QATAR UNIVERSITY

COLLEGE OF ENGINEERING

ASSESSING DOHA'S STREET NETWORK FROM THE PERSPECTIVE OF THE 'COMPLETE STREETS' CONCEPT

BY

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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

June 2017

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ABSTRACT

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Title: Assessing Doha's Street Network from the Perspective of 'Complete Streets' Concept

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Streets are considered dynamic spaces in cities, and their design should be safe, comfortable and efficient for all users. Well-functioning streets can create a healthy lifestyle for a city and its users. Many cities are suffering from transportation issues because of their poorly designed street networks that do not integrate the different modes of transportation, or establish safe environments in which pedestrian and cyclists are treated as kings. In this manner, Doha as a city is experiencing the same kind of problem, creating corridors that do not take into consideration different travel modes, which causes severe congestion, delay and shortage in street capacity and, most importantly, users' dissatisfaction. Therefore, there is a need to investigate and explore some methods that aim to improve cities' street networks. "Complete Streets" is a roadway design concept initiated with the intention of integrating numerous modes of transportation and their variety of users. Complete Streets are also envisioned to provide traffic, safety and public health benefits, and integrate a healthy lifestyle into built environments worldwide. The newly-emerging concept can be adapted in contexts that fail to combine the different street elements that a street should have. Considering the low quality of the current street network, this thesis aims to evaluate the current streets in Doha city based on the degree of users' satisfaction, and provide approaches to enhance them from the perspective of the

‘Complete Streets’ concept. The study analyzes two international case studies that have successfully implemented the concept and improved their current street network and enhanced users’ built environment. The analysis will help in extracting criteria that are used to assess the current performance of the street network and recommending ways to improve them. The methodological approach of this research will focus on the selection of two neighborhoods in Doha based on their contextual location and types of land use: a downtown area or urban center exemplified in Fereej bin Mahmoud, and a suburban area or residential district of Al Waab. Three nominated streets of the existing network within the two areas will be selected based on an evaluation matrix, and assessed according to the users’ perspectives and future preferences and aspirations. This approach is supported by two major data collection tools: a visual questionnaire survey and semi-structured interviews with local authorities. A total of 100 questionnaires were collected for the two selected areas from different types of users. Results showed that users are completely unsatisfied with the current conditions of the selected streets in the two areas, which lack the major components of Complete Street variables: pedestrian, bicycle, green and transit improvements, which has resulted in the absence of safety. The produced results along with the evaluation criteria have helped in improving the current streets’ designs and have created a new enhanced cross-section that meets the concept of Complete Streets.

Keywords: Street Network, Complete Streets, Modes of Integration.

DEDICATION

I dedicate my work to

Nema Ali Abou Daya

Abdelqader Sarhan

My mother and my husband who have supported me throughout the toughest times in my life, especially at this period, devoted themselves and encouraged me to accomplish my dreams and aspirations.

Also, I dedicate my thesis to my family members, brothers and sisters, for their sincere love and prayers.

I cherish your support

Thank you

ACKNOWLEDGMENTS

I would like to express my gratitude to my supervisors, Dr. Shaibu Bala Garba and Dr. Djamel Boussaa, for the useful comments, remarks and engagement through the learning process of this MS thesis. Also, I would like to thank the participants from different local authorities and companies who have willingly shared their precious time during the process of exploring the topic of this dissertation. I would like to thank my parents and friends, who have supported me throughout the entire process, by helping me to put together the pieces of my research. I will be grateful forever for all the support and encouragement provided during the last two years of my research.

Bassma Eissa AbouKalloub

June, 2017

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CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1.Introduction

In the last few centuries, cities have witnessed rapid growth and, as a result, complex issues have developed in the field of transportation. Doha, the study area, is a fast-growing city and has witnessed rapid expansion in the last few years. It started as a small central village and kept expanding to become a city with complex streets which are perceived as poorly designed and are therefore not well-used by the wide range of population, which has reached over 2.5 million (MDPS, 2017). This has led to the creation of problems in transportation exemplified by the creation of corridors that are purely for cars, lacking the integration of different modes of transportation, lack variety in land use and greenery, and which have resulted in the absence of an accessible, secure and safe environment. As a result of the mentioned issues, users' dissatisfaction is dominating the local atmosphere of the city with regard to the current condition of its streets.

Recently, planners have been working with new concepts and ideas to improve the existing status of roadway design and its conventional use. They are struggling to provide solutions that enhance people's way of living and improve their use of existing streets. 'Complete Streets' was initiated as a result of combining several street planning movements and concepts, which were discussed heavily in the last century (Rahman, et al., 2015). The general definition of a 'Complete Street' is one that is safe for all users including drivers, pedestrians, cyclists and transit riders. It is possible to adapt the

‘Complete Street’ concept in different contexts regardless of the region, as it aims to enhance and improve streets that lack the integration vehicle users and pedestrians. The ‘Complete Streets’ movement has widened the focus beyond cars, to planning the streets to be a dynamic and social space for all users to enjoy.

As a result of the current design, the existing streets are becoming inhabited by millions of cars, neglecting other transport elements and discouraging healthy travel modes exemplified by pedestrians and cyclists. For this reason, awareness is spreading among the residents of Doha to call for a change in the existing situation, and that is to create streets which are safe, comfortable and efficient, which the concept of ‘Complete Streets’ aims to accomplish, especially with the hosting of one of the major mega sports events; FIFA 2022.

In the context of Doha, residents of a neighborhood use a network of streets throughout their daily routines to get to their work and/or school, and for recreation. Unfortunately, the current street networks are not designed or built to be safe, accessible and efficient for users. Therefore, it is highly important to improve people’s safety when they are using the streets, along with improving the design of the street network. For this reason, it is essential to investigate the current performance of local streets in Doha city, and be able to accommodate positive changes and mitigate negative impacts on similar streets, not only in Doha, but in the whole region. The main challenge of the modifying the current streets of Doha is to accommodate users of different types of needs, exemplified in disabled users, women with baby strollers and so on.

1.2. Research Hypotheses and Questions

Over the years, there has been a development in understanding how transportation and street networks work within a city, and the latest concept to deal with this issue is the 'Complete Streets' concept, which focuses on the need to integrate different modes of travel along with implementing other elements that the concept comprises. The 'Complete Streets' concept provides a clear framework to improve issues and functions of current street networks in cities. This research also develops a set of hypotheses that draws on the research logic and understanding of the topic and also articulates statements to drive the research:

1- Doha street networks are not performing to the expectations of users.

2- The 'Complete Streets' concept can serve as an instrument for diagnosing the problems of Doha streets.

3- The 'Complete Streets' concept can provide a basis for recommending improvements to the current condition of Doha's street network.

1.3. Research Questions

This study aims to find answers to the following questions which are the spine of the theoretical framework of this thesis. The concept of 'Complete Streets' in reference to the current streets in Doha will be investigated through the following questions:

- How are the current streets of Doha hierarchically organized?

- How do the streets of Doha perform with respect to the expectation of their users?

- How can the concept of 'Complete Streets' provide us with criteria to judge and evaluate the performance of the current street network?

- How can the concept of 'Complete Streets' provide us with a basis for recommending improvements to the streets' current performance?

1.4. Research Objectives

Table 1: Research Questions and Objectives (Developed by the Author)

#	***Research Question***	***Research Objective***
1	How are the current streets of Doha hierarchically organized?	**Investigate** and study the existing hierarchical structure of the street network in Doha city based on route classification, functional aspect – *whether used for mobility or accessibility or both* – and the level of traffic volume in each category *(MMUP, 2015)*
2	How do the streets of Doha perform with respect to the expectation of their users?	**Assess** the current performance of streets in Doha, based on the perspective and preferences of users, and evaluate their level satisfaction towards the current street network.
3	How can the concept of 'Complete Street' provide us with criteria to judge and evaluate the performance of the current street network?	**Utilize** the 'Complete Streets' concept as an evaluation criterion to assess the current conditions of Doha's street network in terms of assessing the presence and absence of certain elements.
4	How can the concept of 'Complete Street' provide us with a basis for recommending improvements to the streets' current performance?	**Develop a set of Recommendations** and guidelines suggesting improvements to the current performance of Doha's existing streets, with different hierarchal classifications.

1.5.Research Design

The research was divided into chapters that drive the logic of this thesis, as illustrated in Figure 1. Chapter 1 and Chapter 2 introduce the main issue of this study, which is the current condition of Doha's street network, and analyze the negative effects it has on users' way of living, and also introduce the concept of 'Complete Streets' from the perspective of other researchers and practitioners by analyzing international case studies. Chapter 3 identifies the methodological approach of this thesis, selection of neighborhoods based on their diverse land uses and activities, the criteria for street selection, and evaluation of the street elements. Chapter 4 explains the context of the study, in which it explores the early formation of Doha city and its street network and planning, and also identifies the creation of the two selected neighborhoods. Chapters 5 and 6 include an assessment of the collected data and discussion of its findings, in addition to providing a set of recommendations and guidelines for the 'Complete Streets' enhancement plans for Doha's street network.

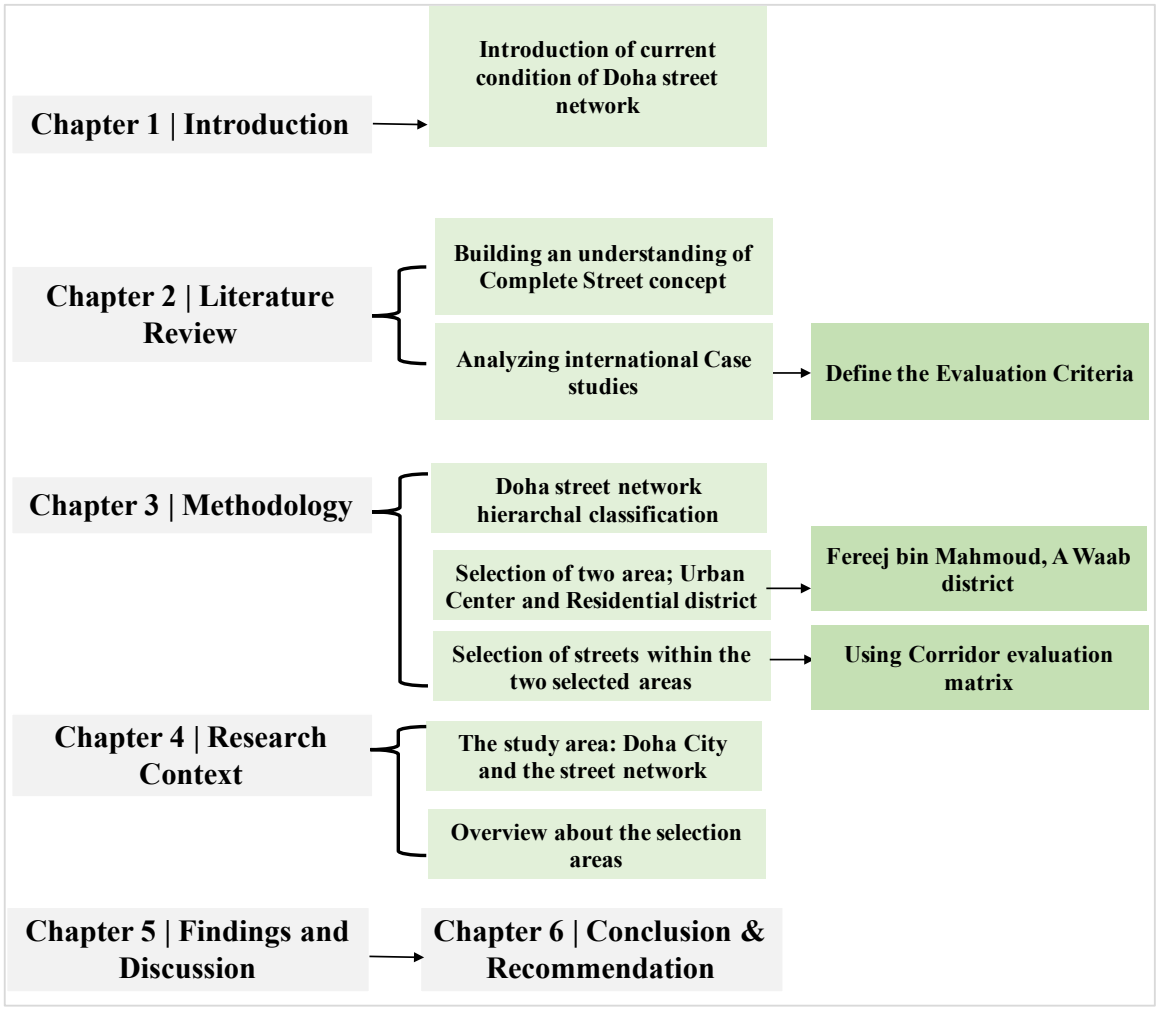


Figure 1: Outline of the Thesis

CHAPTER 2: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1. Introduction

This chapter provides a clear overview about the main core of this thesis, the concept of 'Complete Streets'. The chapter is based on reviewing literature that explores the concept of 'Complete Streets', the early formation of the concept and its role in enhancing existing streetscapes and providing a healthy way of living for users. Such concepts support users' safety in aspects related to walkability and bikeability, and their physical health, including their psychological well-being; community and economic vitality; and address varying environmental concerns. The chapter also explores the different studies that have been conducted by researchers, urban planners and practitioners on street enhancements with regard to 'Complete Streets', though analyzing two case studies. The aim of studying such case study is to investigate the utility of the concept and use it as a means for evaluating the street network and recommend enhancements that improve the users' built environment. Finally, this chapter will provide useful evaluation criteria for the 'Complete Streets' concept, extracted from analyzing the case studies, which can be used for studying the street network of Doha, which is the purpose of this thesis.

2.2. The Evolution of Streets in Cities

It is essential to observe the transformation of transportation in contemporary cities. Over the years, cities have developed and expanded in terms of urban areas to

accommodate the rapid increases in population. As a result, cities have become more complex in terms of transportation and street networks: automobile usage has significantly increased and many people no longer use the streets for walking (Millard, 2011). From this point, and since the twentieth century, authors and advocates including Kevin Lynch, Donald Appleyard, Jane Jacobs, Jan Gehl, Lewis Mumford and William Whyte have studied the effects of different types of streets on vehicular movement, social interaction and public activities in Europe and North America (Southworth and Ben-Joseph, 1997). Many of these authors presented the space that lies within the right-of-way as an idea for active uses generated by the users and which supports their activities. Further discussions focused on the role of streets as a space that houses public activities and boosts the street's vitality, in addition to integrating all modes of transportation and limiting traffic speeds through smart design to increase safety for all the different users (Gunnarsson, 2004).

Nowadays, streets in contemporary cities are an important component of the urban form and the most public of the urban spaces in a city (Rahman at al., 2015). The character of the street varies according to the purpose and function of the location, physical form and appearance, and socioeconomic and cultural characteristics of the inhabitants (Rahman at al., 2015). As a result, this may affect the users' needs and perceptions, which might be different from those of other street users in a certain built environment. In this manner, the design of streets in urban planning has been widely discussed and practiced throughout the years, and this includes the combination of a number of aspects that should be involved and which determine the success of their design.

2.3. Street Enhancement Movements

Researchers, planners and practitioners in the field of transportation are interested in studying significant drivers that have led to positive changes in the built environment within a city. This has led to the rise of several movements that suggest a better quality of living and moving throughout cities' corridors that promotes a healthier lifestyle, without being completely dependent on vehicles. That is when the 'Complete Streets' concept started to flourish as a collective concept of other suggested enhancement movements. The concept was initiated in the context of the US, as there was a desperate need to enhance many urban elements within the built environment and, most importantly, 'streets'. The following table shows a number of urban movements that sought to enhance the streets by evaluating and implementing a number of variables.

Table 2. Street Planning Movements, Definitions and Variables

#	Movement	Definition	Variables
1	**GREEN STREET**	Maximize permeable surfaces, tree canopy and landscaping elements, in addition to increasing urban green space.	• pedestrian • bicycle • multimodal modes of travel
2	**SHARED SPACE**	Creating spaces by removing traditional road separations between automobiles, pedestrians and other street users.	• pedestrian • children at play • bicyclists • vehicular movement
3	**SMART GROWTH**	The founding principle includes the idea of multi-modal transportation.	• walking • bicycling • transit • vehicular movement
4	**LIVING STREETS**	Integrating income, racial and social equity into the design and function of the street that works for people of all ages and physical abilities.	• green spaces • pedestrian • cyclists • reduced motorized transportation • continuous sidewalks • improved crosswalk • safety
5	**GREAT STREETS**	Includes the entire visual corridor, including the public realm and how it relates to the adjacent land uses.	• improved street network • pedestrian • landscaping • street furniture • capitalization on building design and scale.

Table 2 explains the movements that were suggested and practiced to enhance the current situation of streets in different contexts. These movements were eventually merged into a wider concept that collectively combines all the previous movements and their variables, 'Complete Streets', which aims to globalize the definition of street spaces shared by all.

2.4. Complete Streets: An Umbrella Concept

The term ‘Complete Streets’ is considered to be relatively new (McCann, 2010), but there have been a number of initiatives that share some goals with it, including context-sensitive solutions and urban street movements that have been developed in the recent decades (LaPlante, 2008). The first ‘Complete Streets’ policy was adopted in the city of Oregon, in the US, in 1971, in which cities and counties spent a reasonable amount of the state highway fund on facilities for pedestrians and cyclists, which are located on the public right-of-way (Patterson, 2013). It was quite difficult and took a long time to convince people and make them interested in these new facilities that considered cyclists and pedestrians, and placed less emphasis on vehicles. Until 2003, when the term ‘Complete Streets’ was coined by David Goldberg from Smart Growth America, there was no organized movement to advocate for a ‘Complete Streets’ design. The ‘Complete Streets’ movement was the first to advocate for ‘Complete Streets’ design; however, it was not the first to address the safety needs of all road users, as many previous movements and concept were able to address several key principles, but the ‘Complete Streets’ concept came to combine them.

2.4.1. Complete Streets Definitions

This literature review captures some of the definitions for the studied concept from the perspective of several resources and findings. Several definitions have been introduced to define the exact concept of ‘Complete Streets’ as follows:

- ‘Complete Streets’ are streets for everyone, designed and operated to enable safe access for all users, integrating pedestrians, bicyclists, motorists and public transportation users of all ages and abilities to safely move along and across a ‘Complete Streets’ (National Complete Streets Coalition [NCSC], 2010).

- The redefining of the purpose of the street and the development of integrated, connected networks of streets that are safe and accessible for all people, regardless of age, ability, income, ethnicity or chosen mode of travel. The concept also combines active transportation such as walking and bicycling convenient to provide increased access to employment, commerce and education (NCSC, 2012).

- A ‘Complete Streets’ policy encourages projects to be planned and designed to meet the needs of every type of resident or how they travel, which allows the community to save money, accommodate more people and create an environment for all to travel safely. These ‘Complete Streets’ policies may be achieved through a variety of methods including: state laws, local policy ordinances and resolutions; design manuals; inclusion in comprehensive plans; internal policies develop by transportation agencies; executive orders; and even policies developed by the community and agency staff and adopted by elected officials (McCann and Rynne, 2010).

- ‘Complete Streets’ can be defined as “planned, designed, operated, and maintained to provide safe mobility for all users, including bicyclists, pedestrians, transit riders,

and motorists appropriate to the function and context of the facility." (LaPlante, 2008).

- 'Complete Streets' is a concept that creates a city with highways which are safer, livable and inviting to pedestrians, bicyclists, the disabled, public transportation users and motorists (Caltrans, 2010).

2.5. Benefits of Complete Streets

The concept of 'Complete Streets', like other previous movements, was established to achieve a number of goals and objectives and works on accomplishing them for the sake of public health and improving the quality of the built environment for its users. The following benefits can be achieved through a successful implementation of the 'Complete Streets' concept:

- *Increased Transportation Choices:* In which streets that provide multiple travel choices can give people the option to avoid traffic congestion, and increase the overall capacity of the transportation network by providing accessible and efficient connections to different surrounding land uses.
- *Livable Communities:* The creation of multimodal travel options in streets with unique visual character would create a vibrant civic space that supports social interaction, increases public health, and boosts the local economy by establishing a living community.

- *More Walking and Bicycling:* Public health experts are encouraging walking and bicycling as a response to obesity, chronic disease epidemics and other diseases. Streets that provide room for bicycling and walking help children and adults get physical activity.
- *Improved Safety:* The safer the street design for bicyclists, pedestrians and transit users, the fewer traffic accidents there will be.
- *Accessible roadways:* Complete Streets concept provides a comfortable, clear and safe access and travel to streets by users with different needs and disabilities, exemplified in people who have difficulties to navigate without wheelchairs, have dimensioned vision, cannot hear well, or people who tend to move slowly.

2.6. Case Studies of Best Practices

For the purpose of this thesis, and in order to understand how the concept of 'Complete Streets' is practically implemented in streets which have deteriorated physically and socially, two case studies were examined. Because of the lack of researches in the field of street enhancements in the Middle East region, the following case studies were selected from the same context, in order to examine and critically analyze the concept's application on existing streets and to understand how such concepts in applied in streets that needs improvements. The study of the cases focused on the original status of streets that needed to be upgraded using the 'Complete Streets' concept as a means of evaluation and implementation. Generally, the main cause of this street renovation practice is the dissatisfaction of users; therefore, they were an essential part of the evaluation and

implementation process. The two case studies provided design solutions by implementing a number of variables that the 'Complete Streets' concept includes as recommended enhancements for streets. At the end of the sections, lessons learned are provided from the examination and the analysis of each case, which helped in establishing evaluation criteria that suit the context of Doha.

2.6.1. Case Study (1): Canyon Boulevard, Boulder, Colorado, USA

2.6.1.1. General Description

The City of Boulder, Colorado, USA, is known for its brilliant planning practices as well as its greenbelt, and the cycling culture that users initiated a long time ago (National Research Center, Inc, 2007). In 1996, the city decided that the current streets needed improvements that would encourage users to use other modes of transportation besides vehicles. At the same time, the city planners recognized that the area was expanding and the population was continuing to increase.

Figure 2. Location of Boulder City, CO (Google Maps, 2017)

2.6.1.2. Enhancement Plan Using the 'Complete Streets' Concept

The Transportation Master Plan (TMP) created the Multimodal Corridor Project, which included the enhancement of 10 existing streets that were considered to be extremely busy thorough the whole day (City of Boulder, 2006). The enhancement aimed to improve some of the existing elements and integrate some to construct a corridor that worked well for all modes and users, and by this time, the idea of implementing 'Complete Streets' concept and the construction was sue to begin in 2005 (City of Boulder, 2006). The plan focused mainly on Canyon Boulevard Street, one of the busiest corridors of the city with high traffic volumes, and had great potential for enhancement and improvement based on the 'Complete Streets' concept.

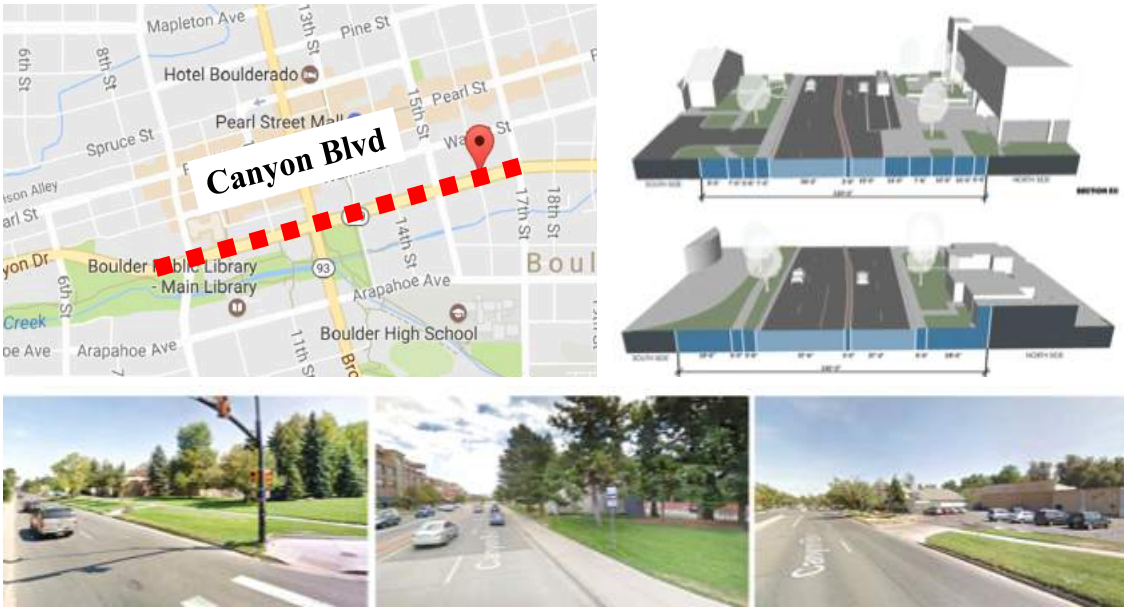


Figure 3. Location Map, Existing Cross-Sections, and Street Status (City of Boulder, 2015)

The plan followed four types of improvement areas: roadways, pedestrian right-of-way, bicycling and transit (City of Boulder, 2006). For the first aspect, roadways, the plan

was to reconstruct the areas in the roads that had deteriorated, in order to avoid any future maintenance problems and to save any additional costs, which were aims of the 'Complete Streets' concept.

Many existing streets in Boulder city, especially in Canyon Boulevard, lacked certain multimodal amenities in roadways such as complete sidewalks or intersection crosswalks. Thus, the plan aimed to address these missing aspects by reconnecting sidewalks and enhancing the existing crossings at most of the current intersections that needed to provide additional safety for the pedestrians. Additionally, more pedestrian signals and crossing count-downs were added (City of Boulder, 2006). In terms of bicycling, a large amount of bicycle trails needed to be added in a number of areas, in addition to connecting different trails to create a more unified network for cyclists all around the city, and adding bicycle route signage.

The last aspect that was considered is transit, in which Boulder City Council has implemented the high-frequency Community Transit Network (CTN). This network has seven main bus routes that provide residents with an easy way to get around the city if they do not own a vehicle (GO Boulder, 2010). These routes were improved with transit stops that contained new signs and pavement platforms (City of Boulder, 2006). For the busier transit stops, more amenities were inserted such as shelters, benches and trash receptacles. To increase the operational efficiency of the CTN system, improvements such as bus bypass lanes and bus signals prioritization were implemented. The enhancement plan aimed to create a buffered bike lane on both sides of the street, north and south amenity zones, sidewalks, tree rows, and a planted center median.

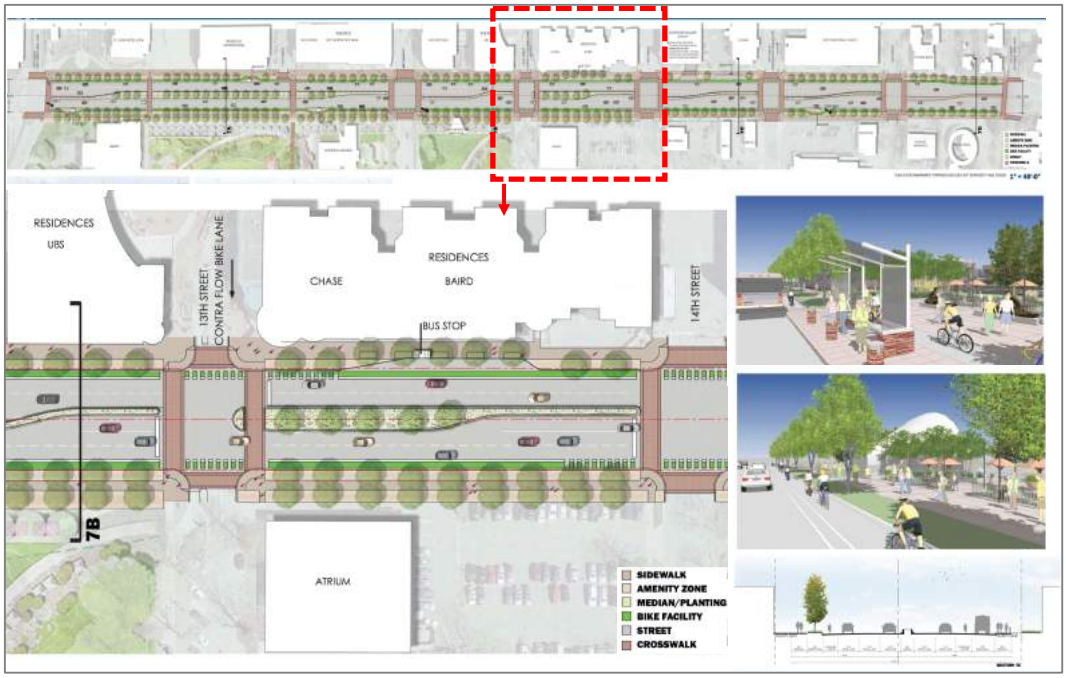


Figure 4. Illustrated Action plans showing the Complete Streets Concept in Canyon Blvd (City of Boulder, 2015)

Figure 5. Enhancements of Canyon Blvd after implementing the Complete Streets Concept (City of Boulder, 2015)

Canyon Blvd street design incorporated both new and improved facilities for vehicular, pedestrian and bicycle use in a way that was visually and artistically appealing, and which was all achieved by using 'Complete Streets' principles drawn by designers and planners. The multimodal corridors address environmental problems through design as well as

socially by encouraging other forms of transportation. Users are now enjoying travelling because of the successful implementation of the concept in a way in which it enhanced the corridors and the surrounding features (City of Boulder, 2015).

