz, 92% are working and 8% are

unemployed. In the second case study, Zone 36 Al Melissa Zone the employment status is 72% working vs. 28% unemployed.

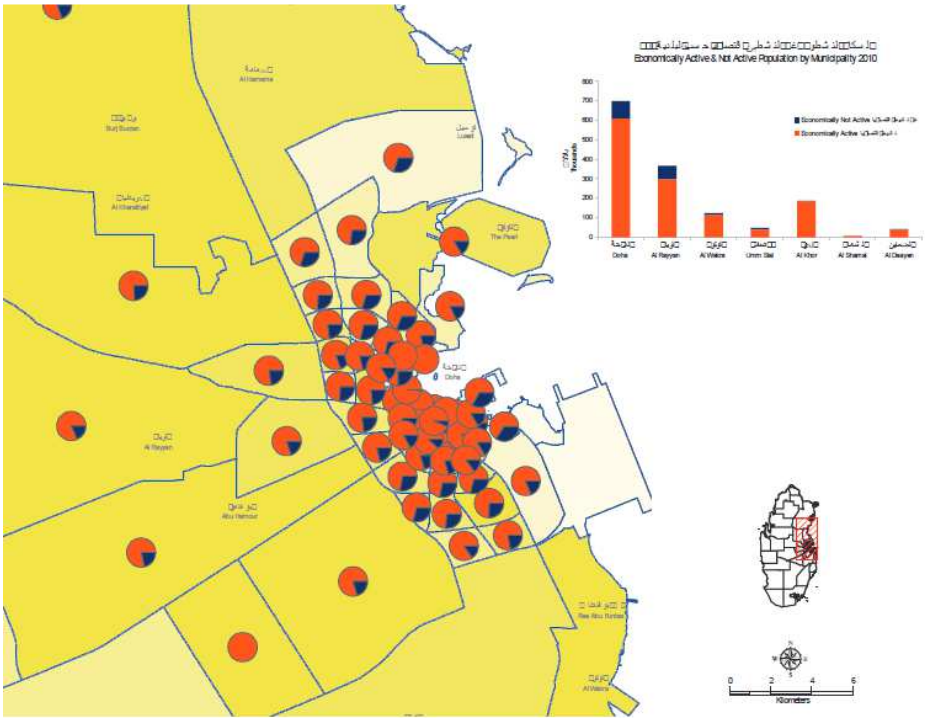

Figure 15. Economically Active and Non-Active Population (source: M.o.M.U. Planning, 2016)

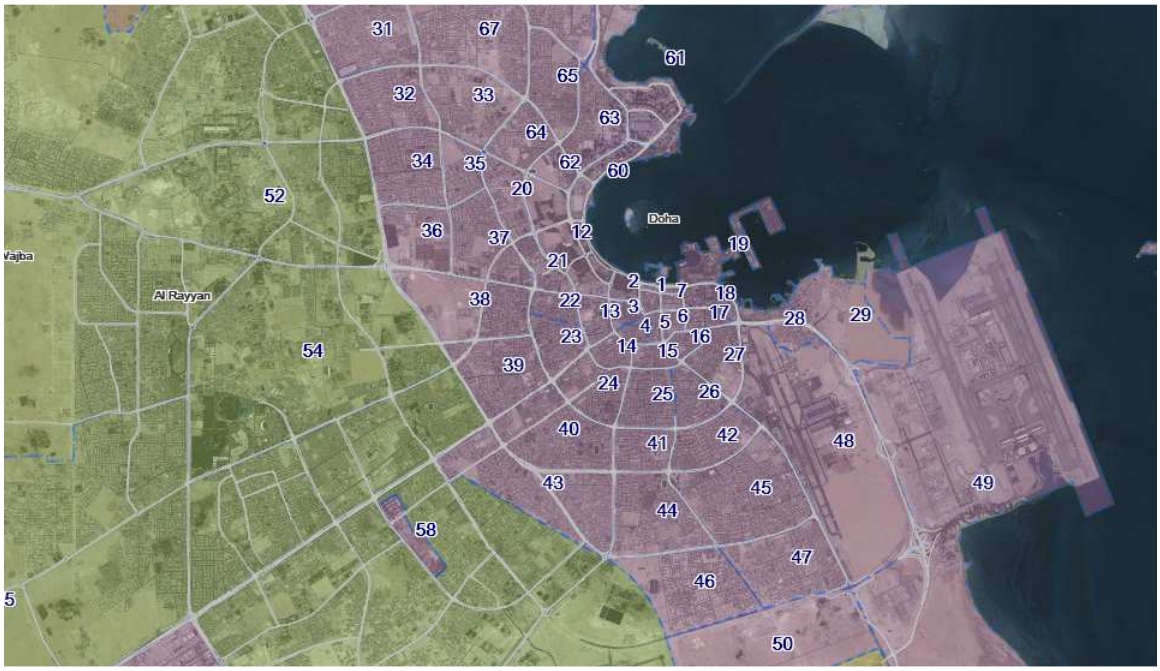

Figure 16: Doha Municipality Location Plan (source: Environement, 2016)

The data collected for the census year 2015 are put in perspective to attribute to the socio-economic study for non –work and work trips. Figure 16 illustrates the Doha Municipality location plan highlighted in light purple. .

5.2 Land Use Factors

This section covers the four factors linked with land use including density, land use mix, street design and internal connectivity, and regional accessibility.

Initially, density is associated with many factors including land use mix, accessibility, transport diversity, and parking management. It is evident that with higher density, travel behavior is affected, leading to different travel behavior implications and decisions.

According to Qatar Atlas 2010 and Distribution of Households by Possession of (or Free Access) to Household Appliances & Nationality percentage 2013 House Expenditure survey (Aditjandra, 2012), it is evident that more than 91 percent of the residents use private transportation as a means of daily basis travel. This ultimately leads to increased air pollution and road traffic in the environment.

Population data and its geographical distribution are essential information for setting up and analyzing social and economic development plans and patterns, respectively. The density of population by zone and municipality are as per the Qatar Census Population, Housing & Establishment, April 2015 (Tiwari, 2016). For the purpose of this study, density is calculated as the number of persons per square kilometer (sqm). Housing Unit types act as an important contributor towards density. Figure 17 illustrates the Housing unit types for Doha, it is evident that Fereej Abdul Aziz has a mix of housing types including flat/apartment/single room (63%), Arabic houses (24%), and Palace/Villa (13%). The population density patterns of low and high areas are clearly portrayed. In the case of Al Fareej Abdul Aziz district the total population is at 15,706 people within an area of 0.5 Km. This equates to a density of 29,513.4 persons per sqm; calculated as the number of person per unit of land area.

Al Messila district on the other hand, has housing unit types of Palace/Villa (68%), Arabic Houses (25%) and Public/ Elderly House (7%), as per Figure 17. Furthermore, Al Messila development area has a population of 6,803 over an area of 2.1 km thus equating to a density of 3,251.3 per square Kilometer. Figure 18 below illustrates the population Density by zone for the year 2015.

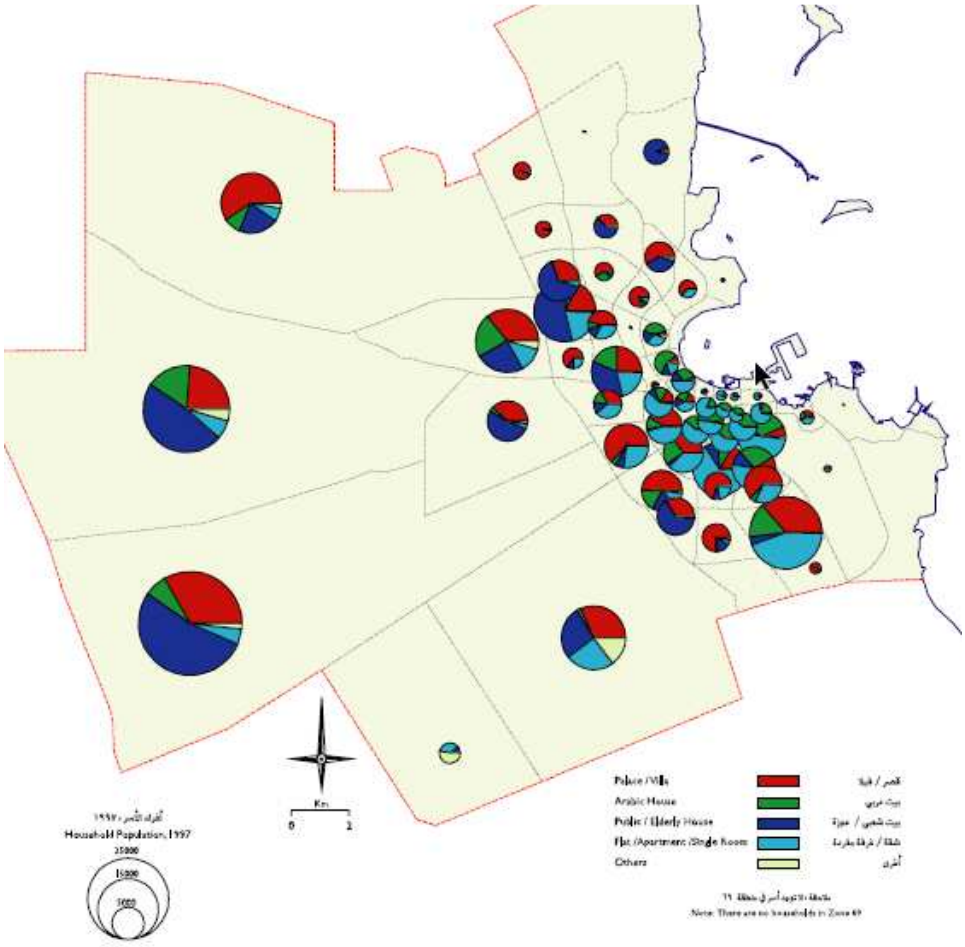

Figure 17. Housing Unit Type (source: Cao, 2014)

