SUSTAINABLE URBAN PLANNING

TRANSPORTATION POLICY FOR ISLAMABAD AND RAWALPINDI

Submitted by:

SAADIA KHIZAR

PIDE2018FMPHILPP08

Supervisor:

DR. JUNAID A. MEMON

PIDE School of Public Policy

PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS, ISLAMABAD

2021

Pakistan Institute of Development Economics, Islamabad

PIDE School of Public Policy

CERTIFICATE

This is to certify that this thesis entitled: **"Sustainable Urban Planning Transportation Policy for Islamabad and Rawalpindi"** submitted by **Ms. Saadia Khizar** accepted in its present form by the School of Public Policy, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Public Policy.

Supervisor:

Dr. Junaid Alam Memon
Assistant Professor,
Pakistan Institute of Development Economics,
(PIDE) Islamabad.

External Examiner:

Dr. Zahid Asghar
Professor and Director,
School of Economics, Quaid-e-Azam University,
(QAU) Islamabad.

Head,
PIDE School of Public Policy:

Dr. Hafsa Hina,
Assistant Professor/HOD
Pakistan Institute of Development Economics,
(PIDE) Islamabad.

Author's Declaration

I _____ hereby state that my MPhil thesis titled _____ is my own work and has not been submitted previously by me or any for taking any degree from Pakistan Institute of Development Economics or anywhere else in the country/world likewise. At any time if my statement is found to be incorrect even after my graduation, the university has the right to withdraw my MPhil Degree.

Date: _____ Student's signature

Name of the Student

_____

Dedication

To my parents, Mr. Khizar Hayat and Mrs. Mussarat Khizar.

And all the silent demons.

ACKNOWLEDGMENTS

A deep sense of gratitude is felt and interminable praises are for Almighty Allah, always and forever.

I am immensely appreciative of my supervisor and the guiding spirit of this research process, Dr. Junaid Alam Memon. Under his noble tutelage, patience, and supportive encouragement, I was rendered able to steer this study towards completion. This thesis in its present form can majorly be ascribed to his brilliant and skillful supervision. Further, yet importantly, I am grateful to Dr. Aqeel Anwar Chaudhry, the internal reviewer for providing me with newer dimensions around the subject. I would also extend veneration and thankfulness to Dr. Zahid Asghar, for his insightful contributions and constructive appraisal.

To Dr. Nasir Iqbal for his positive encourage towards the selection of this topic and idea, his insightfulness pushed me towards challenging research ideology.

Profoundly recognizing my family's love and care, I acknowledge their unconditional support especially my sister and brothers, Mrs. Mehmoona Jawad, Mr. Mouwia Khizar and Mr. Zaid Bin Khizar. My friends were always present for me and some of the conversations with them pushed me to think outside the box and develop an objective understanding.

Lastly, the person who has been most enlightening and engaging throughout my MPhil journey, Afshan Ejaz whom I proudly can address as my best friend, thank you for the continuous discussions and arguments. I am truly thankful for your existence.

It has been a pleasure.

ABSTRACT

Under the sustainable development goals 2030 agenda, the 12th goal of responsible consumption and production states that nations should ensure sustainable consumption and production patterns to reduce effects on environment and human behavior. The consumption of any recourse is considered sustainable if their negative by products does not transfer to future generations or the need of present generation compromises the needs of future generations. Prioritizing efficient usage of recourses and minimalizing the wastage is the desired goal. The consumption patterns of transportation in Islamabad and Rawalpindi are mostly depended on the Private automobile sector and lacks efficient Public Transportation System to address increase demand and consumption of Cars, Taxi Services, or different Private Ventures. Bus Rapid Transit (BRT) like Metrobus are a good initiative but not enough of the increase urban expansion and urban demand. Hence, this study has appointed 200+ buses at present partially operational under different public and semi-public institutes to create a fully functioning conventional Public Bus System based of applied quantitative research for Islamabad and Rawalpindi. The research also analyzed the mobility trend and patterns of the two cities through various sources of Data specific from Google Traffic Live, Public authorities like RTA, ITP, and Private ventures Careem and Uber. The study determine common mobility needs and accurate Public Bus Routes for both inter and intra-city transportation of Islamabad-Rawalpindi.

Keywords: *Urban Transportation, Mobility Metrix, Mobility trend, Public Bus System, Transportation Routes.*

CONTENTS

LIST OF TABLES, FIGURES AND MAPS

LIST OF ABBREVIATIONS

BRT - Bus rapid transit

BRT-Bus Rapid Transit

GEE-Google Earth Engine

GIS - Geographic information system

ITA - Islamabad Transport Authority

ITP-Islamabad Traffic Police

LMBS-Lahore Metro Bus Service

MBS-Metro Bus Services

NTRC - National Transport Research Centre

OSM-Open Street Map

PIA – Pakistan International Airport

PMA-Punjab Mass transit Authority

QGIS- Quick Geographical Information System

RIMA - Rawalpindi and Islamabad Metropolitan Area

RTA - District Regional Transport Authority

UN - United Nations

WSP-West Sustainable Policy

CHAPTER NO: 1

INTRODUCTION

1.1. BACKGROUND OF THE STUDY:

Transportation is critical to the functioning of society whether economic or social. People and goods move according to socio-economic, geospatial, cultural and legal constraints (Wang, Zhang, Hu, Yang, & Lee, 2017). Transportation is one of the essential tools of an urbanized society where your economical choices dominate your personal preferences. An average worker looks for sustainable, affordable, safe and time effective transportation system as his daily income depends on his ability to move where his work takes him. In this highly competitive society, where everything is measured according to the profit it yields, hence, public transportation is an alternative for the working class (Agency, 2005).

In transport sector, increased spatial dispersion with evidential urban expansion and exposure has created both positive and negative impacts/externalities (The Global Economy, 2019). Firstly, it has created mobility challenges for the majority population living under poverty line. Secondly, the negative impacts of a car-based transportation system have grown to the point where they create incremental reduction in mobility and accessibility. Especially issues like congestion, air and noise pollution, traffic accidents, and consumption of finite resources are examples of what has been termed the unsustainability of transportation.

According to a research conducted by Ghaffar (2015), Low road quality, higher road consumption, rapid population and unchecked urbanization has created spatial dispersion in land use and transportation among the Asian countries which further results in creating mobility

challenges for the majority population living under poverty line earning on day to day basis (Muhammad Adeel, 2014).

The ground reality states that the average distance between economic activities are increasing but the accessibility and mobility are reducing with unchecked growth of private sector transportation (Litman, 2007). In this time, the lack of inclusive public transport, poor transportation infrastructure, poor road quality, rising road consumption, rising levels of private automobile ownerships and lack of private sector regulation authority or traffic regulation are creating further issues towards already crumbling mobility options.

A world where businesses, trades, cultural, economic, and physical practices triumphed, a place where goods, products and services were bartered from a place of surplus to a place in need of that good. For example, Labor moving according to their work placement, or as simple as travel to acquire commodities. Hence, the concept of movement was always present in the world where it was a motion to movement for collection of water at domestic level or the travel associate with migration in search of sustainable living in early parts of our civilization.

The movement or travel today's urbanized world are completely different as today's people still are in need to travel to acquire their means of living, to socialize and interact within their communities, to establish links and bonds with their surroundings, to meet substantial requirements of living a good life etc.

Moreover, the travel patterns have evolved quit significantly over hundred thousand years of civilization's effort towards creating an industrially revolutionized world. Travel patterns, now, has been clearly divided into two categories of inter and intra city travel; where inter-city travel means travel between two cities and intra-city means travel within the same city. This study will

focus on creating an inter-city and intra-city Transportation plan for Islamabad-Rawalpindi, Pakistan.

Transportation is generally classified into three broader categories namely land, water, and air transportation as for the modes of transportation we will only focus on land transportation. The most common mode of transport are Railways, Roadways, Waterways, Airways and Pipelines. The land transportation or the roadways are further classified as off road and on road transportation where railway is generally associated with on road transportation (Nijkamp, 1994). For this story, we will focus on off road transportation that deliver services from door-to-door basis, we will specifically focus on passenger vehicles like buses, taxis, Wogan etc.

Islamabad and Rawalpindi are at the center of urban development and are experiencing capital dispersion throughout with new developmental zone and scheme. But sadly, the transportation options of the twin cities are limited to BRT (Metro bus Service), Government regulated Private transport and Private transport.

The existing policy action taken up by Pakistani government has been of mediation or regulation rather than working as provider of any public service. The Regional Transportation Authority (RTA) and Transportation Department, Government of Punjab act as regulators for different Private companies like Daewoo Express or individual entities like Wagons and Taxi owners. The Transportation Department of Punjab and RTA provide services like route permits, registration, licensing, and Road info.

For Public transport projects, the Punjab Mass transit Authority (PMA) working under the guidance of Transportation Department, Government of Punjab has initiated few Public transportation projects like Metro Bus Services (MBS) in Lahore, Islamabad-Rawalpindi, and Multan as well as Orange Line Metro Train in Lahore and Karachi both ongoing projects. The

Lahore Metro Bus System was first initiated in 2013, while Islamabad-Rawalpindi, Multan in 2015 and 2017, respectively. Above all types of transport works on partial mobility mechanism limiting their use as compared to private sector. The LMBS (Lahore Metro Bus Service) also has a Feeder Bus Service which will increase the mobility range as more people be able to use it. Currently, more than 70% travel in Pakistan is supported by Private sector or individual entities.

On the other hand, Private sector consists of Individual Ventures, Private Cars and Semi-Private Vehicles. Urban Transport demand is met with positive response on purchase and import of vehicles by the governmental regulate bodies (Nijkamp, 1994). Hence, resulting in increased number of purchases of personal transport as well as increased number of vehicles on the road directly linked to road accumulation and traffic problems.

The following presents some statistics regarding the increase in the number of privately owned vehicles.

TABLE 1-1: THE NUMBER OF PRIVATELY OWNED VEHICLES OVER THE YEARS

Year	M. Cycle/ Scooter	Motor Car	M. Cab/ Taxi	Motor Rickshaw	D. Van	Pick up	Station Wagon	Buses/ Minibus	Truck	Total
2015-16	6,669.3	6,131.7	186.5	118.5	191.4	166.3	192.0	150.6	263.8	15,568.8
2016-17	11,975.3	6,954.0	197.4	122.0	204.2	176.4	201.9	156.3	276.2	21,858.6
2017-18	14,060.9	7,183.5	197.7	128.1	210.1	187.2	206.6	159.2	280.0	24,268.0
2018-19	14,623.3	7,470.8	205.6	133.2	218.5	194.7	214.9	165.6	291.2	25,238.7

Increased private consumption is also contributing factor of spatial dispersion and extended land cover. Urban area in Pakistan, like Islamabad and Rawalpindi, spread over thousands of kilometers requiring people to travel from one end to another. Hence, the private mode of transport is considered accurate and necessary in the absence of any public transportation alternative which might be more feasible and accessible. The types of transportation currently available is both formal and informal transport like Bus rapid transit (BRT), Wagon, Suzuki, and Qing qi which are used for Public transportation purposes.

There is a gradual increase in the number of the vehicles used in all genres at the rate of ten thousand per one unit according to National Transport Research Centre (NTRC) but for those who cannot have a personal vehicle turn to privately owned Taxi, Wagons etc. Accordingly to Wang et al. (2017), around 80,000 workers and students travel in between the two cities over a distance of 30 kilometers on average to both ends of Islamabad and Rawalpindi (Ramli & Monterola, 2015).

With this description state, the study will explore alternative and efficient transportation policies while utilizing the preexisting recourse the cities of Islamabad-Rawalpindi have to offer (Taylor, 2015). Rawalpindi and Islamabad metropolitan area (RIMA) is the third largest metropolitan district combine in Pakistan with different transport authorities.[1]

Statistically, around 200+ buses or minibuses 30–40-seater are currently operating in Islamabad and Rawalpindi under the indirect authority of varies government or semi government universities but are not operating at full utility as they cater to student or university demand only

[1] Rawalpindi and Islamabad metropolitan area (RIMA) is the third largest metropolitan district combine in Pakistan with different transport authorities namely District Regional Transport Authority (Rawalpindi – RTA) and Islamabad transport Authority (Islamabad – ITA) respectively. It is based on the economic, labor and industrial growth of both the cities as well as the growing urban migration rate towards the twin cities, cumulative rise in the population.

(Jamil., Rashid, & Yar, 2017). This study will collect current data on the number of buses operational in Islamabad-Rawalpindi to establish the Bus system.

The economic activity of a worker depends on the ability to move from one place to another at the cheapest possible option, sadly, Pakistani citizen's mobility is directed by a large private sector with profit maximizing approach where either the rate of travel is expensive, or the routes are not presenting optimal connectivity causing time wastage. In Pakistan, 80% of the transportation sector is private, hence, causing inequality and limited access to spatial distribution.

In Pakistan, sadly, there is a unique lack of public transportation system. Pakistan has created a market for private consumption when it comes to transportation and the public sector is dominated by privately owned taxi/Wagon system or private contractors (Asif Bajwa, 2015). The inefficiencies of this system have led to safety hazards like road accidents, unsafe driving, neglect towards traffic regulation, and increase in bikes and overcrowding in parking spaces. The inefficient structure of transportation also creates undesirable issues like gender inequality and financial exclusion etc. Time management and ease of service has also created inefficiencies in current transportation sector of Pakistan (Camargo Pérez, Carrillo, & Montoya-Torres, 2014).

1.1.2. SUMMARY:

Increased urbanization, spatial distancing and an increased need to mobility has led the author to write about the importance of conventional Public Transportation System. This study plans to create efficient and effective use of already available recourse, Public and Semi-Public Institute's owned Buses used for individual transport (operational university buses), to empower the population of two cities by increasing their mobility. This alternative use of the buses will help create a more financially affordable, environmentally sustainable and more socially acceptable Public transportation plan (Sciara, 2017). This study will illustrate (through QGIS) optimal

connectivity routes both inter and intra city from these buses and the number of buses needed to eliminate demand constraints and spatial constraints (overcrowding by private automobile ownership) for Islamabad and Rawalpindi.

1.2. PROBLEM STATEMENT:

The rapid increase in urban expansion and spatial dispersion has create a huge gap in the demand of affordable and sustainable transportation modes. Governmental response to mobility and transportation issue has boasted the Private Sector consumption like Motor Vehicle Sales reaching all time high of 26,550 units in 2018 and the entry of luxury modes of transport like Uber, Careem, but failed to increase the quality of roads with only 0.1% difference in year 2018-2019 (National Transport Research Centre (NTRC), 2019).