2.6.2. Case Study (2): N Miami Avenue, Miami, Florida, USA

2.6.2.1. General Description

In this case study, a portion of N Miami Avenue was chosen for 'Complete Streets' improvements. This corridor was chosen based on selection criteria founded by the Study Advisory Committee of Miami in order to select the appropriate corridor. Basically, the existing street design had on-street parking lots, while the Midtown area featured some landscaped medians. Miami-Dade Public Works decided to create an enhancement plan for the selected street since it lacked certain street features and suffered from heavy traffic, which its users found unsatisfactory (Miami-Dade, 2014).

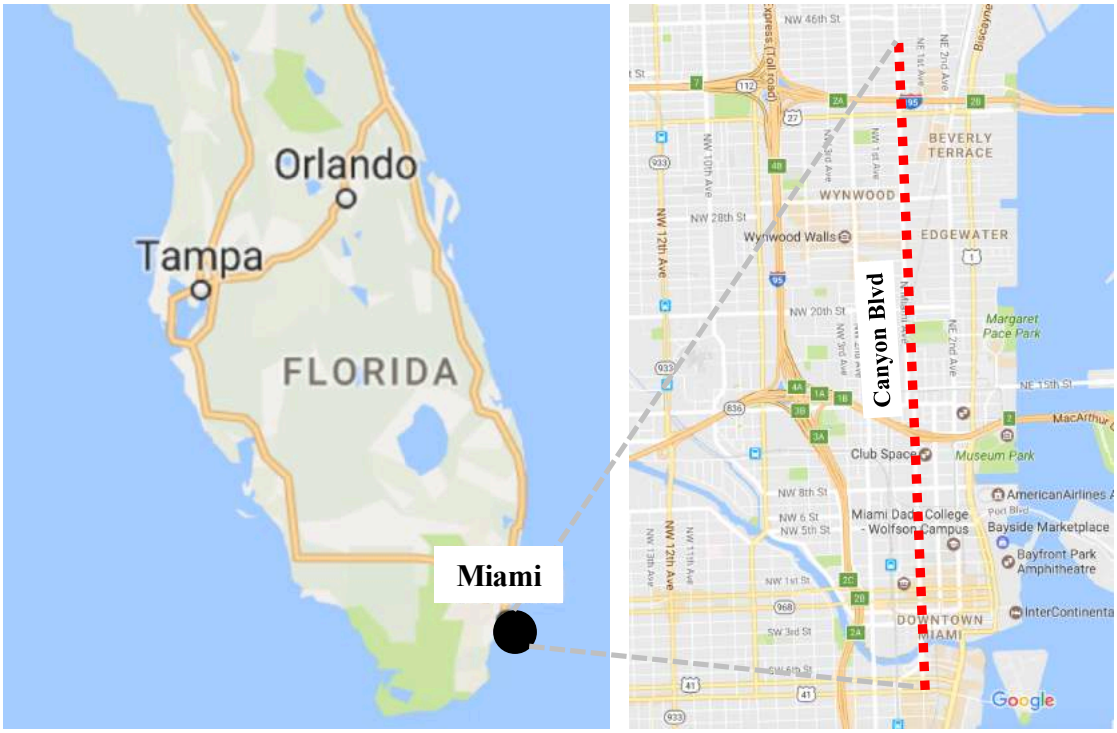


Figure 6. Location of North Miami Avenue, Florida (Google Maps, 2017)

The absence of street features is exemplified in the existence of very limited transit service and amenities such as bus stops and shelters, few crosswalks, which cause safety issues for pedestrian, in addition to lack of bicycle and pedestrian amenities. N Miami Avenue can be envisioned as a north- south bicycle corridor connecting downtown to Midtown and beyond.

2.6.2.2. Corridor Evaluation Criteria

In this case study, the selection criteria for the corridors followed the evaluation of a number of major aspects. These aspects were studied by the Study Advisory Committee of Miami, who voted on and selected corridors for further analysis. Each aspect was weighted with a scale from 1 to 3 to ensure the possibility of implementation. The higher the scores,

the higher the potential to provide enhancements.

- *The current condition of the corridor*

In this aspect, the decision to select a corridor was based on the potentiality and the level of possibility of implementing the 'Complete Streets' concept. The corridor must record high scores in the evaluation criteria matrix in order to be selected for the enhancement plan.

  - Low potential for 'Complete Streets' corridor consideration → (1)
  - Average score for 'Complete Streets' corridor consideration → (2)
  - Ideal for complete 'Complete Streets' consideration → (3)

- *Transit Level of Service*

Improving access to public transit is considered to be a major principle of the 'Complete Streets' concept and essential for promoting a multimodal approach to transportation. The availability of transit services in the designed corridor provides better access (Miami-Dade, 2012). A score was given to the bus trips throughout the day, significantly in the rush hour, as follows:

  - 0 – 2 bus trips during the peak hour →(1)
  - 3 – 5 bus trips during the peak hour →(2)
  - 6+ bus trips during the peak hour →(3)

- *Street Volumes*

Classifications of the street volumes is essential to investigate the potential for applying principles of the 'Complete Streets' concept. Street volumes are divided into three major

statuses: High, Medium and Low.

- 25,000+ ADT (High) → (1)
- 15 – 25,000 ADT or < 8,000 ADT (Medium/Moderate) → (2)
- 8 – 15,000 ADT (Low) → (3)

- *Right-of-Way (ROW)*

The ROW consists of the area that lies between the sidewalks and the amenity zones. Complete streets rely heavily on looking for opportunities to repurpose rights-of-way (ROW) to enhance connectivity for all users (Miami-Dade, 2012). Corridors that lack additional ROW have only a limited possibility of implementing the necessary elements of a Complete Street.

- Less than 5 feet of right-of-way → (1)
- 5 feet of right-of-way→ (2)
- More than 5 feet of right-of-way→ (3)

- *Activity Center Access*

Complete streets can support economic vitality by augmenting multimodal access to major activity centers (Miami-Dade, 2012). These activity centers can be generated from commercial nodes, mixed-use centers, institutional uses, to transit stations.

- No connection to any activity centers → (1)
- Connection to minor activity center(s) or close to connecting to major activity center(s)→ (2)
- Connection to major activity center(s) → (3)

- *Existing Pedestrian and Bicycle Infrastructure*

The ultimate vision for 'Complete Streets' is to provide a visually attractive and functional environment that provides convenient and safe movement for all users with diverse modes of transportation.

- Adequate bicycle/pedestrian facilities present → (1)
- Inadequate bicycle/pedestrian facilities present → (2)
- No bicycle lanes or wide sidewalks present → (3)

2.6.2.3. N Miami Avenue Land Use

The following maps display the existing and the future land uses within the corridor in 2014. It can be seen that the map of existing land use shows a variety of usage: industrial, commercial, residential, recreational and many more. On the other hand, the future land use map contains additional classifications of land use and activities based on their use and density, which helps in avoiding traffic and users being congested along the corridor at different times of the day.

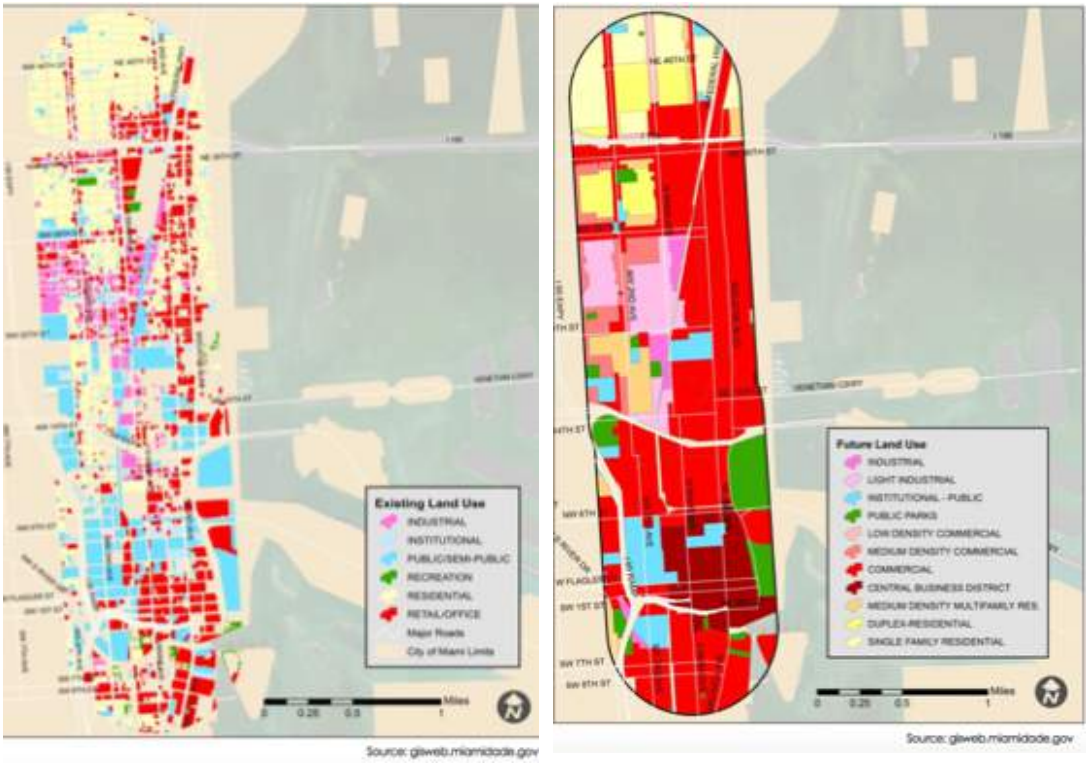


Figure 7. Existing and Future land use maps of N Miami Avenue (Miami-Dade, 2014)

2.6.2.4. Enhancement Plan for the Selected Corridor

The 'Complete Streets' recommendations followed in this case study focused on the area that lies within the existing curb-to-curb right-of-way, in an attempt to minimize the costs of the improvement plan. The plan focused on four major aspects: existing land uses and local activity centers, transit ridership, vehicular volumes, and the existing bicycle and pedestrian infrastructures. The 'Complete Streets' treatments for this corridor emphasized the importance of cyclists and accompanying amenities such as bicycle lanes, sharrows or shared-lane marking, and bicycle racks. In terms of pedestrian amenities, certain improvements were prioritized such as installing street trees, pedestrian-scaled

street lighting, enhanced crosswalks, benches and pedestrian refuge islands. A landscaped median was proposed if there was enough right-of-way.

Figure 8. Proposed Cross-Section of the Selected Corridor Using 'Complete Streets' Principles (Source: Miami-Dade, 2014)

Figure 9. The existing and the planned improved intersection of the selected corridor (Miami-Dade, 2014)

The following table shows the four major aspects of 'Complete Streets' that were implemented in the selected corridor, based on the absence of some of the discussed features, and the improvement actions that were conducted.

Table 3. 'Complete Streets' improvements applied to the selected corridor (Miami-Dade, 2014)

Pedestrian Improvements
Curb extensions/ bulbouts in front of transit shelters.
Add one bench and two trash receptacles for each side of each block.
Pedestrian-scale lighting throughout the corridor.

Bicycle Improvements
Add one bike rack on each side of each block.
Add a sharrow to the wide outside lane in each direction.

Green Improvements
Add landscaping/street trees throughout the corridor.

Transit Improvements
Bulbouts at all transit stops.
Replaced all stops with transit shelters.

Figure 10. The Existing and the Improved Street Features Using the 'Complete Streets' Concept (Miami-Dade, 2014)

This case study is another successful experiment in improving users' way of living by enhancing their built environment, focusing mainly on streets. The integration of different transportation modes created a healthy atmosphere in the selected corridor of N Miami Ave. The local authority has continued developing enhancement plans for the rest of the corridors in the state of Florida (Miami-Dade, 2014).

2.6.3. Lessons Learned from the Case Studies

The aim of studying the two case studies presented above was to examine the concept of 'Complete Streets' as a means of evaluation for streets that need improvements. The two selected case studies highlighted a number of principles that have been used as measuring criteria to evaluate and also to enhance street conditions. The following table illustrates a summary of the implementation actions conducted in the enhancement process based on the context of each corridor.

Table 4. Summary of the Two Analyzed Case Studies

Case Study	**Canyon Boulevard, Colorado**		**North Miami Avenue, Florida**	
Aspect of Analysis	**Existing Condition**	**Implemented Actions**	**Existing Condition**	**Implemented Actions**
Roadways	*Lack of complete sidewalks or intersection crosswalks.*	Reconstruct deteriorated areas in the roads. Signage and landscaping. Reconnected sidewalks and crossings for safety reasons.	*Lack of street landscaping and lighting.*	Installing street trees, pedestrian-scaled street lighting. Landscaped medians. Enhanced intersection crosswalks.
Pedestrian	*Less pedestrian signal.*	Pedestrian signals and crossing count-downs were added. Street buffers for pedestrians	*Lack of pedestrian safety.*	Pedestrian refuge islands.
Bicycling	*Limited number of bicycle trails.* *Lack of signage.*	Addition of bicycle trails. Connected different trails to create a more unified network for bikers. Bicycle route signage.	*Lack of bicycle lanes and marking.*	Bicycle lanes, sharrows or shared-lane marking, and bicycle racks.
Transit	*Lack of transit amenities.*	Implemented the high-frequency Community Transit Network (CTN). Transit stops contained new signs and pavement platforms. The insertion of shelters, benches and trash receptacles in busier transit stops.	*Lack of transit safety at transit stops and related amenities.*	Bulb-outs at all transit stops. Replaced stops with transit shelters.
Land use	*N/A*	N/A	*Concentrated land uses that caused congestion.*	Integration of land uses (live-work-play-shop options). Variety of housing choices and costs. More compact and focused growth with higher densities.

The table below illustrates each principle of the 'Complete Streets' concept and its measurable variables in the form of a checklist containing data extracted from the two analyzed case studies. Table 5 presents the evaluation criteria that can be used and implemented in the study area of this thesis, the street network of Doha city, in order to assess the current street conditions and recommend enhancements and improvements based on tracking these variables and users' preferences.

Table 5. Complete Streets Evaluation Checklist

Principle	Complete Streets Variables	Standard from Miami-Dade 2014)
Pedestrian improvements	Crosswalks/Enhanced pavements	Can be installed at intersections or designated mid-block crossing locations. Should be highly visible so that a pedestrian can see and be seen by oncoming traffic while crossing.
	In-pavement and street lighting	Placed in high pedestrian activity areas and vehicular conflicts. The amount of time lights flash should be based on crossing distance, vehicle speeds and volumes, and pedestrian characteristics (ex. age).
	Pedestrian refuge	Typically provided on wider multi-lane roads to reduce the effective crossing width. Should be signed and illuminated to identify purpose.
	Way-finding signage	Most appropriate for downtown, commercial, tourist-oriented locations, or large institutions. Provide direction, destination, and/or location information for motorists, pedestrians and bicyclists.
Bicycle Improvements	Bicycle lanes	Placement and width of bicycle lanes is dependent on right-of-way width, traffic speed and volume, signalization, turn lanes and parking.
Green Improvements	Amenity improvements	The amenity zone should include intermittent landscaping and street trees using appropriate planting techniques (ex. in grates or planters).
	Planting strip	Width of the planting strip will dictate the size and type of landscaping materials to be installed.
Transit improvement	Bus shelters	Bus shelters should be carefully located so as to not obstruct the sidewalk. In high pedestrian volume areas they should be located in the amenity zone or green zone.
	Bus lanes	When adding a bus lane to an existing street the conversion from an automobile travel lane should be utilized. Widening the roadway or removing parking is not recommended.

2.7. Chapter Summary

Since ’Complete Streets’ brings together a number of definitions, which share a number of variables, from all the movements experienced and studied in the last few decades. The overall aim of the concept is to provide a safer street environment for users with the integration of different modes of travel. The reviewed literature has proposed a number of shared variables and parameters which were taken into consideration when applying the ‘Complete Streets’ concept to existing streets.

Furthermore, several studies have been conducted and a number of urban projects have been implemented in several contexts and different types of corridors. These projects have dedicated their studies to categorizing a number of main ‘Complete Streets’ principles and their measurable variables. These variables are taken into consideration in evaluating current streets and recommending the appropriate amenities to be installed. The extracted criteria from the analysis of the two case studies included five major principles, each of which combined a number of variables, as illustrated in Table 5. It is noticeable that most of the enhancement projects are mainly focusing on the perspectives and the preferences of the street users. People are questioned at the beginning of the project to see what they want and need, and then the local authority provides recommendation policies to start off the improvements to the existing amenities in the studied streets.

CHAPTER 3: RESEARCH METHODOLOGY

3.1.Introduction

This chapter outlines the methodology of this thesis. Both quantitative and qualitative data collection approaches were used to evaluate Doha's current streets using the 'Complete Streets' concept, based on the criteria extracted from the case studies, and in order to recommend actions toward better functioning streets in the city. The first part of this chapter focuses on clarifying the methodological approach of this thesis based on previously reviewed literature. The second part describes the data collection process and analyzes the data to eventually come up with recommendations and improvements for the studied areas of Doha's street network.

3.2.Research Approach

This thesis study focuses mainly on two major aspects: streets and users. In order to construct the research study, it is essential to involve the users in the process used to select the streets, in which they recognize which segments need to be enhanced and which are acceptable as they are. For this reason, the research followed a systematic flow in collecting the study data. First, the evaluation criteria and assessment scale of the study will be identified. Second, the street classification hierarchy for the Doha street network needs to be understood. Third, the selection of the areas will be based mainly on the land use and activities. Fourth, the selection criteria and a matrix will be used in selecting the highest scores for three major hierarchal classifications of street network in the two chosen areas. Fifth, a questionnaire will be drawn up and distributed among users to evaluate the

principles and variables based on the 'Complete Streets' criteria, and, finally, the collected data will be analyzed to eventually recommend enhancements and improvements to the selected street network.

3.2.1. Evaluation Criteria Established for the 'Complete Streets' Concept

The discussed literature review has provided a clear understanding of the 'Complete Streets' concept and its evaluation criteria by analyzing and studying two case studies focusing on different contexts. The following diagram shows the Complete Streets evaluation criteria that have been followed in this study to analyze and evaluate the current street network in Doha city. The criteria included five different steps to reach the sixth and last step, exemplified in designing the enhanced cross-section of the studied streets.

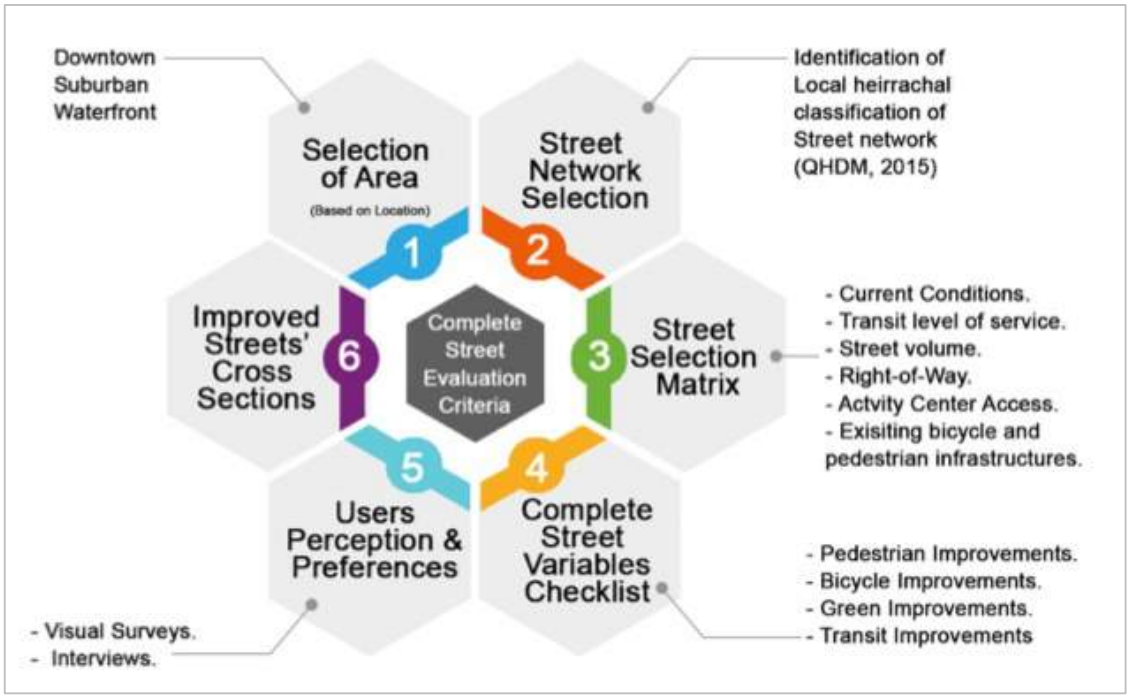


Figure 11. Complete Street Evaluation Criteria (Developed by Author)

Principles and variables from the 'Complete Streets' concept are applicable to be evaluated in the case of Doha city; however, the standards that were extracted from Miami-Dade policies can be adjusted according to what suits the local context of the study and the street network, as shown in Figure 12.

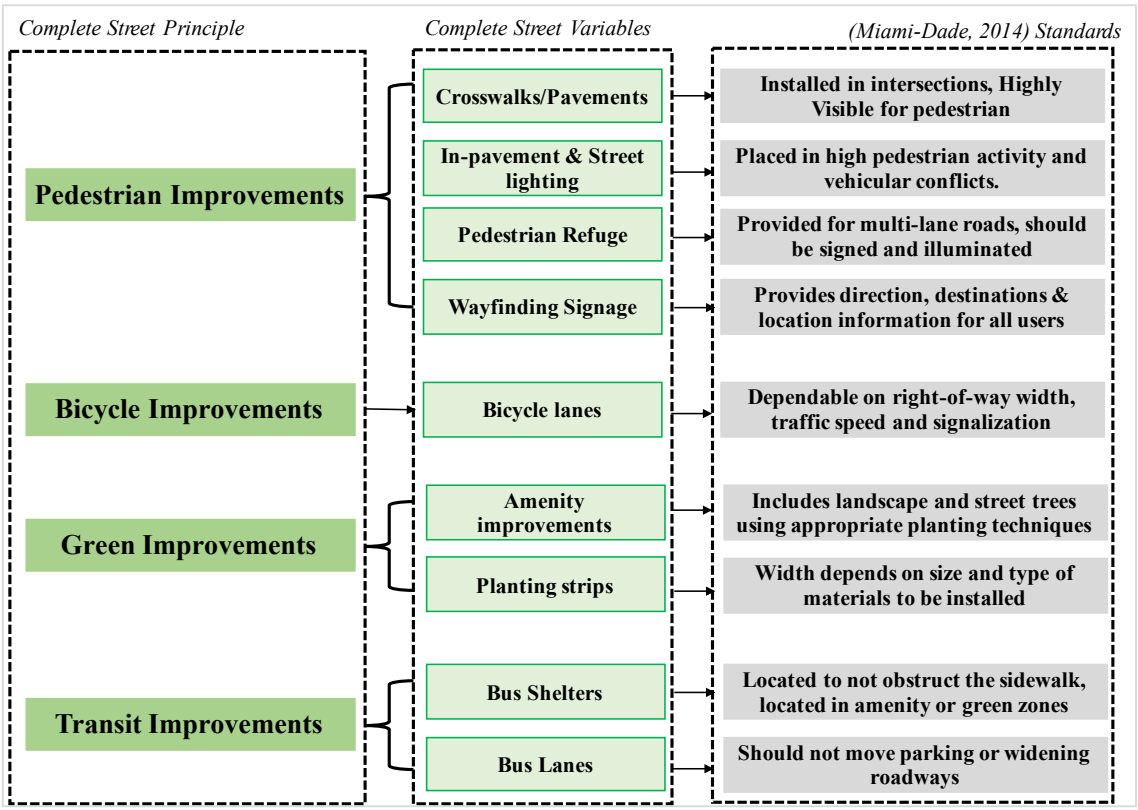


Figure 12. The Established Principles, Variables and Standards of 'Complete Streets' Criteria

3.2.2. Hierarchical Classification of Doha Street Network

The study focuses on the functionality of mobility and accessibly; therefore, it will be conducted on the three main road typologies in Doha: Urban Arterial (major, minor), Urban Collector (major, minor) and Local Access. When implementing the studied

concept, it is essential to identify the street classification and typology of each type of the studied neighborhoods. The following figure shows the classification of streets including the traffic volume and level of land uses, according to the Ministry of Municipality and urban planning authority.

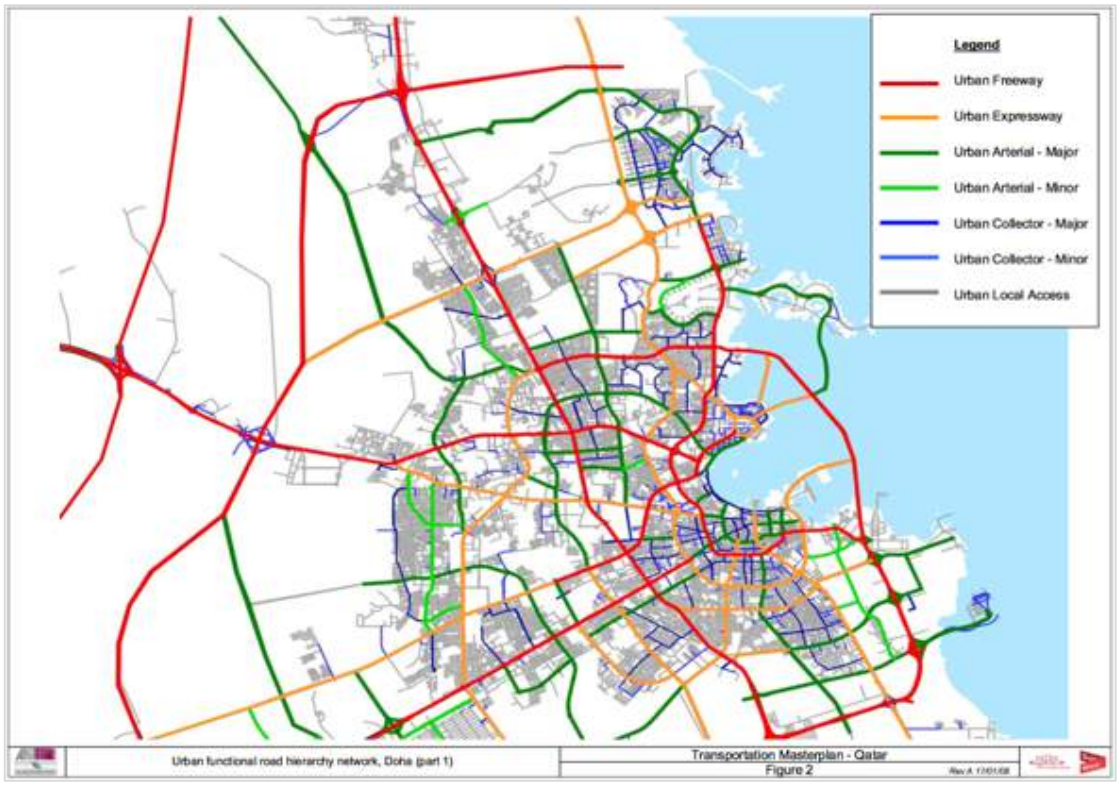


Figure 13. Street typologies and classification marked on the developed areas of Qatar (TMPQ, 2008)

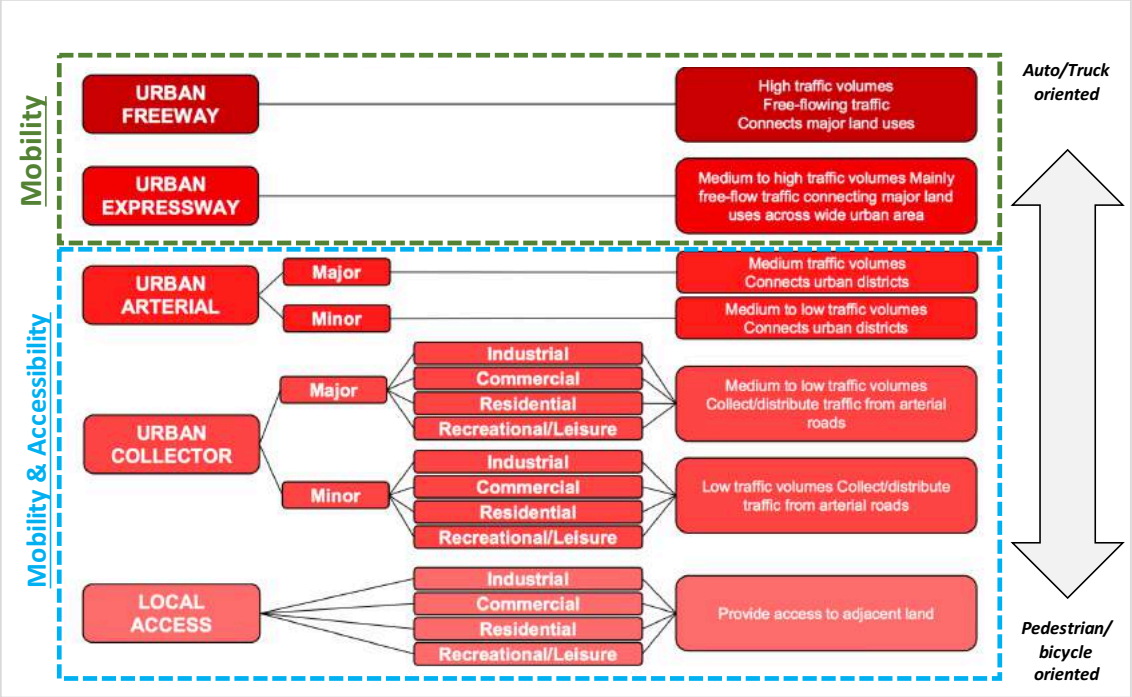


Figure 14. Road hierarchy (MMUP, 2015)

3.2.3. Selection of Study Areas and Street Network

3.2.3.1. Selection Process

This study aims to analyze two different types of areas, study the current condition of their street network and evaluate them to recommend improvements. Two selection criteria were followed in selecting local urban areas. First is the type of area based on contextual location that determines the types of activities and land uses. Second is the variety of street classifications based on MMUP regulations. These criteria were used to systematically select the study areas and to ensure a rationale judgment of its current variables. For the first criterion, the selected study areas are a downtown and a suburban neighborhood, exemplified in an urban center and a residential district, respectively. Downtown neighborhoods (Urban Centers) are developed at moderate to high levels of

intensity. They typically contain a mix of land uses, vertically and horizontally, including commercial and institutional uses that support the surrounding areas (LaPlante and McCann, 2008). The other selected area is a Suburban neighborhood (Residential District), which typically consist of single-family residential developments at a common scale. Larger multi-family buildings such as apartments may also be present.