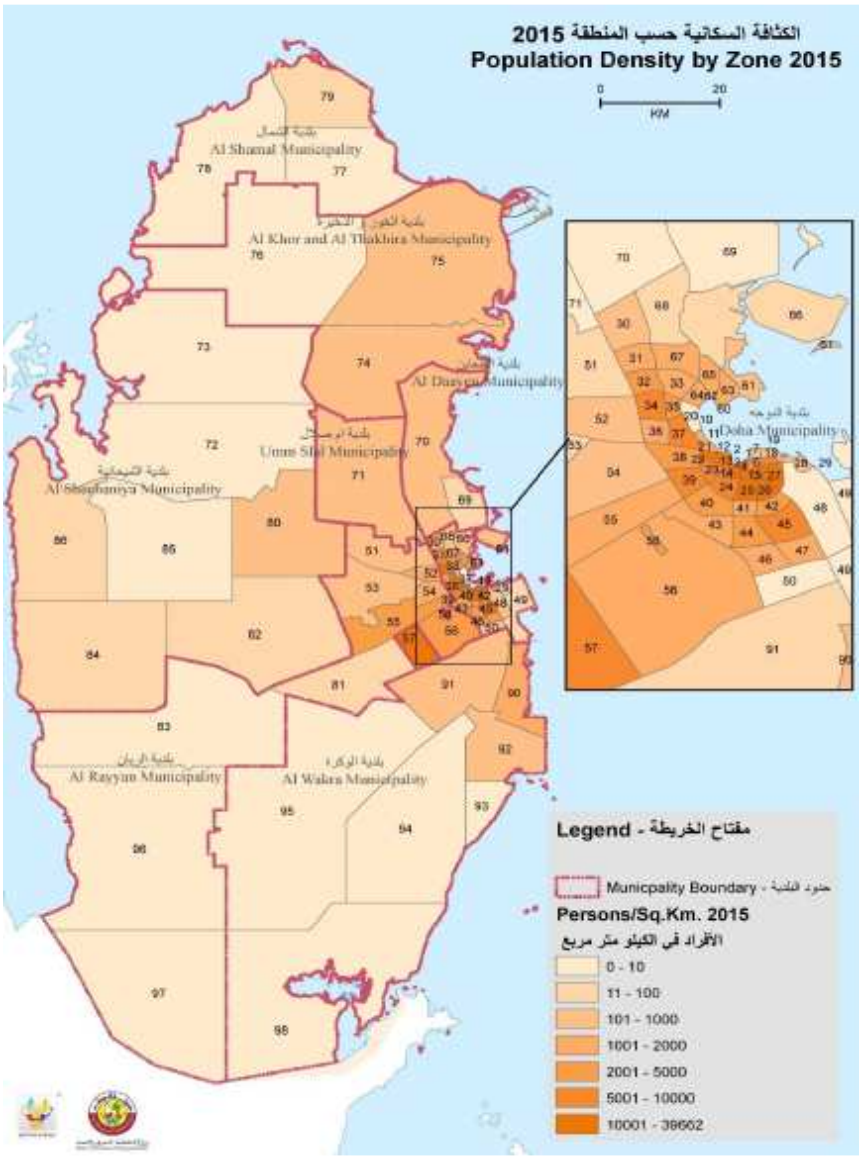

Figure 18. Population Density Zone 2015 (source: Wee, 2016)

Land use mix involves a complementary mix of uses located together in a balanced mix. Employing a balanced mix of land use types allows alternative forms of transport mean to become accessible. It enhances the vitality and security of a district via enhancing community in public spaces and on streets (Wee, 2004). To calculate for land use mix, factor entropy index is adopted.

In order to preserve the continuous theoretical concept of land use mix and allow for measuring comparison, three categories are defined from the dataset. In order to operational for this study, complementary land uses are combined to reduce the 7 categories into three. Residential is as it stands; commercial, schools, and governmental collate into a second category to symbolize commercial and employment destinations within the district ; and the third category park and recreation combines park, community centers and mosques. Open areas are removed from the calculation as these spaces do not contribute to land use mix. Figure 19 and Figure 20 illustrate the land use plan for Fereej Abdul Aziz and Al Messila zones. The number assigned can range from 0 to1, where 1 is a perfect mix and 0 comprises only 1 use. In Fereej Abdul Aziz the Z-score of this is calculated to be 0.28 while Al Messila achieved a Z-score of 0.23. Chapter 6 Interpretation and Discussions explains in detail the difference among the values achieved in both of the study areas. It also amplifies their implication and significance in the urban context.

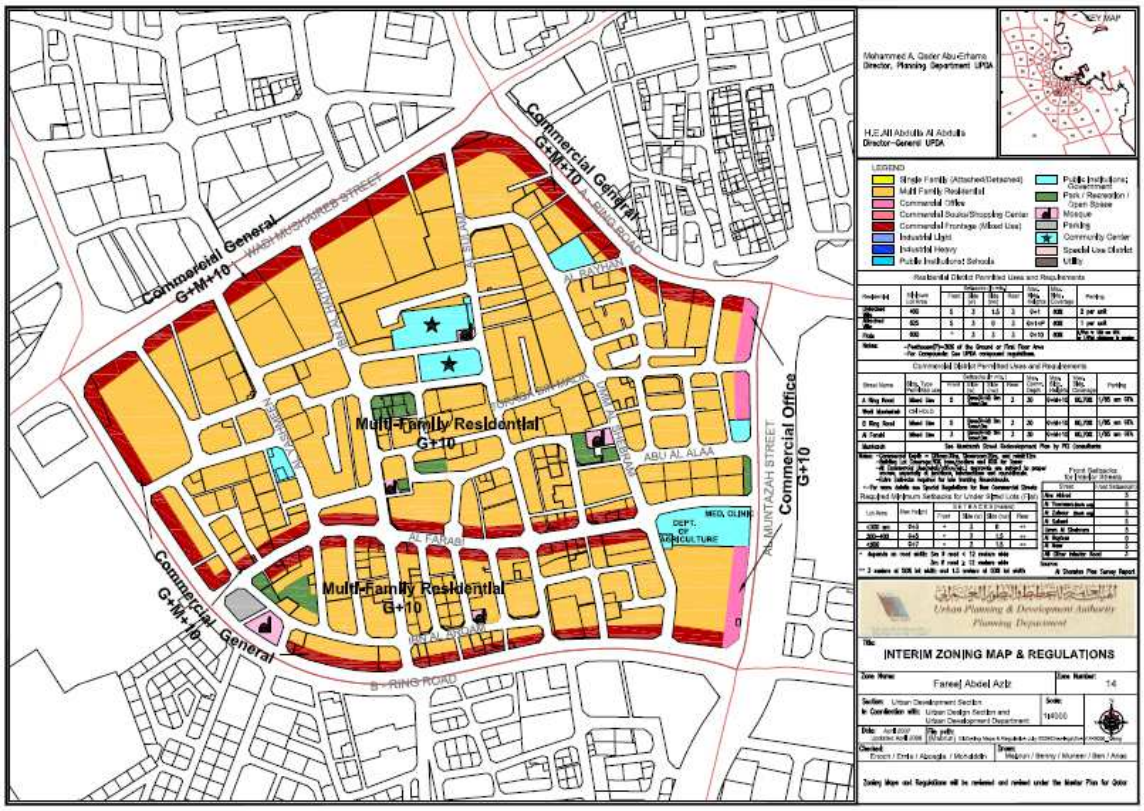

Figure 19. Zone 14 Land Use Plan (source: Ministry of Municipality and Environment)