Islamabad-Rawalpindi are primary example of urban areas having low road quality, high traffic congestion, high spatial constraints and high urban expansion with higher commuting cost and low alternative modes of travel. Currently, in Islamabad-Rawalpindi 260 buses are present and operational at partially utility under different Public and Semi-Public institutions, so, the problem is not the availability of resources but of effective implementation of these resources to get the maximum benefit for the citizens of Islamabad-Rawalpindi. Hence, under 12^{th} SDG of responsible consumption, this study will use the above mentioned 260 buses to create a conventional Public Bus System.

There is a need to create an optimal public transportation plan to increase the general mobility and accessibility of the people of Islamabad-Rawalpindi. Bus system to equip people with better mobility, affordability, and accessibility than those of private consumption. The purpose of this study is to use all the resources (land, buses, labor) Islamabad-Rawalpindi have to create a Public Bus Service to fit all the transportation needs of public in this area.

Hence, therefore, I would like to propose a sustainable and efficient public transportation policy combining both efficiency and utilization of existing resource plus ensure accessibility and mobility of all.

1.3. OBJECTIVES:

The following are the objectives of this study.

- To create a sustainable Public Transportation plan by allocating already existing resources to maximize efficiency and accuracy in transport need.
- To increase accessibility and mobility of individuals by identifying common flow of mass commute or demand patterns in residential and commercial areas of Islamabad – Rawalpindi.
- To use GIS (Geographic information system, QGIS info, QGIS catalog and QGIS Map) for mapping and to illustrate the working routes of proposed public transportation plan.

1.4. RESEARCH QUESTIONS:

After analysis the modes of transportation and the need for an alternative of mass demand of mobility, this study has determined the need for the following research questions for mobility re-equipment's of Islamabad-Rawalpindi.

- How to create a sustainable and efficient Public Transportation plan for Islamabad – Rawalpindi?
- What are the commute patterns of the general population in Islamabad – Rawalpindi?
- What are the optimal routes for the proposed Public Transportation plan to increase mobility and accessibility for all?

1.5. SIGNIFICANCE OF THE STUDY:

The significance or importance of the study is based on the analysis of efficient and accurate usage of transport means in Islamabad-Rawalpindi. The study aims to find a sustainable transportation plan for Islamabad-Rawalpindi by determining the mobility and accessibility of public of the twin cities. Also, this study under 12th SDGs will increase the utilization of preexisting resources of Islamabad-Rawalpindi to benefit more people of the twin cities. Creating a Public Bus System (Bus Sharing) to eliminate the need for private consumption of transport.

The second importance of this study is the data collection technique employed, where the author will have used real time data collection and, hence, develop a database of common mobility patterns of the citizens of Islamabad-Rawalpindi. This database will be beneficial for future research regarding mobility trends and need of urban areas.

1.6. ORGANIZATION OF THE STUDY

The organization of the study includes a brief introduction of transportation, importance and need of transportation, modes, and types of transportation plus Pakistan's transportation conditions, specifically, Islamabad-Rawalpindi's Public (Metrobus), Semi-Public and Private Transportation modes. The second chapter of literature will address the traditional and modern transportation systems and solutions to growing need of movement in both developed and developing countries.

The third chapter will discussion the research design and methods employed for data collection and data analysis. The fourth chapter includes data presentation for the maps generated from QGIS are presented. The fifth chapter addresses the findings and discussion of the study. The last chapter is the conclusion of the study plus recommendations, limitations, and future directions.

CHAPTER NO: 2

LITERATURE REVIEW

2.1. EXISTING LITERATURE:

Literature from various scholars is included in this paper. The works of Camargo Pérez et al. (2014), Litman (2007), Sciara (2017), Ditta, Figueroa, Galindo, and Yie-Pinedo (2018) and Majid, Alam, Madl, and Hofmann (2013) have been great help in understanding the present requirement for the development of Pakistani transportation network. The realistic statistics are simple with the growth in population for the past decade, the transportation requirements also have increase highly. The data shows that, according to United Nations (UN) records, 55% of the world population lives in urban cities and with a growth rate of 1.6 per year, this population is increasing day by day. By 2050, this number is expected to rise to 68%. Hence, the public transport must evolve to meet this growing requirement of the changing priorities of the urban world (Baloch, 2018).

The sustainability of every aspect of nature and natural resources is the main concern for many international welfare organizations for years. Whether it was the consumption of fossil fuels or the protection of environment through environment friendly policies, the aim was to extend the lifeline of our planet as much as possible.

The same attitude also transferred to the transportation and automobile facilities as well to reduce the accumulation of pollution and to reduce consumption of important natural resources. In the 21st century, new innovations in regard to transports and vehicle started, whether it was hydrogen-cars or electric powered cars, the transportation services have come so far. But regarding a 3rd world country, developing nation, like Pakistan where options like hydro power are not feasible given the economic and social status.

Gomina Mama, Yang, and Xia (2014) work on smart technology and sustainability can put forward solutions for a growing nation both in demand and population like Pakistan to meet the economical requirements needed. The transportation is the central road of communication of any economy, trade, and daily office routine. One must acquire a mode for transportation to achieve connective from one place to another. So, currently, transportation, like a telephone, reduces the distance between different markets.

This literature also includes work of different authors namely Awan et al. (2020), Hanif, and Alam (2020), Mohmand et al. (2020), Batool, and Goldmann (2020), Tareen et al. (2018) on the sustainability of transportation and its effect on the longevity of the life of the future generation and the environment. Sustainability is defined as the accessibility of future generation to the present resources for Pakistan. The effect we, current generation, causes on the natural resources will make them disappear.

To understand the aspects of this study, we look at all the concepts of a sustainable transportation. What does general transportation regard to? What would be the future regarding such transports? What are the different requirements for current and future transportation? What is the rate of demand for transportation? What is the longevity of our existing transportation plans? What is sustainable transportation?

The following literature will clear all the known and unknown aspects of the sustainable transportation

2.2. TRANSPORTATION

The transportation in general refers to the movement of the humans, animals and goods from one location to another by any means possible, this definition of transportation was given by

Nijkamp (1994) in his paper on the sustainability of transport in 19th century. He discussed the concept of ever-growing transport and the people's need for transportation. The modes of transportation are ever changing from a small car to airplanes, from boats to modern ships, from a simple bus to large transit projects now a day. The author of this study also agrees with Nijkamp analysis that human need is greater than the present products.

Taylor (2015) states that the evolution of transportation from the late 18th century to the present day, he included the major modes of transport used and has divided them in three main categories namely air, water, and land transportation. All three modes have three features in common, first, fixed infrastructure for transportation like roads, air space or airports and paths, secondly, vehicles or form of transport like Airplanes, Cars. Boats etc., thirdly, the operations governing these two together. The operations include system set in place to operate the transportation system like traffic rules and air traffic regulations.

Lo, Watling, and Cantarellac (2016) argues that the transportation is essential regarding the development of the human civilization with the increase in trades and globalization. He emphasizes that the growth in transportation should be exponential, the greater the better, and that the economic yield is greater as compared to the losses incurred by the lack of social and environment security in transportation facilities. Here the author, of this paper, would disagree with the stands of Lo and states that the importance of transportation aside, the need for long term development is better than short-term burnt-out effect of intense transportation plans like increase production of vehicles regardless of their environmental cost. Also, adding in the affordability of such transportation for the developing countries where poverty can deprive people of this necessity.

The trend in developing countries is still focused on infrastructure development like roads, highways etc. but modes of land transport have seen increase in cars and motorbikes both leading towards unsustainable outputs like carbon dioxide emissions and traffic congestion. Furthermore, the cost of committing or travel is another factor to be considered when regulating traffic policies Awan et al. (2020). The developing countries are pushing the consumption of personalize vehicles by dropping taxes and import charges over the years and now, present day, the government of Pakistan has encouraged private production of automobile by reducing the cost of material goods used in the production of cars. This surplus of supply in cars has created issues of lack of parking space, traffic congestion, traffic jams and traffic violations resulting in accidents.

The cost of traveling in an urban setting is rapidly increasing as Private endeavors are operating unchecked without any competition from public sector of transportation. Lack of alternatives from public sector in transport as enabled private sector to set their own prices regards of public affordability in developing countries like Pakistan Tareen et al. (2018). Whereas the increase spatial constraints like longer distance of travel and the accumulation of population in a limited number of transport (like 40-seater bus accumulating a proportion of 100 people in a large population).

Mohmand et al. (2020) and Batool, and Goldmann (2020) argue that desirability constraint is also a factor is choosing transportation means like accessibility, time of travel and conditions of travel are very important as individual determine their patterns according to their needs. In case of Suzuki and wagon currently operational in Pakistan, the aspects of accessibility and comfort are often neglected leading to consumption of Taxi or even purchasing individual cars as an investment in their desirable mode.

The author Ramudhin and Lalwani (2018) analysis the traffic assignments and the transport flow from major cities in Pakistan. According to him, the transportation in Pakistan is considerably better as compared to the traffic regulations governing that transport. The transport operations efficiency is the downfall of the transportation in Pakistan.

Still, the author of current paper, again, disagrees saying that the size transportation has outnumbered the services provided by the county's traffic regulations. The flow and demand of the increase transportation have left no room for sustainable growth in the operations of the transport like green transportation.

The types of land transportation are also very important namely Passenger transport and Freight Transport. The passenger transport can be public and private whereas freight transport has become the focus of containerization, where large and bulk transport is conducted with large volumes of durable products (Sobhani, Imtiyaz, Azam, & Hossain, 2019). Good planning is required to create effective traffic flow and restrain over urbanization.

From a traditional equilibrium state, there is an assumed balance between the traffic flow and the transportation planning. It is assumed that the network characteristics, such as the rail capacity or link performance, and the travel demand will remain unchanged for an extended period of time (Aifadopoulou, Ziliaskopoulos, & Chrisohoou, 2007).

This assumption, however, does not hold in real life with ever increasing demand of transportation innovations and services with constant planning regarding the operations and networking of said transportation.

In contrast to the equilibrium approach, the new generation of the transportation network dynamics and its modes analysis the evolution on a day-to-day basis or period to period basis. The

author considers the demand vary as the experience of a consumer increases, the greater one understands the network of transport services so the better one gets at analysis his or her long paths and shortened paths to acquiring their goals. Hence the demand shift and the consumer pick the most efficient route (taxi or Uber, the efficiency in time used and resources available leads to best choice) (Bast et al., 2016).

To understand the transportation operation and network, we have to understand the existing policies and attitude behind existing transport and transport infrastructure.

2.2.1. EXISTING TRANSPORTATION PLAN AND POLICY:

The basic aspects of distribution and allocation of the transportation resources is referred as the transportation policy of a country. Where and how to place an essential transport point keeping in view who and for what this transport is going to be used (Cao, 2016). This explains the concepts behind developing a specific transportation policy.

Now, there is a difference between transportation policy and transportation plan, where the policy drives the decision-making regarding allocation of transport resources and the plan is their effective implementation. The two go hand in hand as the policy provides groundwork and the plan executes that.

The terms policy and planning are used interchangeably with one another but hold completely different means, where policy may be design without any planning implications possible and planning is frequently undergoes without any direct policy initiative (Merlin, Levine, & Grengs, 2018).

"Transport policy deals with the development of a set of constructs and propositions that are established to achieve particular objectives relating to social, economic and environmental

development, and the functioning and performance of the transport system (Zuberi, Torkmahalleh, & Ali, 2015)."

The scholars from the paper on the estimates of planning for sustainable transport Bast et al. (2016) emphasis that the problem lies in the planning of the transport services as in the implementation and maintenance rather than the policy behind those plans. Bast et al. (2016) stated that the planning fails to deliver the true intention of a policy. Hanif, and Alam (2020) based on an article on Pakistan's mode of transports states that, in case of Pakistan, the misrepresentation of data is the cause of inaccurate policies.

I, however, disagree with the concepts of planning failure because from the experience and analysis of equilibrium approach (as seen in the previous heading 2.2), we can conclude that the policy is based on unrealistic standards and the data of demand/ supply vary extremely as agreed by Hanif, and Alam (2020). The policy on transportation is further from the ground reality and further from the requirements of the sector. Whether it's the freight transport or passenger transport, the allocation and distribution of adequate resource is not met properly *(Weiner, 2016).*

The major project regarding transport development is focused on the infrastructure development like roads but still the number of road improvement as compared to the growth in travel/ transport demand is extremely low. Governmental authorities in Pakistan are not analyzing the ground data of increase in private vehicles when establishing new policies for building roads. The growth of transport and transport need is exponential whereas the solution is very singular.

The below figure 2.1 by Hassan et al. (2016) shows the development of roads structures in China, Pakistan, India and Bangladesh. Here, the scale for the measurement is between 1 to 7 where 1 is the lowest score and 7 the highest

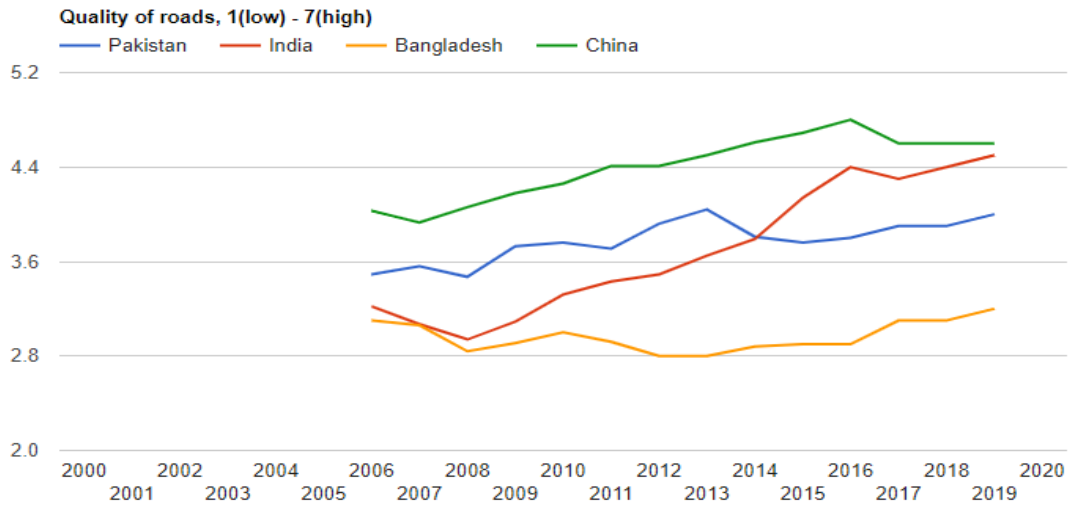


FIGURE 2-2: COMPARATIVE ROAD QUALITY IN SOUTH ASIA

China has improved its road quality to a 4.8 and shifted towards innovative technology to address transportation problem rather than just focusing to road development. Whereas India maintained a stable and steady growth in their road development along with introduction of different transportation modes like intracity train system to address the demand of travel. According to (COHEN, 2016) ,instead of creating separate policies for land use (road quality and infrastructure) and transportation, it is better to create a comprehensive policy for both.