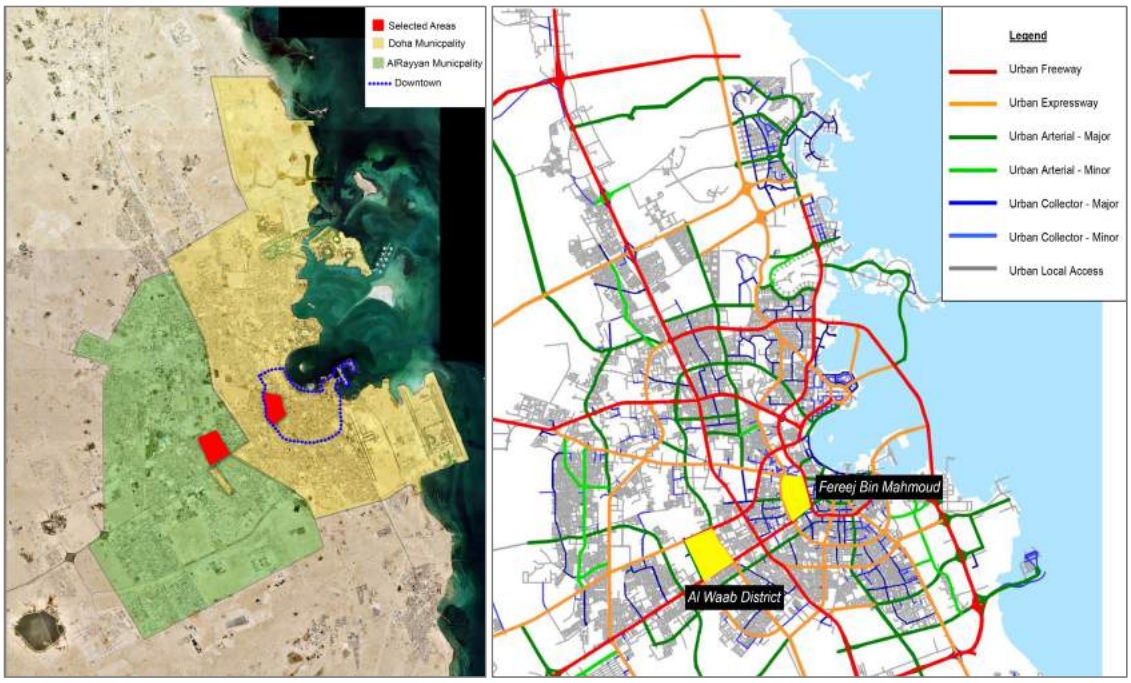


Figure 15. The Two Selected Study Areas: Downtown (Fereej Bin Mahmoud) and Suburban (Al Waab) (Google Maps, 2017)

The selected Urban Center is Fereej bin Mahmoud, as it consists of a variety of commercial and retail activities along with other services that serve the area. It also contains a hierarchal integration of street networks that serves the aim of this study. For the Residential District, Al Waab area was selected because of the high density of residential blocks and typologies, in addition to its having a variety of street network classifications to be analyzed and evaluated.

Figure 16. Selected Urban Center Fereej bin Mahmoud (Google Maps, 2017)

Figure 17. Selected Residential District Al Waab Area (Google Maps, 2017)

The two areas have a wide range of streets with different hierarchal classifications. The Selection of the streets to be analyzed followed the criteria mentioned in (Miami-Dade, 2014) to select corridors within the two areas and to investigate the possibility of improving them, based on the following figure.

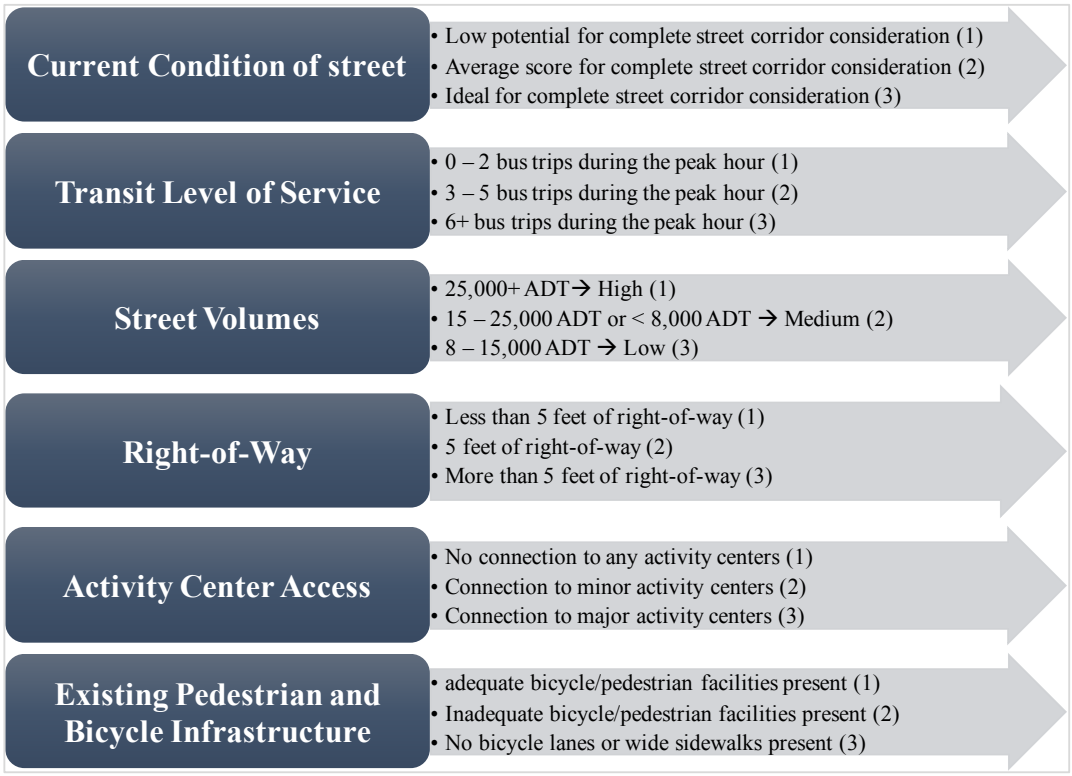


Figure 18. Selection Criteria for the Street Networks of the Two Selected Areas (Miami-Dade, 2014)

Table 6. Matrix of the Urban Center's Selected Streets Based on the Selection Criteria

Corridors of Urban Center	Current Condition of Street	Transit Level of Service	Street Volumes	Right-of-way (ROW)	Activity Center Access	Existing Pedestrian & Bicycle Infrastructure	Total/18
Al Rayyan Rd.	3	3	3	3	3	2	**17**
Al Khaleej St.	3	3	3	3	3	2	**17**
C-Ring Rd.	2	1	3	3	2	2	**13**
Salwa Rd.	1	2	3	3	3	1	**13**
Ibn Mahmoud St.	1	1	1	2	1	1	**7**
Al Jazeera St.	2	1	1	2	1	1	**8**
Qatari bin Al Fujaa St.	3	2	2	2	3	2	**14**
Abdualla Bin Masoad St.	1	1	1	2	1	1	**7**
Al Quds St.	1	2	1	1	1	1	**7**
Al Kindi St.	1	1	1	1	1	1	**6**

For the Urban Center, Fereej bin Mahmoud, most of the street network is commercially designed, in which it contains a variety of land uses, significantly commercial, retail and also housing, as illustrated in Figure 19. Therefore, the selected streets were mainly commercial and publically used and of the area comprised some of the 'Complete Streets' elements that can be improved and enhanced for better performance.

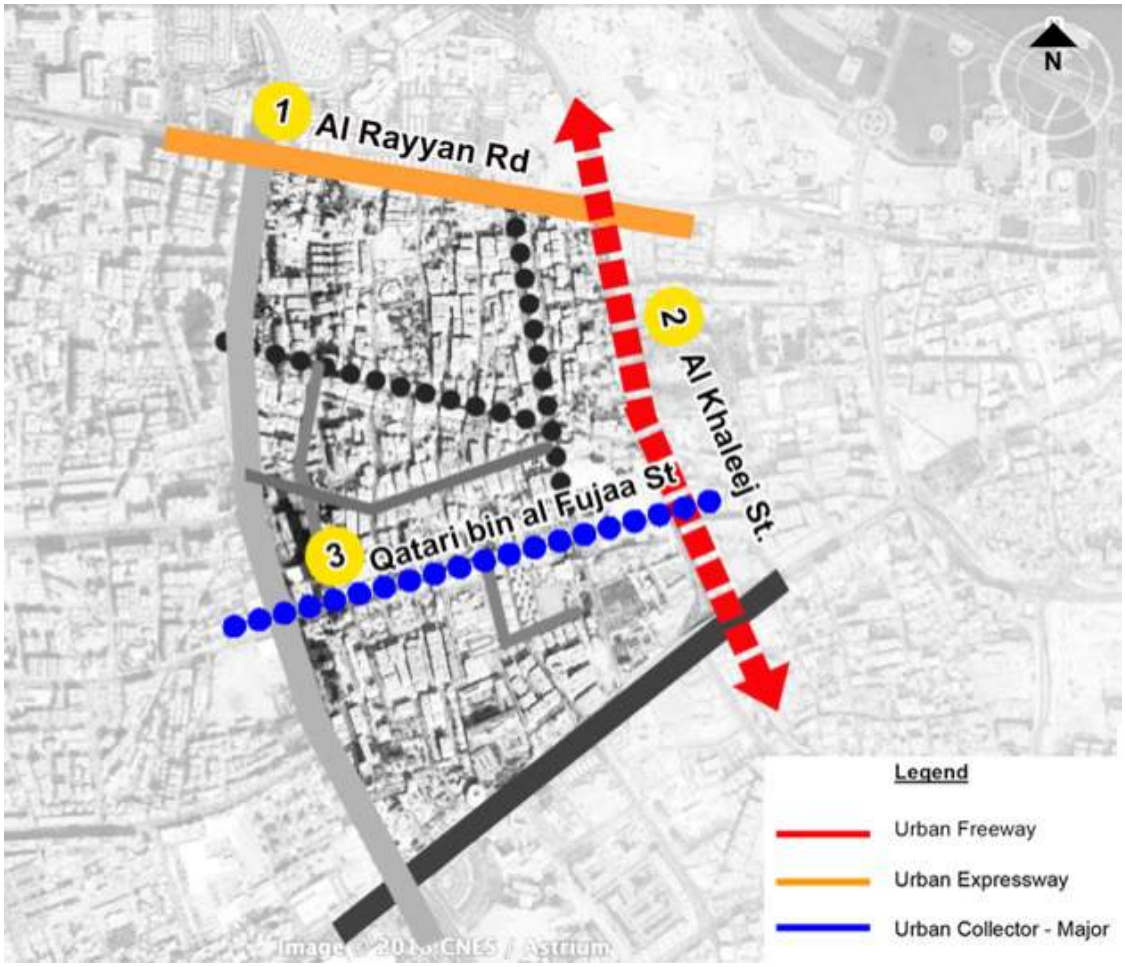


Figure 19. The Streets in Fereej bin Mahmoud Selected for Improvement

For the second selected area, the Residential District, Al Waab Street has the same road classification as Fereej bin Mahmoud; however, it differs in the land use and the types of the selected corridors, as the Al Waab area is mainly residential, although it does have some limited services and land uses that serve its residents. The selected streets, as shown in Figure 20, are newly developed by the Local Work Authority (Ashghal), and contain some of the 'Complete Streets' elements; however, residents believe these streets can be better improved and enhanced by adding additional elements that achieve the concept of

‘Complete Streets’.

Table 7. Matrix of the Selected Streets of the Residential District

Corridors of Residential District	Current Condition of Street	Transit Level of Service	Street Volumes	Right-of-way (ROW)	Activity Center Access	Existing Pedestrian & Bicycle Infrastructure	Total/18
Al Waab St.	1	3	3	3	3	2	**15**
Al Bustan St.	3	3	3	3	3	2	**17**
Salwa Rd	2	1	3	3	2	2	**13**
Al Sidr St.	3	3	3	3	3	2	**17**
Al Ghariya St.	3	3	2	2	2	2	**14**
Snay Bu Hasa St.	2	1	1	2	1	1	**8**

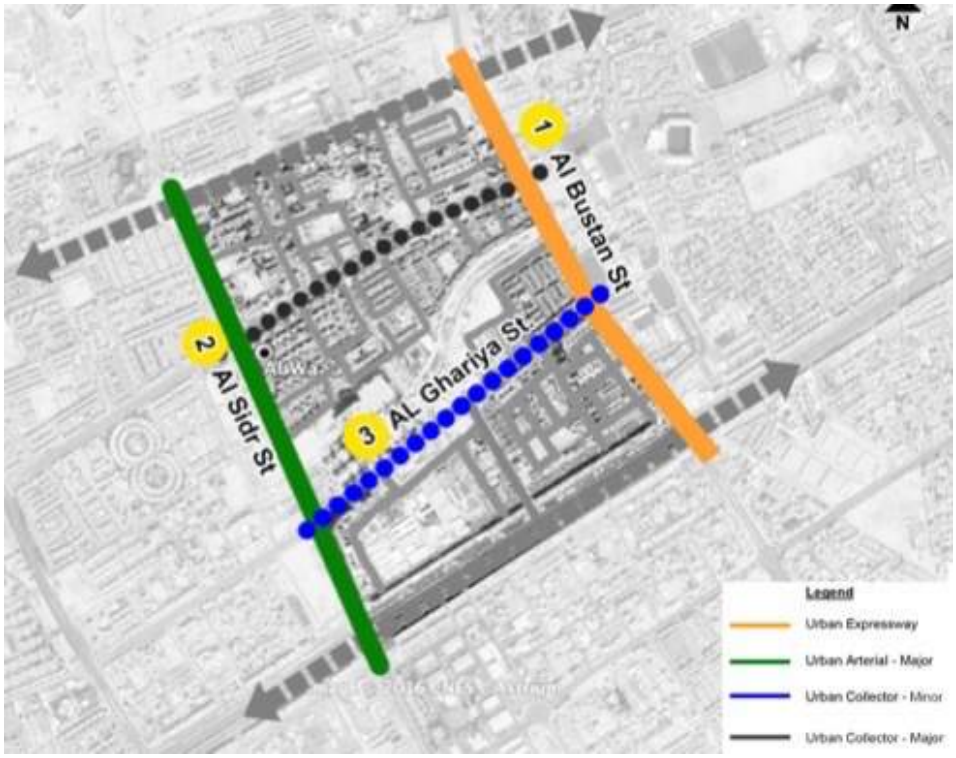


Figure 20. The streets in Al Waab District Selected for Improvement

The following table was developed as a summary of the streets selected to be improved in the two chosen areas.

Table 8. Summary of the Selected Streets in Fereej bin Mahmoud and Al Waab District

Category of Area	The selected Street	Road Classification (TMPQ, 2008)	Justification
Downtown/ Urban Center (Fereej Bin Mahmoud)	Al Khaleej Street	Urban Freeway	• One of the condensed streets in Doha. • Consists of various land uses that serve the two adjacent neighborhoods. • Consists of some 'Complete Streets' elements.
	Al Rayyan Road	Urban Expressway	• One of the condensed streets in Doha. • It consists of some of the 'Complete Streets' elements that can be enhanced. • Ideal for improving based on 'Complete Streets' principles and variables.
	Qatari bin Al Fujaa Street	Major Urban Collector	• Consists of a wide variety of land uses that serve the Fereej. • Lacks 'Complete Streets' elements. • There is the potential to improve the current condition. • A major connector between two main roads (Al Khaleej St. and C-Ring Rd).
Suburban/ Residential District (Al Waab District)	Al Bustan Street	Urban Expressway	• A major connector between two main roads (Al Waab Street and Salwa Road). • Newly developed, some of the main principles of 'Complete Streets' were installed. • There is room for further improvements.
	Al Sidr Street	Major Urban Arterial	• A major urban arterial that connects Al Waab Street and Salwa Road. • Newly developed, some of the main principles of 'Complete Streets' were installed. • There is room for further improvements.
	Al Ghariya Street	Minor Urban Collector	• A collector that connects two residential neighborhoods (north and south) • It consists of housing typologies (standalone villas and residential compounds). • Elements of 'Complete Streets' were inserted.

3.3.Data Collection Tools

This research attempts to use qualitative and quantitative methods for gathering data that support the purpose of the study. Questionnaires and unstructured interviews were utilized in this research to achieve the aim of the study. Questionnaires targeted the residents and the users of each of the selected areas to analyze and evaluate the current

situation and the level of satisfaction regarding the availability of 'Complete Streets' elements. The questionnaire also targeted users' preferences and future aspirations for the current selected streets in order to recommend enhancements and improvements by providing alternatives with respective to the 'Complete Streets' concept. For the qualitative tools used in this thesis, semi-structured interviews were conducted with two local planning authorities in the city of Doha, in order to investigate their future plans and directions towards developing the city's streets.

3.3.1. Questionnaire Survey

A visual survey was conducted and targeted the residents and the users of the selected areas to evaluate their overall satisfaction with the selected streets. The survey also aimed to evaluate the current conditions of the streets from the perspective of their users. The questions were based on two distinctive sections: personal evaluation of the currents streets of the two previously selected areas of study, and the users' preference and what they want and need in these streets, by selecting different treatments presented in visual form (images) of various design elements and variables of the studied concept. Random sampling was used to give users an equal opportunity to be involved in responding to this survey.

3.3.1.1. Pilot Study

A pilot study was conducted to test the validity of the questionnaire and to create a base for the research in terms of responses. Five questionnaire samples were distributed randomly to test if the initial data collected made a good contribution to the study's results

and objectives. The first part of the questionnaire focused generally on the current condition of the street, and how different users perceived the different elements existing in the street, how often they use them and their overall degree of satisfaction. The second part of the survey mainly focused on presenting different treatments that the 'Complete Streets' concept provides for safer and higher quality of living for the users, stressing what participants want to have in their improved streets. Based on this pilot study, the questionnaire was modified and then distributed to different types of users and the neighborhoods' residents.

3.3.2. Semi-Structured Interviews

The second data collection tool involved interviewing experts from two local planning authorities that aim to consistently improve the street network of Doha city. The aim of the interviews was to investigate whether local authorities have knowledge of the concept studied in the thesis, and the potentiality of implementing variables of the 'Complete Streets' concept in the enhancement process. The two local authorities targeted in this study are responsible for the urban planning work that is conducted around the city; they are the Authority of Urban Planning in the Ministry of Municipality and Environment and the Public Work Authority (Ashghal).

Table 9. List of Interviewees, Their Organizations and Discussed Topics, and Site Visits

Interviewee	Local Authority	Topics
Expert in Road Planning and design	Ministry of Municipality and Environment (MME)	- Documents of Qatar Highway Design Manual related to proposed cross-sections for different classifications of street network.
Projects Management Engineer	Road Design Apartment – Public Work Authority (Ashghal)	- The interview aimed to investigate whether Ashgal is planning to create a cross-section that combines all the variables that 'Complete Streets' comprise. - Prototypes and mock-ups of 'Complete Streets' are being implemented in several areas of Doha, for instance, in AlAzizya area, where they have implemented most of the 'Complete Streets' variables in a local road of one neighborhood. - The mock up was created to examine users' perspectives and trigger their level of satisfaction toward such a road design. - The projects related to 'Complete Streets' implementation are classified as confidential and prohibited to be shared with any personnel.
Site Visit to Al Azizya Mock-up	Observation comments	- Shaded seating areas, surrounding an inserted playground. - Insertion of landscaping elements. - Wayfinding signage system inserted indicating the circulation pattern and identification of the area. - The use of speed tables to minimize the speed. - The use of one lane for two vehicular circulation directions, which can cause confusion for drivers.
Images	 *Figure 21.* Images from the site visit to Al Azizya Mock-up of 'Complete Streets' implementation	
Transportation Engineers	Seero Engineering Consulting	- Policy plan of Qatar for all the streets in Doha to determine the exact right-of-way of the selected streets.

3.4.Data Description

The data were originally collected from the users directly, as they expressed their perception and preferences for the selected streets. All the collected data were presented and interpreted into several charts and diagrams showing the percentage of responses for the two selected areas with the two distinctive sections of the survey: the current situation and the future improvements.

3.4.1. Description of the Surveyed Residents

3.4.1.1. Choosing the Sample Size for the Survey

The sample survey was mainly based on the population rates of the two selected areas. There is a wide variation in the population, as it includes locals and expatriates from both areas, including Arabs, Asians, Europeans and Americans. For the visual distributed survey, a total of 100 responses were collected from the two areas, downtown and suburban, whom participated in the investigation of current conditions and future aspirations of the studied streets.

3.4.1.2. Downtown Urban Area: Fereej bin Mahmoud Sample

The first section of the distributed survey dealt with the current condition of the selected streets in the Fereej: Al Rayyan, Al Khaleej and Qatari bin Al Fujaa Streets. The first question focused on users' perception and their opinion about whether the streets have positive aspects according to 'Complete Streets' variables.

For the first Street, Al Rayyan Street, the questionnaire surveyed different types of participants about what they like about the current condition of the street. The highest percentage of responses was for street lanes, with 36% of users thinking that the street has an appropriate number of lanes that suit the traffic volume. A number of participants (34%) observed that the street has a sufficient number of green areas. Other existing elements of the studied street, such as street Signs (16%), street lighting (25%), and existence of walking areas (18%), bicycling areas (9%), and bus stops (7%), were marked with various percentages by the participants according to their perception of the existence of the mentioned elements. In addition, the survey included the negative issues that the street has from the perspective of users. Significantly, walking areas (53%), bicycling areas (38%) and bus stops (29%) had the highest percentages of respondents, as the street lacks the presence of areas dedicated to these aspects, such as shelters and seating areas. Surprisingly, 38% of participants mentioned that street lanes are inappropriate and need to be improved. On the other hand, other elements exemplified in street lanes, signs, lighting and green areas had the lowest percentages, with participants ranking them as positive aspects of Al Rayyan Street. In terms of the existing condition of the street lighting, the majority and the highest percentage of participants (48%) agreed that the street needs more lighting poles for better illumination at night.

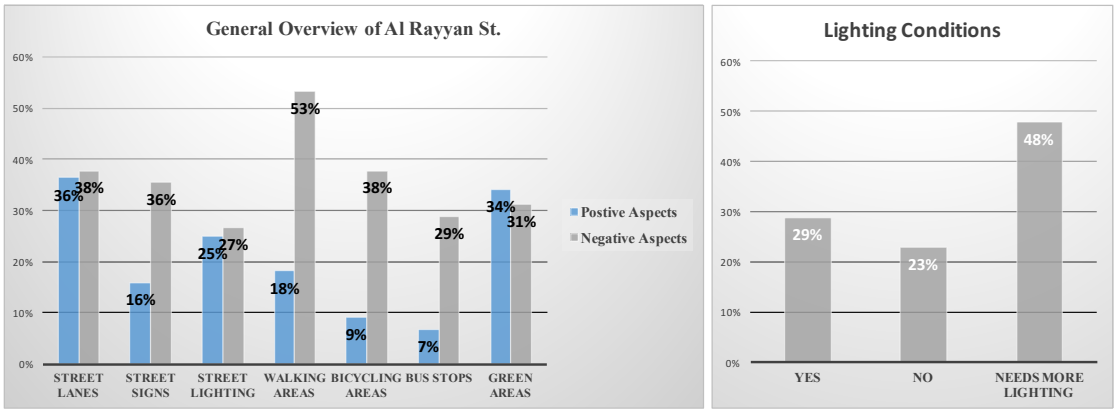


Figure 22. General Overview of Al Rayyan St. from the Perspective of Users

Since the street lacks dedicated areas for walking and cycling, according to the users' evaluation, 51% of the participants have never experienced such activities in the studied street. At the same time, participant have never experienced using the bus either in this street. According to the survey, there are a number of street aspects that participants agreed were obstacles that prevent walking or cycling in Al Rayyan Street; driving behavior had the highest percentage (68%), followed by absence of bicycle amenities and racks (45%), the local weather conditions (34%), and lack of bus stops and other related amenities (28%).

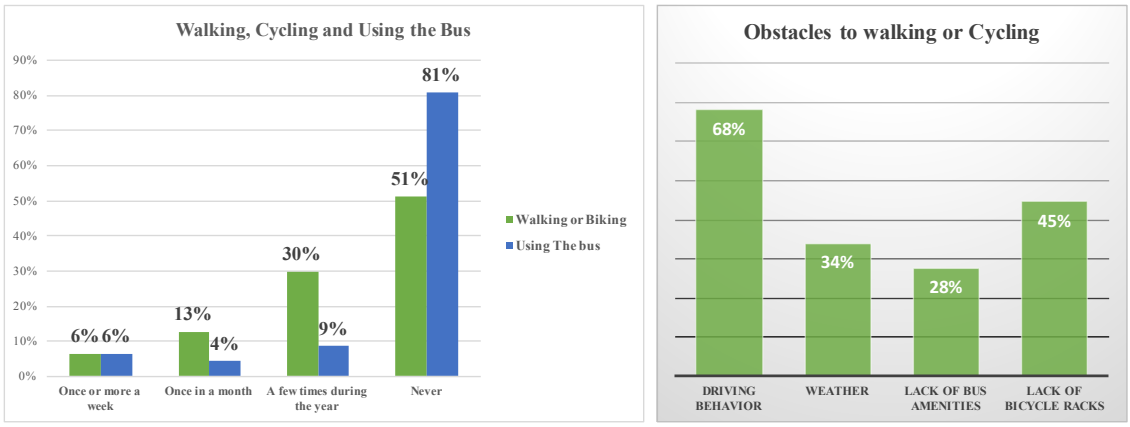


Figure 23. General Perception About Walking, Cycling and Using the Bus in Al Rayyan St.

With regard to the safety level, the majority of respondents feel safe using the street (38%), whilst a similar percentage of respondents stated that they feel unsafe (32%), and (23%) of the participants feel very unsafe driving, walking or cycling in Al Rayyan Street. In terms of street way-finding and the existing signage system, the highest percentage of survey respondents have never lost their way in the street (33%), while (9%) admitted that they find the street is misleading and the existing signage system is not efficient.

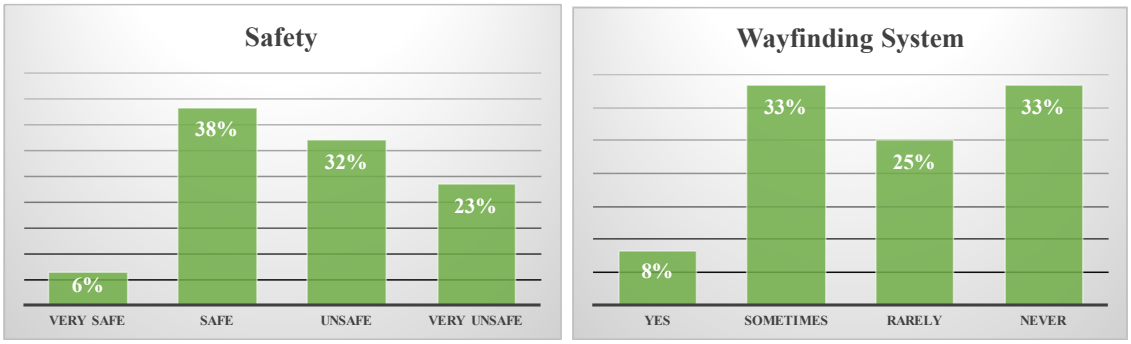


Figure 24. Safety and Wayfinding Aspects in Al Rayyan St.