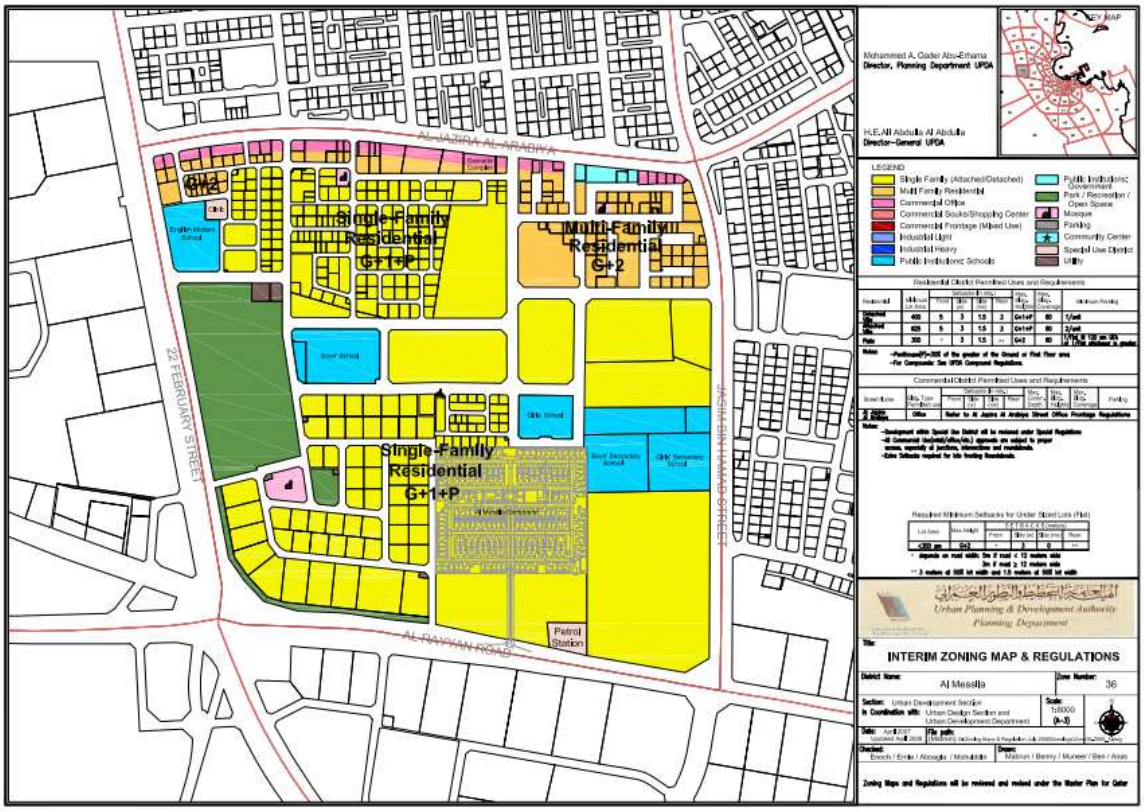

Figure 20. Zone 36 Land Use Plan (source: Ministry of Municipality and Environment)

Street density and internal connectivity of the built environment defines the design and accessibility factor. To calculate for Fereej Abdul Aziz's street density, the total street length of 11,114 m is divided over the total area of 0.5Km. This achieves a density of 22,228 meters per square kilometer. In the case of Al-Messila street density; a total street length of 18,151m is divided over a total area of 2.1Km. This achieves a density of 8643.3 meters per square kilometer. It is an indication that the greater the value is the greater the connectivity and denser the street. The lower the value is an indication to less streets and poor connectivity of road network. An explanation and overview of the street density and internal connectivity values obtained will be covered in Chapter 6 Interpretation and Discussions of this thesis.

This is followed by the indication of internal connectivity calculated as the intersection density. Intersection density is calculated as the number of street intersections divided by the number of intersection dead end. The higher values indicate a higher level of connectivity.

Finally the regional accessibility is calculated for both of the study areas. This is measured as the distance from home to the nearest public transport. To illustrate this circumference circles are taken to measure the furthest distance from transportation node. Currently, the State of Qatar has one main transport system in place; Qatar's public bus network, which is undergoing a major expansion to support the new metro and light rail system underway.

As per the illustrated Figure 21 Fereej Abdul Aziz has the furthest residential at a measured average distance of 350m. Al-Messila on the other hand has the furthest residential at a measured distance of 1000m and an average measured distance of 650m.

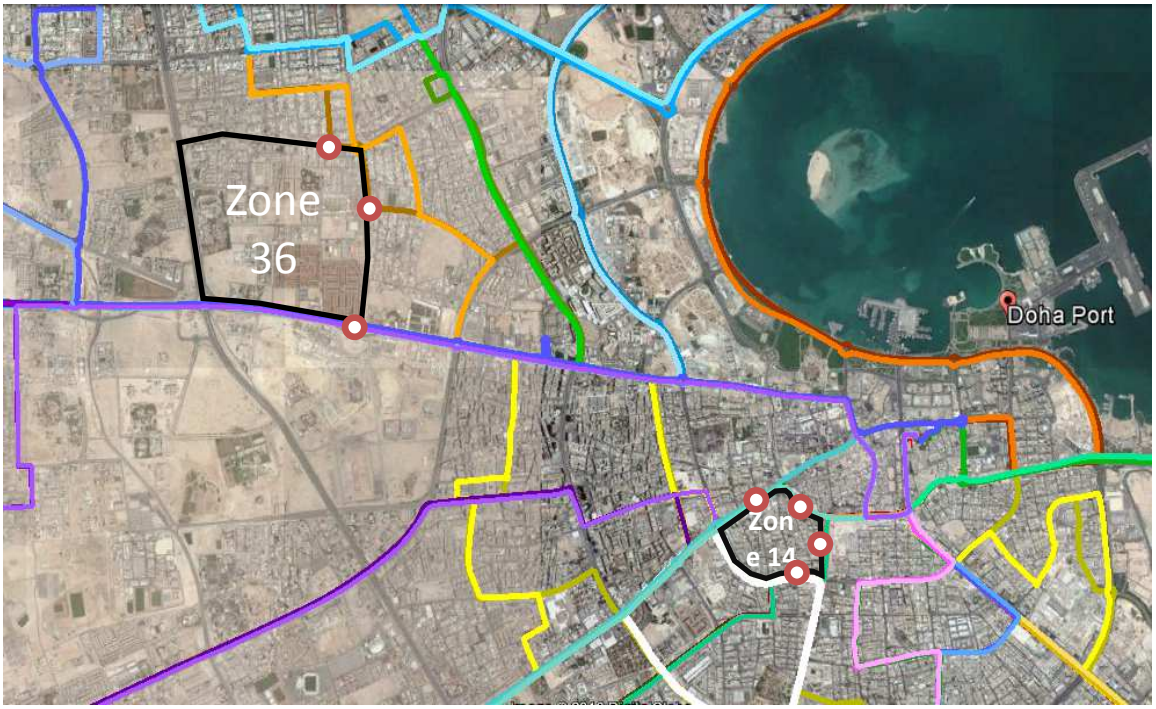

Figure 21. Qatar Bus Map (source: Communications, 2015)

5.3 Travel Behavior

In this study, travel demand model forms a core part in understanding travel behavior. A strategic study has been developed by the Ministry of Municipality and Environment for analyzing traffic conditions including point of origin, destination, trips and driving patterns to calibrate and validate the Qatar Strategic Transportation Model. Traffic count data for the Qatar Strategic Transportation Model is based on survey studies rather than utilizing the typical method of calculating for land use trip generation rates. This is the case for Doha as it is undergoing an unexpected rapid development. The high economic growth, large numbers of immigration, continuous change in land use

development and other factors result in a different population curve, activity and transport pattern, and consequently this result in different travel behavior patterns.

A number of data sets were collected within the study area including census data 2015, household survey data 2010 and traffic count data 2010. The household survey data included demographic and travel behavior characteristics of Qatar residents. The sample size of the survey included 6,450 households and a total of 38,830 persons were surveyed. On a similar note the traffic count data includes automatic traffic counts and roadside interviews.

Table 7. Trip Rates Per Planning Zone (source: Qatar Transport Model Planning Report)

		Total Trips from Home			Trips to Work	
Planning Zone	**Residents**	**Number of Trips**	**Trips Rate Per Residents**	**Employee**	**Number of Trips**	**Trip Rate per Employee**
1	642	1,241	1.9	6,919	8,266	1.2
2	307	566	1.5	829	1,051	1.3
3	7,196	12,903	1.8	8,574	10,608	1.2
4	9,747	17,857	1.8	5,033	6,521	1.3
5	2,944	5,539	1.9	4,152	5,100	1.2
6	3,971	7,364	1.9	6,827	6,045	1.2
7	1,959	3,798	1.9	5,093	6,133	1.2
10	286	466	1.6	88	166	2.1
11	56	103	1.8	547	977	1.8
12	934	1,465	1.6	2,737	3,540	1.3
13	7,294	12,242	1.7	4,859	6,085	1.3
14	9,986	18,059	1.8	1,194	2,096	1.8
15	9,594	17,344	1.8	2,607	3,876	1.5
16	9,439	17,229	1.8	2,815	4,137	1.5
17	6,921	12,177	1.8	3,313	4,371	1.4
18	765	1,268	1.7	2,022	2,667	1.3
19	184	341	1.9	1,084	1,238	1.1
20	25	33	1.3	3,162	3,302	1.0
21	566	562	1.0	1,880	2,008	1.1
22	7,347	11,888	1.6	1,906	2,780	1.5
23	8,761	13,969	1.6	5,281	6,585	1.2
24	9,642	14,384	1.5	6,369	8,190	1.3
25	19,582	30,381	1.5	5,976	8,413	1.4
26	17,794	29,694	1.7	9,612	12,290	1.3

27	22,026	36,807	1.7	4,125	5,876	1.4
28	1,759	2,744	1.5	1,245	1,935	1.6
29	0	0	0	3,955	4,917	1.2
30	3,521	4,497	1.3	1,153	1,344	1.2
31	4,243	5,285	1.2	1,269	1,769	1.4
32	7,592	9,960	1.3	957	1,293	1.4
33	2,762	3,927	1.4	1,065	1,247	1.2
34	18,455	26,597	1.4	1,399	2,235	1.6
35	4,970	6,832	1.4	1,483	1,960	1.3
36	2,845	3.768	1.3	901	1,137	1.3
37	12,732	18,405	1.4	12,478	13,504	1.1

The Qatar Strategic Transport Model is calibrated with population classification, trip purposes, activity chain and trip distribution based on mode choice model. The model is built on a set of collected data, illustrated in Table 7 above. It indicates the zones and their corresponding total trips from home and total trips to work, based on residents and employees respectively.