The below statistics show the rapid increase in transportation as compared to the road consumption and road quality has been of slow progression where almost 95.6% of transport is conducted through roads. Whereas the road quality is comparative very less from figure 2.1 (Cortés, Burgos, & Fernández, 2010).

The institution of policy enforces order in transport, which is by nature chaotic as people attempt to travel from one place to another as fast as possible. It is policy's responsibility to resolve the conflict and optimize everyone output in the economy (Lee and Miller 2018).

TABLE 2-3: ROAD CONVERGE VS. RAILWAY COVERAGE IN PAKISTAN

Year	Road	Railway
2015-2016	1,187 km	1,246 km
2016-2017	1,266 km	1,342 km
2017-2018	1,573km	1,378 km
2018-2019	1,875 km	1,984 km
Traffic Distribution	95.6%	4.4%

2.2.2. TRANSPORTATION POLICY AND PLAN IN PAKISTAN:

The Pakistani transportation policy 2018 refers to all the transport modes; (as seen in the transportation 2.2 heading) air, land, water, and railway transportation. According to National Transport Research Centre (NTRC), Pakistan's transportation has keep in touch with the growth economic activities of the country given the national growth goal of +7% GDP (gross domestic product) and annual growth (M. Shahbaz, A. Chaudhary, & I. Ozturk, 2017a).

The objectives of NTRC are to build an efficient, equitable, reliable, safe, and environmentally sustainable transport policy. Plus, increase people mobility and accessibility to increase their economic output, hence, reducing poverty in this process. The transport policy develop by NTRC should provide collective and individual transport recourses to the people at the least possible cost

(Mahmoudi, Song, Miller, & Zhou, 2019). The Asian Development Bank (ADB) will extend assistance in developing and formulating the National Policy for Pakistan.

The below showed figure 2.2 according to NTRC display the currently operational modes of transportation in Islamabad-Rawalpindi and highlights the routes of these transports. The transportation modes included are BRT (Metrobus), Suzuki, Wagon, Bus and Quinqui. The most used means of transport are government regulated private ventures of Suzuki and Wagon whereas little to no routes are visible for the bus system.

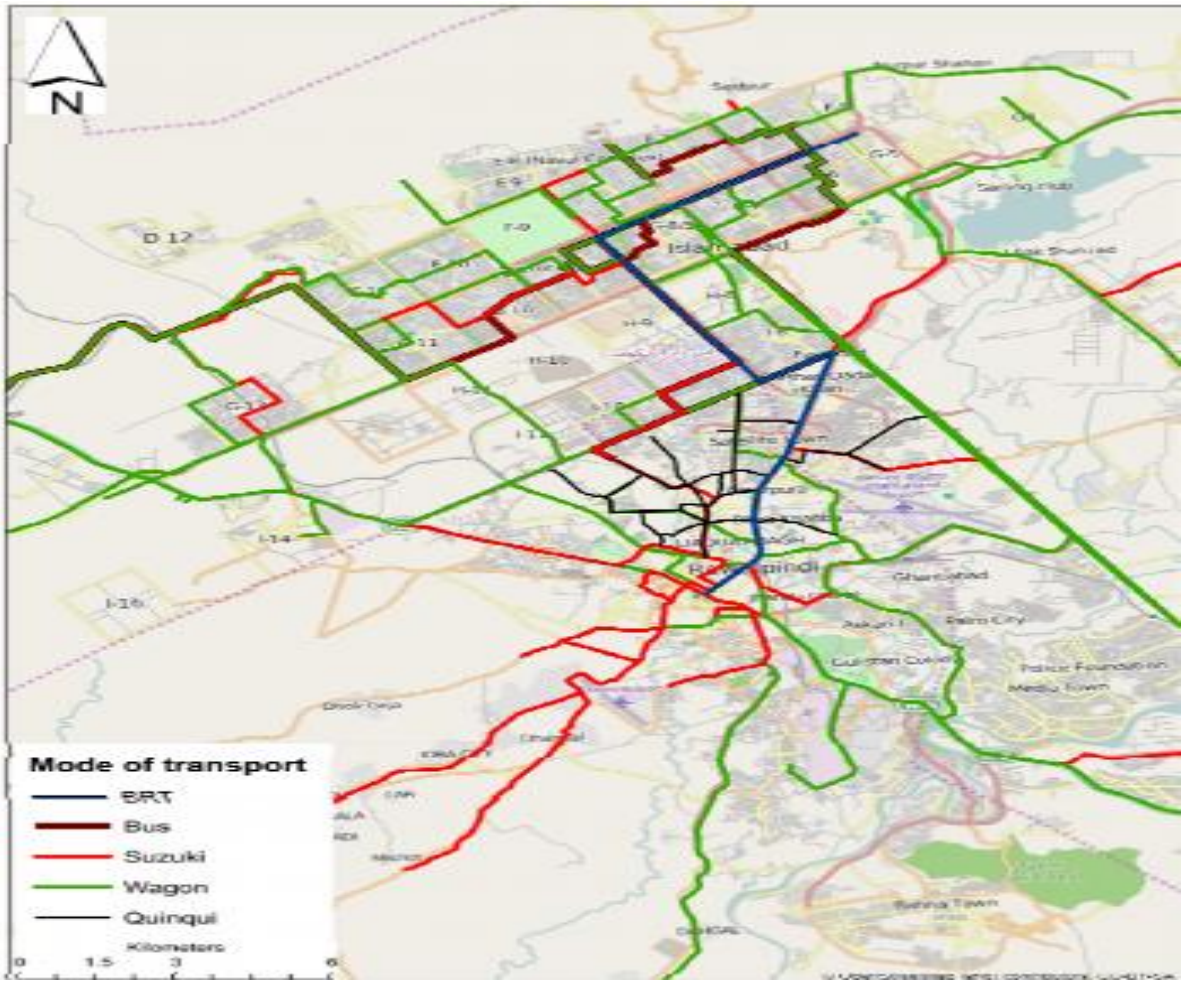


FIGURE 2-4: CURRENTLY AVAILABLE MODES OF TRANSPORTATION IN ISLAMABAD-RAWALPINDI

The distribution of Public and Private modes of transportation is very uneven but still the routes are frequently used indicating that the citizens of Islamabad-Rawalpindi are willing to use common transportation routes as they are willing to use these semipublic modes like Suzuki and Wagon. Hence, they are ready for more alternatives in public transportation.

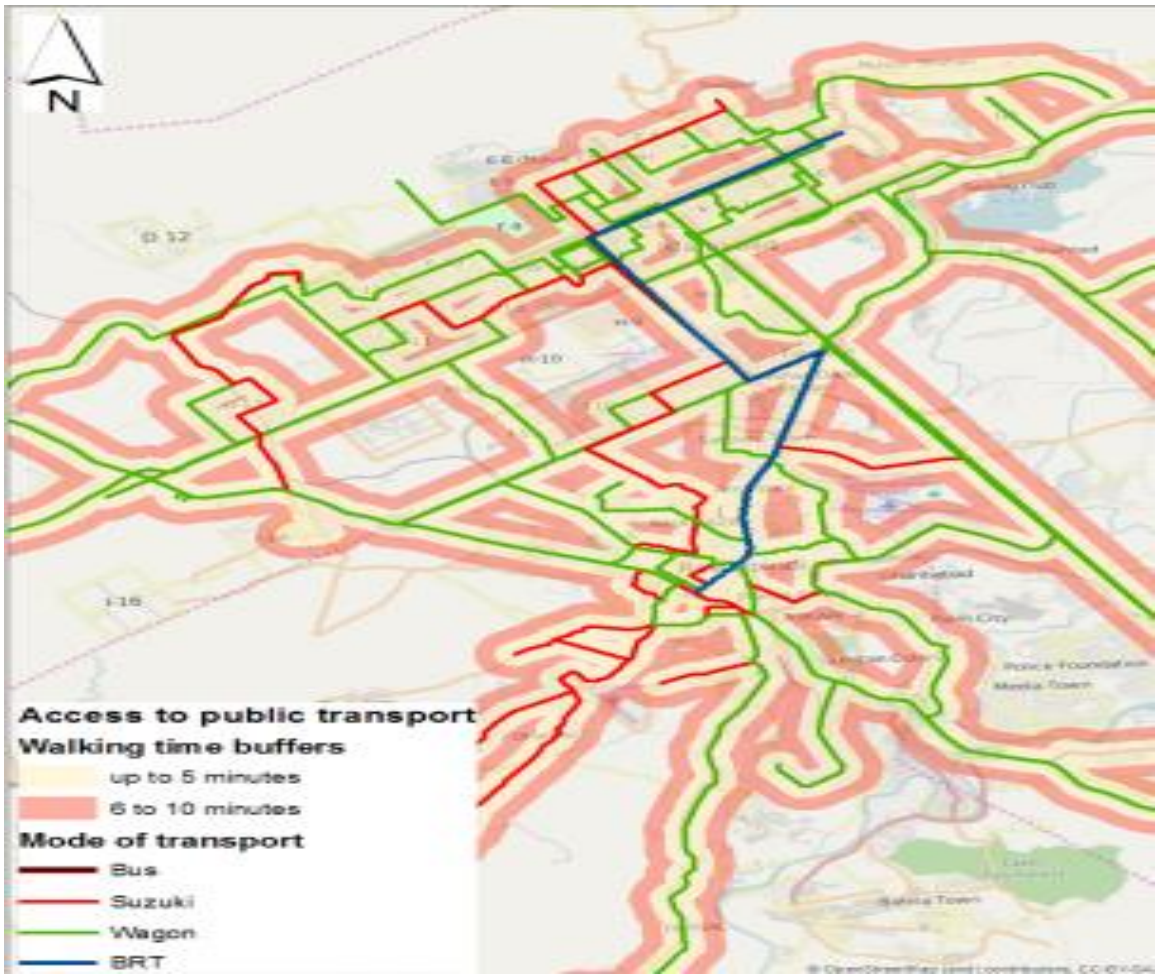


FIGURE 2-5: ACCESSIBILITY OF DIFFERENT TRANSPORT MODES THROUGH FOOT

The figure 2.3 by (Baloch, 2018) illustrates the current working routes of different transportation mode available in Islamabad-Rawalpindi and the possible distance for accessibility of current transportation networks. This map shows the accessibility and willingness of the citizen to use public transport. The walking distance of 5-10 minutes can employ people around the radius of 1 kilometer and allow them easy and cheap accessibility and mobility.

Till the point of this research, two comprehensive National Transport Policy has been presented namely 2006-2007 National Transport Policy and, the recent, 2018 National Transport Policy (M. Shahbaz, A. R. Chaudhary, & I. Ozturk, 2017b). The National Transport Policy (NTP) purposed and approved by the Pakistan Muslim league Nawaz Party (PML-N) during their last regime. The NTP included policies regarding Air, Rail, Mass Transit, Urban Transport and Maritime Business mode to address the issues relating to the growing population and progressing national economy (Ramli and Monterola 2015).

The Pakistan Civil Aviation Authority responsible for the air transportation will be amended under the new NTP with separation of power between regulatory authority and services provision responsibilities. For this policy includes updating existing airports and building or expending new airport in major cities like Lahore and Karachi (Sobhani et al., 2019).

Ministry of Planning, Development and Reform with association to Department of international Development and ADB will develop the new NTP for Railway and Land Transportation. Specific consideration regarding passenger transport will be made to increase the usage of public transport and non-motorized transport modes (Mohmand, Wang, & Saeed, 2017).

To analysis sustainability, we will calculate the total transport both private and public as public transport to increase accessibility in remote areas. For freight transportation, the road transport of larger loads will be shifted to the rail and increase in the capacity of the railways itself would be proposed. The railway is designed to support longer travels as compared to the road line that are being damaged through bulk loads and are not sustainable (Sciara, 2017).

For I, the author of this literature, see that the problem in this National Transport Policy orientation is not of the separation between the air, rail and land but of the integration between these routes. The combination of freight and passenger transportation in a single transport resource

will produce optimal utility for that recourse. From recent survey, it is clear intra city freight transport is also very important and necessary for economic growth. Seeing the example of China and India, we can also develop combined transport for Passenger and Freight loads.

In Pakistan, statistics show that more than 80% of the rail lines are 50 km long or less in length limiting their utility level and increase consumption of fuel for more than 50 km runs. In other words, the railway is ineffective and inefficient in carrying out its responsibilities. Similarly, the road lines are constructed during the World War II and are out dated to hold both freight and commercial transportation (Donaldson, 2018).

In Pakistan, the author should not forget about the newest entries into transportation sector are big corporate private transport service like Careen/ Uber and the already existing informal private sector in transportation like Taxi and bus services (Batur & Koç, 2017). It is foolish of the study to think that the consumption needs of the entire population of Pakistan can be managed by the governmental transport alone.

The private and public transportation go hand in hand, but that does not mean a free run for the private sector. They should accountable and regulated under the rules generated by the authorities on transportation and there should be limitation in the operations of such private services (Adeel, Yeh, & Zhang, 2016). Taxes and cost adjustment mechanism for the protection of consumers and the public sector should be placed.

Sadly, Pakistan still has to develop an appropriate regulatory authority for the transportation sector. Still, the private is informal and non-regulated under the government of Pakistan. The Private Sector of transportation, in a survey conducted on 2017 December; consume bulk of the services with estimate 80% and 20% margins of activities falling under Private and Public sector respectively. This is a large gap in revenue generation for the public sector, plus, also hinderers

the individual's ability to minimize their expense on transport facilities as the Private sector works on the basis of profit rather than welfare.

From my perspective, the problem lies with the formulation of accurate policies regarding transport services as the authority have misinterpreted the data and formulated inefficient policies which do not address the bigger picture in the transportation sector. Creating bigger and larger transport or mass transit facilities are not the objective here but increase or maximize the utility of the existing transport facilities is what needed.

Increase the competitiveness between private and public transport, the complete and full utility of existing transport facilities, increase the ability of revenue generation in transportation sector, those are the objectives I, the author of this study, would like to propose.