For the second studied street, Al Khaleej Street, participants were also surveyed about the current status, in terms of positive and negative issues that the street has. In terms of what people liked the most about the street, it was also the street lanes (43%), which they think are adequate in number for the current traffic volume. Street signs and lighting came joint second in the list of positive elements about the street with 27%. On the other hand, participants stressed the significant absence of walking areas (52%), bicycling areas (58%), bus amenities (32%) and the absence of green areas in the street (48%). In addition, lighting should be improved and increased in the studied street, based on the participants' assessment.

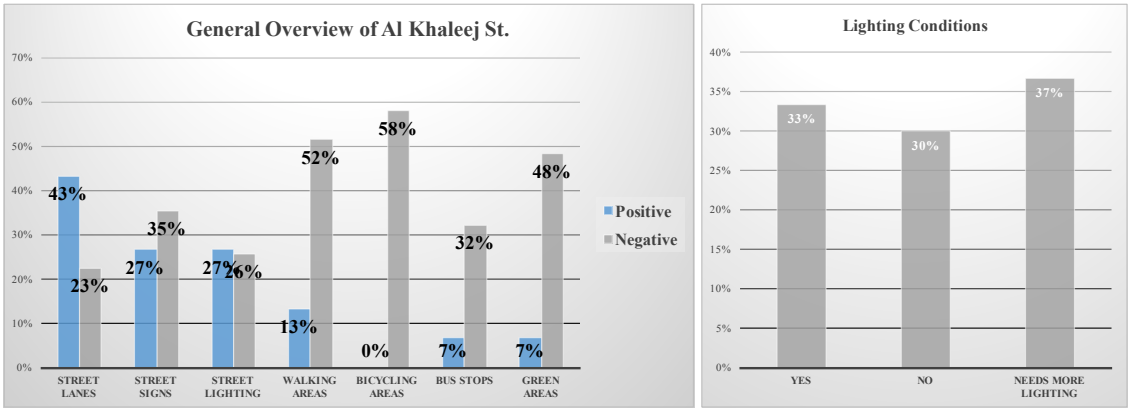


Figure 25. General Overview of Al Khaleej St. from the Perspective of Users

As previously mentioned in the findings for Al Rayyan Street, users never use Al Khaleej Street for walking or cycling (74%) or taking the bus (80%). According to the survey, people categorized driving behavior (60%), lack of bicycle racks (53%), weather conditions (33%) and lack of bus amenities (37%) as the biggest obstacles that prevent walking and cycling in this street.

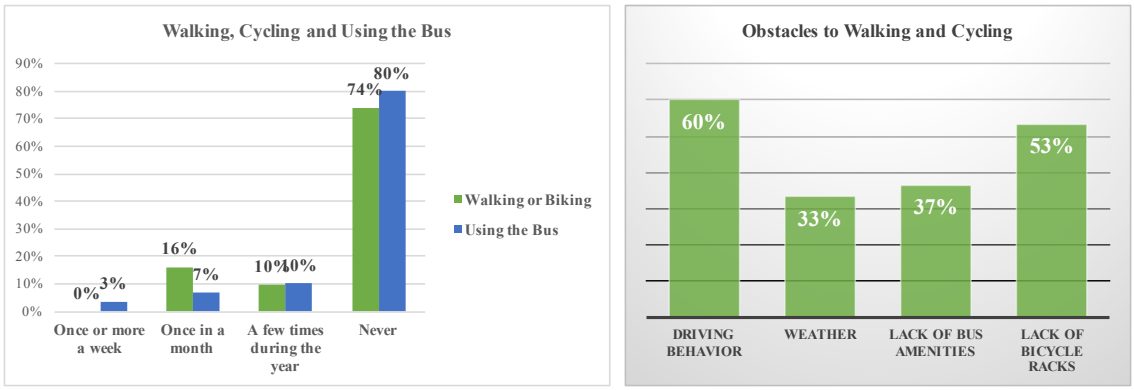


Figure 26. General Perception about Walking, Cycling and Using the Bus in Al Khaleej St.

With regard to the level of safety, the majority of participants (43%) feel unsafe using this street. In terms of signage system, 37% of users lost their way while using this street's signs and way-finding strategies, which indicated that there is a desperate need to improve the current way-finding system in Al Khaleej Street.

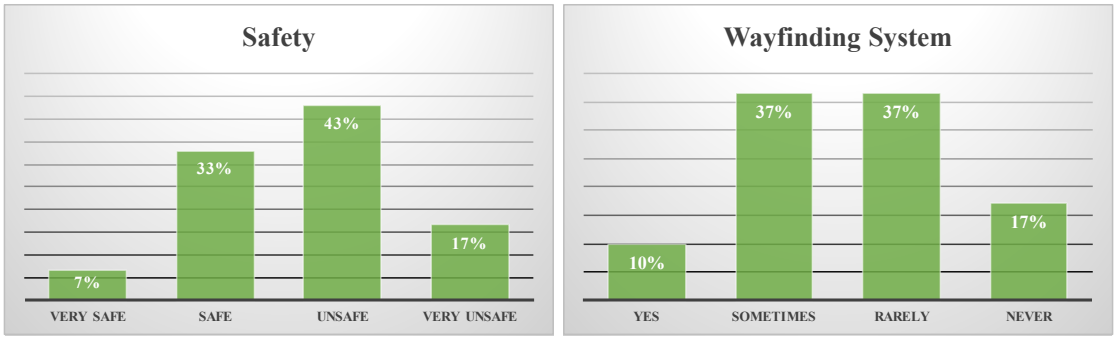


Figure 27. Safety and Wayfinding Aspects in Al Khaleej St.

For the third and last selected street, Qatari bin Al Fujaa Street, participants were asked about what they like about the current street, and the majority (50%) evaluated that the street lanes are efficient and adequate for the current design of the street. On the hand, 60% of users referred to the insufficient availability of areas that are dedicated to walking

in the street. According to the survey answers, participants thought that the street misses a lot of aspects that should be enhanced to provide better quality, such as street signs (56%), lighting (44%), bicycling racks and other related amenities (52%). They also felt that there was an absence of bus stops and shelters (32%) and that the street lacks the presence of green areas and landscaping (56%). Furthermore, lighting at night must be increased, according to the 65% of the survey respondents.

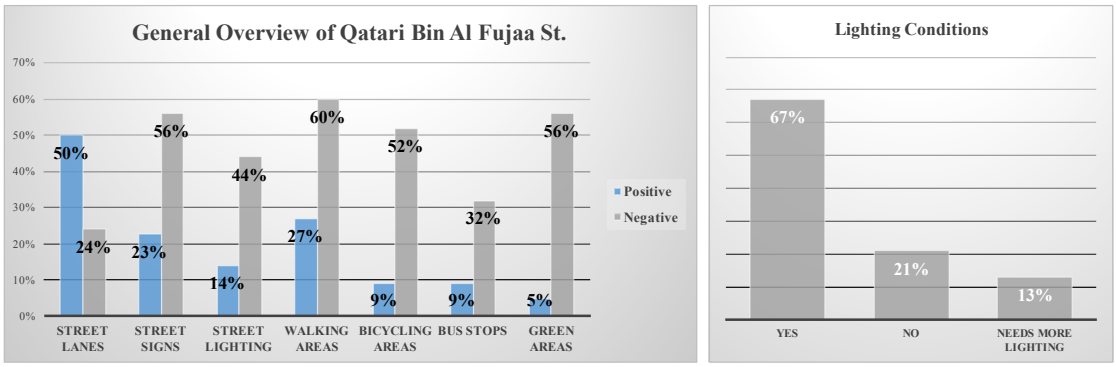
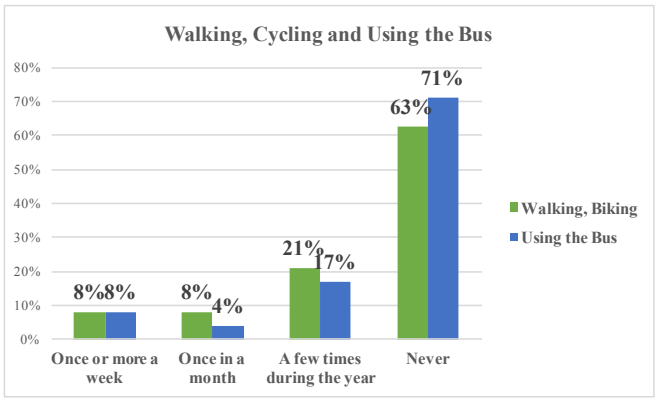


Figure 28. General Overview about Qatari bin Al Fujaa St. from the Users' Perspective

Similar to the previous selected streets, a high percentage of respondents (71%) have not used the street's bus amenities or cycled there; however, 21% of participants, probably the neighborhood's residents, have used the street for walking. The respondents felt that the biggest obstacles to walking and cycling are driving behavior (35%) and lack of bicycle racks (65%) in addition to the local weather conditions (45%).



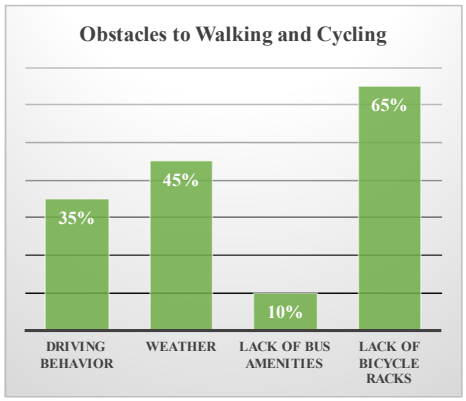
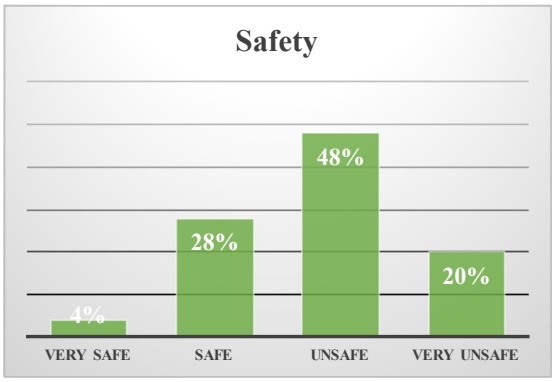


Figure 29. General Perception about Walking, Cycling and Using the Bus in Qatari bin Al Fujaa St.

In terms of safety, the majority of participants (48%) agreed that the street is not safe at all. Moreover, 42% agreed that it is rare to be lost in the streets of Qatari bin Al Fujaa.



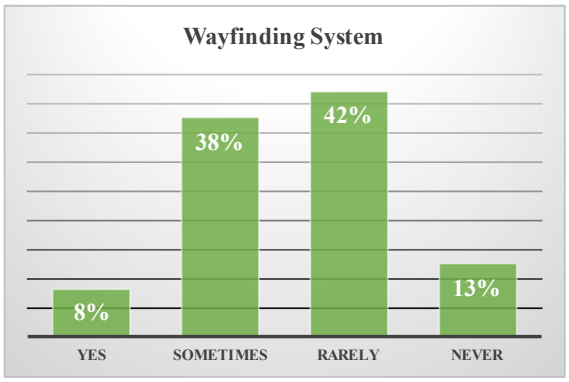


Figure 30. Safety and way-finding aspects in Qatari bin Al Fujaa St.

In terms of street enhancement, the second section of the distributed survey included several treatments of the 'Complete Streets' concept that have been implemented in other cities worldwide based on the utilization of the concept's variables. Two visual images of street and junction treatment extracted from the 'Complete Streets' concept were

inserted into the survey to identify what people prefer to have at Fereej bin Mahmoud junctions. Participants agreed that such treatment of complete junctions should be implemented in Doha and that it suits the local context. For the crosswalk treatment, participants preferred to implement a design where the crosswalks are painted in bright colors (60%), and also the grid type of crosswalks (55%). In terms of future improvements related to bicycle racks and lanes, participants preferred to have colored lanes dedicated only to bicycle movement (52%) more than other rack enhancement treatments. According to the survey answers with regard to green areas, an equal percentage of respondents (64%) selected images that represent green areas on the sides of the street, forming a barrier between the street lanes used for vehicular movements and walking pavements, for more safety. For the bus lanes and shelter treatments, 62% of participants chose to have dedicated lanes, whenever possible, with boundaries that prevent the bus from interfering with the vehicular lanes.

Figure 31. Users' Preferred Improvements from the Complete Streets Variables in Fereej bin Mahmoud

3.4.1.3. Residential District: Al Waab District Sample

Moving on to the second selected study area category, this is a residential district, exemplified in Al Waab. The selected portion of Al Waab District is a multi-user area with different housing typologies. The area's streets can be considered to be well-maintained. However, in investigating whether these streets need enhancements or not, it is essential to take into account users' opinions. As previously prepared with Fereej bin Mahmoud, three major streets were selected for the questionnaire.

The first street, Al Sidr, is one of Al Waab's major streets; it connects Al Waab Street with Salwa Road. According to the survey answers, participants preferred the design of street lanes (75%) followed by the unique design of the street's lighting (50%) and its signage system (42%), and the green areas that currently exist (33%). On the other hand, respondents thought that the street was lacking an area completely dedicated to walking (57%) and cycling (43%). The majority of respondents stated that the street has sufficient lighting at night with a sufficient number of lighting poles.

Figure 32. General Overview of Al Sidr St. from the Perspective of Users

Surprisingly, the majority of respondents stated that they have never walked or cycled (38%), or used the bus in the studied street; however, 33% stated that they have used the street a few times during the year. Participants thought that the absence of bicycle racks and other related amenities (65%) is the biggest obstacle to walking and cycling in the street, in addition to negative weather conditions (45%).

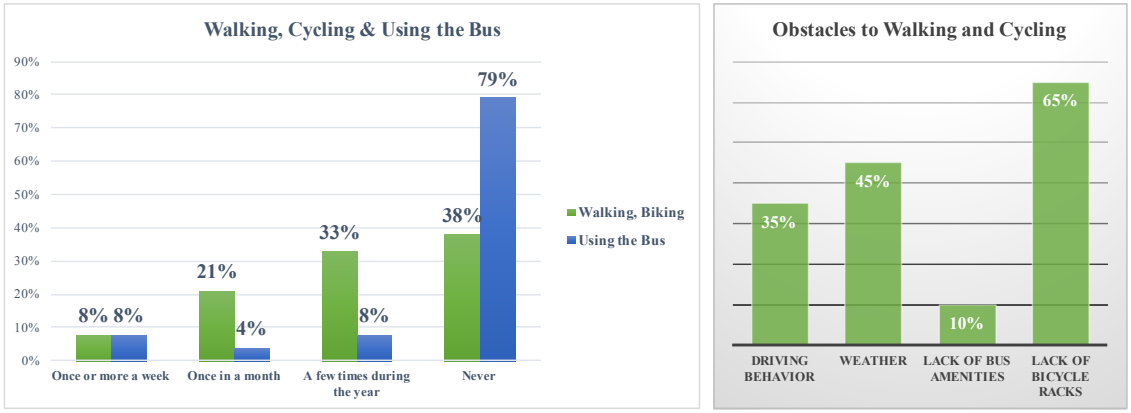


Figure 33. General Perception about Walking, Cycling and Using the Bus in Al Sidr St.

With regard to the level of safety, 50% of participants indicated that the street's overall environment is unsafe, while 25% stated that it is very safe to walk and cycle in

this street. In terms of way-finding, 42% of the respondents stated that it is rare to lose one's way in Al Sidr Street.

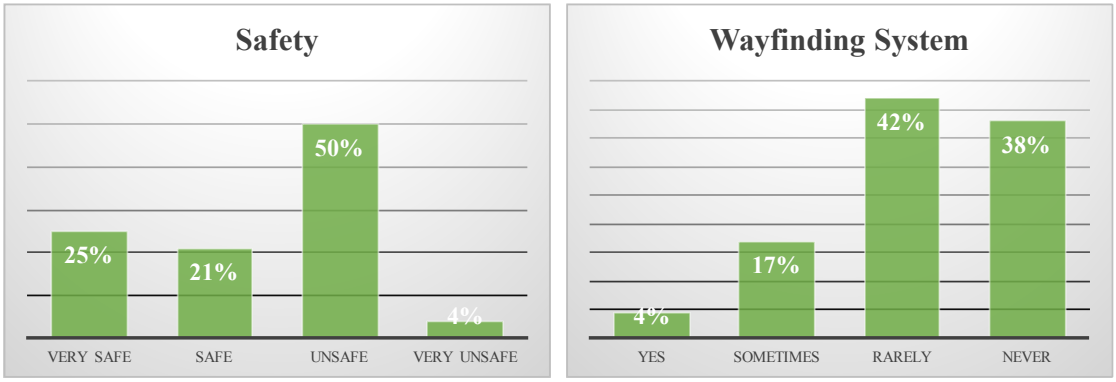


Figure 34. Safety and Wayfinding Aspects in Al Sidr St.

For the second selected street, Al Ghariyah, participants highlighted that the presence of adequate street lanes (65%), a unique design for the street signs (52%) and lighting (48%) are the most preferable elements in this street. On the other hand, users noted that the street lacked the presence of walking and bicycling areas (52%), in addition to greenery and landscaped areas (52%). The level of lighting at night is sufficient for 48% of respondents, similar to the previous streets.

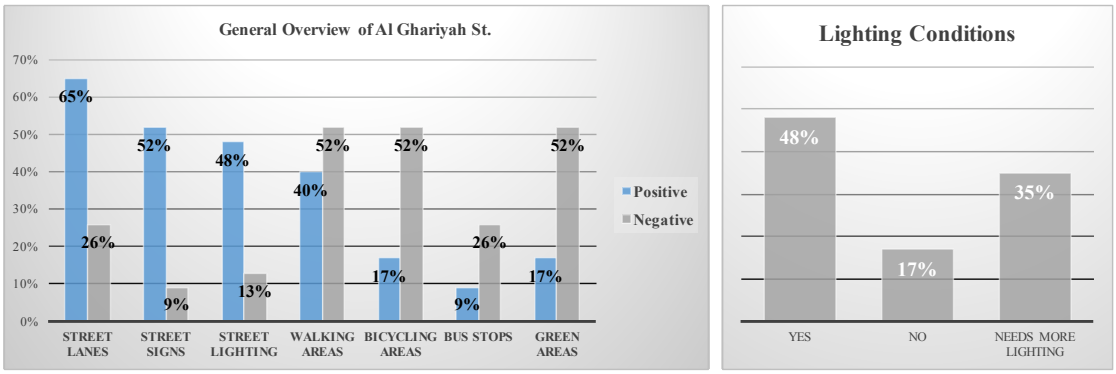


Figure 35. General Overview of Al Ghariyah St. from the Perspective of Users

In this street, it is rare to find participants walking or cycling, based on the survey answers. This can be considered as the biggest obstacle in the street, as 59% of the respondents pointed out that there is a significant absence of bicycle racks. According to the survey answers, 83% of respondents felt that the bus and its amenities are rarely used in the studied street.

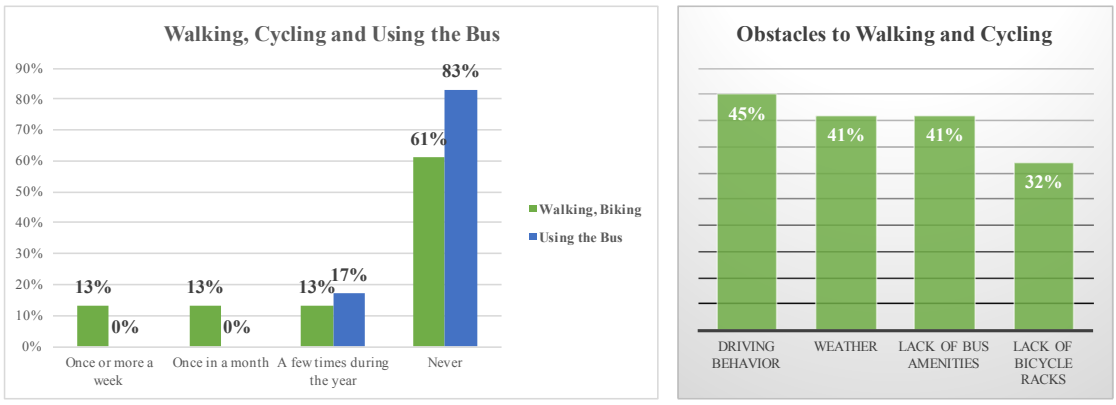


Figure 36. General Perception about Walking, Cycling and Using the Bus in Al Ghariyah St.

In terms of safety issues, 48% of users considered Al Ghariyah street to be an unsafe street in which to walk or cycle, but 35% of users felt that it is safe to move around; and 41% believed that it is a street in which one rarely loses one's way.

Figure 37. Safety and Wayfinding Aspects in Al Ghariyah St.

The third and last street, Al Bustan, is one of the major connectors between Al Waab Street and Salwa Road. Street lanes (70%), street lighting (61%) and street signs (57%) are the three major elements that users thought that they are adequate in terms of street design. However, walking areas (43%), bus stops (43%) and bicycle areas (57%) are the major three aspects that are absent in the studied street and should be provided based on the participants' opinions.

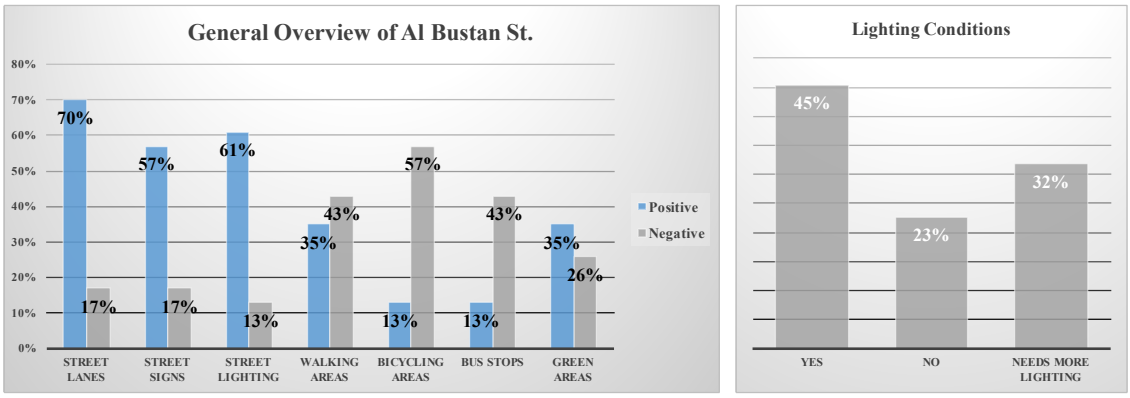


Figure 38. General Overview of Al Bustan St. from the Perspective of Users

The street is never used for walking or cycling (57%) or even the bus (74%) for multiple causes that are considered to be obstacles, such as driving behavior (45%), weather and lack of a bus stop and other related amenities (41%), and lack of bicycle racks (32%).

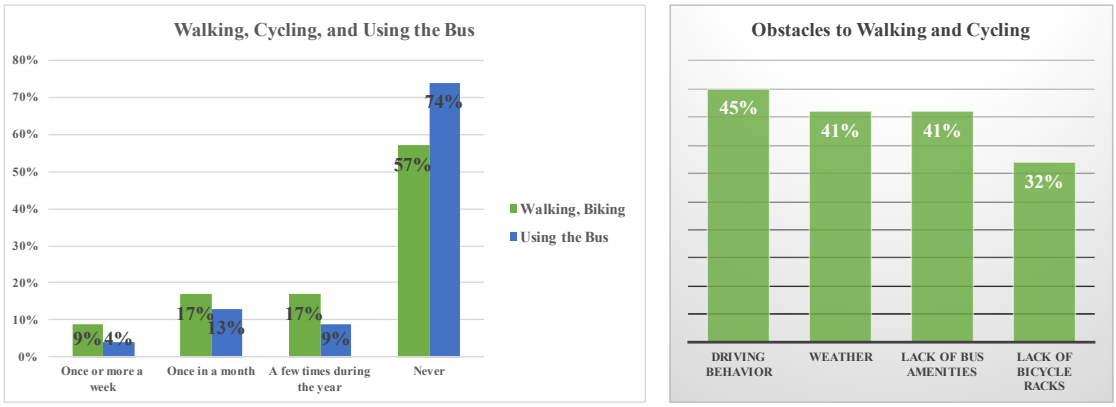


Figure 39. General Perception about Walking, Cycling and Using the Bus in Al Bustan St.

With regard to the safety level, 39% of respondents feel that the studied street is safer than the previous streets, and it has an adequate way-finding system in which users have never been lost (43%).

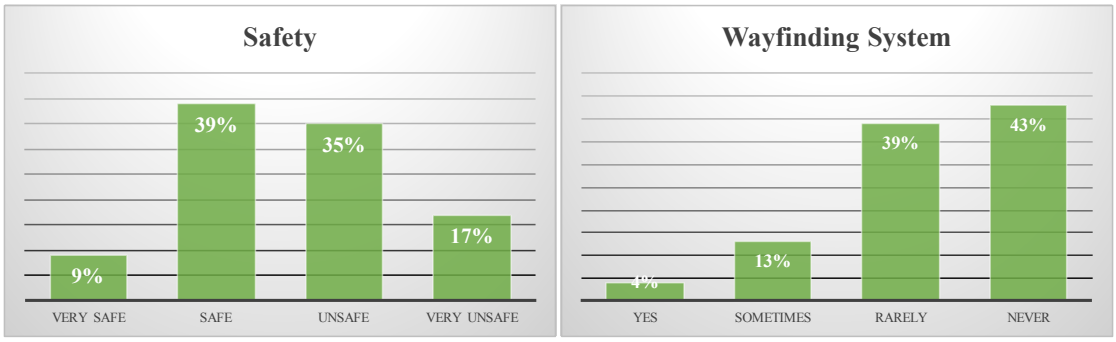


Figure 40. Safety and Wayfinding Aspects in Al Bustan St.

For the future enhancement of the selected street, and similar to Fereej bin Mahmoud, respondents strongly wished that the street and junction treatments shown in the provided images could be implemented at the junctions of Al Waab district to provide a safer environment in the district. For the crosswalk treatment, participants preferred the implementation of a design where the crosswalks are painted in bright colors (60%) at the junctions and other areas dedicated to walking. In terms of future improvements related to bicycle racks and lanes, participants preferred to have colored lanes dedicated only to bicycle movement (52%) more than other rack enhancement treatments. Apparently, users enjoy seeing large areas of greenery and landscaping distributed in the street's medians and on the sides as barriers. According to the survey answers, 64% of the respondents selected the option of green areas on the sides and in the medians of the street, forming a barrier between the street lanes used for vehicular movements and the pavements used for walking, for more safety. For the bus lanes and shelters treatments, participants chose to have colored lanes dedicated only to bus movements with shelters distributed along the studied street (42%).

Figure 41. Users' Preferred Improvements from the Complete Streets Variables in Al Waab District

3.5.Chapter Summary

This chapter has introduced and established the core of this thesis. It has discussed the methodological approach that was followed in this research to achieve the aim of this study, assessing the street network of Doha in terms of the 'Complete Streets' concept. In the previous chapter, Literature Review, evaluation criteria were established from the analysis of the two case studies, and these have been used in this chapter to evaluate the two selected areas: one is concerned with the wide variety of land uses and is considered to be an urban center, and the other area is mainly residential with different housing typologies and a few services that correspond to the residents' needs. The chapter also introduced the hierarchal classification of the Doha street network designed by TMPQ- MMUP, which helped in understanding the linkage between one connector and the other. A questionnaire survey was designed targeting the residents of the selected areas and other users, using a random

sampling method, to understand how people evaluate and perceive the selected streets. This chapter also focused on presenting the initial survey answers that explore the positive and negative issues related to the current condition of streets in the two selected areas, along with exploring the different future improvements that users have selected in order to enhance the current condition and provide a safer environment in which they can walk, cycle and use other transport modes, exemplified as buses. The produced visual survey was essential to understand whether people are familiar with 'Complete Streets' treatments and what basic elements are streets missing that should be provided. Surprisingly, participants cooperated well in evaluating the current conditions of the selected streets for the two areas, and indicating the different aspects of the 'Complete Streets' concept that they would like modified and/or implemented in their streets.

CHAPTER 4: RESEARCH CONTEXT

4.1.Introduction

This chapter focuses on the area of the study of this thesis, Doha city, and describes the evolution of the city's street network from the early stages until today. First, it presents a brief historical background of the city's street planning over the years and also how the local network has been developed until today. This chapter also emphasizes the selected neighborhoods, Urban Center and Residential District, in terms of historical background, urban evolution, size, land use mix and the current street conditions.