The model calibration details are built in the program. This allows the processing of trip generation and trip distribution. Trip generation includes the trip rates by purpose, trip rates by municipality and planning zone, while trip distribution includes data on the parameters, average trip length or duration and mode choice.

Once processing is made, home based work and non-work trips are extracted from the QSTM Model 2015. They are categorized by various modes of mobility including private car (alone/ and car pooling), bus, taxi, walking, biking, etc. The different land use factors of density, regional accessibility, mix and connectivity have impacted travel behavior in the following study areas as follow.

For both zones 14 and 36, the mode of transportation is dependent on the person's nationality, gender, income, and car availability. As per Figure 22 private car's is the dominating mode of transport among men of high income and woman with car availability. Woman without cars and children are commonly passengers, while those people of the population with low income or are laborers are those who usually walk.

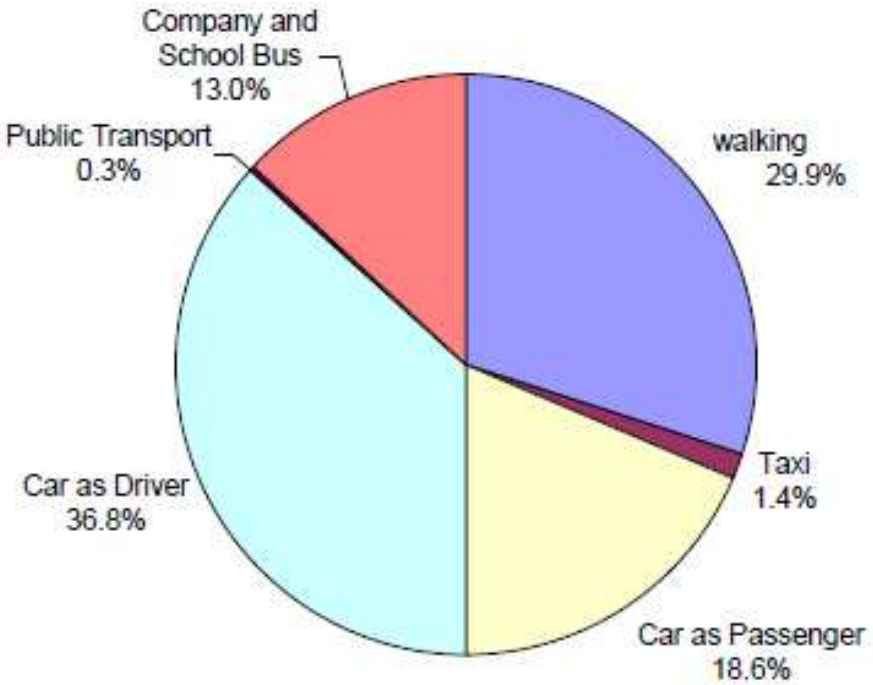

Figure 22. Modes of Transportation Qatar (source : Ministry of Development Planning and Statistics)

The number of residents residing in zone 14 is 9,986 with an average number of 18,059 home based non-work trips. The number of employees in the zone is 1,878 persons with an average number of 3,297 work based trips. Car drivers of private vehicles make up the greatest number of automobiles on streets. The area has an origin demand of 24,533 private vehicles and a destination demand of 24,542 private vehicles illustrated in Figure 23 and Figure 24, respectively. More than 59% of the residents use private transport for everyday use. Approximately 9% have reported riding buses and 32% employ walking.

Code 14

Name Fereej Abdel Aziz

Basis | OD demand | User-defined attributes

	DSeg	Origin demand	Destination dema	Internal trips
1	C Private Car	24533.599	24542.547	1530.077
2	CB Company Bus	116.791	116.791	8.202
3	HP Heavy Goods Vehicle (permitted)	476.140	476.180	1.710
4	HR Heavy Goods Vehicle (restricted)	0.000	0.000	0.000
5	L Light Goods Vehicles	801.267	801.245	4.280
6	X Public Transport	6883.949	6928.852	585.426

Figure 23. Origin- Destination Demand for Zone 14 Fereej Abdul Aziz (source: Qatar Strategic Transportation Model)

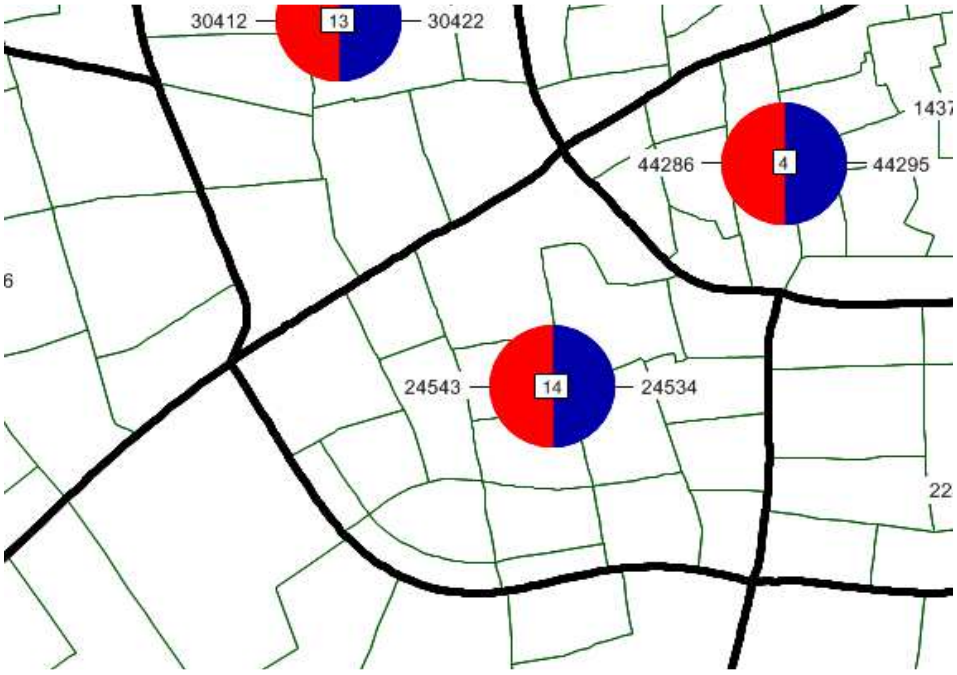

Figure 24. Origin – Destination Trips for Zone 14 (source: Qatar Strategic Transportation Model)

In the second study area, zone 36, the number of residents residing in the zone is 15,706 with an average number of 9,010 home based non-work trips. The number of employees in the zone is 2,154 persons with an average number of 2,718 work based trips. Car drivers of private vehicles make up the greatest number of automobiles on streets. The area has an origin demand of 8,620 private vehicles and a destination demand of 8,624 private vehicles illustrated in Figure 25 and Figure 26. Private vehicles are the most common mode of transport calculated at more than 72% of the total vehicle use. Approximately 16% have reported riding buses and walking has a share of 12%.

Code 36

Name Al Messila

Basis | OD demand | User-defined attributes

	DSeg	Origin demanc	stination dema	Internal trips
1	C Private Car	8619.929	8623.832	524.210
2	CB Company Bus	43.627	43.627	5.829
3	HP Heavy Goods Vehicle (permitted)	274.900	274.970	0.500
4	HR Heavy Goods Vehicle (restricted)	0.000	0.000	0.000
5	L Light Goods Vehicles	450.054	450.035	0.960
6	X Public Transport	2173.999	2163.524	61.677

Figure 25. Origin- Destination Demand for Zone Fereej Abdul Aziz (source: Qatar Strategic Transportation Model)

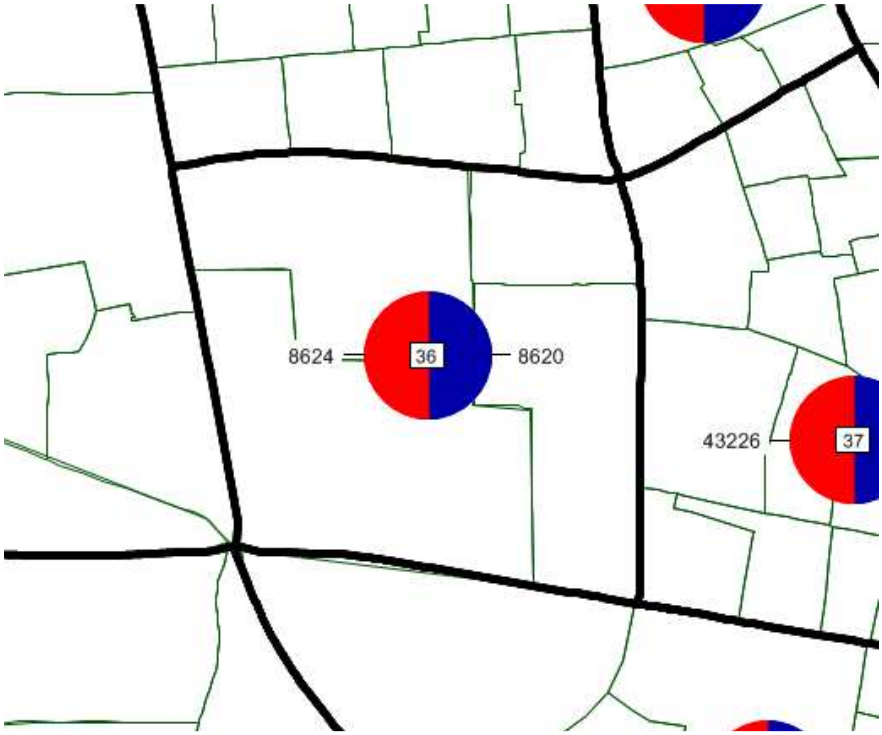

Figure 26. Origin – Destination Trips for Zone 36 (source: Qatar Strategic Transportation Model)

The data collection section demonstrates the gathering and measured information based on the identified variables in a systematic method. This section enables to respond to the main research questions and evaluate major findings, interpretation and discussion in the next chapter to follow.