2.2.3. POLICY PROBLEMS WITH PAKISTAN'S TRANSPORTATION PLAN

The problems that are in forefront are pretty obvious; over subsidization, lack of public and private competition, lack of analysis in demand determination, the gaps in the supply side, lack of innovation in the transport policy and planning, lack of innovation in transport modes and many others (Aamir, Masroor, Ali, & Ting, 2019). The policy in general lacks strong empirical support and data needed to determine what will work on field and what will not.

The concept of over subsidization of increase utility of an individual to move around at the least cost possible in turn affect the governmental revenues and increase debt toll the country itself. If the subsidization is not compensated with the increase in economic productivity, it is time to realize its inefficiency and wastage (Amiri Khorheh, Moisiadis, & Davarzani, 2015).

This control on the fee of a public transport is over burden and over kill for the governmental activities regarding other functions of the government; more productivity functions at that, for

example, subside on the agriculture activities. The current fares on the urban transportation in Pakistan are mostly 30-60% less than that of the reasonable levels (Batur & Koç, 2017).

Another problem in regard to the determination of demand and supply of the services is an important one. In my opinion, the author of this paper, the need to calculate the utility of a service and the consumption against it, plus, the private sector competition available with it should determine the number of increase in such service (Sobhani et al., 2019).

The NTRC has data on the long of the roads and railway currently present under Pakistani jurisdiction with the total amount falling under less than 2,000 km. The newly include part under CPEC is not calculated in this study as the productivity of CPEC road lines is not yet measurable (Lester, Winters, & Pham, 2019).

The length is expected to increase under the CPEC agreement but the traffic distribution clearly poses a problem as there is a clear burden on the roads rather than the railways (Litman, 2017). The purpose of this paper was to address the growing need for a better and more optimal policy regarding the transportation needs of Pakistan. The policy experts have failed to deliver on promises of future success in the department of transport policy and planning (Baloch, 2018). The sustainability of mobility for people optimize their working hours and productivity and hence the output generated by those people (Mahmoudi et al., 2019).

2.3. SUSTAINABLE TRANSPORTATION:

The sustainable transportation refers to the means of transportation that are environment friendly and has longevity growth with the growth of the society. Sustainable transportation also talks about the balance between current and future consumption of the transportation facilities (Greene & Wegener, 1997).

Sustainability of any individual resource requires it to be used with the mindset that the expansion of such resources is compulsory and exploiting it would result in elimination of such resources. The sustainability in transportation also indicates its use for the future generations and its implications towards environment, economic and social wellbeing.

The transportation sector is one of the largest growing need to the 21st century, with people moving further and faster than ever before (Shahbaz et al., 2017a). The intents to develop better and more sustainable system for the transportation will improve the economy and the daily life altogether.

Urban transport problems in Pakistan are managed by building larger and better roads. By contrast, the principles of sustainable transport encourage using low cost public transport that could perform well in mixed land use and high density Pakistani cities (Majid et al., 2013).

2.3.1. SUSTAINABLE TRANSPORTATION CONSUMPTION MODEL OF CHINA:

To develop an effective model of sustainable transportation policy, we engage the help of already existing material on the efficient and effective model used around the world. To perfectly implement these policies, we have to look at the similarities needed by the Pakistani transportation policies like does it address the rapid increase in population? (Aggarwal & Jain, 2016) Does it calculate the over urbanization of some area over the others? Does it measure the changes in demand and supply of the regions? Does it analysis the consumption pattern similar to Pakistan? Does it address the increase in private consumption over public consumption like Pakistan?

For that purpose, we have employed China's transportation model proposed by Li, Chi Man Hui, Xu, and Li (2012) and Chen, Kockelman, and Zhao (2015) who discuss the fundamentals of

a optimal policy orientation in regards to transportation addressing all factors that may vary in different models of same data patterns.

The first model discussed here is based on the population growth and addressed the rate at which population use of vehicles increases.

2.3.1.1. NUMBER OF VEHICLE MODEL

The number of the vehicle sub model represents the increase in demand of the transportation. Hence, the governmental response of increased investment and development of the public transportation is given (Zuberi et al., 2015).

However, the traffic overcrowding and air pollution caused by increased use of vehicles will counter to the economic growth and population progression (Wang, Lu, & Peng, 2008).

2.3.1.2. TRANSPORTATION DEMAND MODEL

The transportation demand sub model is the determination of needs and depends on the total urban population. These analyses the patterns of travel among the population of the city like what are the constant routes under consumption (Chang, Zhang, Danao, & Zhang, 2013).

The demand also calculates the time and distance a single individual travels and the total vehicle kilometers having traveled (VKT) (Cao, 2016).

2.3.1.3. TRANSPORTATION SUPPLY MODEL

Transportation supply reflects the level of urban infrastructure construction and maintains a dynamic balance with the transportation demand side (Shunping, Baohua, Shuang, & Qipeng, 2010). As the author of this paper, I feel that the model given by the Chinese University on the sustainability and adequate growth of transportation facilities is an opportunity in developing Pakistan's own model of effective and efficient transportation policy. Pakistan is on its way to a

more stable economy and stable growth, for that a good and stable transport will only facilitate towards faster achievement of those goals.

2.4. SUMMARY:

The literature of this study focuses on the need of transportation and the externalities associated with it as well as the dynamics of urban setting and the role of a good transportation plan. The modes of land transportation ranging from private to public endeavors should provide effective and efficient use of different resource. The literature examines the comparison between the resource availability and their current utilization in Pakistan. The literature discusses the consumption needs of an urban living and the cost of travel between different social classes. The literature also deliberates the lack of governmental provisioned transportation facility with full accessibility, affordability and meeting all the needs of mobility.

CHAPTER NO: 3

METHODOLOGY

3.1. RESEARCH DESIGN:

In this study, the author used applied quantitative research to address practical mobility problems of Islamabad and Rawalpindi by using real-ground data. The author wishes to establish a working transportation plan that will function on bases of responsible consumption under SDGs utilizing the existing resources to employ the twin cities with a Bus Service. The purpose of using applied research is to create an implementable public transportation plan for Islamabad – Rawalpindi through QGIS software.

3.2. DATA AND METHODOLOGY:

In this study, the author has opted to collect secondary source data on geographic and geospatial values of Islamabad and Rawalpindi. For the secondary data, the author has collected GIS shapefiles data (polyline, polygon, point, multipart polyline and multipoint) on the administrative boundaries of Islamabad-Rawalpindi, Road Map/structure of Islamabad-Rawalpindi through QuickOSM search Plugin (open street map) and Google satellite. Whereas also created a few shapefiles on union councils of Islamabad and Rawalpindi through different processing tools of QGIS like vector geometry, Geoprocessing and Data Management tools as well as QGIS Plugin such as LRS, ORS tools and PgChainage etc.

As well as, secondary on the number of buses currently operation in Islamabad-Rawalpindi (already existing resource) was also collected from individual universities only. The data of mobility patterns was also collected from secondary sources.

For creating an inclusive transportation structure, it is important to remove any financial, gender, Spatial, desirability or any other barriers from the secondary data of mobility, as well as the reliability and accuracy of the study conducted that is why it is necessary to acquire data from all possible venues. the reason behind multiple inquires for mobility data is to, also, reach a saturation point for common (majority) mobility patterns.

For this study, the author has attempted to use secondary data depending on the availability of mobility patterns or data of the people's travel patterns of say for the last 6 months (before COVID-19) from either Google or from Public/Private development projects or companies, respectively. Hence, the author has conducted six inquires with different governmental, semi-governmental and Private parties namely:

- From Uber and Careem Supply Centre Islamabad and Rawalpindi, respectively acquired data on 100 sample rides between Islamabad and Rawalpindi.
- From Regional Transportation Authority (RTA) collected info on Minibus, Suzuki, and Wagon routes as well as stops.
- From Islamabad Traffic police (ITP) data on entry points of Islamabad from Rawalpindi as well as the flow of traffic on each point.
- From WSP Australia and LeadDogs United States consultant companies provided data on travel demand and travel need within Islamabad and Rawalpindi respectively from a survey based on desirability and need of travel.
- From Pakistan GIS (Dr. Naeem Malik) and Pakistan Bureau of Statistics acquired data on taxi stands, area of service and frequency of taxi demand.

- From Google API (Direction API, Distance Metrix API and Road API), Google Cloud Platform, Google Earth Engine/Python Console in QGIS.

This spatial database consisting of layers of data on both geographical structures and analysis of the people's mobility patterns which will help create optimal routes of connectivity for the public transportation plan (buses).

3.3. DATA COLLECTION TECHNIQUE:

There are two data collection technique employed in this study. Firstly, the secondary data was collected from online database like Humanitarian Data Exchange, Open Street Map, Google Map, Google Archives, Google Earth Engine Catalog, Google Cloud Platform (the source code for JavaScript and Python EE & console are included in Appendix B).

Secondly, the data was collected by direct contact like in person interviews and queries (visitation) with different Public and Private entities like RTA, ITP and Careem (List of contacts and name of references are included in Appendix B). Also, indirect contact methods were used like email and calls with entities like Uber, WSP, Leaddogs, PBS, Pakistan GIS, and Individual Universities for Bus Data.

3.3.1. PROCEDURE FOR EXTRACTING TRAFFIC LAYER DATA FROM GOOGLE:

Google Maps Platform has different Maps JavaScript API and one of the maps is Traffic Layer API which uses Direction API (destination address and origin address) and Distance Metrix API to calculate the time duration to cover desired area including the traffic delay.

The author used Google Cloud Platform to obtain API key for Direction API, Distance Metrix API and Road API using them to construct traffic layer over a specific latitude and longitude of Islamabad and Rawalpindi. The code (available in Appendix B) was processed using JavaScript

and later converted into usable code for Google Earth Engine/Python Console plugin in QGIS and extracted data for a period of 15 days.

3.4. DATA ANALYSIS TECHNIQUE:

For this study, the author would use QGIS software to organize and analysis data of transportation services in Islamabad-Rawalpindi. QGIS and Google Maps catalog was used to create the spatial database and map is used to illustrate transportation plan with the help of interval plugins and tools as mentioned above.

3.4.1. MAPPING:

In QGIS different datasets are merged as layers and these layers are graphically represented by using attribute analysis to explore information on these layers. The following types of spatial layers were used to analysis and address the research questions of this study (Routray, 2001).

- Polyline – Roads Shape file and mobility flow (primary roads, secondary roads, tertiary roads, and trunk roads as well as routes of semi-public and private transport available in Islamabad-Rawalpindi).
- Polygon – union council and administrative boundaries of Islamabad and Rawalpindi.
- Point Data – functional attributes for health education business centers and Pakistan's Travel Demand data etc.
- Multipart polyline – Mobility trends and Mobility Metrics.

Further, plugins like Open Street Map (OSM) search, Open Road Service (ORS), QGIS resource sharing, Google Earth Engine (GEE) combined with tools like vector analysis, chainage,

research tool and proportional data representation, the author was able to create a Mobility Metrics of Islamabad-Rawalpindi with both direct and derived mobility.

This Mobility Metrics is used to create new bus routes for Islamabad and Rawalpindi based on the flow of transportation need of the twin cities. The author also mapped out the common and most frequent used nodes in connectivity to establish optimal, efficient, and accurate routes of new public transportation system proposed by this study.

3.4.2. MOBILITY METRICS AND CONNECTIVITY:

The mobility metrics determines the technique for data analysis bu dividing the collected data into two classes: direct mobility and derived mobility.

For this study, the author used Routray (2001) reference to produce the final product of this study which is to create Bus Service Routes for optimal connectivity. Hence, this study will use Road topology and Cartography to create those Maps. Alpha (observed number of nodes), Beta (tree type connectivity), Shimbel (selecting the common path in complex setting for connectivity index), detour (suggesting different routes) and Gamma index connectivity is used for creating transport routes in QGIS Map (Crampton & Krygier, 2018).

3.4.3. DETERMINATION OF STOP DENSITY AND TRIP GENERATOR:

The study will determine the trip generator of each route proposed based on high or low travel density of that area. The final routes will be divided into major trip generators and minor trip generators depending to the length of the route and their potential stops.

Also, the author will determine the ratio of stops or stop density for each route based on accessibility factor. Here, the ideal distance from and to a potential stop is taken as 1.2 kilometers

or 15 minutes walking approx. as referred by Clarence Perry's 15 minutes' city in 1900s. it is also a pattern followed for recent modern city designs.

The formula to estimate the stop density of each route is as follows.

Equation

$$\text{Duration t from A to B} = \text{Duration c}\frac{\sum N}{\sum N} + \alpha + \beta + \pi \quad (3.1)$$

Whereas,

Duration $_t$ from A to B = Duration of travel between two consecutive bus stations.

Duration $_c$ $\sum N$ = Total duration of travel on one complete Bus Route.

N = Total number of stations 1.5 km apart on that Route

α = Traffic constant.

β = Traffic signal constant.

π = Occupancy of Passengers (loading and unloading).

Also, the formula to calculate the number of buses used per route is as follows.

Equation

$$Nb = Duration\ c \sum N - Duration\ t\ from\ A\ to\ B \quad (3.2)$$

So, the number of buses on one route is equal to total time used to travel on one route (in minutes) divided by the duration of travel between two consecutive bus stations.

3.5. LOCALA OF THE STUDY:

The area of Islamabad and Rawalpindi was chosen for the study with a geographical area of 906.5 and 259-kilometer square respectively with road structure. The population of the two cities stands at 1,601,600 and 2,743,101 with the population density as per square kilometer of about 2,089 people (5,410 per square mile) and 1,039 respectively (Asif Bajwa, 2015).