4.2.Street Evolution in the City of Doha

During the 18th century, the Al Maadhid tribe and its leading family clan. Al Thani, moved from central Arabia to settle on the northern coast of Qatar, where they resided in the area around Zubara (Weidmann, et al., 2012). Later, clashes and tribal conflicts occurred that led to the selection of a settlement area, exemplified in Al Bidda area, based on the availability of a water source that supported their fishing activities (Adham, 2008, p.221). The area started to grow and develop, and housing settlements started to appear along with roads. However, the road network was not a result of conscious planning but rather the consequence of the collective building efforts of each family (Weidmann, et al., 2012).

Figure 42. The settlement areas in 1947 and 1971 (source, Weidmann, et al., 2012)

Weidmann, et al. (2012, pg.41) stated that: "During the 1950s and 1960s settlement patterns were determined by the development of modern infrastructure such as roads and the supply of fresh water and electricity". At this time, the first formal master plan was designed for the city of Doha by Llewelyn-Davies, a British firm, establishing a planning strategy that has informed the rapid growth of the city ever since.

Figure 43. Llewelyn Davies Master plan for the city of Doha (Davies, 2017)

The created master plan in the period from 1950's to 1960' has established detailed designs for the city in terms of town planning and residential areas and has recommended a set of regulations and policies to control the urban expansion of the city and building construction.

Streets started to become wider and roundabouts were introduced in this period of the city's development. A few years later, in 1977, new urban regulations started to appear and several areas within Doha's boundaries started to prepare a space for new developments. The configuration of the street network started to become clearer and wider to accommodate the defined designs of roundabouts, and lanes were widened to

accommodate additional vehicular movement. Ten years after these remarkable changes, a satellite image captures the clear formation of the grid-like quarters that are intersected by major and minor roads. In addition, buildings started to be compacted and new developments were introduced such as high-rise building located in the heart of Doha. Furthermore, moving to 1995, when urban development started to take a defined shape in the heart of the capital city, streets continued to expand to accommodate more cars and roundabouts were modified to be larger for the same purpose.

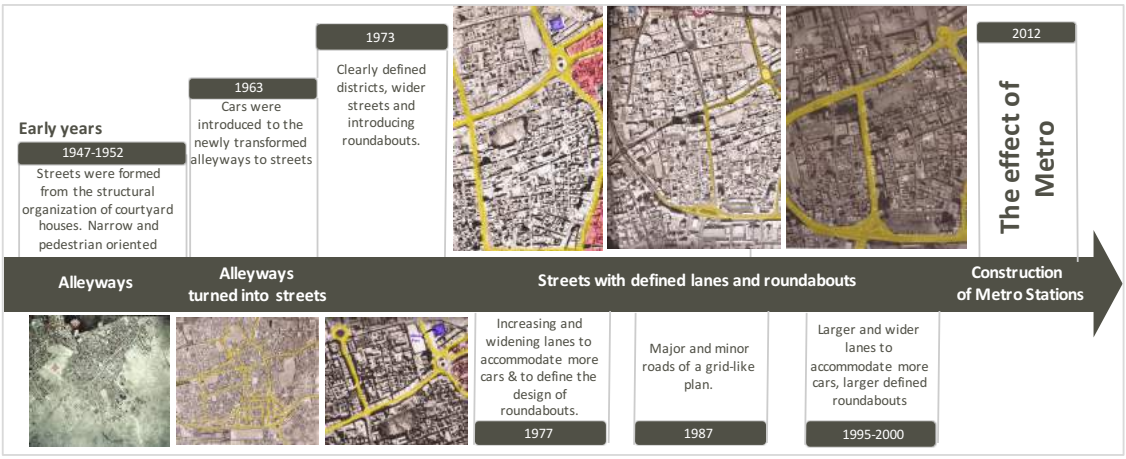


Figure 44. Timeline of Street Evolution in Doha City

4.3.Doha Streets Today

Nowadays, in the year 2017, the street network of the city of Doha has been developed to ease mobility and connectivity from the capital city to the neighboring areas. Local authorities have exerted a great deal of effort in the identification and development of a functional road network hierarchy that can accommodate the transport demands placed upon it by land use pressures, facilitate the continuing expansion and prosperity of the area,

and provide an attractive environment for residents and visitors to Qatar (TMPQ, 2008). The current street network is not settled yet, as it is continuing to develop and expand to accommodate the increase in the population and the arrival of the World Cup in 2022. For the current condition, many streets need improvement in terms of the basic amenities and services, which has resulted in the appearance of problematic issues that relate to congested streets, polluted environments and lack of integration of modes of transportation.

4.4.Overview of the Selected Areas

For this study, it was necessary to select two case studies to evaluate the current condition of Doha's street network. For the sake of analyzing different street functions, two different areas with different land use and activities with different contextual locations were chosen. An urban center and a residential district are the main focus of this thesis. In the following sections, a brief overview about the two areas is presented to introduce them.

4.4.1. Downtown Areas/Urban District: Fereej Bin Mahmoud

Fereej bin Mahmoud is considered one of the densest urban centers in the heart of Doha Municipality. The total area of the neighborhood is approximately 1.8 square kilometers (Qatar Atlas, 2010). This large area of urban settlement gives a diversity of land uses, most significantly commercial and retail activities, which best suits the study of this thesis.

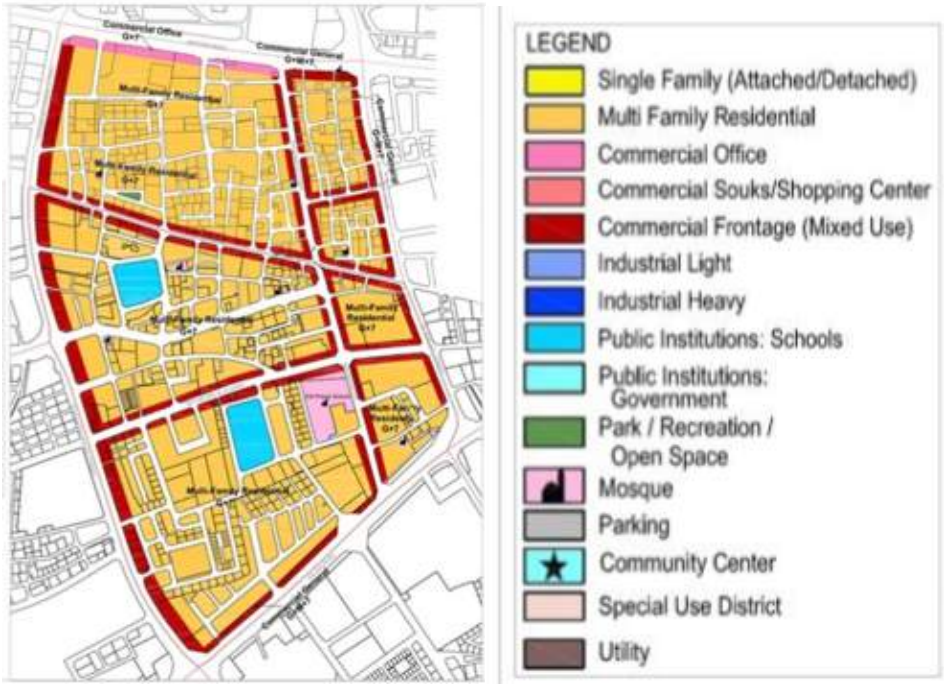


Figure 45. Land use map of Fereej bin Mahmoud (MMUP, 2008)

The neighborhood has evolved over the last decade and has grown rapidly from the center of Doha. The following maps showing the historical evolution of the area.

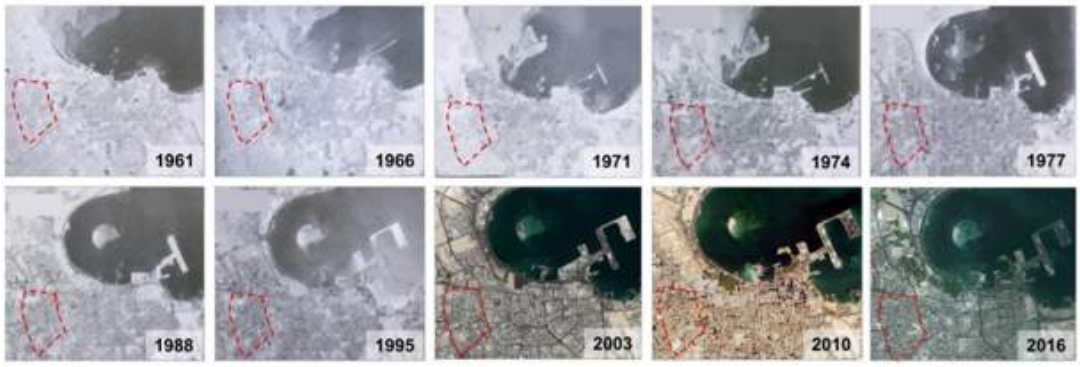


Figure 46. Urban evolution of Fereej bin Mahmoud (Awwaad, 2016)

The neighborhood is bounded from the eastern side by Al Khaleej Street, which is classified as an urban freeway that contains high traffic volumes and connects different

land uses. C-Ring road bounds the neighborhood from the western side, and is considered to be an urban expressway with a medium traffic flow. Al Rayyan Road and Salwa Road, from the northern and southern sides respectively, limit the boundaries of the neighborhood. According to QSA data from the 2010 census, the settlement comprised 8,398 housing units and 814 establishments. In terms of population, there were 24,172 people living in the settlement, of which 68% were male and 32% were female. Out of the 24,172 inhabitants, employed persons made up 67% of the total population. Females accounted for 16% of the working population, while males accounted for 84% of the working population. Awwaad (2016) pointed out some of the main issues faced in Fereej bin Mahmoud in terms of the street conditions and elements.

Figure 47. Street conditions in Fereej Bin Mahmoud: a. Street signage and residential frontages; b. Retail and commercial footages in a main road; c. Parking accommodation and building facades in a local road; d. Enhanced street conditions along the C-Ring Road (Awwaad, 2016, p.97)

4.4.2. Suburban/Residential District: Al Waab Area

Al Waab is considered one of the newly developed districts in the history of city planning of Doha. It is located in between the municipalities of Doha and Al Rayyan in Qatar. The settlement has witnessed tremendous growth, beginning in the mid-1990s, resulting in the construction of numerous residential compounds to house expatriates, villas, and commercial and medical developments (Fahmy, 2015). The meaning of the

word *waab* refers to a "vast area that accommodates things". It was given this name because of its greenery, level topography and fertile soil (Fahmy, 2015). According to QSA records, Al Waab City, a real estate development currently being constructed in the settlement, is set to add 639 villas, 1,293 apartments and 425 hotel rooms to the settlement. Furthermore, a number of roadside retail centers have been constructed parallel to Salwa Road, the highway linking Doha to the south of the country and Saudi Arabia. The land use of the studied neighborhood is mainly residential with different of housing typologies, in addition to some services that serve the needs of the residents.

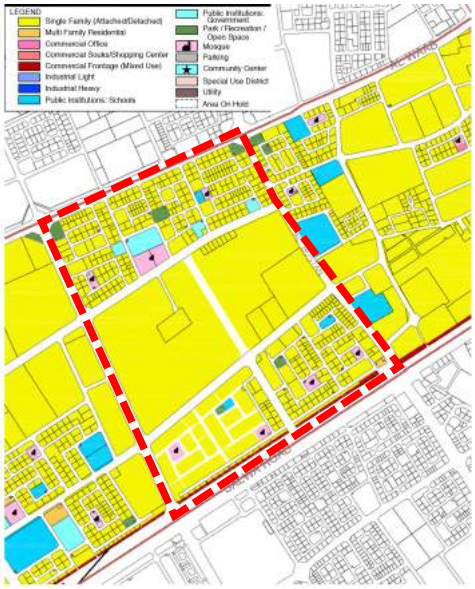


Figure 48. Land use map of Al Waab District (MMUP, 2008)

Figure 49. Urban Evolution of Al Waab (GIS imagery)

Planning for the urban evolution of the Al Waab district started in 2003, where the area was divided into plots to accommodate different housing typologies for a wide variety

of users from different cultural backgrounds. Year by year, residential compounds and standalone villas were built in addition to some features providing services such as parks, mosques and public institutions. The residential district is bounded by four major roads from the four sides. From the northern side, Al Waab Street is a major connector between the residential compounds and villas and the most famous shopping malls in Doha, Villagio and Hayat Plaza, along with the Aspire Zone Foundation (also known as Doha Sports City). Salwa Road bounds the neighborhood from the south, while Al Sidr Street and Al Bustan Street provide the boundaries from the west and east sides respectively.

CHAPTER 5: RESEARCH FINDINGS AND IMPROVED STREET DESIGN RECOMMENDATIONS

5.1. Introduction

In this chapter, the visual survey answers are analyzed based on its contexts. The analysis provided the base of the next step: improving the current street cross-section design based on users' perspectives and preferences. The enhancement process will be based on analyzing the survey data to categorize the presence or the absence of Complete Streets variables in the form of a checklist. The present and moderately present variables will be maintained or slightly enhanced to what better suits the users. The street variables that participants agree are absent will be added to what suits the street right-of-way and the traffic volumes.

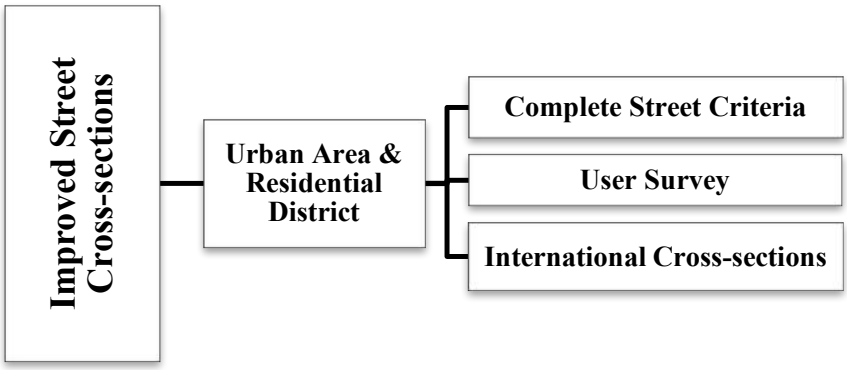


Figure 50. The Process of Assembling the Improved Cross-sections (Author)

5.2. Data Analysis of Urban Area: Fereej bin Mahmoud

5.2.1. Discussion of the Results

The surveyed results have reflected the level to which the users are aware of their surrounding streets, what they like about them and what they feel is missing in order for improvements to be made. For the Urban Area exemplified in Fereej bin Mahmoud, the

majority of respondents have stressed the availability of sufficiently designed street lanes, green areas and street lighting. On the other hand, the Fereej and its selected streets significantly lacked designed areas dedicated for walking and cycling, in addition to the absence of bus stops that should include the basic amenities: a shelter and waiting areas. This draws attention to the quality of the current streets and the potentiality of improving them based on the Complete Streets criteria. It is essential to point out that users of Fereej bin Mahmoud never use the bus, or even walk or cycle in the neighborhood's street, because of the dominant driving behavior of other users, which has created an unsafe environment. In addition, users sometimes lose their way in the internal streets of the Fereej, but generally participants agreed that the current streets are not difficult to navigate.

Figure 51. Current Conditions of Fereej bin Mahmoud Streets (Author)

In the case of the downtown area, exemplified in Fereej Bin Mahmoud, the neighborhood is a mixture of residential and commercial land uses. In this study, the focus was on the

streets that adjoined commercial and retail land uses to investigate how commercial streets with different rights-of-way perform in the city of Doha.

5.2.1.1. Street 1: Al Rayyan Street

Figure 52. Images of Al Rayyan Street (Author)

Figure 53. Top view of Al Rayyan Street (Qatar GIS Portal, 2017)

Al Rayyan Street is an Urban Expressway (medium to high traffic volumes, mainly free-flowing traffic, connecting major land uses within a large region) with a ROW of 64 meters; it acts as the northern boundary of the selected neighborhood. It provides entry to the residential blocks and the commercial stores that serve the area. According to the results, users identified the positive and negative issues relating to the studied street. The following table represents a checklist of the 'Complete Streets' variables based on the survey respondents, marking each principle with its variables as Present, Moderately Present and Absent.

Figure 54. Typical Traffic on Al Rayyan St. on a Weekday at (1) 8 am, (2) 3 pm, (3) 8 pm (Google Maps, 2017)

Figure 55. Typical Traffic on Al Rayyan St. on a Weekend at (1) 8 am, (2) 3 pm, (3) 8 pm (Google Maps, 2017)

Table 10. Complete Streets Checklist for Al Rayyan Street, Fereej bin Mahmoud

Complete Streets Principles	Complete Streets Variables	Present/ Moderately Present /Absent	Design Comments
Pedestrian Improvements	*Crosswalks/pavements*	MP	Should be enhanced to accommodate walking users.
	Street lighting	P	-
	Pedestrian refuge/pavement	MP	Provide safe racks for pedestrian, and ramps for users with special needs, bordered by greenery strips.
	Way-finding signage	MP	Should be improved to provide a complete navigation system, preventing users from losing their way.
Bicycle Improvements	*Bicycle lanes and racks*	A	The enhanced design should provide separate lanes for safe cycle use.
Green Improvements	*Amenity improvements*	MP	Should be well-maintained to provide space for street furniture (benches, trash cans, etc.)
	Planting strips	MP	Increase landscaped areas and utilize them as barriers to provide safer walking areas.
Transit Shelters	*Bus shelters*	A	Should be provided along with seating areas.
	Bus lanes	A	Should dedicate an extra lane for buses if available or can be added into a multi-use lane.

Figure 56. Presence and Absence of Variables in Al Rayyan St. (Author)

With regard to the improvement process, and according to the checklist presented in **Table 10**, a 'Complete Streets' enhancement plan should be followed with the elements that are absent in the studied street, exemplified in pedestrian or walking areas, bicycle lanes, bus lanes and shelters. According to the visual survey answers, the following 'Complete Streets' treatments were highly preferred by the participants in terms of improvements.

Figure 57. Participants' Preferred Complete Streets Treatments: Crosswalks, Bicycle Lanes, Bus Lanes (Author)

5.2.1.2. Street 2: Al Khaleej Street

Figure 58. Images of Al Khaleej Street in Fereej bin Mahmoud (Author)

Al Khaleej Street is considered as an Urban Freeway; it shapes the east side of the selected neighborhood with a right-of-way of 32 meters. The street is categorized to accommodate high traffic volumes and free-flowing traffic that connects major land uses. According to the survey, the following checklist presents what the respondents like and do not like about the selected street, along with other existing elements.

Figure 59. Typical Traffic of Al Khaleej St. on a Weekday at (1) 8 am, (2) 3 pm, (3) 8 pm (Google Maps, 2017)

Figure 60. Typical Traffic of Al Khaleej St. on a weekend at (1) 8 am, (2) 3 pm, (3) 8 pm (Google Maps, 2017)

Table 11. Complete Streets checklist for Al Khaleej Street

Complete Streets Principles	Complete Streets Variables	Present/ Moderately Present /Absent	Design Comments
Pedestrian Improvements	*Crosswalks/pavements*	A	Should be inserted to accommodate pedestrians.
	Street lighting	P	-
	Pedestrian refuge/pavement	A	Provide safe racks for pedestrian, and ramps for users with special needs, bordered by greenery strips on the sides of the roads.
	Way-finding signage	MP	The street is missing signs to assist people in navigating to their destinations. More should be inserted that contain street names and areas.
Bicycle Improvements	*Bicycle lanes and racks*	MP	Provide separate lanes for safe bicycle use.
Green Improvements	*Amenity improvements*	P	-
	Planting strips	MP	Increase landscaped areas and utilize them as barriers to provide safer walking areas.
Transit Shelters	*Bus shelters*	A	Should be provided along with seating areas.
	Bus lanes	A	Should dedicate an extra lane for buses if available or can be added into a multi-use lane.

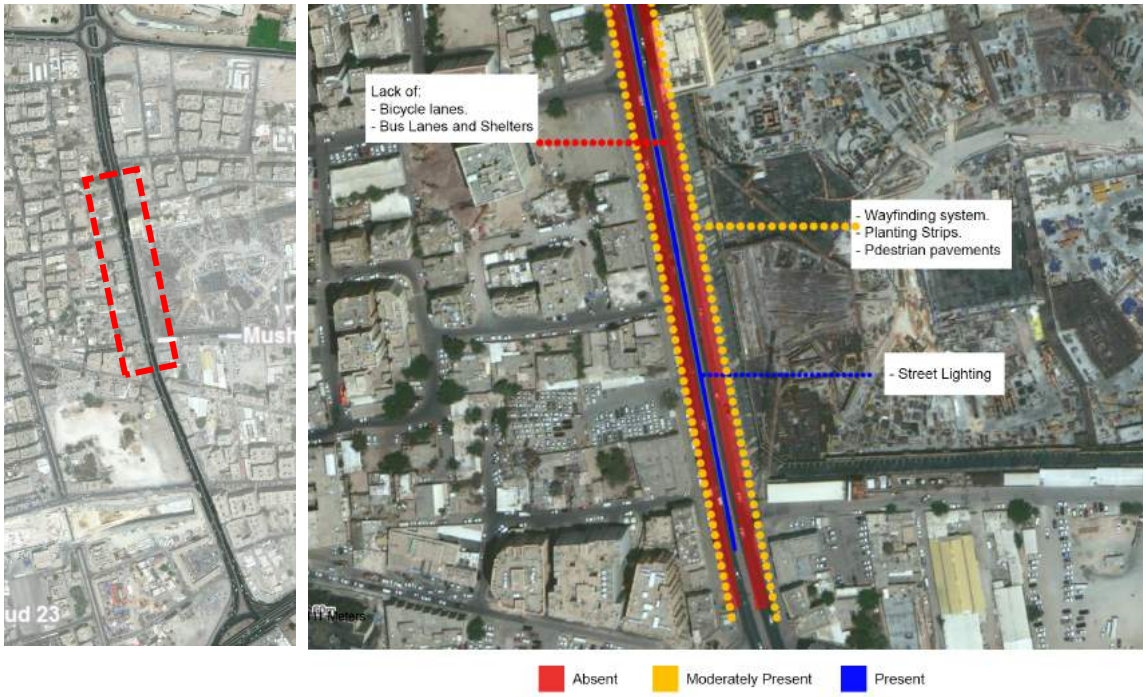


Figure 61. Existing Condition of Al Khaleej St. (Author)

The visual survey has also contributed to our knowledge of what users would prefer to have in their streets, and what types of improvement are suitable for each classification of the selected streets. For Al Khaleej Street, with its high traffic volumes, participants preferred to have brightly colored crosswalks and pavements for pedestrians, in order to attract the attention of vehicle drivers. In addition, they wanted bicycle lanes that are also colored for safer use, and bus amenities such as shelters and a bus lane which will be inserted as a shared lane to accommodate the high volumes of traffic and not cause more traffic.

Figure 62. Participants' Preferred Complete Streets Treatments: Crosswalks, Bicycle Lanes, Bus Lanes (Author)

5.2.1.3. Street 3: Qatari bin Al Fujaa Street

Figure 63. Images of Qatari bin Al Fujaa Street in Fereej bin Mahmoud

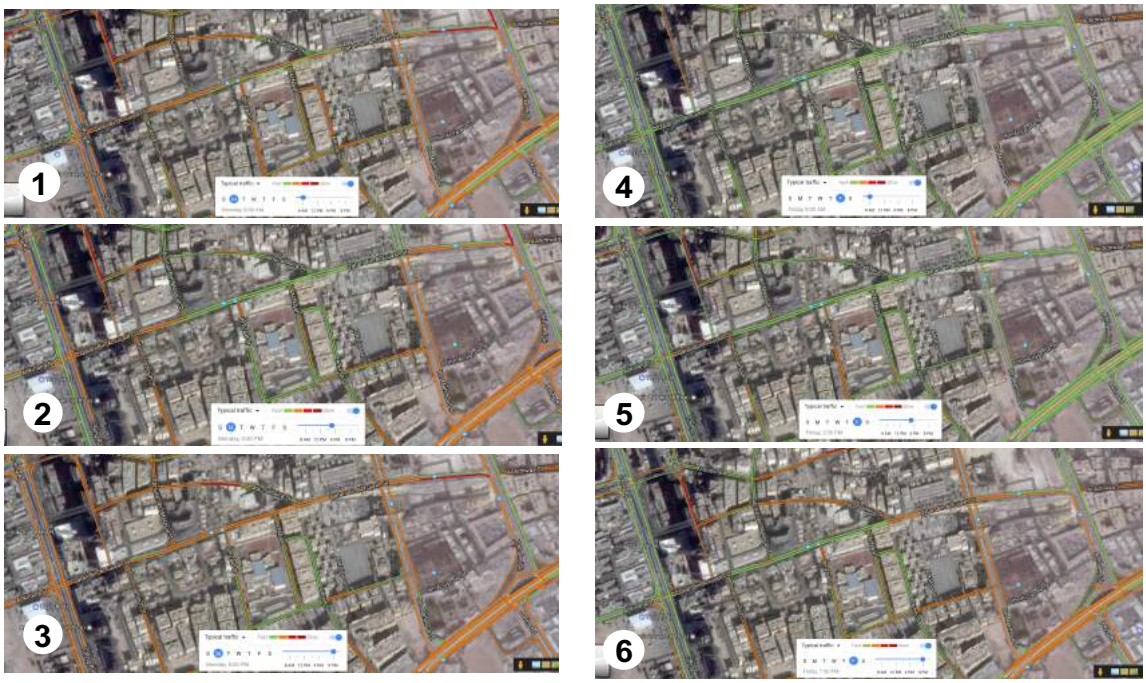


Figure 64. Typical Traffic of Qatari bin Al Fujaa St. on a weekday at (1) 8 am, (2) 3 pm, (3) 8 pm, and a weekend (4) 8 am, (5) 3 pm, (6) 8 pm (source: Google Maps, 2017)

Figure 65. Current street condition of Qatari bin Al Fujaa St. (Author)

This selected street is one of the busiest local roads of Fereej bin Mahmoud. It is categorized as a major urban collector according to (MMUP, 2015), with medium to low

traffic volumes, and it collects and distributes traffic from arterial roads. The selected street has a right-of-way of 24 meters.

Table 12. Complete Streets Checklist Based on Participants' Answers

Complete Streets Principles	Complete Streets Variables	Present/ Moderately Present /Absent	Design Comments
Pedestrian Improvements	*Crosswalks/pavements*	MP	Should be enhanced to accommodate walking users.
	Street lighting	MP	Should be increased and enhanced for better illumination at night.
	Pedestrian refuge/pavement	A	Provide safe racks for pedestrian, and ramps for users with special needs, bordered by greenery strips.
	Way-finding signage	MP	Should be improved to provide a complete navigation system, preventing users from losing their way.
Bicycle Improvements	*Bicycle lanes and racks*	A	The enhanced design should provide separate lanes for safe bicycle use.
Green Improvements	*Amenity improvements*	MP	Should be maintained and enhanced to provide spaces for greenery and buffers for pedestrians.
	Planting strips	A	Landscaping and planting strips should be inserted along the street.
Transit Shelters	*Bus shelters*	A	Should be provided along with seating areas.
	Bus lanes	A	Should dedicate an extra lane for buses if available or can be added into a multi-use lane.

Figure 66. Absent and Moderately Present Variables of Qatari bin Al Fujaa St. (Author)

Based on the visual survey, which was focused on the future enhancement of the selected street, it is apparent that participants highlighted a number of treatments to be implemented for the missing 'Complete Streets' variables of the street. According to the checklist in **Table 12**, the street lacked pedestrian walking areas, bicycle lanes, green areas and bus amenities. The following images show the treatments that the participants greatly preferred for the four missing variables.

Figure 67. Participants' Preferred Treatments for Pedestrian Areas, Bicycle Lanes, Green Areas And Bus Amenities (Author)

5.3. Data Analysis of the Residential District: Al Waab District

5.3.1. Discussion of Results

The surveyed results have revealed the participants' level of knowledge in relation

to their surrounding streets, and exposed what they like about them and what they feel is missing, in order to make improvements. For the residential district exemplified in Al Waab, the majority of respondents stressed the availability of sufficiently designed street lanes, signs and street lighting, in addition to green areas. On the other hand, the district and its selected streets significantly lacked areas dedicated for walking and cycling, but did have a wide pavement area that people unintentionally used for these purposes. The district lacked bus stops that should include the basic amenities, a shelter and waiting area. This draws attention to the quality of the current streets and the potentiality of improving them based on the 'Complete Streets' criteria. It is essential to point out that users of Al Waab district never use the bus, but they do walk and cycle a few time during the year in the neighborhood's street. Regardless of the weather, lack of bicycle racks and the overall behavior of vehicle drivers, the streets do encourage users to walk and sometimes cycle on the existing pavements. On the other hand, the mentioned obstacles are considered to generate an unsafe environment that cannot be used comfortably. As another positive point, users highlighted that the streets of Al Waab have a very easy navigation system: it is easy to move around without getting lost, such as in the streets of Fereej bin Mahmoud.

5.3.1.1. Street 1: Al Sidr Street

Figure 68. Images of Al Sidr Street, Al Waab District (Author)

This street bounds the neighborhood from the west side, and is categorized as a Major Urban Arterial street, which has medium traffic volumes and connects urban districts. The street has a right-of-way of 64 meters.