CHAPTER 6: MAJOR FINDINGS: INTERPRETATION & DISCUSSION

This section presents the research interpretation and discussion in response to the land use planning impact on travel behavior. Land use factors have direct correlation and implication to one another. The urban land use factors including regional accessibility, land use mix, connectivity, and improved transit options are strongly associated with one another (Hamidi, 2014; Liu, 2007). This dissertation is focused on the relationship between built environment and travel behavior including vehicle ownership, mode of transport and home based trips, particularly for work and non-work trips. In both work and non-work based trips, land use impact's commuter decisions, and have a direct influence on travel behavior (Pritchard, 2014). This dissertation aims to investigate the level of influence land use factors have on travel behavior. Further to this, other findings have been made on home based trips, self-selection, travel behavior & land use impact and finally planning issues.

It is important to note that as per the Household and travel behavior surveys it is clear that individuals in dense central areas and in less concentrated spaces tend to use private transportation as a mean of travel. The only group of people that use other means of transport are the labor class. Labor class tends to use public transport or shared transport.

The land use maps Figure 19 and Figure 20 show that commercial areas and job locations are sprawled throughout both selected zone areas. Searching and securing a job demands flexibility and self selection from individuals. People's preferences do not

influence their job locations, so it is assumed that land use characteristics of the workplace in this case have little influence on travel behavior.

6.1 Home Based Trips

The Qatar Strategic Transportation Model calculates travel for work trips. The model evaluates the impact of built environment and socio-economic factors on home based work trips by different modes of transit. To understand different influences of land use variables, results have been categorized and are comparable, see Table 8. The results indicate that home based trips are largely influenced by the built environment.

Table 8. Comparison Study between Fereej Abdul Aziz and Al Messila (source: developed by author)

Built environment measures at buffer-based scale	**Fereej Abdul Aziz – Zone 14**	**Al Messila – Zone 36**
Entropy Density	0.28	0.23
Street Density	2,2228	8,643.3
Residential Density	29,513.4	3251
Distance from home to closest bus stop (m)	330	650

Table 8 illustrates a comparison between the land use attributes of Fereej Abdul Aziz and Al Messila Neighborhood. As per the table, Fereej Abdul Aziz district scored a higher Entropy value (0.28) indicating a varied land use mix and diversity, with Al Messila (0.23) not far from a comparable land use mix as that of Fereej Abdul Aziz. The existence of land use mix increases active transport among destinations and activities.

Providing for a range of activities in a district increases social interaction and undergoes multiple activities, in the one trip chain. The entropy index has an optimistic influence on the likelihood of travelling to work by public transport, and on non-motorized trips supported by the Qatar Strategic Transport Model. Hence, the lower diversity in land use the higher the probability for private transport travel to work and less by walking/cycling. The Entropy indexes in both zones show a similar relationship towards non-work trips. Results show that in higher entropy index and greater mixed land use, private car trips are less in use and non-motorized trips that obtain service shopping and other nearby activities are more.

Fereej Abdul Aziz urban neighborhood achieved a street density of 2,2228m/sq km amplifying that the study scope is more compact which achieved a much higher level of density in comparison to Al Messila neighborhood which achieved 8643.3m/sq Km. Fereej Abdul Aziz neighborhood is developed in compact short distance arrangement to facilitate land uses and public transportation. Literature studies imply that density has direct implications on travel behaviors by decreasing ownership of cars and VMT (Bhatia, 2008) and guides to an increase of walking and transit trips (Greenwald, 2009). It is evident that in the area of Fereej Abdul Aziz density is higher than Al Messila providing shorter distances between destinations, making accessibility higher for transit and increasing encouragement to walk. Despite street density not having affected major travel behavior impacts, internal connectivity endorsed larger car trips and greater public transit and walking.

High street density increases connectivity, reduces travel distances and increases public transport route options (Cervero, 2010). In this study, however, the neighborhood with higher density Fereej Abdul Aziz provides more accessibility for private car use, generates greater congestion and lacks pedestrian safety. The lack of pedestrian safety measures thereof lead to decreased walking and cycling in the area. The same can be implied for internal street connectivity; whereby walking and cycling trips are minimized and car trips are increased. The results indicate that people with greater street connectivity are inclined to use non-motorized trips, due to the unsafe pathways and lack of pedestrian facilities.

As an overall, Fereej Abdul Aziz generated a higher density, mixed use and complete planning than Al Messila, and has the potential to achieve a high regenerative symbiotic district. The district is planned and designed with a dense mixed use urban fabric with the ability to reduce green house gas emission and reduce resource use to assist in decreasing the environmental footprint of the city and urban sprawl.

The high mixed use density has lead to higher concentration of economically active population in the central zones of Doha's main economic centre. The district of Al Fareej has varied land use types that also contribute to an active population and increased trips. The neighborhood has the outer circumference and one boulevard populated with high density commercial strips also contributing to increased trip generation. While the central uses are multifamily residential buildings.

Residential and job densities in both zones affect people's travel behavior. Thereby residents in denser zones (Fereej Abdul Aziz) use more public transport and walking/cycling modes to travel to work and non-work. This is achievable when options are made available. However, for both study areas negligence is evident in the lack of public transportation and urban landscape sector. This limits people's options and enforces continued private motorized vehicles transit.

There is little consideration provided towards the public realm sector resulting to uninviting spaces. Design limitation towards the public realm limits people's willingness to leave their cars and engage in walking and/or use public transport. It is evident that both study areas lack walking facilities due to the strong summer heat and humidity in this part of the world. The majority of the pedestrian network in Doha have non conforming spaces and sidewalks that discourage pedestrians from walking. There is consistent evidence in research that mixed land use (i.e. the presence of multiple destinations) is a critical element in enabling a neighborhood's walkability but that alone does little to enforcing people to engage in non-motorized transport modes. Other means of incentives need to be put in place to attract non-motorized transport and public transport.

The distance from home to nearest bus stand are distant, influencing increased car trips and under-utilization of non-motorized and public transportation. As per the analysis, it is clear that Zone 14 Fereej Abdul Aziz has a closer measured distance to public transport nodes, offering a seamless connectivity that supports the existing and

future economy and transition of Qatar. Closer distances assist in the transition from a private vehicle based society to a modern, sustainable, multi modal society.

Density is considered to be the most influential factor of built environment on work trips. The socioeconomic elements are in agreement with the cultural prospect. Females in Qatar are less likely to drive and are leaning towards drivers dropping them off. This is in association with the findings of recent research showing that males use private vehicles to work (Tiwari, 2016). Also, the more distant the work place is, the greater the travel distance and travel trips and the fewer non-motorized trips performed. Also, residential characteristics, comprising the amount of workers and amount of private cars effect traveler's decisions. Adults with access to private vehicles rely significantly on using them and are less interested in using public transit and non-motorized modes. Also people with high income and vehicle ownership are one of the most influential actors of travel behavior and mostly use private vehicles to travel.

6.2 Self Selection

Another element that impacts travel behavior is self selection. The opportunity for travelers to select their travel chains as per their preference, cost and benefits to obtain desired activities (Cao, 2014) may it be work or non work trips .The land use factors of the built environment influence travel chains through altering trip opportunities. Self selection puzzles the relationship between the built environment and travel behaviors and thus hold a crucial suggestion of land use for impacting travel behavior (TRBIOM, 2005).

Residential self-selection is the relation among travel behavior and built environment and therefore brings important suggestions in regard to land use and transportation efficiency. Empirical studies illustrate that the emergence of self selection in understanding individuals' travel behavior is important (Mokhtarian, 2002). In addition to the basic needs decision making, travel behavior is determined by peoples' attitudes towards travel (Salomon, 2001).

For the purpose of this study, it is crucial to account for the individuals' decision making on selecting preferred neighborhood. Residents make choices based on the socioeconomic characters of the neighborhood. In this section home based work and non-work trips are not considered as they both share the same endogenous factors. It is apparent that the built environment variables are largely linked with the socioeconomic factors, thus imposing that various individuals live in different locations and transport differently. For example people with higher income live in districts with less residential density and less job densities, in areas with greater travel distances to sub centers and Central Business District similar to the case of Al Messila. Thereby the decision of higher income residents are linked directly to their transport behavior including; lower tendency to use public transit or walking trips, low residential and job density, less mixed land uses, higher street density and further away from the Central Business District.

6.3 Travel Behavior and its Impact from Land Use

Land use planning and self-selection have direct implication on travel behavior. It is found that as density increases automobile use, travel declines through increased proximity and availability of transport modes (Davis, 2001). However, in the case of Qatar this has not been achieved due to the high dependency on private vehicle and scattered land uses.