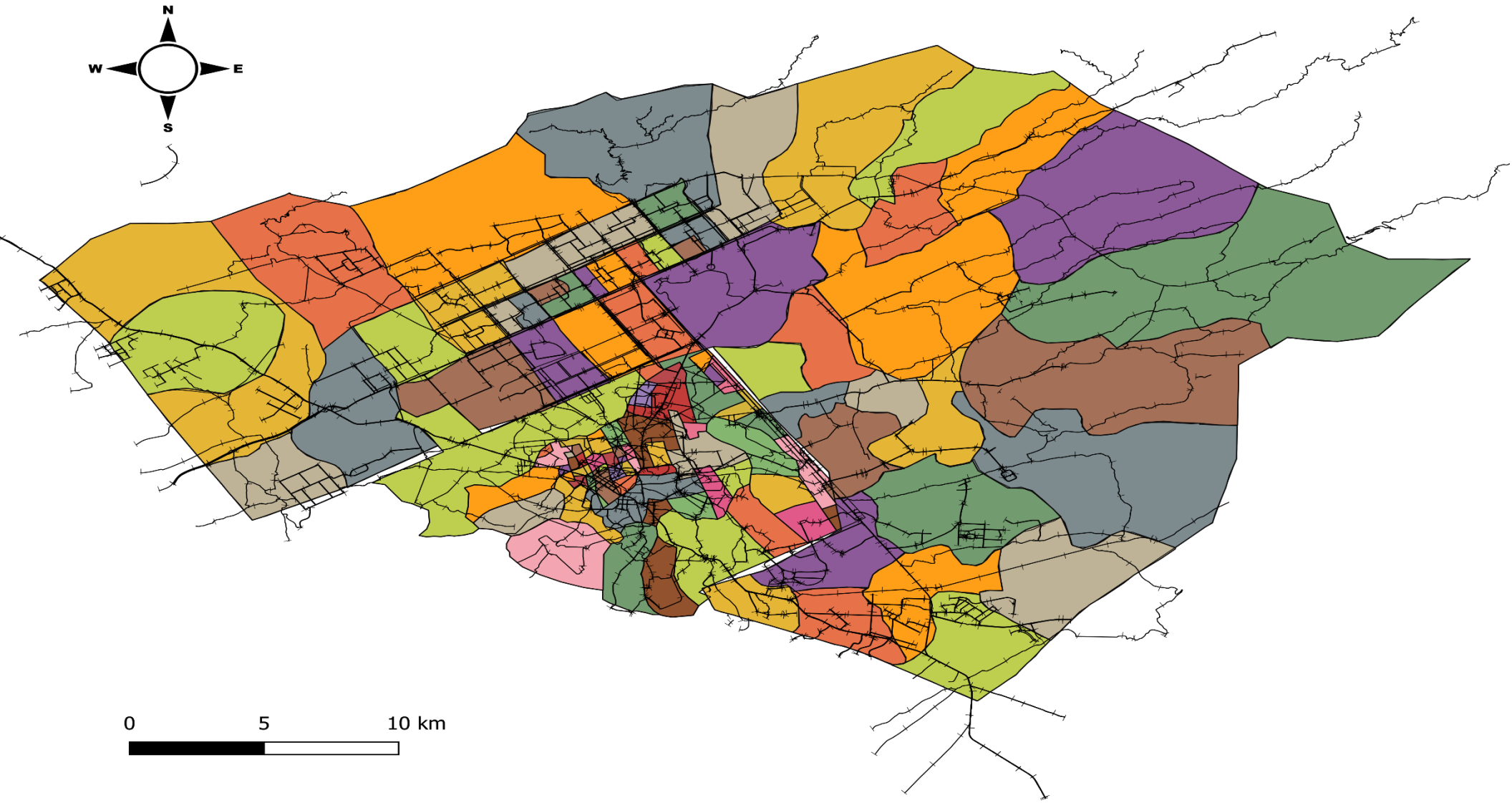
Administratively, the two cities (Islamabad-Rawalpindi) consist of 50+ union councils each. The reason behind the selection of these two cities is their growing economic and financial stature. Firstly, the city of Islamabad being the Federal Capital attracts a lot of attention both from local and foreign sectors and the growing migration rate towards Islamabad requires adequate measures of transportation to facilitate the travel demand of the masses. Rawalpindi also has the same magnitude of attention for being associated to the Federal Capital of Islamabad and have direct connecting routes between the two cities, hence, the name twin cities

Secondly, the reason behind selecting these two cities is also their common shared administrative boundary which is getting vaguer and vaguer by the day as the two cities have huge interaction with one another.

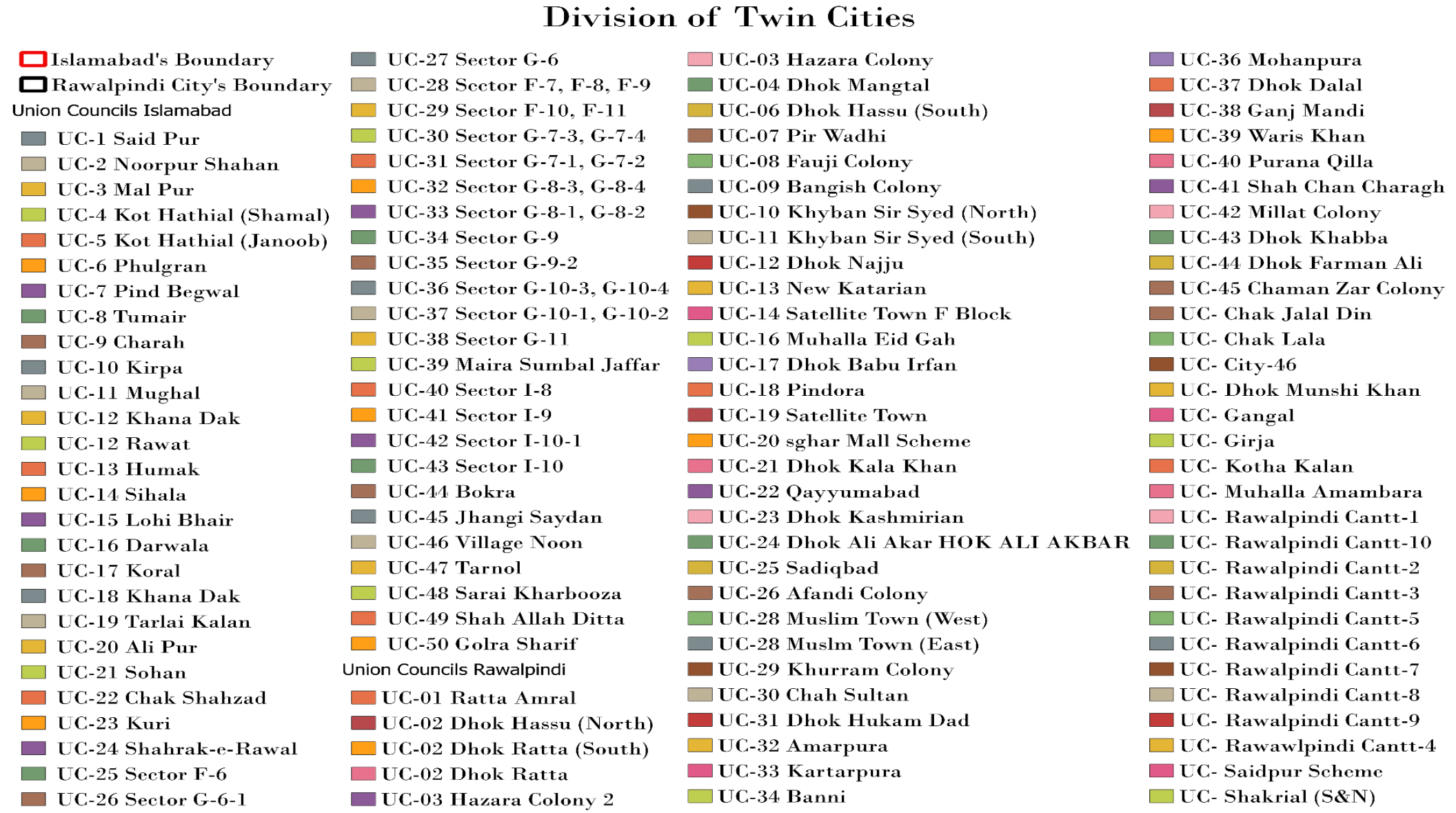
3.5.1. SAMPLING TECHNIQUE:

For accurate representation and data analysis, it is important to work with smaller area to understand the demand of mobility better. (Sciara, 2017) Therefore, the area of Islamabad and Rawalpindi will be studied on UC level. So, by the process of elimination we will identify most frequented union councils of both cities and use them to create the transportation plan. For this study, each union councils will be studied independently as to acquire their individual travel demand patterns. The union councils with higher percentage of demand will be selected.

MAP 3-6: UNION COUNCIL DIVISION OF ISLAMABAD AND RAWALPINDI WITH ROAD CONNECTIVITY



MAP 3-7: NAMES OF THE UNION COUNCIL OF BOTH ISLAMABAD AND RAWALPINDI



CHAPTER NO: 4

DATA PRESENTATION

4.1. DATA PRESENTATION:

Understanding the need for planned spatial development and urbanization is the sustainability goal of the developing nation of Pakistan with large population to cater for and maintain a constant growth rate for generations to come. The need to travel and move is exponentially growing in modern urbanized societies with increasing land covers and growing land use distributions, the travelling time between places has rapidly doubled over the last decade even for the developing countries like Pakistan.

The economic growth of any country is associated with their ability to invest in developmental needs of their people. Developed countries with large budgets can invest larger amounts in developmental projects but developing countries like Pakistan are presented with limited options when concerned with development of the country. Developmental projects like infrastructure are also foreign aid funded causing a conflict of interest in planning, but sustainability should be the priority for the Pakistan's government.

Transportation is also one of the areas that requires constant upgradation depending on the need of the economic activities of any country. The requirement to travel for work or business activities and for social needs are primary considers of majority of the population of any country plus the ease of travel greatly increases the flow of economic development. For a developing country, the investment in transportation sector means providing opportunities to the people to grow and work freely regardless of their financial dependencies or financial status.

In the case of Pakistan, developmental budget is comparatively less to the growing transportation demand with increased urban dispersion and unplanned accumulation of large numbers of travel, the cities of Pakistan are overcrowded with extreme numbers of private vehicles as a solution to transport need. There are issues like congestion and over parking reducing the efficacy of increasing road quality which has also been neglected as the improvement in road structure is comparatively low to the depreciation of roads over time.

Islamabad and Rawalpindi are the primary example of costly solution to transportation problems including reverting to private consumption of vehicles to introducing unregulated private transport services as well as lack of conventional transport services like bus system, but the government of Pakistan has put its trust in unstructured semipublic transport service where profits are above accessibility and accuracy. Private consumption is not a solution for middle-low-income classes but sadly, the response of the government for them is another expensive solution with large infrastructure cost (sunk cost) and middle to low accessibility option, Metrobus Service BRT project or catering to private consumption of transport by building new flyovers and developing no stop corridors in the middle urban setup.

Hence, the structure of Pakistan's transportation system is a big question mark for researchers as well as urban developers. Complex accumulation of infrastructure has left no room for growth especially for Rawalpindi, where a standard road structure is based on 3 to 5 lanes system, Rawalpindi's primary roads are over consumed. Land is a very limited resource and Pakistani government is abusing that resource to the extreme of no turn. Instead of building on simpler solutions, like a public transport system, the answers to Pakistani mobility issues are addressed through heavy construction projects which, in fact, take longer time for short term problem.

Under 12th SDG, shared mobility promotes responsible consumption and encourages sustainability for the betterment of human race. Pakistan too has the resources to shift from colonial developmental mindset to more sustainable and futurist ideas. Currently under the administrative control of universities in Islamabad-Rawalpindi are buses that can be used to create a public transportation system (Bus transport service), where there is no need to build new highways of bridges to accommodate the functioning of this bus system.

This study will highlight the concept of shared mobility and bus transport system. Shared mobility is defined as the optimal utilization of a vehicle/vehicles of any kind. It means allowing several people or goods to travel in the same transport at the same time to reduce individual kilometer travelled. For sustainability and less environment emissions, it is better to allow one vehicle on road than 10 individual cars. Creating a public transportation system based on shared mobility could result in the sustainable growth of our country's transport sector. Countries like India and China are moving forward by creating shared mobility-based transport of all form, from cars to minibuses. Pakistan too can create such a system and this study will, similarly, try to prove that theory.

For this study, the author needed to collect multiple sorts of data including data on buses currently operational under government or public universities. Buses are an important part of this thesis as they are the representative of sustainable consumption and the travel sharing plan. For limiting consumption and wastage of commodities, this study will create a public transport sharing system employing the surplus resource of buses currently operational but not fully consumed.

4.1.1. DATA ON THE AVAILABILITY OF BUSES:

Public transportation is environmentally, socially, and economically superior to any form of private transportation as public transport are based on sharing of one larger vehicle among several

people at the same time and cost which is equally accumulated among them. So, creating a public transport system could eventually reduce the number of vehicles on the road as well as the number of individual car trips. A public transport system can be based on different types of vehicles like minibuses, cars, trains, and buses.

For this study, the number of buses available is very important as they provide the key foundation for building this transportation plan of this study. Under SDGs 2030, the 12th goal states the responsible consumption of resource regardless of their abundance. Islamabad-Rawalpindi have the resource to build a proper public transportation plan as there are 175 buses currently partially operational under universities within Islamabad-Rawalpindi territorial borders.

Partially operational buses are restricted to the staff or students at a single university, hence, serving only a marginal portion of the population in Islamabad-Rawalpindi. Also, the usage of the resource (buses) is limited to specific timing only for each university, other than that, the bus is either vacant or non-operational. Increasing the utility of these buses by employing them for our public transport system is a sustainable idea like any ride sharing system.

TABLE 4-8: THE NUMBER OF BUSES UNDER INDIVIDUAL UNIVERSITIES LOCATED IN ISLAMABAD-RAWALPINDI

Sr.	Name	Location	Established	Type	No # of Buses
1.	Quaid-I-Azam University	Islamabad	1967	Public	30
2.	Pakistan Institute of Engineering and Applied Sciences	Islamabad	1967	Public	4
3.	National Defense University	Islamabad	1970	Public	7

4.	Allama Iqbal Open University	Islamabad	1974	Public	5
5.	International Islamic University	Islamabad	1980	Public	48
6.	National University of Sciences and Technology	Islamabad	1991	Public	5
7.	COMSATS University	Islamabad	1998	Public	14
8.	National University of Modern Languages	Islamabad	1969	Public	15
9.	Bahria University	Islamabad	2000	Public	-
10.	Federal Urdu University of Arts, Science and Technology	Islamabad	1949	Public	6
11.	Institute of Space Technology	Islamabad	2002	Public	3
12.	Air University	Islamabad	2002	Public	4
13.	Shaheed Zulfiqar Ali Bhutto Medical University	Islamabad	2013	Public	-
14.	National University of Technology	Islamabad	2018	Public	2
15.	Pakistan Institute of Development Economics	Islamabad	1957	Public	4
16.	National Skills University	Islamabad	2021	Public	-
17.	National College of Arts	Rawalpindi	1875	Public	5
18.	Pir Mehr Ali Shah Arid Agriculture University	Rawalpindi	1970	Public	8
19.	Fatima Jinnah Women University	Rawalpindi	1998	Public	3
20.	University of Gujrat	Rawalpindi	2004	Public	-
21.	Rawalpindi Medical University	Rawalpindi	1974	Public	6
22.	National University of Medical Sciences	Rawalpindi	2015	Public	2
23.	Rawalpindi Women University	Rawalpindi	1950	Public	4
Total		**175**			
Regional Transportation Authority Registered Buses		**265**			

The above-mentioned table 4.1. presents the recent number of buses owned by an individual university. The data was collected through indirect inquires like phone calls and emails etc. there are a total of 23 public universities in Islamabad-Rawalpindi and only 19 responded to the questions regarding their bus number, whereas 2 universities failed to respond (Bahria University and University of Gujrat) and the other 2 universities do not have a transportation system in place (Shaheed Zulfiqar Ali Bhutto Medical University [SZABMU] and National College of Arts).