Figure 69. Typical Traffic of Al Sidr St. on a weekday at (1) 8 am, (2) 3 pm, (3) 8 pm (Google Maps, 2017)

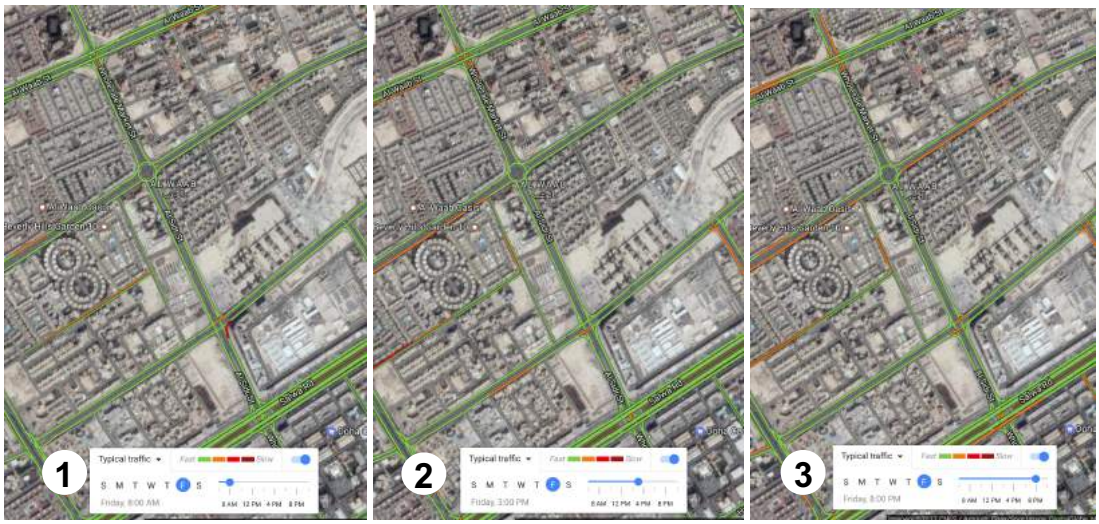


Figure 70. Typical Traffic of Al Sidr St. on a weekend at (1) 8 am, (2) 3 pm, (3) 8 pm (Google Maps, 2017)

Table 13. Complete Streets Checklist Based on the Responses for Al Sidr St.

Complete Streets Principles	Complete Streets Variables	Present/ Moderately Present /Absent	Design Comments
Pedestrian Improvements	*Crosswalks/pavements*	P	-
	Street lighting	P	-
	Pedestrian refuge/pavement	MP	Should be maintained to provide safe racks for pedestrians, and ramps for users with special needs, bordered by greenery strips.
	Way-finding Signage	MP	Should be improved to provide a complete navigation system, preventing users from losing their way.
Bicycle Improvements	*Bicycle lanes and racks*	A	The enhanced design should provide separate lanes for safe bicycle use.
Green Improvements	*Amenity improvements*	P	-
	Planting strips	MP	Landscaping and planting strips should be increased along the street.
Transit Shelters	*Bus shelters*	A	Should be provided along with seating areas on the existing pavements.
	Bus lanes	A	Should dedicate an extra lane for buses if available or can be added into a multi-use lane.

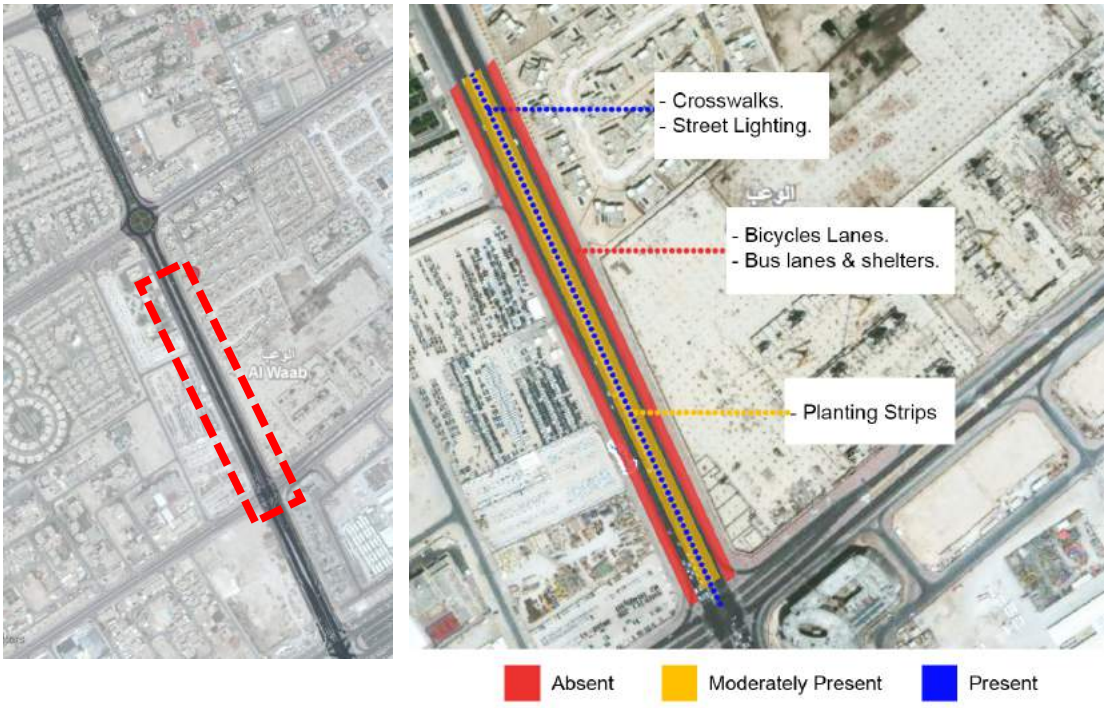


Figure 71. Absent, Moderately Present, and Present Variables in Al Sidr St. (Author)

Based on the enhancement visual survey distributed to different users and the district's residents, it is obvious that users preferred different types of 'Complete Streets' treatments from the ones selected in Fereej bin Mahmoud. For this particular street, the missing variables are exemplified in the absence of bicycle lanes, bus shelters and lanes, which should be maintained and inserted according to what suits the street's right-of-way.

Figure 72. Participants' Preferred Treatment for the Absent Variables in Al Sidr Street (Author)

5.3.1.2. Street 2: Al Ghariyah Street

Figure 73. Images of Al Ghariyah Street (Author)

Al Ghariyah Street is categorized as a minor urban collector according to (MMUP, 2015), with medium to low traffic volumes, and it collects and distributes traffic from arterial roads. The selected street has a right-of-way of 50 meters.

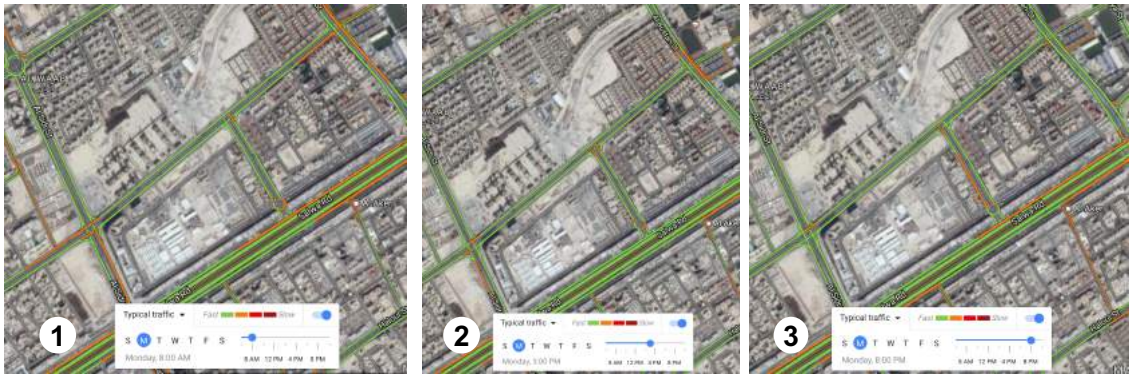


Figure 74. Typical Traffic of Al Ghariyah St. on a weekday at (1) 8 am, (2) 3 pm, (3) 8 pm (Google Maps, 2017)

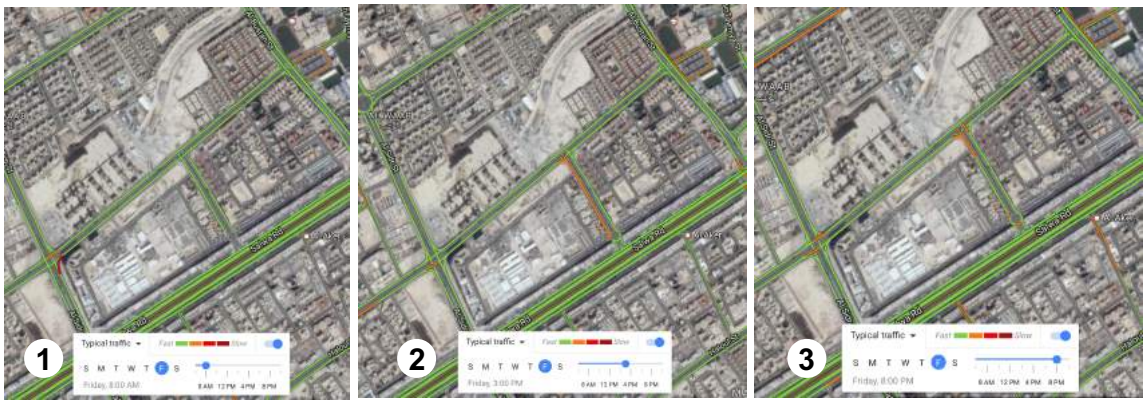


Figure 75. Typical Traffic of Al Ghariyah St. on a weekend at (1) 8 am, (2) 3 pm, (3) 8 pm (Google Maps, 2017)

Figure 76. Absent and present variables of Al Ghariyah St. (Author)

Table 14. Complete Streets Checklist Based on Responses for Al Ghariyah St.

Complete Streets Principles	Complete Streets Variables	Present/ Moderately Present /Absent	Design Comments
Pedestrian Improvements	*Crosswalks/pavements*	P	-
	Street lighting	P	-
	Pedestrian refuge/pavement	MP	Should be provided for pedestrians, and ramps for users with special needs, bordered by greenery strips.
	Way-finding Signage	P	-
Bicycle Improvements	*Bicycle lanes and racks*	A	The enhanced design should provide separate lanes for safe bicycle use.
Green Improvements	*Amenity improvements*	P	-
	Planting strips	A	Landscaping should be inserted as buffer zones between vehicular lanes and pedestrians.
Transit Shelters	*Bus shelters*	A	Should be provided along with seating areas on the existing pavements.
	Bus lanes	A	Should dedicate an extra lane for buses if available or can be added into a multi-use lane.

Based on the participants' responses and as shown in Table 14, Al Ghariyah Street was missing four major variables: pedestrian lanes, bicycles racks, planting strips and greenery, and finally bus lanes and shelters. The visual survey highlighted the treatments that the participants wanted to be taken into account for implementation purposes.

Figure 77. Participants' preferred treatments for Al Ghariyah Street (Author)

5.3.1.3. Street 3: Al Bustan Street

Figure 78. Images of Al Bustan Street (Author)

This street is categorized as an Urban Expressway (medium to high traffic volumes, mainly free-flowing traffic, connecting major land uses within a large region) with a ROW of 40 meters; it acts as the northern boundary of the selected neighborhood. It provides entry to the residential blocks and the commercial stores that serve the area.

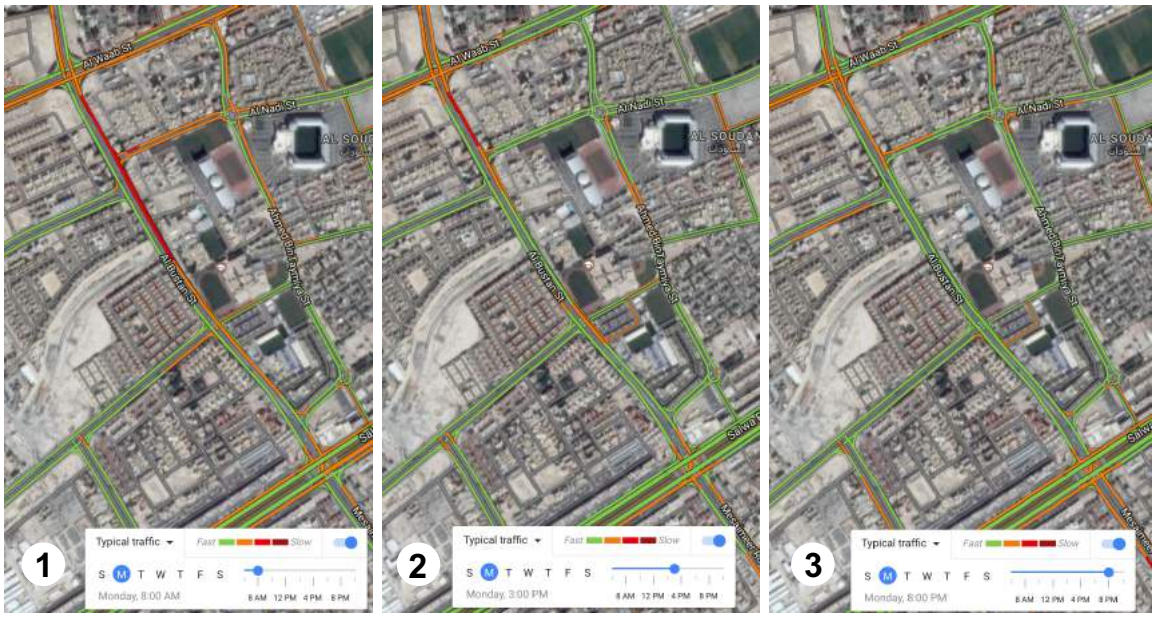


Figure 79. Typical Traffic of Al Bustan St. on a weekday at (1) 8 am, (2) 3 pm, (3) 8 pm (Google Maps, 2017)

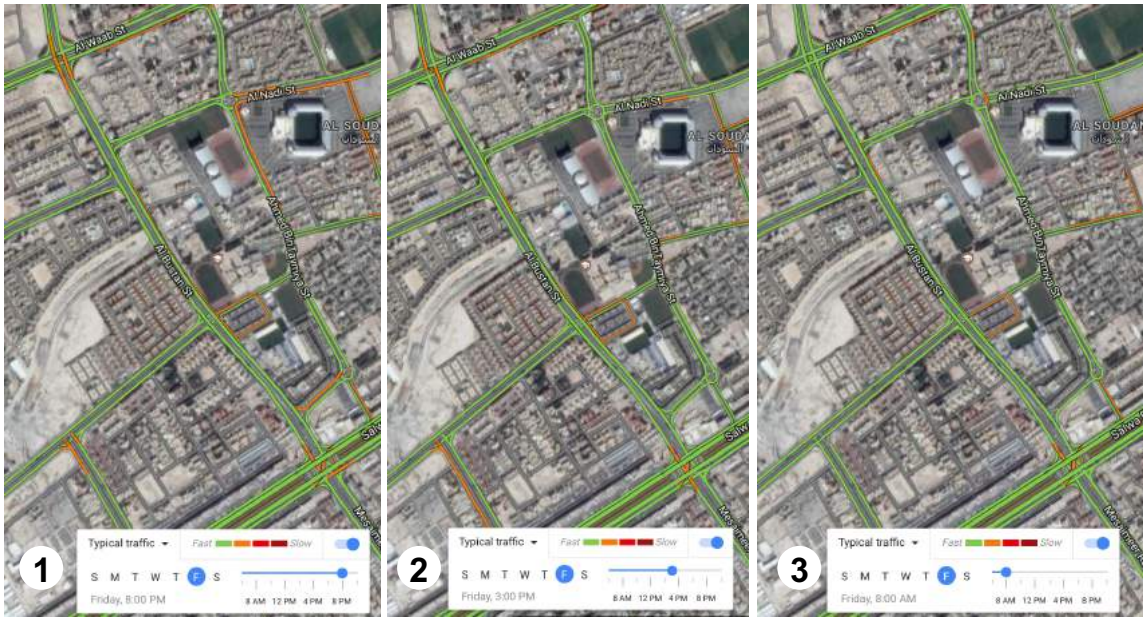


Figure 80. Typical Traffic of Al Bustan St. on a weekend at (1) 8 am, (2) 3 pm, (3) 8 pm (Google Maps, 2017)

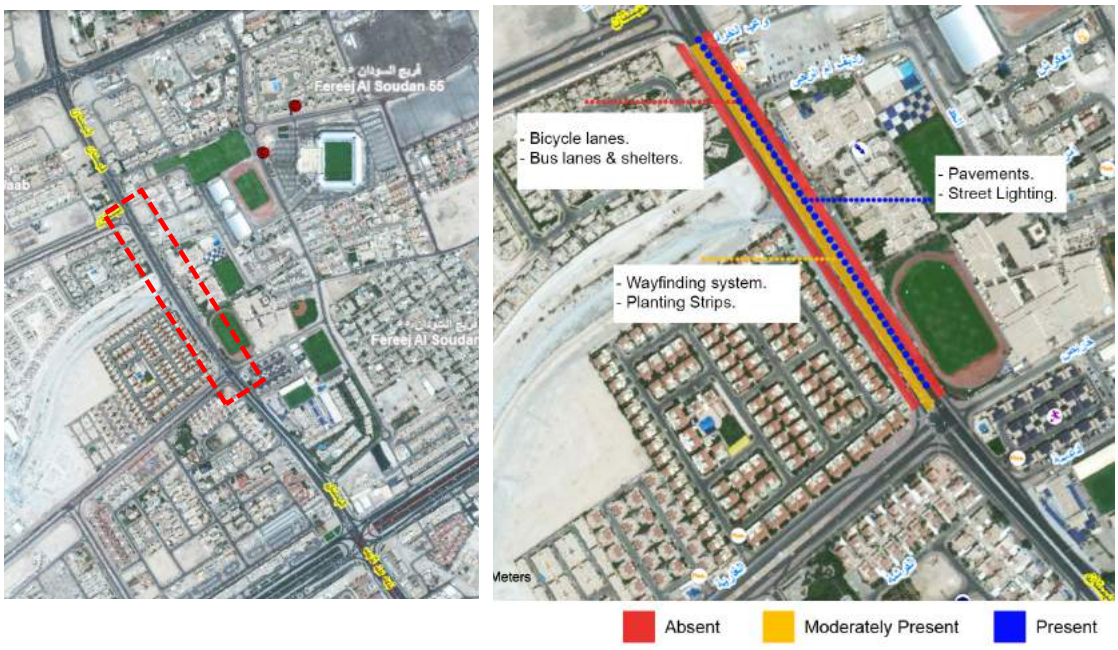


Figure 81. Absent, Moderately Present, and Present Variables in Al Bustan St. (Author)

Table 15. Complete Streets Checklist based on Respondents' Responses

Complete Streets Principles	Complete Streets Variables	Present/ Moderately Present /Absent	Design Comments
Pedestrian Improvements	*Crosswalks/pavements*	P	-
	Street lighting	P	-
	Pedestrian refuge/pavement	MP	Should be provided for pedestrians, and ramps for users with special needs, bordered by greenery strips for a safe walk.
	Way-finding Signage	MP	Should be enhanced to provide a perfect navigation system.
Bicycle Improvements	*Bicycle lanes and racks*	A	The enhanced design should provide separate lanes for safe bicycle use.
Green Improvements	*Amenity improvements*	P	-
	Planting strips	MP	Should be increased to include more green areas and landscaping.
Transit Shelters	*Bus shelters*	A	Should be provided along with seating areas on the existing pavements.
	Bus lanes	A	Should dedicate an extra lane for buses if available or can be added into a multi-use lane.

In terms of street enhancement, the same variables were noted as being absent in the street: pedestrian and walking areas, bicycle racks, bus lanes and shelters. The majority of respondents highlighted the need for various treatments to be implemented in the street, which were quite similar to the three streets of Al Waab district. The following images are extracted from the visual survey and based on users' preferences.

Figure 82. Participants' Preferred Treatments: Pedestrian, Bicycle Lanes and Bus Amenities (Author)

Table 16. Summary of the Absent, Moderately Present and Present Variables in Downtown and Suburban Areas

Variables	**Downtown area (Urban Center)**	**Suburban area (Residential District)**
Existing variables	- Motor vehicle lanes - Pedestrian pavements	- Pedestrian pavements - Street lighting - Signage system
Moderately presented variables	- Signage system - Planting strips - Street lighting	- Planting strips
Missing/Absent variables	- Bicycle lanes - Bus shelters and amenities (waiting areas, shaded kiosk)	- Bicycle lanes - Bus shelters and amenities (waiting areas, shaded kiosk)
Preferable Complete Streets treatment for variables with description	- Bicycle lanes: preferably colored and in a separate lane, or shared with a pedestrian path. - Pedestrian crossing: preferably with lane markings. - Bus lane: preferably colored to be distinguishable. - Planting strips: contain grass, trees and other landscaping elements to provide natural buffer zones.	- Bicycle lanes: preferably colored and in a separate lane. - Pedestrian crossing: preferably with lane markings. - Bus lane: preferably colored to be distinguishable. - Planting strips: contain grass, trees and other landscaping elements to provide natural buffer zones in central and side medians for more safety.

5.4. Improved Cross-Section based on 'Complete Streets' Concept

International cross-sections have been designed to suit the context of the studied streets. Basically, the design of the cross-section is based on the hierarchal classification of the street and the right-of-way (ROW). Each design has standard characteristics and 'Complete Streets' variables that must be included in the street for enhancement purposes.

The local hierarchal classification of the street network in Doha follows a similar international categorization of streets and their improvements based on the ROW and type of street. The international cross-sections are US-based, specifically Miami and North Carolina states. These cross-sections can be taken into consideration in the improvement process for the existing cross-sections of the studied streets in both Fereej bin Mahmoud and Al Waab residential district, and also compared to the local cross-sections produced in the Qatar Highway Design Manual by the Ministry of Municipality and Environment (MME) in 2015.

The following diagram shows the road classification of the selected streets of the downtown and suburban areas in Doha city. Other international, US-based, cross-sections are used to compare the 'Complete Streets' variables with the local cross-sections produced by the MME. The diagram helped in categorizing the concept's common variables for the four major principles: pedestrian, bicycle, green and transit improvements. In addition, the designed classification diagram assessed in the enhancement process for the local cross-sections along with the users' perception about the current and future design of the selected streets.

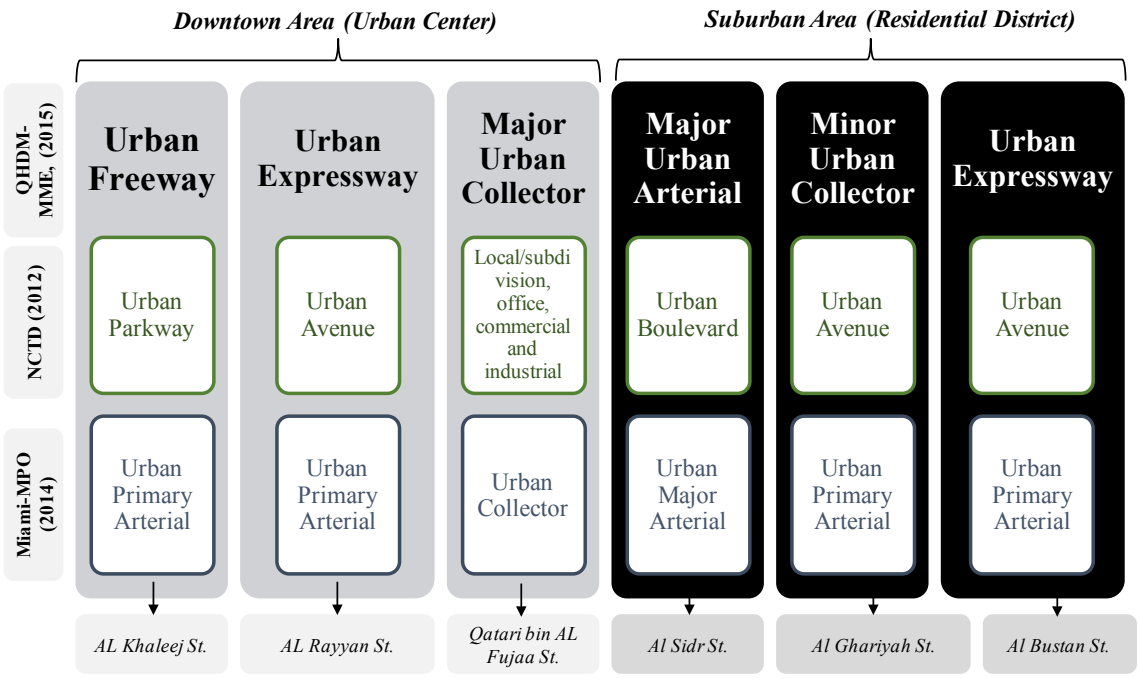


Figure 83. Road Classifications for the Two Selected Areas According to MMUP, North Carolina, and Miami States (Author)

Each of the cross-section designs from both sources (North Carolina Department of Transportation, 2012, and Miami-Dade MPO, 2014) have established a number of design guidelines for each variable of the 'Complete Streets' criteria. The following table shows each road classification for Doha's roads and the corresponding street classification for North Carolina and Miami states.

Table 17. Urban Freeway Design Guidelines

Doha Road Classification	North Carolina Transportation Department (2012) design guidelines		Miami MPO (2014) design guidelines	
Urban Freeway	**Complete Streets Principle: Pedestrian Improvements**			
	Urban Parkway	Landscaped central median as separation between lanes.	**Urban Primary Arterial**	Pedestrian zone located adjacent to land uses.
		Multi-use path zones: for pedestrians and bicyclists.		On-street parking should be provided as a buffering zone.
	Complete Streets Principle: Bicycle Improvements			
		Included in the multi-use path.		Bicycle zone should be provided based on the capacity needs. It should be added between travel lanes and pedestrian zones.
	Complete Streets Principle: Green Improvements			
		Green zone of planting strips and trees to separate the multi-path zone from the motor vehicle lanes.		Higher speeds and volumes require spaces with adequate landscaping as a buffering zone.
	Complete Streets Principle: Transit Improvements			
		Shared with motor vehicle lanes.		Preferred locations are generally cross streets and high traffic generators.

Table 18. Urban Expressway Design Guidelines

Doha Road Classification	NCTD (2012) design guidelines		Miami MPO (2014) design guidelines	
Urban Expressway	**Complete Streets Principle: Pedestrian Improvements**			
	Urban Avenue	Sidewalk zone with adequate width to allow pedestrians to walk safely and comfortably.	**Urban Primary Arterial**	Pedestrian zone located adjacent to land uses. On-street parking should be provided as a buffering zone.
	Complete Streets Principle: Bicycle Improvements			
		Accommodation for bicyclists in a zone separate from the motor vehicle zone.		Bicycle zone should be provided based on the capacity needs. It should be added between travel lanes and pedestrian zones.
	Complete Streets Principle: Green Improvements			
		Landscaped or hardscaped area along the edge of the street, including grass, landscaping and shade trees in planting strips.		Higher speeds and volumes require spaces with adequate landscaping as buffering zone.
	Complete Streets Principle: Transit Improvements			
		Shared with motor vehicle zones.		Preferred locations are generally cross streets and high traffic generators.

Table 19. Major Urban Collector Design Guidelines

Doha Road Classification	NCTD (2012) design guidelines		Miami MPO (2014) design guidelines	
Major Urban Collector	**Complete Streets Principle: Pedestrian Improvements**			
	Local/subdivision, office, commercial and industrial	Sidewalk zone with adequate width to allow pedestrians to walk safely and comfortably.	**Urban Collector**	Pedestrian zone is crucial because of high pedestrian volumes. Should be spacious with unobstructed sidewalks and pedestrian-scale lighting.
	Complete Streets Principle: Bicycle Improvements			
		Shared with vehicle and parking zones.		Shared with a mixed vehicle zone that serves cars, buses, trucks and bicycles.
	Complete Streets Principle: Green Improvements			
		Consists of planting strips with street trees between sidewalk and the edge of the street.		Street trees or other landscaping elements that provide extra buffering between pedestrians and vehicles.
	Complete Streets Principle: Transit Improvements			
		Shared with vehicle and parking zones.		Shared with a mixed vehicle zone that serves cars, buses, trucks and bicycles.

Table 20. Major Urban Arterial Design Guidelines

Doha Road Classification	NCTD (2012) design guidelines		Miami MPO (2014) design guidelines	
Major Urban Arterial	**Complete Streets Principle: Pedestrian Improvements**			
	Urban Boulevard	The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably.	**Urban Major Arterial**	Should allow for comfortable travel with appropriate widths for adjacent and surrounding land uses.
	Complete Streets Principle: Bicycle Improvements			
		A zone for bicyclists separate from vehicular traffic.		Due to higher speeds, in order to provide comfort and safety for bicyclists, a dedicated lane would be needed. This zone would also add to the buffer between travel lanes and the pedestrian zone.
	Complete Streets Principle: Green Improvements			
		Serves to separate the sidewalk from the vehicles. This zone contains landscaping and trees or sometimes hardscape treatments.		Very important to provide a comfortable buffer for pedestrian travel, although some configurations could include a median or on-street parking with intermittent landscaping.
	Complete Streets Principle: Transit Improvements			
		Shared with a mixed vehicle zone that serves cars, buses, and trucks.		Shared with a mixed vehicle zone that serves cars, buses, and trucks.