The district of Fereej Abdul Aziz and Al Messila have varied land use types that contribute to an active population, trips and travel behavior. In Fereej Abdul Aziz's neighborhood the outer circumference and internal street split the block into two areas occupied by high density (Ground+10) commercial strips. The strips generate high trips at a rate of 12.771 trips/100sqm of Gross Floor Area as per the Dubai trip generation and parking rates manual (DTGPRM, 2013). The central spaces are occupied by high density (10 stories high) multi residential housing and a few public schools. The multi residential housing has a rate of 0.5 trips/ number of units while schools have a respective rate of 2.7 trips/ 100 sqm of Gross Floor Area. Table 9 illustrates the population density and population growth for the years 2004, 2006, 2010 and 2015. It is evident that from 2010 to 2015 Fereej Abdul Aziz witnessed great boom in the area. This resulted to a total number of 28,403 home trips for the total 15,706 residents in 2015, illustrated in Table 10. Of those 1,877 persons are employed with a generated 3,296 work trips as per Qatar Strategic Transportation Model.

Table 9. Fereej Abdul Aziz Density and Population Over the Years (source: developed by author)

Year	Zone	Population Density Km2	Area in Km	Population
2015	14 Fereej Abdul Aziz	29,513.4	0.5	15,706
2010	14 Fereej Abdul Aziz	20,309.5	0.5	10,808
2006	14 Fereej Abdul Aziz	18,770.7	0.5	9,986
2004	14 Fereej Abdul Aziz	17,641.0	0.5	9,385

Table 10. Fereej Abdul Aziz Trips (source: developed by author)

	Total Trips from Home			Trips to Work		
Year	**Residents**	**No. of Trips**	**Trip Rate per Resident**	**Employee**	**No. of Trips**	**Trip Rater per Employee**
2006	9,986	18,059	1.81	1,194	2,096	1.76
2015	15,706	28,403	1.81	1,878	3,297	1.76

In Al Messila neighborhood multifamily residential (Ground+1+Pent) are the dominating land use at a covered area of 56% from the total district, imposing little traffic generation in this area. Multifamily residential land use has a trip generation rate at 0.5 trips/ number of units as per the Dubai trip generation and parking rates manual. The district has one edge of the block occupied by a commercial souq strip at the North of the development. Al Messila has a trip generation rate of 12.771 trips/100sqm of Gross Floor Area (DTGPRM, 2013). The rest of the neighborhood is composed of multifamily Residential use (Ground+2). The trip generation rate for multifamily residential is 6.3 trips/ number of units and schools have a trip generation rate of 2.7 trips/ number of units (DTGPRM, 2013).

Table 11 illustrated the population density and population growth for the years 2004, 2006, 2010, and 2015. It is evident that from 2006 onwards Al Messila witnessed a great boom with a consistent growth rate.

This results to a total number of 9,010 home trips for the total 6,803 residents in 2015 as illustrated in Table 12. Of those 2,155 persons are employed with a generated 2,718 work trips as per Qatar Strategic Transportation Model.

Table 11. Al Messila Density and Population Over the Years (source: developed by author)

Year	Zone	Population Density Km2	Area in Km	Population
2015	36 Al Messila	3,251	2.1	6,803
2010	36 Al Messila	2,257	2.1	4,716
2006	36 Al Messila	1,361	2.1	2,845
2004	36 Al Messila	1,428	2.1	2,984

Table 12. Al Messila Trips (source: developed by author)

	Total Trips from Home			Trips to Work		
Year	**Residents**	**No. of Trips**	**Trip Rate per Resident**	**Employee**	**No. of Trips**	**Trip Rater per Employee**
2006	2,845	3,768	1.32	901	1,137	1.26
2015	6,803	9,010	1.32	2,155	2,719	1.26

6.4 Planning Issues

This chapter covers key planning issues which will assist in establishing policies and parameters that will influence how planning can be managed today and in the future. In an effort to meet future demand, decision makers need to take advantage of opportunities in response to issues. It is critical to raise awareness among policy makers, department of transportation and planning, and the public in regard to the magnitude of planning issues and safety problems. Land use planning and transportation investments shall trigger to reduce the number of issues.

"The high dependency of private transportation has led to increased traffic and congestion on Qatar's roads. The condition appears as use increases. This leads to slower vehicle speeds, longer trip times and longer queuing length", stated Ahmed Seyam. He added "that despite the common practice in Qatar, streets are designed with a capacity that withstands large volumes of vehicles. However, the one user private vehicle ownership is high that street capacity are overflowed setting in extreme traffic congestion".

Environmental concerns are also on the rise as a consequence; household members are exposed to pollutants, which affect the health of individuals and children. Smoke and odors from car exhaust affect 7% of high standard living Qatari and 20% of the low standard living Qataris (source: Statistics, 2015).

Table 13 illustrates the percentage of Qatari individual's exposed to smoke and odor pollutions from cars.

Table 13. Percentage of Qatari Individuals Exposed to Pollutants (source: Ministry of Development Planning and Statistics)

Pollutants	Highest Standard of Living Qataris	Lowest Standard of Living Qataris	Total
Smoke and odours from car exhaust	6.7	19.8	7.4

Duncan Fox is concerned with the people lifestyles as a consequence of high dependency on transportation. He stated that "as people depend highly on private transportation, physical fitness levels decrease. The importance of general health and well-being of people needs to be re-established". Changing people's life styles and providing opportunities for walk-ability shall improve the body's ability to function efficiently and effectively in all aspects of life, including work, leisure etc.

Another transportation issue key that Duncan Fox mentioned is in relation to costs associated with traffic including accidents, consumers and infrastructure. Large mentioned that large numbers are invested in societal costs associated with vehicles accidents as a consequence of frustrated drivers and congestion.

There is an urge to introduce an instrument to respond to the heavy traffic, congested roads, pollution, and other external costs associated with private ownership.

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

This chapter of the research includes three section including the policies and guidelines, conclusion, and limitation and future research opportunities.

It has become evident throughout the course of research that land use planning carries great impact on travel behavior. Many forces come in perspective when influencing the urban fabric and form of a city. For that reason it is critical to control and put constraints on the way our cities grow and mature. Therefore, a number of policies and guidelines are then proposed in section two, as an instrument to shed light to the main research question, aim and supporting objectives.

The second section is the conclusion, which draws a conclusion to the thesis representing the contribution towards knowledge. Finally the last section covers the limitations and future research opportunities underpinned for this thesis. This section contains the various limitation and restraint obstructed throughout the course of preparing the research. It also covers future research opportunities underpinned for this thesis.

7.1 Policies and Guidelines

The thesis assesses the impact of land use planning on travel behavior. As a developing country with a fast movement, Qatar appears to be an icon and a potential to become a magnet for trading and tourism. There is an urge to introduce an instrument to respond to the heavy traffic, congested roads, pollution, and other external costs associated with private ownership.

The findings of this thesis work to contribute to policy planning guidelines. These guidelines may assist multiple entities in Qatar to control travel behavior. Such entities include Urban Planner of Ministry of Municipality and Environment (MME) and Transport Planners of Ashgal, Qatar Rail and Ministry of Transportation and Communication (MoTC). There is clear lack of integration and consistency of policies in Qatar. Therefore it is critical that both urban planners and transport planners work in conjunction to one another to ensure sounds integration of land use and transport policies and systems.

The land use planning guidelines and recommendation includes the consolidation of urban context via increased density and mixed use planning to encourage people to leave their car and allow for the continued development of public transit and transportation infrastructure. Enforcing stronger design control to create compact, dense mixed use urban environment will assist in decreasing the car use and encourage environmentally sustainable transport modes. It will also increase security, vitality, economic development of the area and promote shifts to transit non motorized modes. It is important to note that communities need to have high densities to support transit system.

In metropolitan increased densities from existing levels can be achieved to reduce private vehicle use. Regulations towards increasing density will result to decreased dependency on solo-commuting and increase the demand and use of public transportation.

Policies shall impose incentives to locate economic firms in dense high cost centers to ensure agglomeration benefits. This can be achieved in multiple imposed incentive structure, by introducing subsidies to encourage firm to locate in core area, or enforcing additional costs where it in not advisable.

Self selection and housing demand is dependent on household income. As income increase, so does the demand for housing. People demand more spacious living space in suburban locations. As such they willingly give up the luxury of access to job, amenities etc. While others prefer urban living; these include young single persons, these people support high density policies. Policies need to be set up to balance household from settling in high density areas through reducing the number of zoning restrictions.

Planning policies need to be established to foster location of major traffic, limit new developments and balance jobs and housing. Controlling built environment will affect travel behavior in light of the population and employment trends identified earlier in this thesis. It is reasonable to say that such policies with slow down the process of decentralization.

Each community shall have schools, infrastructure, amenities and services that support and serve its neighborhood. They shall also have a measureable built environment in respect to distances from home to work and non work trips. Policies shall be initiated to locate land use planning to nearby centers. That is to enable reaching desired destination, services and local shopping's through local networks. This shall also be supported by sustainable choice of travel modes.

Another is the relocation of land use to more compatible land use to create pedestrian friendly neighborhoods, typically in suburban distant from major job centers and accessible through automobile and public transport. These communities would have many benefits but the likelihood of private vehicle is one of them.

Another land use policy should aim to introduce varied public transport modes with incentives that encourage locals and non-locals to use these modes of transport. These incentive may include locating transit stops strategically, being cost efficient and /or time efficient. Another incremental change that would significantly control travel behavior is the encouragement to resort to mode shares.