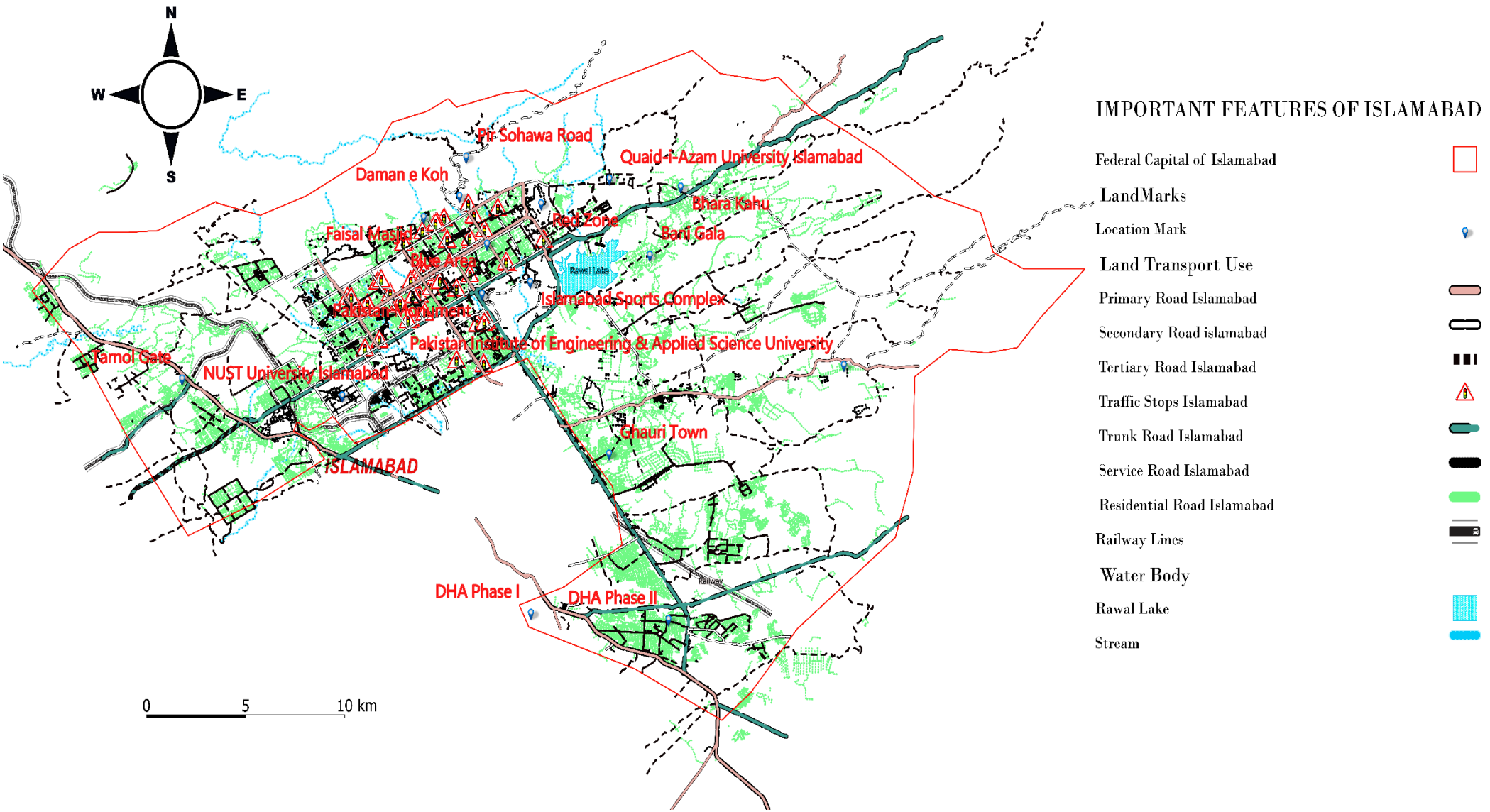
The above-mentioned buses are more than enough to create a public transportation system efficient for both Islamabad and Rawalpindi's mobility needs. As well as the data from Regional Transportation Authority (RTA) is also presented above on the number of buses current registered for Islamabad-Rawalpindi zone (265). But for this study, the author will only use university registered under the name of a university to increase their utility by applying them for all citizens of Islamabad-Rawalpindi.

The next set of data collected is on administrative division of Islamabad-Rawalpindi and the road structure of the twin cities as it is important to know where the public transportation routes are located on the map.

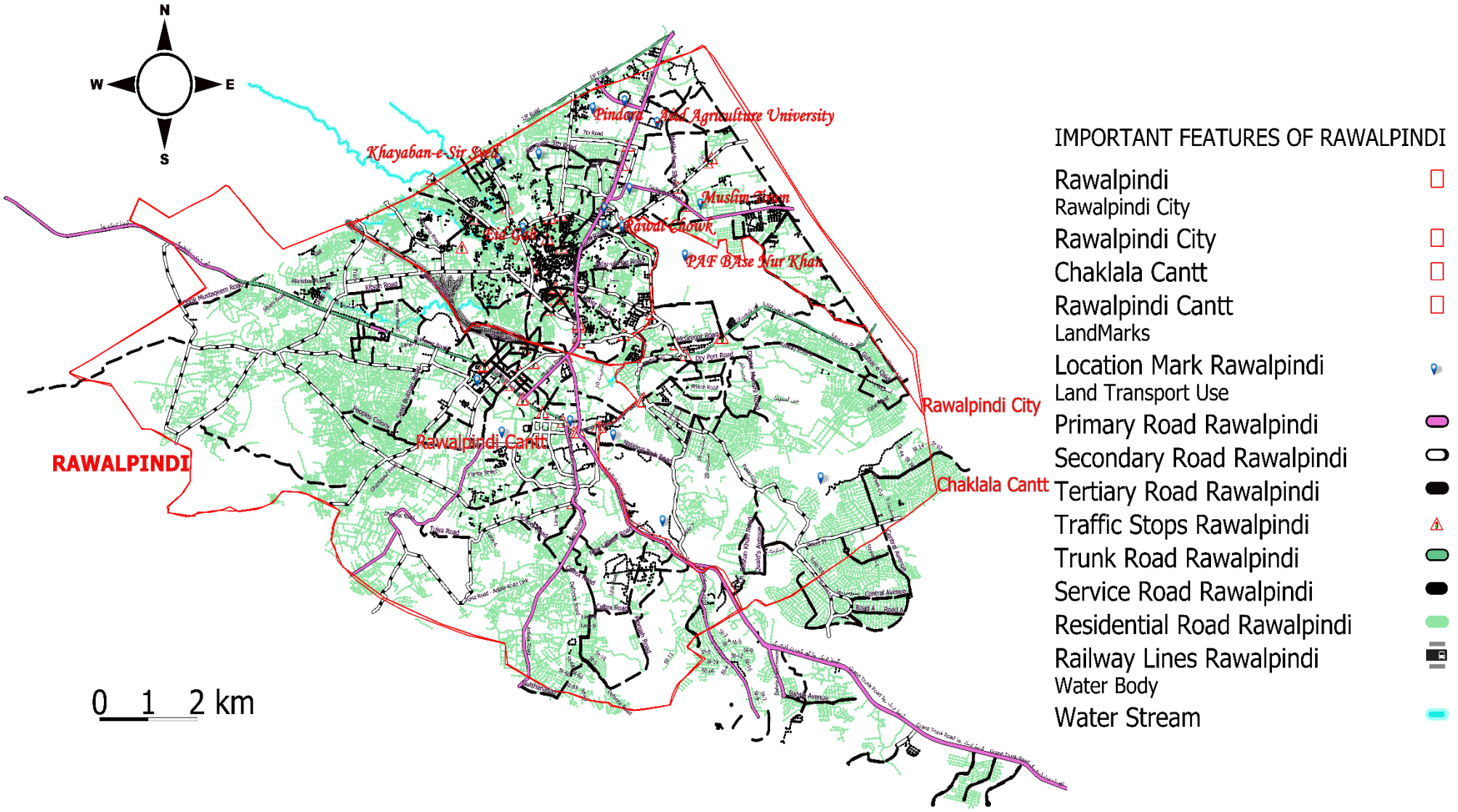
4.1.2. ADMINISTRATIVE BORDERS AND ROAD STRUCTURE OF TWIN CITIES:

The data presented below highlights the boundaries of Islamabad-Rawalpindi which are the area of the study according to the methodology (Chapter no 3, Heading 3.5). The area of the study includes Islamabad over 906.5-kilometer square and Rawalpindi City over 259-kilometer square, whereas the total area equals to 1,165.5-kilometer square. The population of the two cities stands at 1,601,600 and 2,743,101 with the population density as per square kilometer of about 2,089 people (5,410 per square mile) and 1,039 respectively

MAP 4-9: IMPORTANT FEATURES OF ISLAMABAD HIGHLIGHTING THE ROAD CONNECTIVITY (PRIMARY, SECONDARY AND TERTIARY ROAD)



MAP 4-10: IMPORTANT FEATURES OF RAWALPINDI HIGHLIGHTING THE ROAD CONNECTIVITY (PRIMARY, SECONDARY AND TERTIARY ROAD)



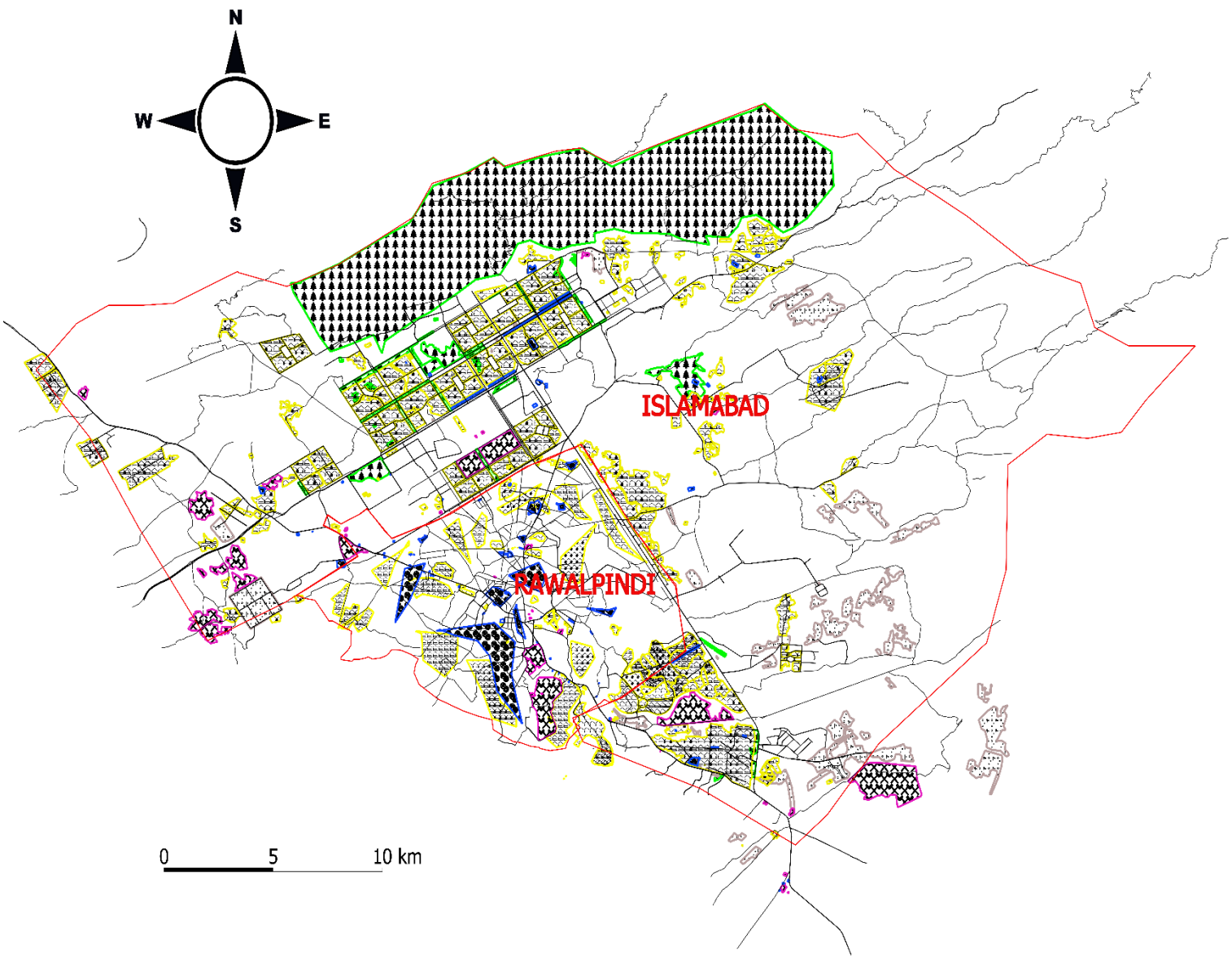
The administrative division of Rawalpindi are at three levels namely Rawalpindi District, Rawalpindi Tehsil and Rawalpindi. For this study, the author has only included Rawalpindi city in study which consists of Rawalpindi City, Rawalpindi Cantt and Chaklala Cantt (Appendix A).

The base layer of the map also consists of road structure of the twin cities like Primary roads, Secondary roads, Tertiary roads, Trunk roads, Service roads and Residential roads. The data also presents the number of stop lights in twin cities. A total of 133 and 82 stops lights are present in Islamabad and Rawalpindi, respectively. The structure of the roads is important to understand the movability of a bus on these roads as well as to create a feasible transport route based on the common mobility along these roads' lines.

The above-mentioned data was collected using Open Street Map Search (Quick OSM Search) in the form of shapefiles and were clipped or merged using vector geometry and geoprocessing tools in the QGIS system. Plugin for ORS and QGIS resource sharing were also installed to have a better representation of the legends and the final map output.

The author has also included map on the current land use of Islamabad and Rawalpindi, so, that the patterns of mobility are reasonably explained according to the area type like residential use or commercial use. The mobility demand might also decrease, or increase based on the area type, for example, for a commercial area mobility is higher during market hours but less in mornings as compared to industrial or construction areas where employees arrive early in the morning. The land use is divided into commercial, industrial, residential, and future construction zones along with forest division especially for Islamabad. This understanding of land use will help in predicating farther development in mobility especially to new housing schemes and newly constructed infrastructure.