Table 21. Minor Urban Collector Design Guidelines

Doha Road Classification	NCTD (2012) design guidelines		Miami MPO (2014) design guidelines	
Minor Urban Collector	**Complete Streets Principle | Pedestrian Improvements**			
	Urban Avenue	Sidewalk zone with adequate width to allow pedestrians to walk safely and comfortably.	**Urban Primary Arterial**	Pedestrian zone located adjacent to land uses. On-street parking should be provided as a buffering zone.
	Complete Streets Principle: Bicycle Improvements			
		Accommodation for bicyclists in a zone separate from the motor vehicle zone.		Bicycle zone should be provided based on the capacity needs. It should be added between travel lanes and pedestrian zones.
	Complete Streets Principle: Green Improvements			
		Landscaped or hardscaped area along the edge of the street, including grass, landscaping and shade trees in planting strips.		Higher speeds and volumes require spaces with adequate landscaping as a buffering zone.
	Complete Streets Principle: Transit Improvements			
		Shared with motor vehicle zones.		Preferred locations are generally cross streets and high traffic generators.

5.4.1. Improved Cross-Section of Downtown area (Fereej bin Mahmoud)

5.4.1.1. Al Rayyan Street

In the case of Fereej bin Mahmoud, it is considered to be a vital and an active urban center in the downtown region of Doha. For this reason, its streets are categorized as having medium to high traffic volumes at most times during the day. The current design of the selected streets lacked major variables and components that satisfy the 'Complete Streets'

concept and provide a safer environment for users. The following comparative analysis of the three cross-sections of the same road classification for Doha (MMUP), North Carolina and Miami states shows the different variables included (**Figure 84**). The improved cross-section integrates components that exist in the local cross-section created by MMUP and is based on users' responses to the distributed questionnaires.

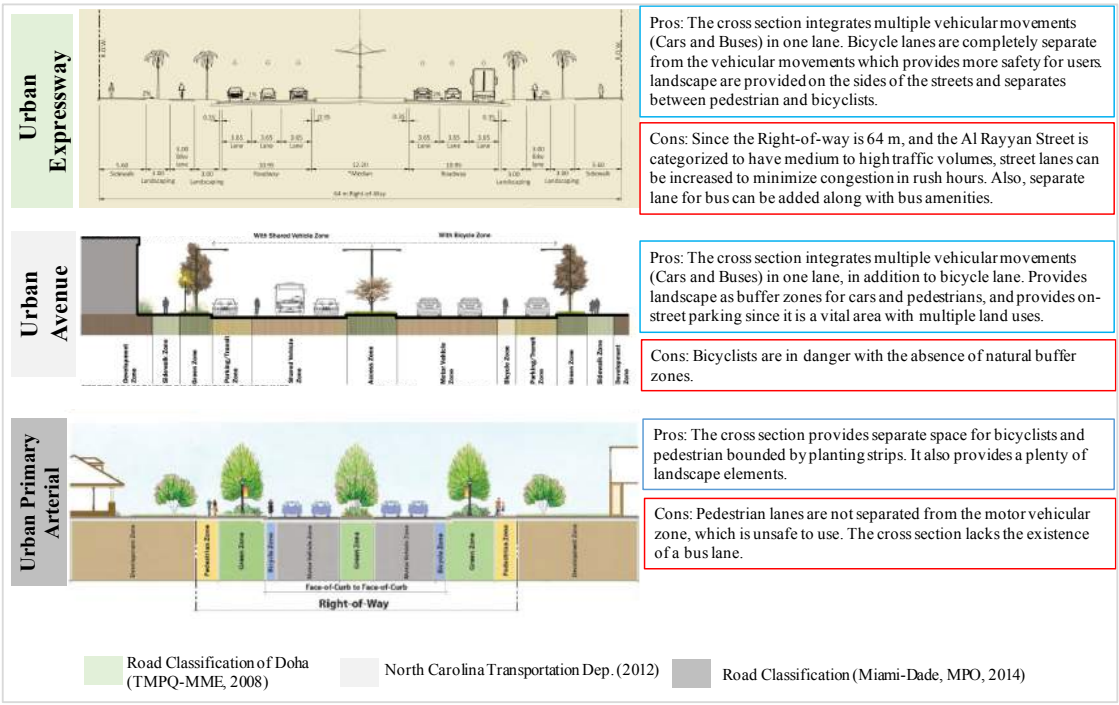


Figure 84. Comparative Analysis of Three Cross-Sections of the Same Road Classification as Al Rayyan St (Author)

Figure 85. Enhanced Cross-section of Al Rayyan Street (Author)

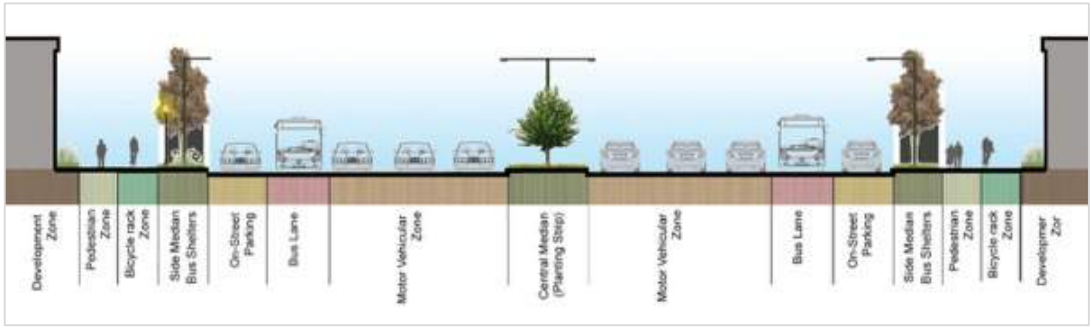


Figure 86. Illustrative Section of the Improved Variables of Al Rayyan Street (Author)

Table 22. Summary of the Street Conditions Before and After Complete Streets Improvements

Street Components	Before	After	Design Comments
Number of lanes	Four lanes	Six lanes	Lanes were increased since the road is classified as accommodating medium to high traffic volumes.
Central Median	Exists	Exists	Minimized the existing median to fit in a landscaped area and trees as a natural barrier.
Side Median	Absent	Absent	No need to have a side median since there is no service road.
On-street parking	Absent	Exists	Increased on-street parking lots.
Pedestrian path	Absent	Exists	Designed as a separate path, with ramps for users with special needs, bounded by planting strips for safety reasons.
Cyclist path	Absent	Exists	Designed as a separate path bounded by planting strips for safety reasons.
Bus lane and shelter	Absent	Exists	Inserted a separate lane to reduce the traffic, and provided shelters.
Lighting	Moderately exists	Exists	Increased the number light bulbs.
Landscape and greenery	Moderately present	Exists	Increased the landscape density and the amount of planting strips and trees.

Figure 87. Before and After Views of Al Rayyan St. (Author)

5.4.1.2. Al Khaleej Street

AL Khaleej Street is one of the most highly congested streets in the area of Fereej bin Mahmoud, as it has plenty of retail and commercial stores that create an economically vital environment. The section of the street that was selected for improvement consisted of two lanes along with on-street parking that support the requirements of the retail store. The improved cross-section kept the two lanes for motor vehicular movement, and added a service road to avoid or minimize the congestion that can occur on busy days. Cyclists and pedestrians are completely separated from these lanes. In addition, the lighting bulbs were increased, as per the users' preferences.

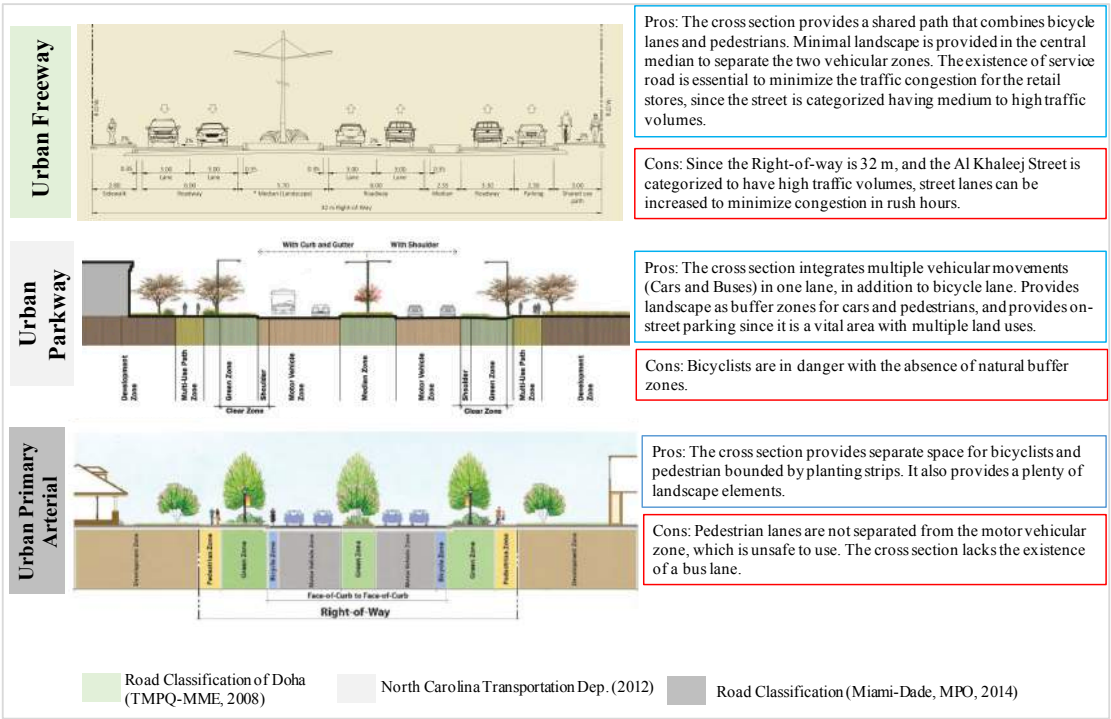


Figure 88. *Comparative Analysis of Three Cross-Sections of the Same Road Classification As Al Khaleej St (Author)*

Figure 89. Enhanced Cross-Section of Al Khaleej Street (Author)

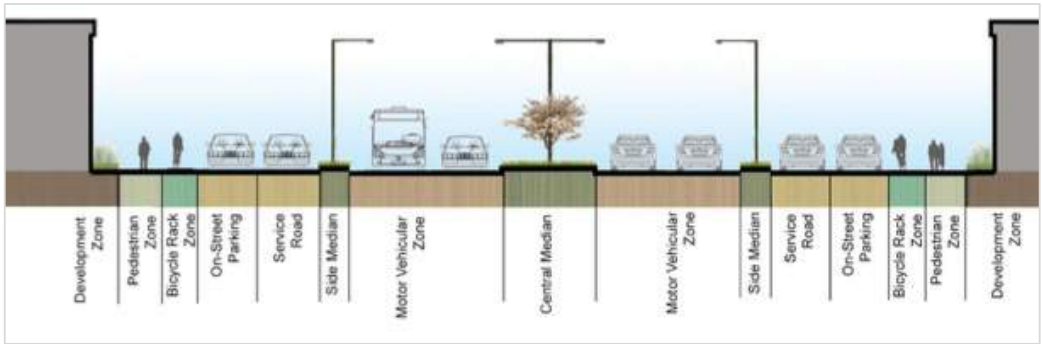


Figure 90. Illustrative Section of the Improved Variables of Al Khaleej Street (Author)

Table 23. Summary of the Street Conditions Before and After Complete Streets Improvements

Street Components	Before	After	Design Comments
Number of lanes	Four lanes	Four lanes	-
Central Median	Exists	Exists	Minimized the existing median to fit in a landscaped area and trees as a natural barrier.
Side Median	Absent	Exists	There is a need to have a side median since a service road was provided
On-street parking	Absent	Exist	The insertion of parking lots beside the service road for commercial purposes.
Pedestrian path	Absent	Exists	Designed as a separate path, with ramps for users with special needs, bounded by planting strips for safety reasons.
Cyclists path	Absent	Exists	Designed as a separate path bounded by planting strips for safety reasons.
Bus lane and shelter	Absent	Exists	Shared with the other motor vehicles (car, truck, etc.).
Lighting	Moderately exist	Exists	Increased the number of lighting bulbs.
Landscape and greenery	Moderately present	Exists	Increased the landscape density and the amount of planting strips and trees.

Figure 91. Before and After Views of Al Khaleej St. (Author)

5.4.1.3. Qatari bin Al Fujaa Street

This is a well-known street, with many shops and commercial land uses that make the space more vital and, indeed, more car-congested. The current design of the street supports walking and cycling activities; however, it does not provide safe spaces in which to walk or cycle. For this reason, the enhanced design of the street provides separate lanes for pedestrian and cyclists bounded by natural buffers, exemplified in planting strips, along with on-street parking to minimize the congestion that can occur due to the existing retail activities.

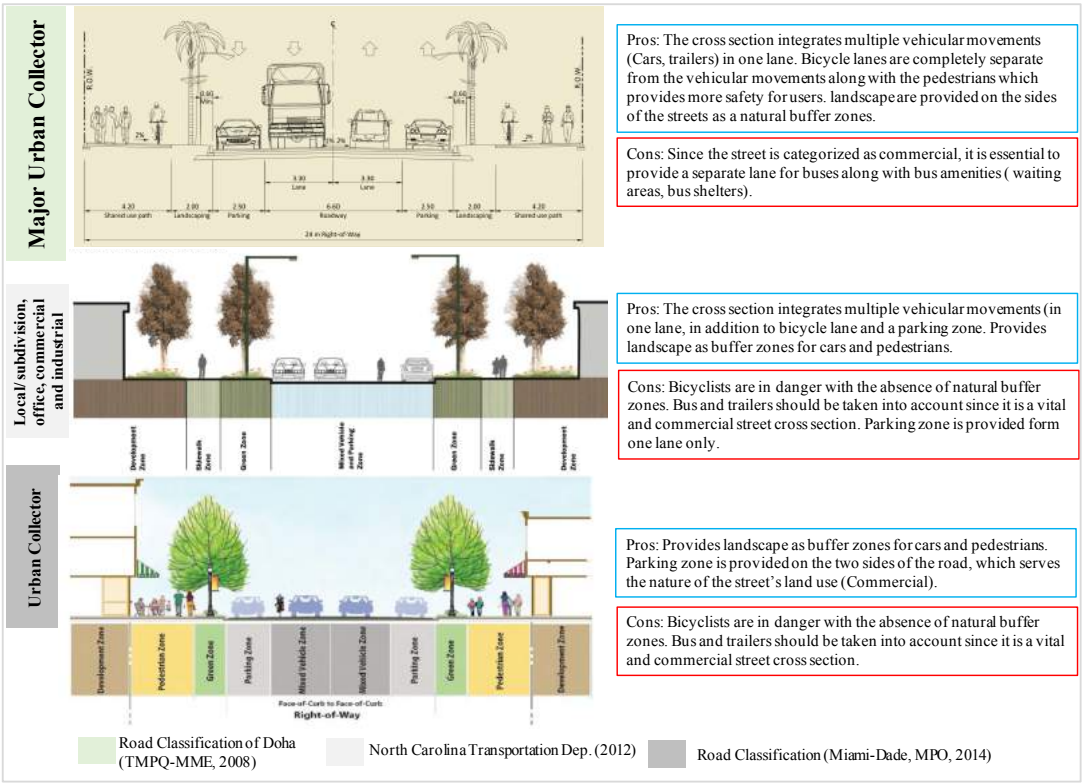


Figure 92. Comparative Analysis of Three Cross-Sections of the Same Road Classification As Al Khaleej St (Author)

Figure 93. Enhanced Cross-section of Qatari bin Al Fujaa Street (Author)

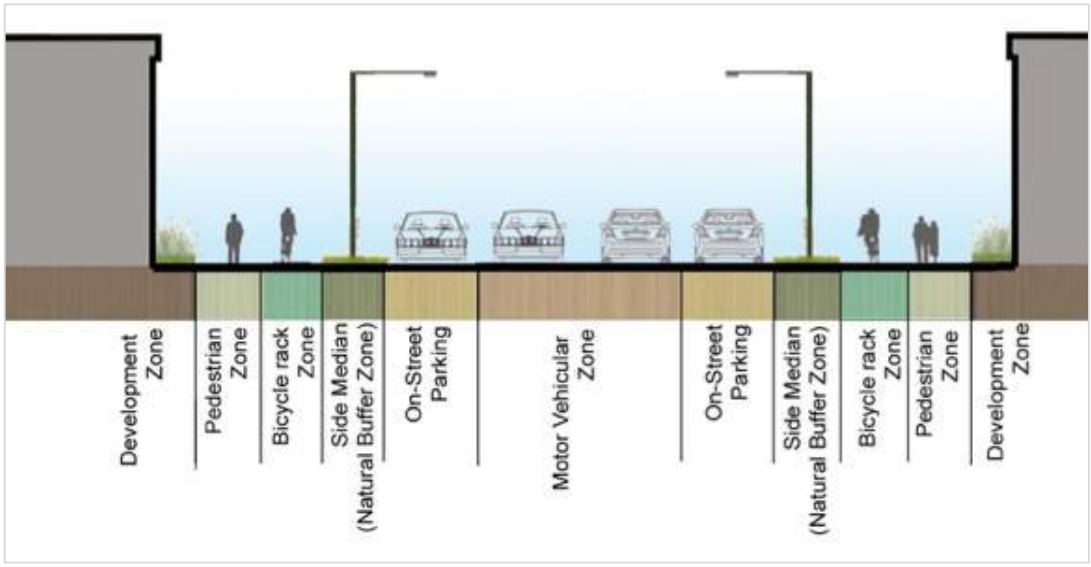


Figure 94. Illustrative Section (A-A) of the Improved Variables of Qatari Bin Al Fujaa Street (Author)

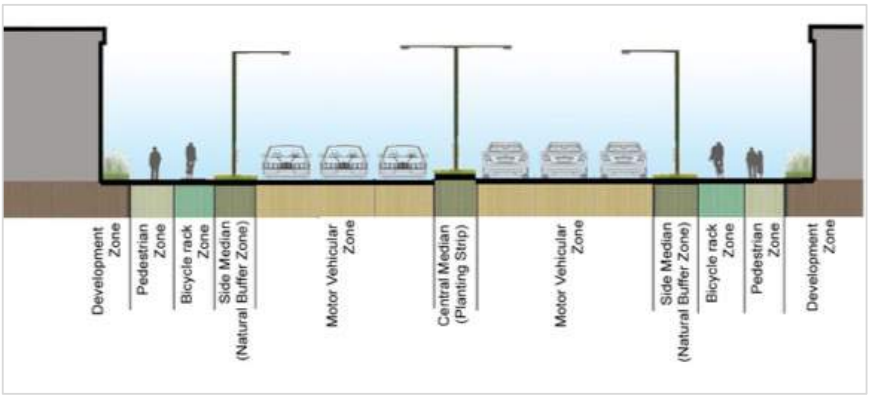


Figure 95. Illustrative Section (B-B) of the Improved Variables of Qatari Bin Al Fujaa Street (Author)

Table 24. Summary of the Street Conditions Before and After Complete Streets Improvements

Street Components	Before	After	Design Comments
Number of lanes	Two lanes and then turns into three lanes	Two lanes and then turns into three lanes	-
Central Median	Exists only near the junction	Exists only near the junction	Provided a central median with a planting strip near the junction for safety reasons.
Side Median	Absent	Absent	No need to have a side median since there is no service road.
On-street parking	Absent	Exists	Increased on-street parking lots.
Pedestrian path	Absent	Exists and turns into a shared path near the junction	Designed as a separate path, with ramps for users with special needs, bounded by planting strips for safety reasons.
Cyclist path	Absent	Exists and turns into a shared path near the junction	Designed as a separate path bounded by planting strips for safety reasons.
Bus lane and shelter	Absent	Exists	Shared with the motor vehicle lanes.
Lighting	Moderately exists	Exists	Increased the number of lighting bulbs.
Landscape and greenery	Absent	Exits	Increased the landscape density and the amount of planting strips and trees.

Figure 96. Before and After Views of Qatari bin Al Fujaa St. (Author)

5.4.2. Improved Cross-Sections of Suburban Area (Al Waab Residential District)

5.4.2.1. Al Sidr Street

The absent and the moderately present variables were identified and the improved cross-section aims to increase them. The improved design was produced based on the evaluation of the three cross-sections of the same road classification for MMUP, North Carolina and Miami states, as shown in **Figure 97**. It aimed to bridge the gaps between the current and future cross section that prevents the accomplishment of the 'Complete Streets' concept in the middle of a residential neighborhood. In the case of Al Sidr Street, the street originally lacked dedicated spaces for pedestrians, cyclists and bus lanes and their associated bus shelters.

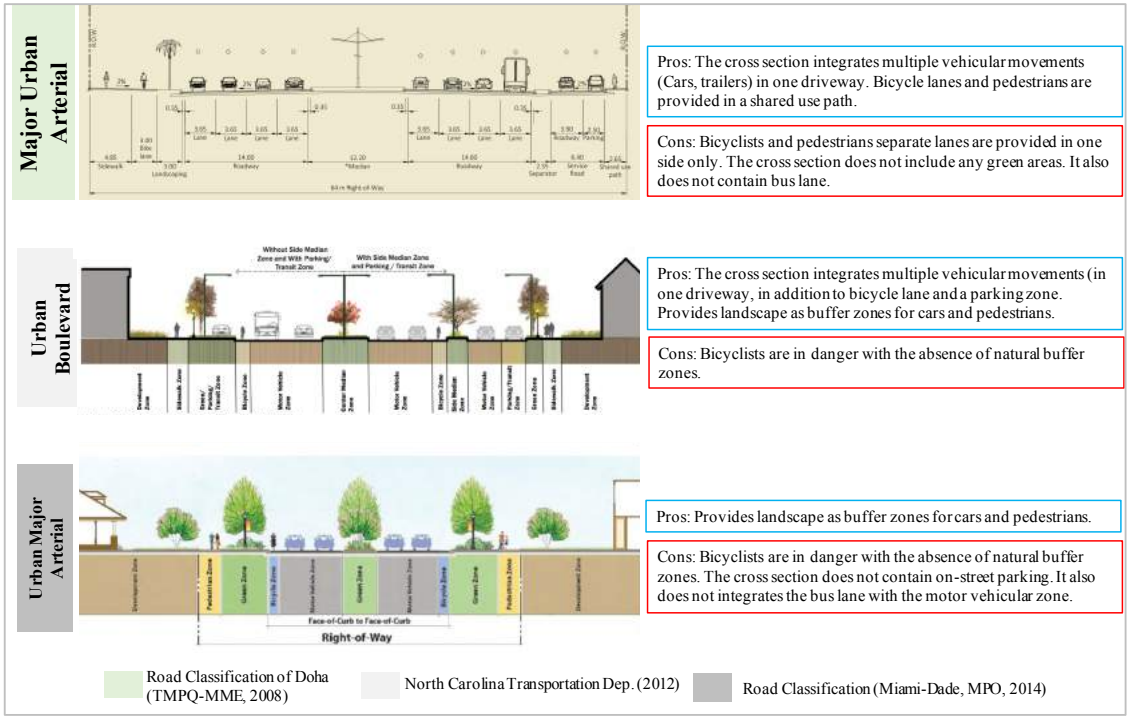


Figure 97. Comparative Analysis of Three Cross-Sections of the Same Road Classification As Al Sidr St (Author)

Figure 98. Enhanced Cross-section of Al Sidr Street (Author)

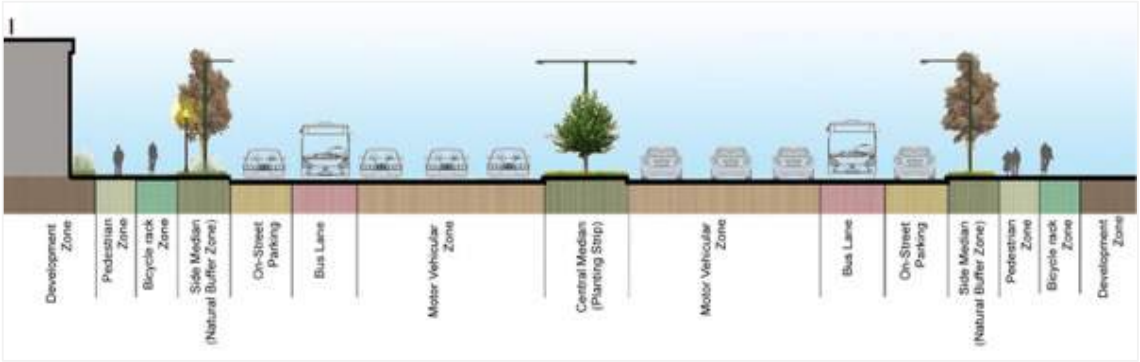


Figure 99. Illustrative Section of the Improved Variables of Al Sidr Street (Author)

Table 25. Summary of the Street Conditions Before and After Complete Streets Improvements

Street Components	Before	After	Design Comments
Number of lanes	Six lanes	Eight lanes	Two lanes were added dedicated to buses.
Central Median	Exists	Exists	Minimized the existing median to fit in a landscaped area and trees as a natural barrier.
Side Median	Exists in some areas	Designed to go all the way up the street.	Designed to go all the way as a separator between pedestrian paths and motor vehicular movement zones.
On-street parking	Exists	Exists	Increased on-street parking lots.
Pedestrian path	Absent	Exists	Designed as a separate path, with ramps for users with special needs, bounded by planting strips for safety reasons.
Cyclists path	Absent	Exists	Designed as a separate path bounded by planting strips for safety reasons.
Bus lane and shelter	Absent	Exists	Inserted a separate lane to reduce the traffic.
Lighting	Moderately exists	Exists	Increased the number of lighting bulbs.
Landscape and greenery	Moderately present	Exists	Increased the landscape density and the amount of planting strips and trees.

Figure 100. Before and After Views of Al Sidr St. (Author)

5.4.2.2. Al Ghariyah Street

Al Gharaiyah Street connects two major roads leading to Al Waab from the northern side and Salwa Road from the southern side. The existing design of the street supports walking and cycling activities; however, it does not provide safer spaces for these activities to be heavily practiced. The new, improved street design has created separate spaces and lanes dedicated for buses and for cars along with spaces prioritized for pedestrians and cyclists to accomplish the 'Complete Streets' concept.