Enhancement should also be invested in streetscape character to provide pedestrian friendly walking environment. The neighborhood environment should promote sidewalk, short walking distance routes to desired land use destinations, shading devices and street furniture.

It advocates more so than providing provision for private transport, the neighborhood should have pedestrian design priority in the network circulation in areas between home, work and recreation. Policies towards providing for side walk will play a significant role in encouraging commuters to use public transport and engage in car pooling.

But it is important to note that as density increases consideration needs to be made towards the city growth. As the city grows so greatly their overall metabolic rate, which is the rate of the city's resource consumption (material, water and energy), also grows.

Increase in the of the city's metabolism needs to be controlled through the introduction of planning policies and procedures.

Land use planning and transportation planning policy interventions can be an effective means to manage automobile use and travel behavior. The policies and guidelines look at three dimensions of the urban form including density, diversity and design. It can be concluded that policies towards density and mixed land use influence public transport use, car pooling and solo-community.

7.2 Conclusion

It has been imposed that land use patterns influence accessibility, being driven by people's ability to reach desired services and activities. This in turn influences mobility and thus the type and amount of travel activity. It is unfortunate to note that Qatar is experiencing congested road networks and environmental concerns as a result of unplanned land use distribution.

This thesis research examined the extent land use planning influenced travel behavior. An analysis for travel behavior patterns has been carried out for both of the study areas. Namely, these are Fereej Abdul Aziz and Al Messila which have been examined with respect to home based travels to work and non-work trips. Through site observations, interviews, secondary data and the Qatar Strategic Transport Model we are able to understand and assess travel pattern mechanisms in the fast growing economy of Qatar.

It is established that self-selection and land use are both crucial deciding elements influencing travel behavior with emphasis to work and non work trips. Factors of the built environment influence travel chains through altering trip opportunities. Self selections puzzle the relationship between the built environment and travel behaviors and thus hold a crucial suggestion of land use for impacting travel behavior.

As for the land use factors, density is the most influential factor of urban fabric on work trips. The entropy index has a constructive influence on the possibility of travelling to work by transit and non-motorized trips. Higher density is found to provide more accessibility for car use leading to greater congestion and safety concerns rise for unequipped pedestrian walkways. Negligence is evident in the public transportation provision and there is a deficiency in the pedestrian urban mobility sector. The findings also illustrate that distances to nearest bus stops are great thus discouraging their use.

Furthermore, it is crucial to point out that the outcomes reveal the commuter's decision towards travel trips. The more distant the work place is to a household, the greater the distance travelled and thus less non-motorized trips are made. Also, household and neighborhood characteristics play a role in the commuter's decision. Depending on the community's number of employee's and number of private cars, commuter decisions are made.

As part of the findings, a set of issues have been identified. These include the generation of heavy traffic, congested roads, pollution, and other external costs associated with private ownership. These issues have led to safety concerns and environmental issues which in turn led to the introduction of policies and guidelines.

The land use policies and guidelines are aimed to control and achieve sustainable efficient planning objectives. These policies and guidelines shall be governed by governmental and/or private entities of Qatar to ensure implementation.

Policies shall support increased consolidation of urban landscape through high density of mixed use planning. This will aim to get people out of their car and support continued development of public transit and infrastructure.

Planning policies need to be established to foster location of major traffic, limit new developments and balance jobs and housing. Controlling built environment will affect travel behavior in light of the population and employment trends. Also, land use policies should aim to introduce pedestrian friendly neighborhoods and varied public transport modes with incentive to encourage locals and non-locals to use these public modes of transport.

The policies are aimed to incorporate land use planning and transportation planning. The methods at which these policies can be enforced and implemented are through incentive strategies. Another notably efficient method to improve policies is via the increased level of public awareness towards travel behavior.

Despite the mentioned policies for implementation, the impact of land use planning is not conclusive in this dissertation. Only two neighborhoods have been studied, as such future research shall be engaged to seek more cases to strongly conclude on this topic. Future research is necessary to support the identified policy statement and revitalize and sustain Doha's streets.

7.3 Limitations and Future Research Opportunities

Over the last decade Qatar has witnessed a rapid growth in its economic and industrial sector that transformed small port cities to large sprawling metropolitan as a result of oil and gas economies.

The city began to witness down falls due to lack of implementation of master plans, poor land use planning and lack of processes (Rizzo, 2014). Urban communities depended highly on motorized movement and cities became uninviting and poorly designed. Current studies imply that car ownership in fast rapid markets has been peaked. This is due to the economic augmentation and rising incomes.

In response to analyzing the relationship between land use and travel behavior the research had limitation. Firstly, the analysis of data has a few limitations in regard to the selected data collection and statistics. Most of the analysis conducted is calculated at a large scale implying that accuracy may not be so high. As such the calculations may be deceptive.

Secondly, the research methodology had a limitation in regard to conducting direct consultation including interviews and questionnaires within the selected units of analysis. This is due to the economic level in the study area; Fereej Abdul Aziz district is mainly composed of labor working class which makes communication difficult and makes it complex for women to enter the area.

Thirdly, the data collection used for the analysis of the research is for the year 2015 rather than 2016 which may not provide the most current situation of the travel behavior character and situation.

With the limitations of study scale and the setting of area from a social, cultural or economical perspective it is difficult to identify whether the differences reported are significant. It is questionable how strongly related the land use planning is to travel behavior. Despite the mentioned policies for implementation, the impact of land use planning is not conclusive in this dissertation. Only two neighborhoods have been studied, as such future research shall be engaged to seek more cases to strongly conclude on this topic. Future research is necessary to support the identified policy statement and revitalize and sustain Doha's streets.

REFERENCES

Adham, K. (2008). Rediscovering the Island: Doha`s Urbanity from Pearls to Spectacle, in Elsheshtawy, Y., ed. *The Evolving Arab City*.

Aditjandra, P. T. (2012). Understanding neighbourhood design impact on travel behaviour. *World Transit Report*.

Ardeshiri, R. (2016). The impacts of built environment on home-based work and non-work trips: An empirical study from Iran. *El Sevier, A*, 196-207.

Bernick, M., & Cervero, R. (1997). *Transit Villages for the 21st Century*. New York: McGraw-Hill.

Bhatia, V. (2008). Genre Analysis, ESP and Professional Practice. *English for Specific Purposes*, 161-174.

Bose, J., & Sharp, J. (2003). Measurement of Travel Behaviour in a Trip-Based Survey Versus a Time Use Survey: A Comparative Analysis of Travel Estimates Using the 2001 National Household Travel Survey and the 2003 American Time Use Survey. *Bureau of Transportation Statistics, Department of Transportation*, 1-43.

Bose, J., Joy. (2003). Measurement of Travel Behaviour in a Trip-Based Survey Versus a Time Use Survey: A Comparative Analysis of Travel Estimates Using the 2001 National Household Travel Survey and the 2003 American Time Use Survey. *Bureau of Transportation Statistics, Department of Transportation*, 1-43.

Brownstone, J. (2013). The Impact of Residential Density on Vehicle Usage and Fuel Consumption: Evidence from National Samples.

Butler, S. (2004). Planning for Street Connectivity: Getting From Here to There.

Cao, X. (2014). Residential self-selection in the relationships between the built environment and travel begaviour: Introduction to the special issue. *Journal of Transport and Land Use* 1-3.

Cao, X. (2014). Residential self-selection in the relationships between the built environment and travel behabior: Introduction to the special issue. *Journal of Transport and Land Use* 1-3.

Cervero, R. (2000). Walk-and-Ride: Factors Influencing Pedestrian Access to Transit. *Journal of Public Transportation, 3*(4), 1-23.

Cervero, R., & Kockelman, K. (1997). Travel Demand and the 3Ds: Density, diversity adn Design. *Transportation Research: Transport & Environment, 3*(2), 199-219.

Cervero, R. (2010). Travel and the Built Environment: A Meta-Analysis. *Journal of the American Planning Association, 76*, 265-294.

Chatman, R. (2003). Traffic and Sprawl: Evidence from U.S. Communting, 1985 To 1997. *Planning and Markets, 6*(1).

Chen, R. (2002). Measuring Sprawl and Its Impacts.

Crane, M. (2001). The influence of land use on travel behavior: specification and estimation strategies. *Transportation Research Part A*.

Crane, R. (2000). The Influence of Urban Form on Travel: An Interpretive Review. *Cambridge Systematics*

Davis, G. (2001). Land Use and Travel Choices in the Twin Cities.

DEACON, L. (2013). PLANNING SIDEWALKS: IMPLICATIONS OF REGULATING SIDEWALK SPACE IN THE EAST VILLAGE. *SUBMITTED IN PARTIAL*

FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE MASTER OF SCIENCE IN URBAN PLANNING.

Dill, J. (2005). Measuring Network Connectivity for Bicycling and Walking.

DTGPRM, G. (2013). Dubai Trip Generation and Parking Rates Manual

Duncan, R. (2002). Residential Self Selection and Rail Commuting: A Nested Logit Analysis. *University of California Transportation Center*.

Dyck, F. (2011). Reading space to 'address' spatial quality *Spatial Innovation planning design and user involvement*

Eidlen, E. (2010). What Density Doesn't Tell Us About Sprawl. 2-9.

Environment, M. o. M. a. (2017). Doha Municipality Location Plan from http://geoportal.gisqatar.org.qa/qmap/index.html

Esmaeili, A. (2011). The influence of urban physical form on trip generation evidence from metropolitan Shiraz Iran. *Indian J Scientific Technology 4*.