MAP 4-11: LAND USE FOR ISLAMABAD-RAWALPINDI INDICATING MAJOR COMMERCIAL, RESIDENTIAL, AND INDUSTRIAL AREAS



LAND USE FOR TWIN CITIES

Area of the Study

Road Structure Islamabad & Rawalpindi

Commercial Land Cover

Islamabad's Commercial Area

Rawalpindi's Commercial Area

Industrial Land Cover

Islamabad's Industrial Area

Rawalpindi's Industrial Area

Resdential Land Cover

Islamabad's Resdential Area

Rawalpindi's Resdential Area

Construction Land Cover

Islamabad's Construction Area

Forest Land Cover

Islamabad's Forest Area

After analyzing the base maps of roads and boundaries, let's move on to the mobility trends of the twin cities. The mobility trends commonly referred as the mobility metrics are explained below.

4.2. MOBILITY METRICS:

The study is analyzed based on the concept of Mobility Metrics classification which determine connectivity nodes and the optimal route of travel within these nodes (Litman, 2007). The concept of mobility metrics is being defined as the aggregated points data on daily mobility as well as long termed detailed mobility of a particular area or time. The nodes in a mobility metrics are standardized conversion of point data from starting and ending of a trip (like where a trip stars and where a trip ends). The mobility metrics helps accumulate the trip information and then provides aggregate of various trips over time (Bolack, 2018).

This study has determined travel patterns of Islamabad-Rawalpindi from different types of land transport existing in the area including private, public and government regulated semipublic transport. Now, using mobility metrics classification we will analysis the common routes of Islamabad-Rawalpindi currently under use of the people. All the different nodes (starting and ending of a trip) obtained from different transport modes are converted into points data in sync with the road structure of Islamabad-Rawalpindi. All the types of transport can be classified as either Direct Mobility or Derived Mobility under the mobility metrics.

The direct mobility can be defined as the mobility of an individual user from start to finish with their accurate location data, but the derived mobility is restricted between two predetermined nodes that are not the user's actual location but are preexisting routes or stops (Sunwo, 2019). The author will now explain the function of direct and derived mobility as well as the classification of the data acquired for this study like what is the types of mobility classification for Uber, Careem,

Suzuki, Google Traffic live and discuss the link connectivity between all these nodes. The link connectivity will help determine common patterns of travel in these data points.

4.2.1. DIRECT MOBILITY:

The Direct Mobility is basically an independent mobility measurement, for example, a trip an individual makes from their home to their workplace, here the nodes accurately represent the start and finish of the travel (Smith, 2016). The grouping of the travel patterns in direct mobility depends on classifications like random based, temporal dependencies and spatial dependencies (Ayesha, 2011).

The random-based dependence is classified as the absence of any restriction in the movement of the nodes and the temporal dependencies is common travel with movement of nodes influence by past nodes. The spatial dependence includes movement of nodes based on the nodes around it in a group mobility. Hence, meaning that increased spatial activities near the mobility nodes will automatically indicate a positive common pattern.

For this study, four mobility data are based on direct mobility namely, Careen travel patterns over the period of 6 months (Random-based dependence), Travel demand from WSP an Australian NGO working on transportation (Temporal dependence), Entry points most used between Islamabad and Rawalpindi from Islamabad Traffic Police office (Spatial dependence) and Google traffic live acquire from GEE and GMP (Temporal dependence).

4.2.2. DERIVED MOBILITY:

The Derived Mobility models work based on the geographical limitation of any data points. The derived mobility relies on the topology dynamics of the movement of nodes (starting and ending points) (Ayesha, 2011). Mobility within a restricted area and limited information on the

origin location is called derived mobility (Green, 2014). But it is beneficial in analyzing general commonality in a travel pattern. The author for this study will employ derived mobility to aggregate the travel patterns of 4 separate sources of data. The derived mobility helps integrated different travel patterns together by the geographical restriction. Metro bus service is a primary example of derived mobility as the stations of the Metro bus are restricted to a single route and the people flow from and to those station based on the requirement. It is easier to establish common nodes of derived mobility as there are already lesser in number and are based on similar construct of mobility routes.

For this study, the derived mobility classification includes five different datasets namely mobility routes of Metro bus service data acquired from Pakistan GIS agency, Taxi stands, Rickshaws and frequency data from Pakistan GIS, Suzuki, Wagons and minibuses data from RTA, University routes from Quaid-e-Azam University, Allama Iqbal Open University, and Islamic International University and Uber service area within Islamabad-Rawalpindi.

The following provide description on the models.

TABLE 4-12: THE MOBILITY METRICS BY ALAN PHILLIP 2010

S. No	Mobility Metrics Categories	Metrics class Characteristics	Mobility Model
1.	**Direct Mobility**	Random based	Without any dependencies and restriction invoked in model
		Temporal dependence	A node actual movement influenced with its past movement
		Spatial dependence	The movement of a node influenced by node around it happen in group mobility
2.	**Derived mobility**	Geographical restrictions	Node movement restricted in certain geographical area
		Hybrid structure	All mobility metrics classes are integrated to attain the structure

Now, the maps presented below show the data of direct mobility classification from which the author will generate point data of nodes (start and end) and determine the common mobility of Islamabad-Rawalpindi.

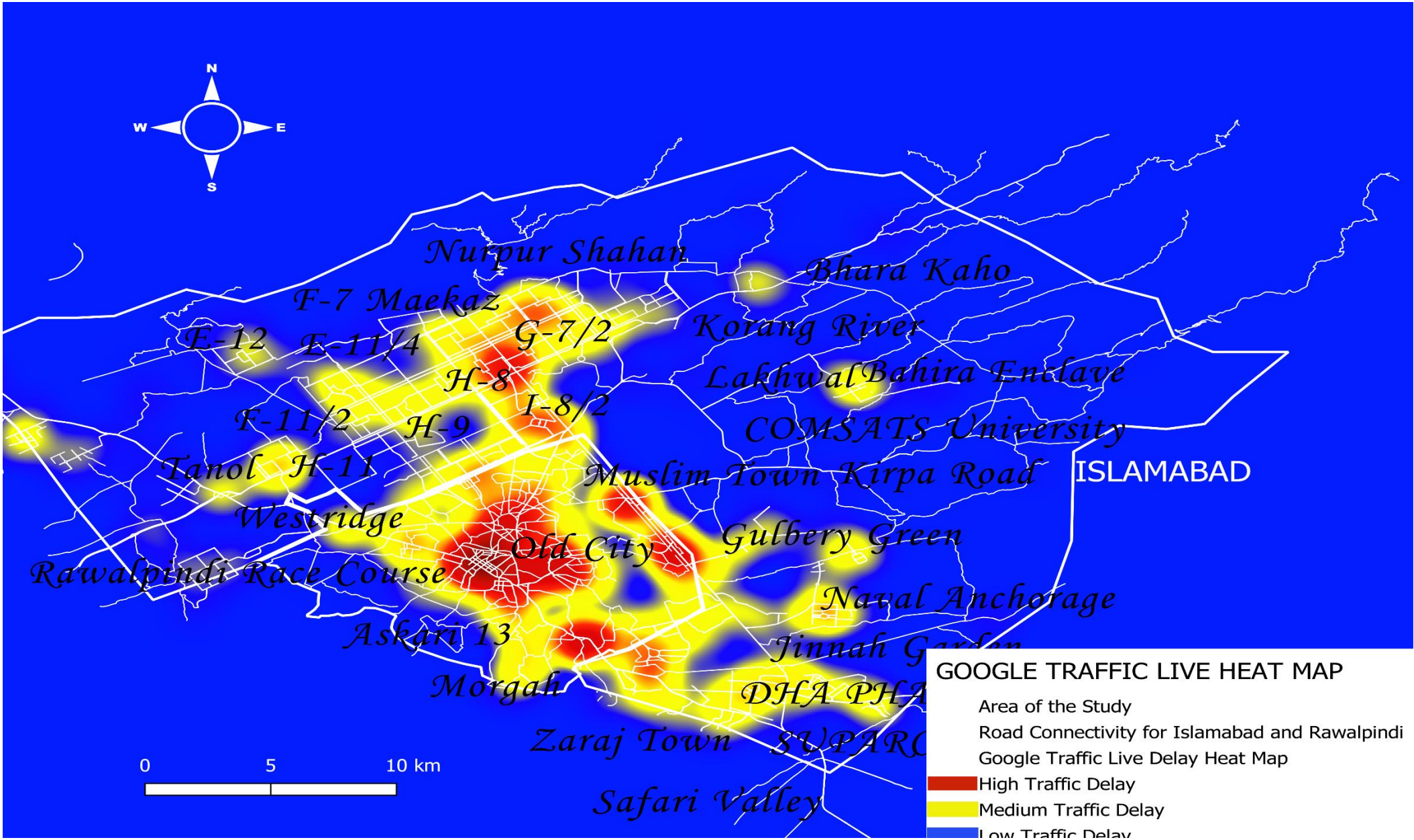
The first data presented below id based on the google traffic live data extracted from GMP and Python GEE using JavaScript API, Direction API, Road API and Distance Metrics API. The google data represents the flow of traffic on the road connectivity of Islamabad-Rawalpindi as well as provide direction of mobility. The data consists of high flow mobility, medium flow mobility and low flow mobility. The road API is used to track the road connectivity on the google map, whereas the direction API provides the flow of traffic to and from a fixed latitude and longitude. And the distance metrics API provide the distance between two points with the delay in time duration by traffic.

The second map provides the data on Careem rides throughout Islamabad and Rawalpindi which is classified as mobility within Islamabad, mobility within Rawalpindi, mobility from Islamabad to Rawalpindi and mobility from Rawalpindi to Islamabad. The data for Careem rides were obtained through direct contact at the supply chain office of Careem both in Islamabad and Rawalpindi (contact info of Careem office given in Appendix B).

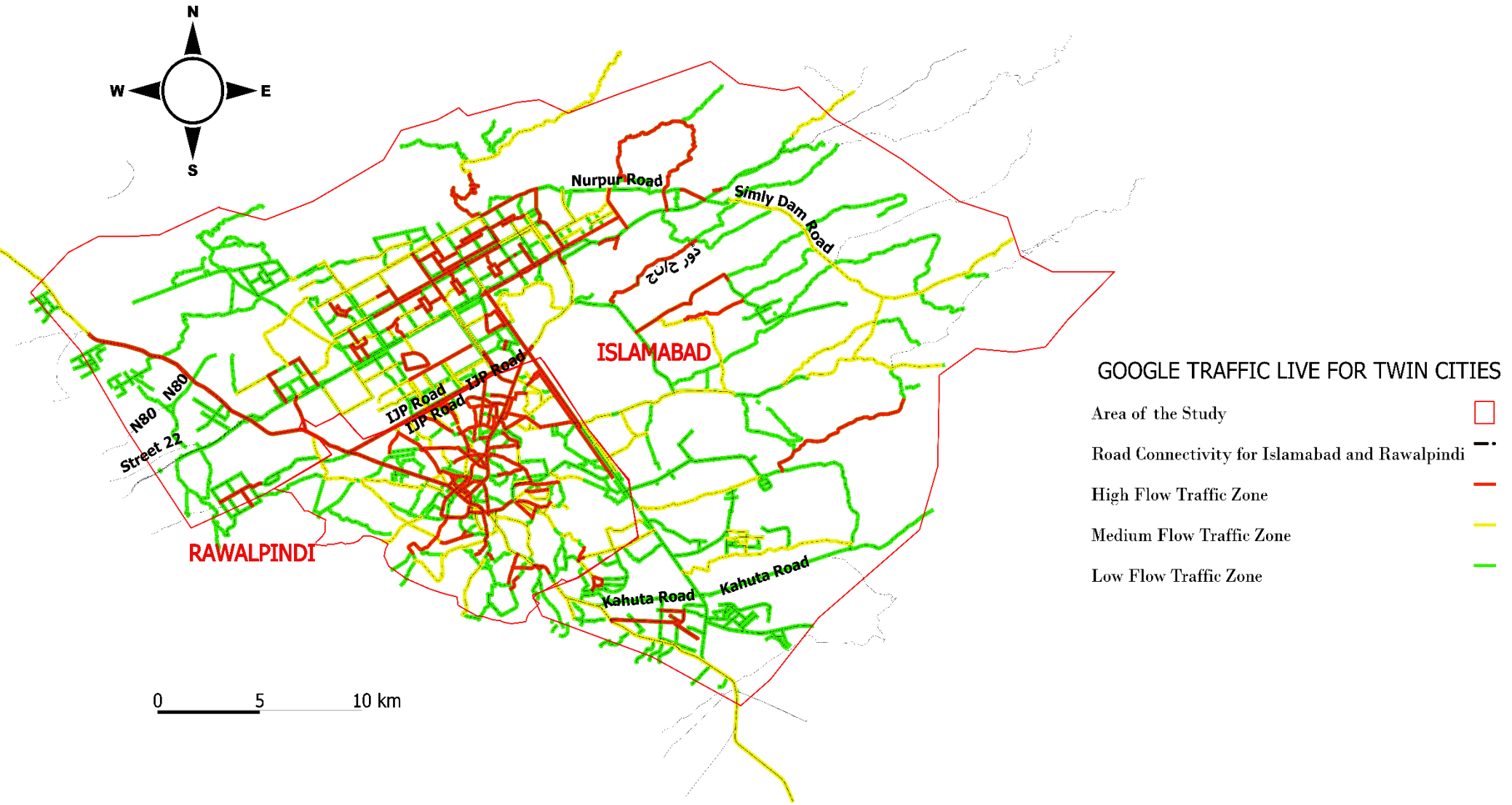
The third map was obtained through direct contact with Islamabad Transportation Police office (contact info given in Appendix B) which provides data on the major highways and the flow of cars entering Islamabad from Rawalpindi. The density of the flow is denoted by the color ranging from dark red to light-yellow. The dark red represents higher number of cars entering from that route, whereas orange represents medium flow of transport on that highway and the light-yellow means very little traffic on that route.