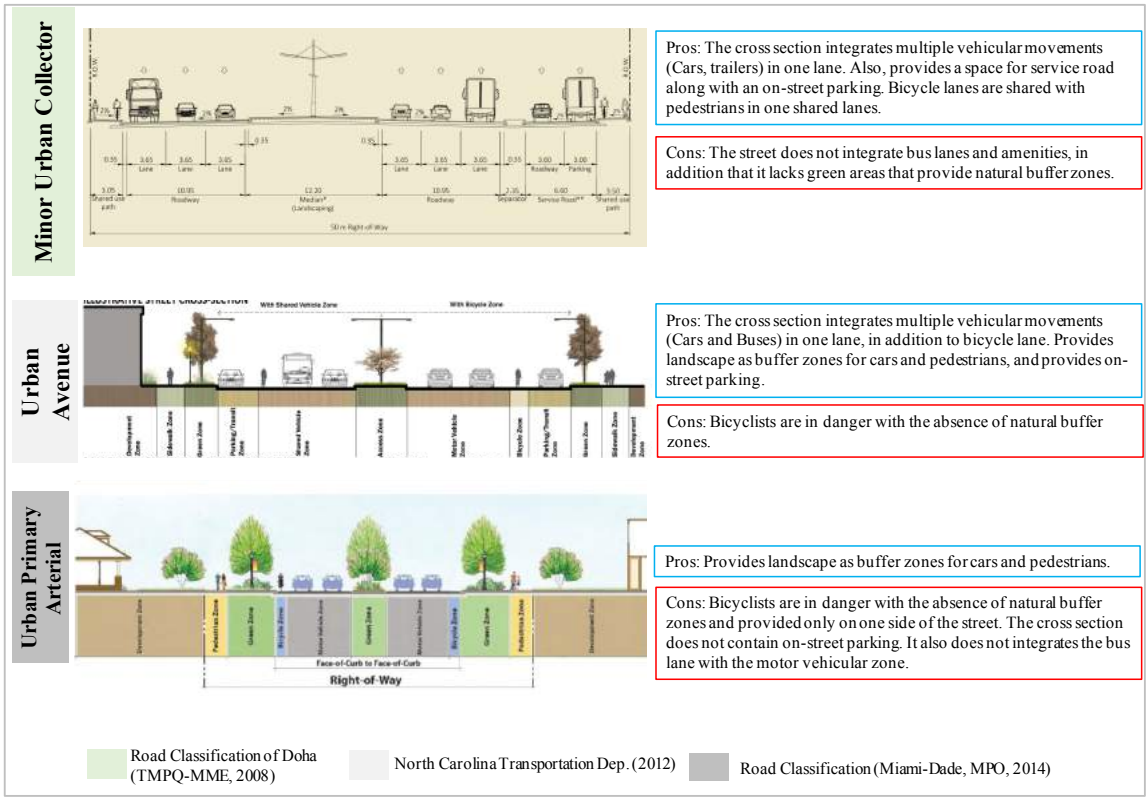


Figure 101. Comparative Analysis of three Cross-Sections of the Same Road Classification As Al Ghariyah St (Author)

Figure 102. Enhanced Cross-section of Al Ghariyah Street (Author)

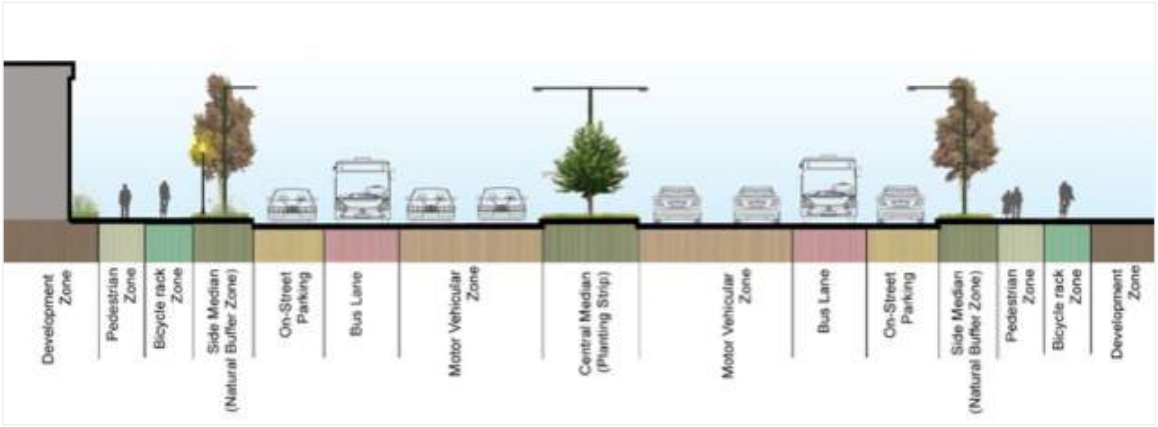


Figure 103. Illustrative Section of the Improved Variables of Al Ghariyah Street (Author)

Table 26. Summary of the Street Conditions Before and After Complete Streets Improvements

Street Components	Before	After	Design Comments
Number of lanes	Four lanes	Eight lanes	Two lanes were added for buses.
Central Median	Exists	Exists	Minimized the existing median to fit in a landscaped area and trees as a natural barrier.
Side Median	Exists in some areas	Designed to go all the way up the street	Designed to go all the way as a separator between pedestrian paths and motor vehicular movement zones.
On-street parking	Exist	Exists	Increased on-street parking lots.
Pedestrian path	Absent	Exists	Designed as a separate path, with ramps for users with special needs, bounded by planting strips for safety reasons.
Cyclist path	Absent	Exists	Designed as a separate path bounded by planting strips for safety reasons.
Bus lane and shelter	Absent	Exists	Inserted a separate lane to reduce the traffic.
Lighting	Moderately exists	Exists	Increased the number of lighting bulbs.
Landscape and greenery	Absent	Exists	Increased the landscape density and the amount of planting strips and trees.

Figure 104. Before and After Views of Al Ghariyah St. (Author)

5.4.2.3. Al Bustan Street

The street is considered to be one of the major streets in Al Waab District as it connects two major roads, Al Waab and Salwa roads. Similarly, the current design of the street supports walking and cycling activities, as people can often be seen practicing these

activities; however, it does not provide safe boundaries for either activity. The newly improved cross-section prioritizes pedestrians and cyclists in this street.

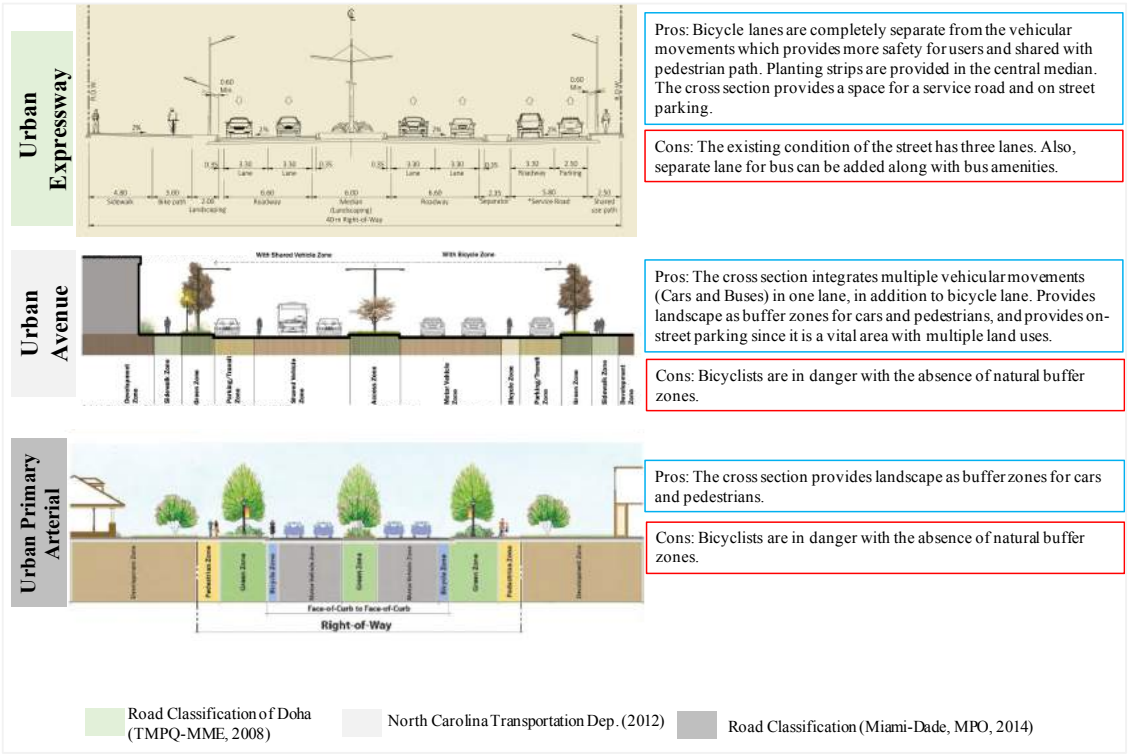


Figure 105. Comparative Analysis of Three Cross-Sections of the Same Road Classification As Al Bustan St (Author)

Figure 106. Enhanced Cross-section of Al Bustan Street (Author)

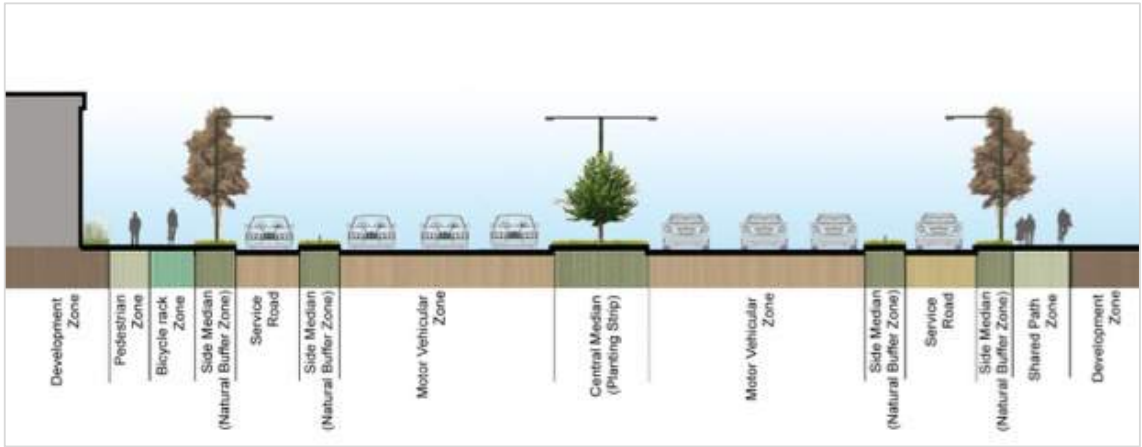


Figure 107. Illustrative Section of the Improved Variables of Al Bustan Street (Author)

Table 27. Summary of the Street Conditions Before and After Complete Streets Improvements

Street Components	Before	After	Design Comments
Number of lanes	Six lanes	Six lanes	Remains the same.
Central Median	Exists	Exists	Minimized the existing median to fit in a landscaped area and trees as a natural barrier.
Side Median	Exists in some areas	Designed to go all the way up the street	Designed to go all the way as a separator between service road and motor vehicular movement zones.
On-street parking	Absent	Absent	Instead of the parking, a service road was provided to reach surrounding land uses.
Pedestrian path	Absent	Exists on one side	Designed as a separate path on the right side of the street, with ramps for users with special needs, bounded by planting strips for safety reasons. A shared path is provided on the left side of the road for both pedestrians and cyclists.
Cyclist path	Absent	Exists on one side	Designed as a separate path on the right side of the road bounded by planting strips for safety reasons. A shared path is provided on the left side of the road for both pedestrian and cyclists.
Bus lane and shelter	Absent	Exists	Can be replaced with the service road, depending on the level of use of the bus in this particular street.
Lighting	Exists	Exists	No change in lighting.
Landscape and greenery	Absent	Exist	Increased the landscape density and the amount of planting strips and trees.

Figure 108. Before and After Views of Al Bustan St. (Author)

5.5. Chapter Summary

This chapter has provided the core of this thesis. It has analyzed the data collected from the responses of 100 different types of users of two different areas, a downtown area and a suburban area, in relation to their thoughts about the current design of the selected streets and what they would prefer to see in future designs produced by the two local authorities. The chapter has also categorized the absent, moderately present and present variables defined from the 'Complete Streets' concept that needed to be modified, enhanced and inserted into the improved cross-section of the six selected streets. Additionally, it has drawn future images of these streets after the improvements, based on respondents' preferred treatments of different variables to be included in the cross-section design. In order for the improved street designs to be produced, a comparative analysis was created between the locally produced cross-sections of MMUP, and two international cross-sections based in North Carolina and Miami states with different design guidelines according to the road classification. The three designs were compared based on the road

classification, right-of-way and ‘Complete Streets’ variables included in the design. The comparative analysis along with the users’ responses provided a base for producing the new, improved street designs.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

This chapter summarizes the thesis topic and its findings, and recommends actions that could be taken to enhance the design of Doha's street network to prevent all the problems that occur today. The 'Complete Streets' concept was taken as this study's approach to solving many of the problems that negatively affect today's built environment, and therefore lead to users' dissatisfaction. 'Complete Streets', as its name suggests, combines different modes of travel along with prioritizing pedestrians and cyclists over car drivers and passengers, and treats them as the street's kings. The initiation of the concept was because of the need to have healthy, high-quality and safer roads to use, in addition to connecting different land uses and bringing them together. This thesis study was reached through an investigation of the concept through reviewing other literature that focused on studying the concept from different aspects and defined its variables for implementation purposes.

The literature review reviewed two case studies that sought to modify and enhance their built environments and improve the street conditions through the concept of 'Complete Streets'. Analyzing the two case studies created a base to establish evaluation criteria and create a list that combined a set of principles and variables that can be used as a checklist to assess the current streets in Doha city. The variables that were agreed to define the 'Complete Streets' concept are: pedestrian, bicycle, green and transit improvements.

The main objective of this thesis is to evaluate the current design of Doha city's

streets, using the established criteria of 'Complete Streets'variables as concluded from the literature review. For this to be achieved, streets were selected from different hierarchal classifications that provide different treatment based on the right-of-way. Finally, the study aims to improve the current designs of cross-sections and establish a set of recommendations and guidelines to be followed for future road planning and design of similar street classifications.

The thesis has greatly considered users' perspectives and aspirations, since they are the major consumers of these designed streets. Accordingly, two major tools were selected to collect the data needed for the improvement process: a visual questionnaire distributed among different types of users, and semi-structured interviews to investigate the street planning from the local authorities' perspective. The collected data focused on the current conditions of the streets and the preferences for the future, improved designs of two selected neighborhoods based on their contextual location and variety of land uses. A downtown area exemplified in an urban center of Fereej bin Mahmoud and a suburban area of a residential district of Al Waab were chosen for this study, and three different street classifications were selected from each area.

Downtown areas are formed to be dense urban areas that support plenty of land uses, depending heavily on commercial and retail stores, in addition to residential blocks. Therefore, the streets are designed to accommodate mainly medium to heavy traffic volumes at different times of the day, and so they are car-congested most of the time. As a result, safety is an aspect that is absent in this environment and, for this reason, users felt

that the streets were not suitable for walking or cycling. The participants were in general agreement that variables related to the 'Complete Streets' concept were missing or only moderately present in some areas, which should be modified and increased based on their future preferences and aspirations. Similarly, in suburban areas, exemplified in Al Waab residential district, some of the 'Complete Streets' variables were absent, and, unlike Fereej bin Mahmoud, Al Waab is considered to be a quiet environment, since the majority of land use is residential. In the two cases, users stressed the possibility of improvement and insertion of the defined variables based on the nature of each street.

In summary, a number of problems were identified in relation to the existing street design of both Fereej bin Mahmoud and Al Waab district, based on the defined variables of the 'Complete Streets' concept, as follows:

- Lack of safe separation of and well-integrated circulation routes for pedestrian, cyclists and motor vehicular movement including cars and buses.
- Lack of planting strips and landscaping elements that can be counted as natural buffer zones between each variable.
- Lack of transit amenities, including a separate lane for buses and related facilities exemplified in shelters, shaded or air-conditioned waiting areas.

The corresponding future preferences that were developed based on the aspirations of users stressed the creation of an integrative street planning system that combines all the variables mentioned earlier that were missing in the current designs of the selected streets in both areas. The improved cross-sections have been developed based on users'

perspectives and the comparative analysis between Doha's street classification and the corresponding street types in two states in the United States. This has helped in the establishment of a set of street planning recommendations for the selected streets with different rights-of-way.

6.1.Recommendations and Guidelines

As this thesis has considered six streets in two different neighborhoods and different rights-of-way, it is essential to produce a set of recommendations and design guidelines that are based on the comparative analysis that created the improved cross-sections. The following recommended dimensional guidelines are based on the road classifications of the two different selected areas. Such recommended guidelines can be developed further by studying more streets and making comparisons with other international cross-sections.

6.1.1. Downtown Streets – Fereej bin Mahmoud

6.1.1.1. Urban Expressway

Al Rayyan Street was selected and categorized as an urban expressway of with ROW of 64 meters. The following street component dimensional guidelines were utilized for the improved design of the cross-section.

Table 28. Dimensional Guidelines of Urban Expressway Roads

Variable	No. of Lanes	Bus lanes and Amenities	Central Medians	Side Medians	Cyclist Zone	Pedestrian Zone	Green Zones
Dimension (m)	3.65 m	5.50 m	10 m	1 – 5 m	1.50 m	1.5- 2.5m	Minimum 1m > more
Description	Three lanes on each side. On-street parking is provided.	Provided after the motor lanes. Bus shelters are distributed evenly along the street.	Depending on the addition of other variables.	Depending on size of planting strips.	Inserted after a side median for safety reasons.	Inserted at the limits of ROW for safety reasons.	Depending on the size of separator and the types of landscaping inserted.

6.1.1.2. Urban Freeway

Al Khaleej Street was selected and categorized as an urban freeway with a ROW of 32 meters. The following street component dimensional guidelines were utilized for the improved design of the cross-section. It is essential to mention that the street is one of the most commercially vital streets in the Fereej, and the treatments inserted were designed to support the retail activities.

Table 29. Dimensional Guidelines of Urban Freeway Roads

Variable	No. of Lanes	Bus lanes and Amenities	Central Medians	Side Medians	Cyclist Zone	Pedestrian Zone	Green Zones
Dimension (m)	3.65 m	-	5 m	1 m	1.50 m	1.5- 2.5m	Minimum 1m > more
Description	Two lanes on each side. On-street parking and a service road are provided.	Bus lane is shared with the motor vehicular zones. Bus shelters are distributed evenly along the street.	Depending on the addition of other variables.	Depending on size of planting strips.	Inserted after a side median for safety reasons.	Inserted at the limits of ROW for safety reasons.	Depending on the size of separator and the types of landscaping inserted.

6.1.1.3. Major Urban Collector

Qatari bin Al Fujaa Street was selected and categorized as a major urban collector with a ROW of 26 meters. The following street component dimensional guidelines were utilized for the improved design of the cross-section. With such a small ROW, the street is considered commercially vital, and so treatments were inserted that were designed to support the retail activities. The design of this street started with two lanes providing on-street parking, pedestrian and cycling lanes, and, nearing the junction, the street turns into three lanes on each side to accommodate more traffic to avoid congestion.

Table 30. Dimensional Guidelines of Major Urban Collector Roads

Variable	No. of Lanes	Bus lanes and Amenities	Central Medians	Side Medians	Cyclist Zone	Pedestrian Zone	Green Zones
Dimension (m)	3.30 m	-	1 m	-	1.50 m	1.5- 2.5m	Minimum 1m > more
Description	Two lanes on each side with on-street parking, and turns into three lanes closer to the junction.	Bus lane is shared with the motor vehicular zones. Bus shelters are distributed evenly along the street.	Minimized to accommodate three lanes on each side closer to the junction.	N/A	Inserted after a side median for safety reasons. Closer to the junction, a shared path is created for both pedestrians and cyclists.	Inserted at the limits of ROW for safety reasons. Closer to the junction, a shared path is created for both pedestrians and cyclists.	Depending on the size of separator and the types of landscape inserted.

6.1.2. Suburban streets – Al Waab Residential District

6.1.2.1. Major Urban Arterial

Al Sidr Street was selected and categorized as an urban freeway with a ROW of 64

meters. The street is a main connector between Al Waab Street and Salwa Road. The following street component dimensional guidelines were utilized for the improved design of the cross-section.

Table 31. Dimensional Guidelines of Major Urban Arterial Roads

Variable	No. of Lanes	Bus lanes and Amenities	Central Medians	Side Medians	Cyclist Zone	Pedestrian Zone	Green Zones
Dimension (m)	3.65 m	5.50 m	10 m	5 m	1.50 m	1.5- 2.5m	Minimum 1m > more
Description	Three lanes on each side. On-street parking is provided.	Provided after the motor lanes. Bus shelters are distributed evenly along the street.	Depending on the addition of other variables.	Depending on size of planting strips.	Inserted after a side median for safety reasons.	Inserted at the limits of ROW for safety reasons.	Depending on the size of separator and the types of landscape inserted.

6.1.2.2. Minor Urban Collector

Al Ghariyah Street was selected and categorized as an urban freeway with a ROW of 50 meters. The following street component dimensional guidelines were utilized for the improved design of the cross-section.

Table 32. Dimensional Guidelines of Minor Urban Collector Roads

Variable	No. of Lanes	Bus lanes and Amenities	Central Medians	Side Medians	Cyclist Zone	Pedestrian Zone	Green Zones
Dimension (m)	3.65 m	5.50 m	5 m	5 m	1.50 m	1.5- 2.5m	Minimum 1m > more
Description	Two lanes on each side. On-street parking is provided.	Provided after the motor lanes. Bus shelters are distributed evenly along the street.	Depending on the addition of other variables.	Separating the on-street parking and the pedestrian and cyclist paths.	Inserted after a side median for safety reasons.	Inserted in the limits of ROW for safety reasons.	Depending on the size of separator and the types of landscape inserted.

6.1.2.3. Urban Expressway

Similar to Al Rayyan Street in Fereej bin Mahmoud, Al Bustan Street was selected and categorized as an urban expressway with a ROW of 40 meters. The street is a major connector between Al Waab and Salwa Road. The following street component dimensional guidelines were utilized for the improved design of the cross-section.

Table 33. Dimensional Guidelines of Urban Expressway Roads

Variable	No. of Lanes	Bus lanes and Amenities	Central Medians	Side Medians	Cyclist Zone	Pedestrian Zone	Green Zones
Dimension (m)	3.65 m	-	4 m	1 m	1.50 m	1.5- 2.5m	Minimum 1m > more
Description	Three lanes on each side. On-street parking and a service road are provided.	Bus lane is shared with the motor vehicular zones. Bus shelters are distributed evenly along the street.	Depending on the addition of other variables.	Separator between the service road and the car lanes.	Inserted after a side median for safety reasons from the right side, and, from the left side, a shared path is inserted for both pedestrians and cyclists.	Inserted at the limits of ROW for safety reasons from the right side, and, from the left side, a shared path is inserted for both pedestrians and cyclists.	Depending on the size of separator and the types of landscape inserted.

6.2.Limitations of the Research

This research could have been more comprehensive and accurate if more data were available. However, most of the local authorities' documents relating to road planning and design are classified as confidential and cannot be publically shared. This affected the possibility of collecting more useful data to support the core study of this thesis. Certain challenges were faced with regard to the visual surveys, as a number of the expatriate participants were not familiar with some of the selected streets, and so the questions were answered randomly.

6.3.Opportunities for Future Research

This research can be further developed in many different ways. For example, the 'Complete Streets' concept can be linked to other supporting concepts in the field of urban

planning, such as: Transit Oriented Developments (TOD), Economic Revitalization, Psychological Wellbeing and Social Equity. In the case of Transit Oriented Development (TOD), the concepts of Complete Streets and TOD are strongly connected and interrelated. The existence of TOD along with a successful implementation of the 'Complete Streets' concept can establish an integrative compact walking community, away from being car-centric, and provide a higher level of safety for pedestrians, bicyclists and other modes of travel rather than cars. In the case of economic revitalization, a future study could investigate the possibility of implementing the 'Complete Streets' concept based on how it reduces the cost of travelling from one destination to another. Further studies could be conducted regarding how the 'Complete Streets' concept is able to determine the value of properties in order to support local businesses and encourage business growth in the community. Several studies show that people can release stress and mental fatigues by providing streets with restorative atmosphere, which what 'Complete Streets' provide in its followed variables. The enhanced design of streets using the 'Complete Streets' concept increases the the physical restoration of people, as it increases the social connections between users and sense of place. The concept of 'Complete Streets' can also be related to social equity, as further studies could investigate the provision of clear access to economic opportunities and users' daily needs and wants, without revealing any form of discrimination, in terms of gender, age, income, race, ethnicity or ability. A street designed utilizing the studied concept should respect all users anytime and anywhere.

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APPENDIX A – QUESTIONNAIRE SURVEY SAMPLE

Assessing Doha Street Network from the Perspective of 'Complete Street' Concept
Questionnaire Survey- Doha 2017
Thesis Focus on Urban Design | MUPD 760
Master Degree in Urban Planning and Design

كلية الهندسة
College of Engineering
QATAR UNIVERSITY

Dear Sir/ Madam,

I would like to invite you to participate in this research questionnaire and highly appreciate your support. This is my Thesis Project which focuses on **Assessing Doha Street Network from the perspective of 'Complete Street' Concept.** The participation is voluntary, and you can skip any question or withdraw at anytime.

The aim of my thesis is to evaluate the current street network of Doha and recommend a set of improvements using a criteria extracted from a newly emerging urban concept 'Complete Street'.

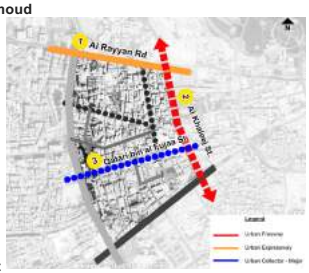
This questionnaire is therefore based on two distinctive surveys:

1. *Your opinion about current street conditions*
2. *Your preferences and future enhancements of the streets.*

For further information: Please contact Bassma Eissa at Qatar University. Email: ba080664@qu.edu.qa
Mobile: +974 55736175

The selected Areas for the study are:

1. **Fereej bin Mahmoud**



2. **Al Waab District**

(1) Fereej bin Mahmoud- Al Rayyan Street – *Existing Condition*



What do you like about this street? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
What do you think this street missing? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
How often do you walk or bike in this street?	Once or more a week		Once in a month		A few times during the year		Never
What do you think are the biggest obstacles to walk and bike in Al Rayyan street? (*Check all that apply)*	Driving behavior		weather		Lack of bus stop amenities		Lack of bicycle racks
Do you use the bus?	Everyday		Sometimes		Rarely		Never
Do you feel safe when walking or biking around this street?	Very safe		safe		Unsafe		Very unsafe
Do you loose your way in this street while driving?	Yes				No		
Do you think the street has enough lighting at night?	Yes		No		Needs More lighting		

(1) Fereej bin Mahmoud- Al Khaleej Street - *Existing Condition*

What do you like about this street? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
What do you think this street missing? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
How often do you walk or bike in this street?	Once or more a week		Once in a month		A few times during the year		Never
What do you think are the biggest obstacles to walk and bike in Al Khaleej street? (*Check all that apply)*	Driving behavior		weather		Lack of bus stop amenities		Lack of bicycle racks
Do you use the bus?	Everyday		Sometimes		Rarely		Never
Do you feel safe when walking or biking around this street?	Very safe		safe		Unsafe		Very unsafe
Do you loose your way in this street while driving?	Yes				No		
Do you think the street has enough lighting at night?	Yes		No		Needs More lighting		

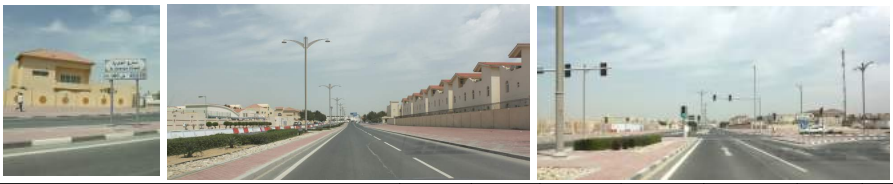
(1) Fereej bin Mahmoud- Qatari bin Al Fujaa- *Existing Condition*

What do you like about this street? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
What do you think this street missing? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
How often do you walk or bike in this street?	Once or more a week		Once in a month		A few times during the year		Never
What do you think are the biggest obstacles to walk and bike in Qatari bin Al Fujaa street? (*Check all that apply)*	Driving behavior		weather		Lack of bus stop amenities		Lack of bicycle racks
Do you use the bus?	Everyday		Sometimes		Rarely		Never
Do you feel safe when walking or biking around this street?	Very safe		safe		Unsafe		Very unsafe
Do you loose your way in this street while driving?	Yes				No		
Do you think the street has enough lighting at night?	Yes		No		Needs More lighting		

(2) Al Waab District – Al Sidr Street - *Existing Condition*

What do you like about this street? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
What do you think this street missing? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
How often do you walk or bike in this street?	Once or more a week		Once in a month		A few times during the year		Never
What do you think are the biggest obstacles to walk and bike in Al Sdir street? (*Check all that apply)*	Driving behavior		weather		Lack of bus stop amenities		Lack of bicycle racks
Do you use the bus?	Everyday		Sometimes		Rarely		Never
Do you feel safe when walking or biking around this street?	Very safe		safe		Unsafe		Very unsafe
Do you loose your way in this street while driving?	Yes				No		
Do you think the street has enough lighting at night?	Yes		No		Needs More lighting		

(2) Al Waab District – Al Ghariyah Street - *Existing Condition*



What do you like about this street? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
What do you think this street missing? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
How often do you walk or bike in this street?	Once or more a week		Once in a month		A few times during the year		Never
What do you think are the biggest obstacles to walk and bike in Al Ghariyah street? (*Check all that apply)*	Driving behavior		weather		Lack of bus stop amenities		Lack of bicycle racks
Do you use the bus?	Everyday		Sometimes		Rarely		Never
Do you feel safe when walking or biking around this street?	Very safe		safe		Unsafe		Very unsafe
Do you loose your way in this street while driving?	Yes				No		
Do you think the street has enough lighting at night?	Yes		No		Needs More lighting		

(2) Al Waab District – Al Bustan Street- *Existing Condition*



What do you like about this street? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
What do you think this street missing? (*Check all that apply)*	Street lanes	Street signs	Street lighting	Walking areas	Bicycling areas	Bus stops	Green areas
How often do you walk or bike in this street?	Once or more a week		Once in a month		A few times during the year		Never
What do you think are the biggest obstacles to walk and bike in Al Bustan street? (*Check all that apply)*	Driving behavior		weather		Lack of bus stop amenities		Lack of bicycle racks
Do you use the bus?	Everyday		Sometimes		Rarely		Never
Do you feel safe when walking or biking around this street?	Very safe		safe		Unsafe		Very unsafe
Do you loose your way in this street while driving?	Yes				No		
Do you think the street has enough lighting at night?	Yes		No		Needs More lighting		

Improvements using Complete Streets Variables –

(Applicable for both areas – Fereej Bin Mahmoud & Al Waab District)

Do you think this type of street treatment is useful to have?	**Yes**	**No**	**Does not suit streets of Doha**
			
Which crosswalk and pavement treatments does the street need the most?			
			
Do you think the street needs bicycle lanes?			
			
Do you think the street needs trees and green areas? ***(you may choose more than one)***			
			
What treatment do you think the street needs for bus lane and shelters?			
			

تم بحمد الله..