Ewing, R. (1995). Beyond Density. Mode Choice, And Single-Purpose Trips. *49*, 15-24.

Faggion, R. (2015). The Development of Vital Precincts in Doha: Urban Regeneration and Soci- CUltural Factors. *American Joruanl of Engineering* 120-129.

Faggion, R. (2015). The Development of Vital Precincts in Doha: Urban Regeneration and Socio-Cultural Factors. *American Journal of Environmental Engineering*, 120-129.

Frank, L. (2008). Urban form, travel time, and cost relationships with tour complexity and mode choice *Transportation 35*, 37-54.

Fromherz, A. (2012). *Qatar: A Modern History*. Washington, DC: Georgetown University Press.

Furlan, R., & Faggion, L. (2015). The Souq Waqif Heritage Site in Doha: Spatial Form and Livability. *American Journal of Environmental Engineering, 5*(5), 146-160.

Ghasrodashti, R., & Ardeshiri, M. (2016). The impacts of built environment on home-based work and non-work trips: An empirical study from Iran. *Transportation Research Part A: Policy and Practice*, 196-207.

Greenwald, G. (2009). Drug Decriminalization in Portugal: Lessons for Creating Fair and Successful

Drug Policies. *Cato Institute Whitepaper Series*.

Greenwald, M. (1999). Land Use, Urban Design, and Non-Work Travel: Reproducing for Portland, Oregon, Empirical Tests from other Urban Areas.

Guerra, R. (2011). Urban Densities and Transit: A Multi-dimensional Perspective. *UC Berkeley Center for Future Urban Transport*.

Hamida, R. (2014). Measuring Urban Sprawl and Validating Sprwal Measures.

Handy, M. (2010). Draft Policy Brief on the Impacts of Residential Density Based on a Review of the Empirical Literature.

Handy, R. (1998). Union Theological Seminary Archives 1.

Hanly, J. (2013). The impact of Land Use Patterns on Travel Behaviour. *Association for European Transport*.

Hanson, S. (1999). Overview of Transportation and Land Use Interactions. *Fedetal Highway Administration* 10-24.

Hanson, S. (1999). Overview of Transportation and Land Use Interactions *An Overview: Land Use and Economic Development in Statewide Transportation Planning* (pp. 10-24): Federal Highway Administration.

Hawkins, L. (2007). Fused Grid Assessment: Travel And Evironmental Impacts Of Contrasting Pedestrian And Vehicular Connectivity.

Heaton, A. (2015). Transit Oriented Development Will Transform Cities: Report

Holtzclaw, J. (1990). Explaining Urban Density and Transit Impacts on Auto Use. *Natural Resources Defense Council*.

. Home Sweet Home: A Growing Population is Driving Demand for More Affordable Housing. (2014), from http://www.oxfordbusinessgroup.com/analysis/home-sweet-home-growing-population-driving-demand-more-affordable-housing

Jensen, P. (2004). Urban Structure matters, even in Journal of Environmental Planning and Management.

JICA. (2011). The Research on Practical Approach for Urban Transport Planning.

Kahn, M. (2012). The Impact of Center City Economic and Cultural Vibrancy on Greenhouse Gas Emissions from Transportation.

Kenworthy, P. (2006). Opolis: An International Journal of Suburban and Metropolitan Studies. *2*(1).

Kockelman, K. (1997). Travel Behavior as a Function of Accessibility, Land Use Mixing, and Land Use Balance: Evidence from the San Francisco Bay Area. *Transportation Research Record 1607*, 117-125.

Kolko, J. (2011). Making the Most of Transit Density, Employment Growth, and Ridership Around New Stations.

Kuzmyak, R. (2012). Land Use and Traffic Congestion. *Arizona Department of Transportation*.

Larco, N. (2010). Overlooked Density: Re-Thinking Transportation Optins in Suburbia.

Li, C., & Lai, T. (2014). Sustainable Development and Transit-Oriented Development Cities in Taiwan

Litman, T. (2016a). Land Use Impacts on Transport. *Victoria Transport Policy Institute*, 0-70.

Litman, T. (2016b). Land Use Impacts on Transport. *Victoria Transport Policy Institute*.

Liu, H. (2007). Vehicle CO2 Emissions and the Compactness of Residential Development.

MacLean, H. (2004). Alternative transport fuels for the future. *Int. J. Vehicle Design, 35*.

Modarres, M. (1993). What Every Engineer Should Know About Reliability and Risk Analysis.

Naess, A. (2003). Arne Naess between Reason and Emotion.

Narayan, G. G. D. (2003). Another Look at Travel Patterns and Urban Form: The US and Great Britain. *Urban Stud, 40*.

Aditjandra, X., Mulley. (2012). Understanding neighbourhood design impact on travel behaviour: An application of structural equations model to a British metropolitan data. *Transportation Research Part A*, 22-32.

Perkins, C. (2002). Travel Behaviour:A review of recent literature. *Curtin University of Technology Urbanet*(3).

Peter, S. (2005). Travel behaviour of low-income residents: studying two contrasting locations in the city of Chennai, India. *Journal of Transport Geography, 13*, 265-274.

Planning, G. (2008). Qatar National Vision 2030. In http://www.mdps.gov.qa/portal/page/portal/gsdp_en/qatar_national_vision/qnv_2030_document/QNV2030_English_v2.pdf (Ed.).

Planning, M. o. M. U. (2016). The Center for GIS. *Qatar Statistics Authority, State of Qatar*.

Pratt, R. (2003). Land Use and Site Design: Traveler Repsonse To Transport System Changes.

Primerano, A. (2005). The Travel Effects of Community Design. *28th Australian Transport Research Forum*.

Pritchard, J. (2014). Spatial Analysis of Transportation-related Social Exclusion in the Lisbon Metropolitan Area *Science Direct: Procedia - Social and Behavioral Sciences Volume 111*, 440-449.

Radwan, K. (2014a). Rebuilding the Transportation System in the CIty of Doha. *Traffic and Logistics Engineering, 2*, 241-247.

Radwan, K. (2014b). Rebuilding the Transportation System in the City

of Doha. *Journal of Traffic and Logistics Engineering, 2*.

Rail, Q. (2016). Doha Metro from Randall Crane1

Ewing, e. (2010). Traffic Generated by Mixed-Use Developments - A Six-Region Study Using Consistent Built Environmental Measures. *Journal of Urban Planning and Development*.

Rizzo, A. (2013). Rapid urban development and national master planning in Arab Gulf countries. Qatar as a case study. *EL Sevier*.

Rizzo, A. (2014). Rapid urban development and national master planning in Arab Gulf countries. Qatar as a case study. *Research Group of Architecture, Lulea University of Technology*, 50-57.

SACOG. (2008). Impact of Gas Prices on Travel Behavior. *Sacramento Area Council of Governments*.

Sadhu, S., Tiwari, G. (2016). An activity pattern - destination land use choice model of low income households of informal settlements - Case study of Delhi. *Transportation Research Part A : Policy and Practice*, 265-275.

Shaaban, K., & Radwan, E. (2014). Rebuilding the Transportation System in the City of Doha. *Journal of Traffic and Logistics Engineering 2*(3), 241-247.

State, M. (2007). Access Management and Land Use Planning. Retrieved from

Tiwari, S. (2016). An activity pattern - destination land use choice model of low income households of informal settlements - Case study of Delhi. *Transportation Research and Injury Prevention Programme*(Transportation Research Part A), 265-275.

TRB-IOM, T.(2005). Does the built environment influence physical activity? Examining the evidence.

Vance, C., & Hedel, R. (2007). The impact of urban form on automobile travel: disentangling causation from correlation. *Springer Science + Business Media B.V.*, 575-588.

VTPI. (2008). Online TDM Encyclopedia. *Victoria Transport Policy Institute*.

Wee, B. (2016). Information, communication, travel behavior and accessibility. *The Journal of Transport and Land Use*, 1-16.

Wee, G. (2004). Accessibility evaluation of land use and transport strategies: Review and research directions. *Journal of Transport and Geography*, 127-140.

Wee, G. (2004). Accessibility evaluation of land use and transport strategies: Review and research directions. *Journal of Transport Geography* 127-140.

Wee, K. (2004). Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography 12*, 127-140.

Weitz, J. (2003). Jobs-Housing Balance' Planning Advisory Service Reports. *American Planning Association, Planning Advisory Service*.

Wiedmann, A. M. S. F. (2013). Evolving Urbanism of Cities on the Arabian Peninsula. *Open House International*, 4-5.

Witlox., V.. (2011). Going soft: on how subjective variables explain modal choices for leisure travel. *European Journal of Transport and Infrastructure Research*.

Wu, Q. (2016). Application of statistical index and index of entropy methods to landslide susceptibility assessment in Gongliu (Xinjiang, China). *Environ Earth Science*, 2-13.

Zaina, S. (2015). Integrated Approach for the Improvement of Human Comfort in the

Public Realm: The Case of the Corniche, the Linear Urban Link of Doha. *American Journal of Sociological Research, 5(3)*, 89-100.

Zaina, S. (2016). URBAN PLANNING IN QATAR: STRATEGIES AND VISION FOR THE DEVELOPMENT OF TRANSIT VILLAGES IN DOHA *Australian Planner*.

Zhang, X. (2013). Is Smart Growth Associated with Reductions in Carbon Dioxide Emissions? , 62-70.