MAP 4-13: GOOGLE TRAFFIC LIVE DATA ON MOBILITY FOR ISLAMABAD-RAWALPINDI HIGHLIGHTING HIGH FLOW TO LOW FLOW AREAS

*For further Details on Google Traffic Live Data and the collection process visit Appendix A

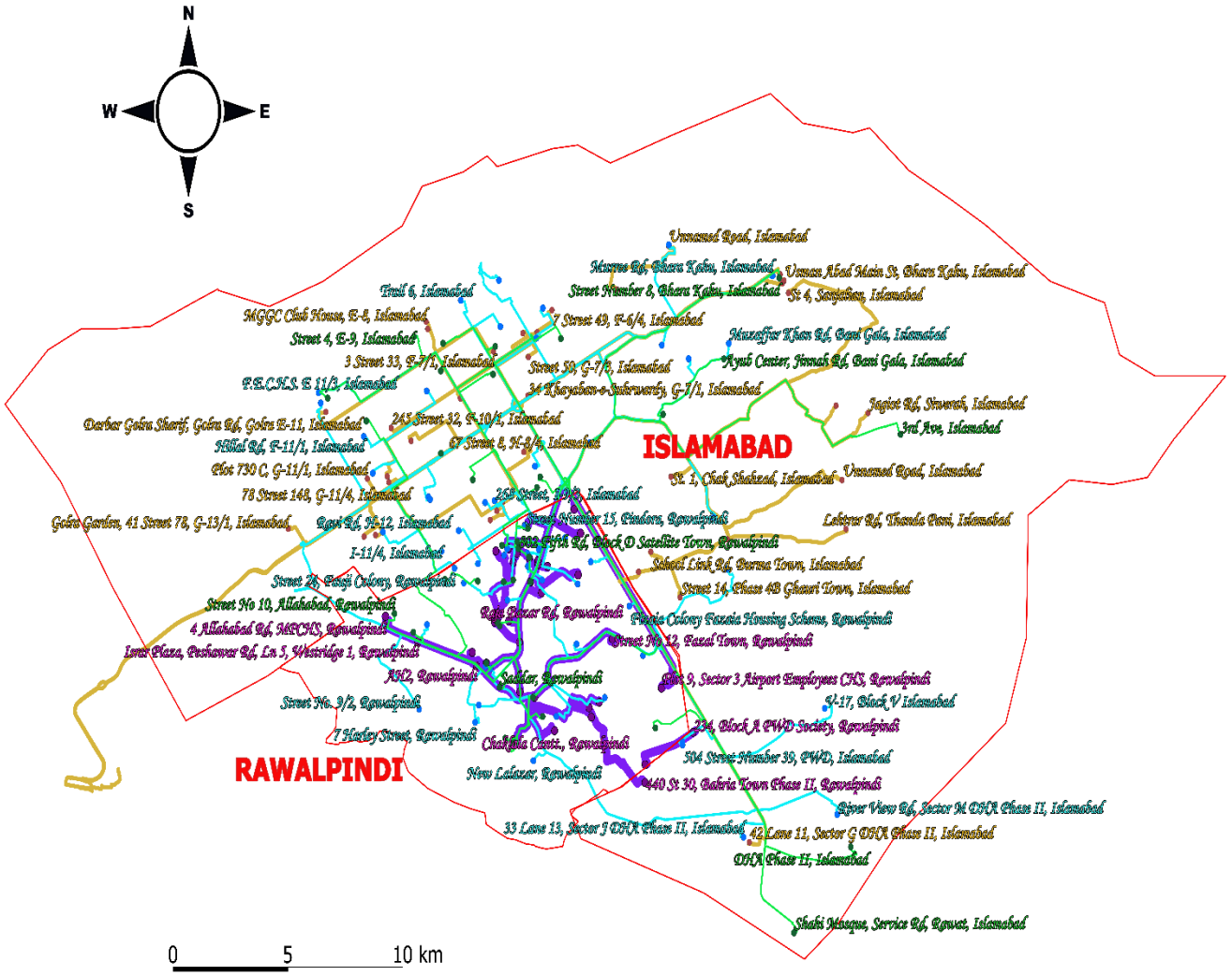


MAP 4-14: GOOGLE TRAFFIC LIVE ROAD ON MOBILITY FOR ISLAMABAD-RAWALPINDI HIGHLIGHTING HIGH FLOW TO LOW FLOW AREAS



MAP 4-15: CAREEM TRAVEL PATTERNS AND MOBILITY TREND FOR ISLAMABAD-RAWALPINDI

*For further Details on Careem Data visit Appendix A and B



CAREEM TRAVEL PATTERNS FOR TWIN CITIES

Area of the Study

Careem Travel Patterns from Islamabad to Rawalpindi

Careem Point Data from Islamabad to Rawalpindi

Careem Routes from Islamabad to Rawalpindi

2 Street 38, F-7/1, Islamabad to Chaklala Cantt., Rawalpindi

3rd Ave, Islamabad to Commercial Market Rd, Block B S.Town, Rawalpindi

4 Street 39, G-10/4, Islamabad to 12-14 Liaqat Rd, Nanakpura, Rawalpindi

Careeam Travel Patterns from Rawalpindi to Islamabad

Careem Point Data from Rawalpindi to Islamabad

Careem Routes from Rawalpindi to Islamabad

7 Harley Street, Rawalpindi to 17 Street 10, MPCHS E-11/1, Islamabad

Chaklala Homes, 197 Street 1, Chaklala Scheme 3, Rawalpindi to Madina, Islamabad

Omer Ln, Bilal Colony Shamsabad, Rawalpindi to Korang Road, I-10 Markaz, Islamabad

Careem Travel Patterns within Islamabad

Careem Point Data within Islamabad

Careem Routes Within Islamabad

Plot 730 C, G-11/1, Islamabad to Usman Abad Main St, Bhara Kahu, Islamabad

3 Street 33, F-7/1, Islamabad to E-9/3, Islamabad

42 Lane 11, Sector G DHA Phase II, Islamabad to 2 Street 56, F-7/4, Islamabad

Careem Travel Patterns within Rawalpindi

Careem Point Data Within Rawalpindi

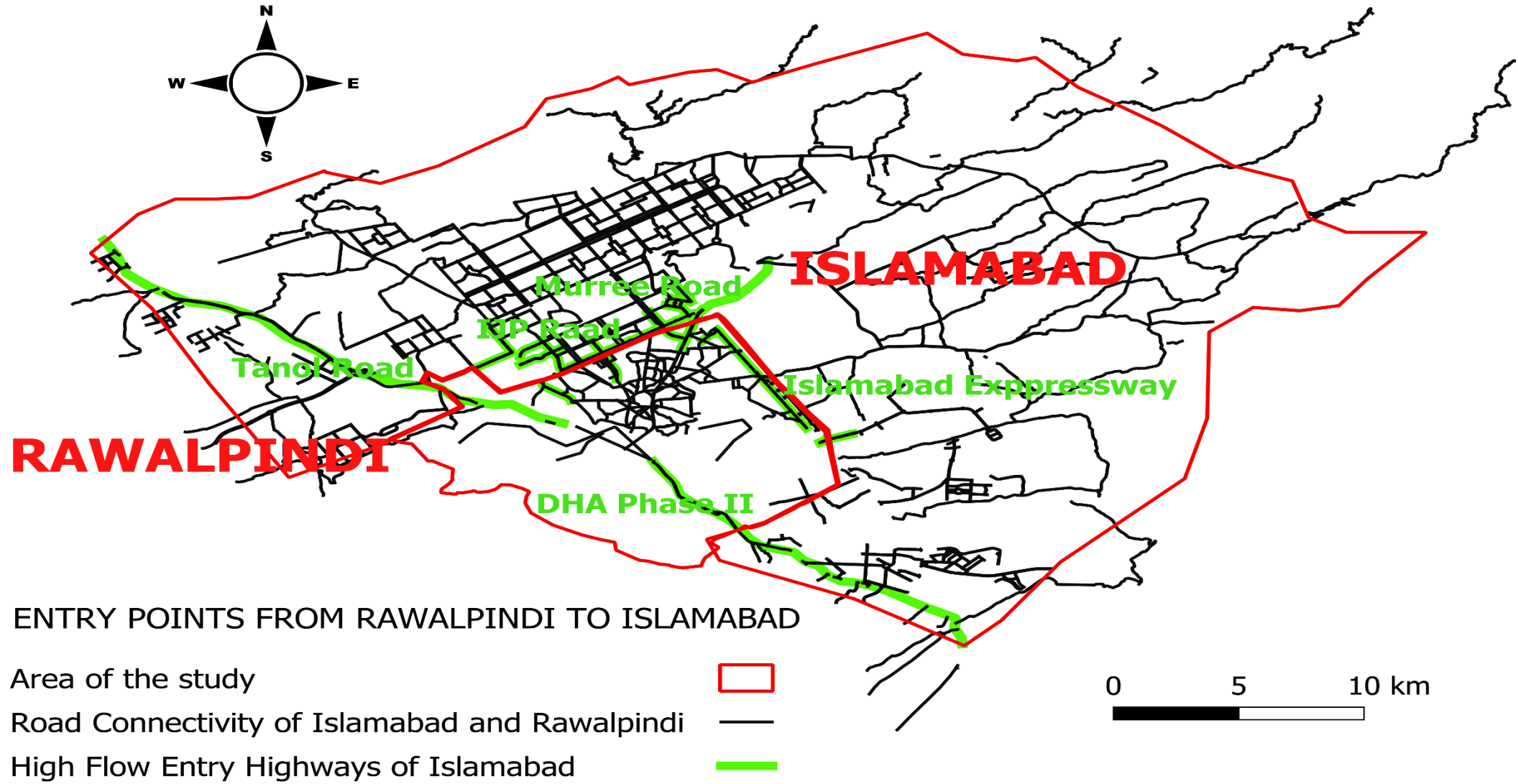
Careem Routes Within Rawalpindi

Holy Family Rd, Block E S Town, Rawalpindi to Rashid Minhas Rd, Saddar, Rawalpindi

Israr Plaza, Peshawar Rd, Ln 5, Westridge 1, Rawalpindi to AH2, Rawalpindi

Jamia Masjid Abbasia, Quaid Street, Muslim Town, Rawalpindi to Pindora, Rawalpindi

MAP 4-16: FREQUENTLY USED ENTRY POINTS FROM ISLAMABAD TO RAWALPINDI ACCORDING TO ISLAMABAD TRAFFIC POLICE (ITP)



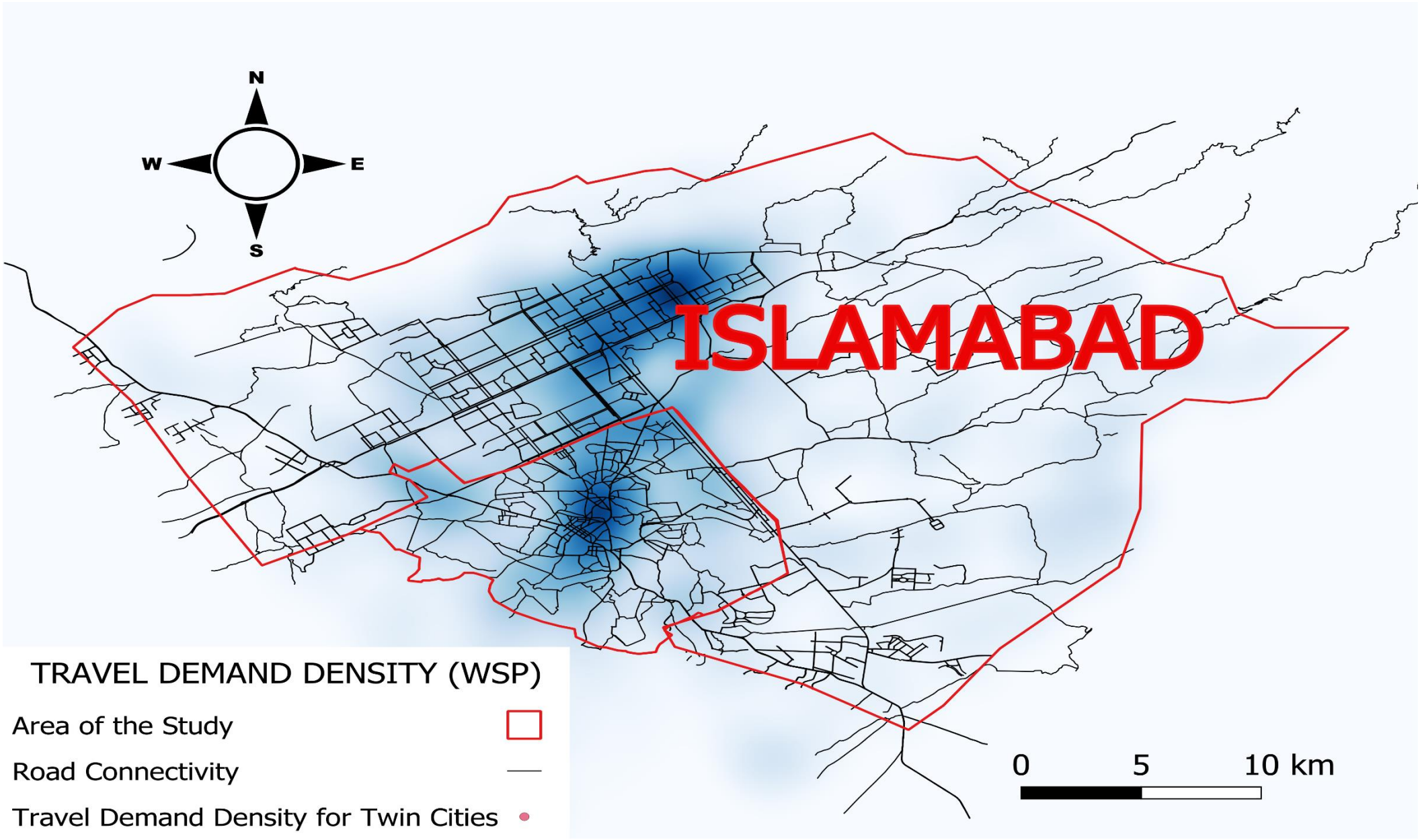
The last of direct mobility maps is the travel demand data obtained from WSP (Western Sustainability policy agency Australia) explaining the range of desirability of each point data in the map. This data was collected through an online survey by WSP in Pakistan for understanding the mobility patterns of daily lives of the population for the most demanded mobility.

The next section includes data on the derived mobility patterns, for example, the location of a single bus stops or the Metro bus lines which is geographical restricted within that line only. The derived mobility metric help determine the flow of trips in different area with common shared mobility. Public transport is a good example of derived mobility. The following data was included as derived mobility, firstly, the data of Uber service area is included as derived mobility as only sections of high, medium, and low flow mobility were acquired from the Uber representatives. For Uber's data, the author created a heat map to represent the density of mobility and travel demand at each level with color ranging from red to blue where red represents high mobility and blue represents low mobility areas.

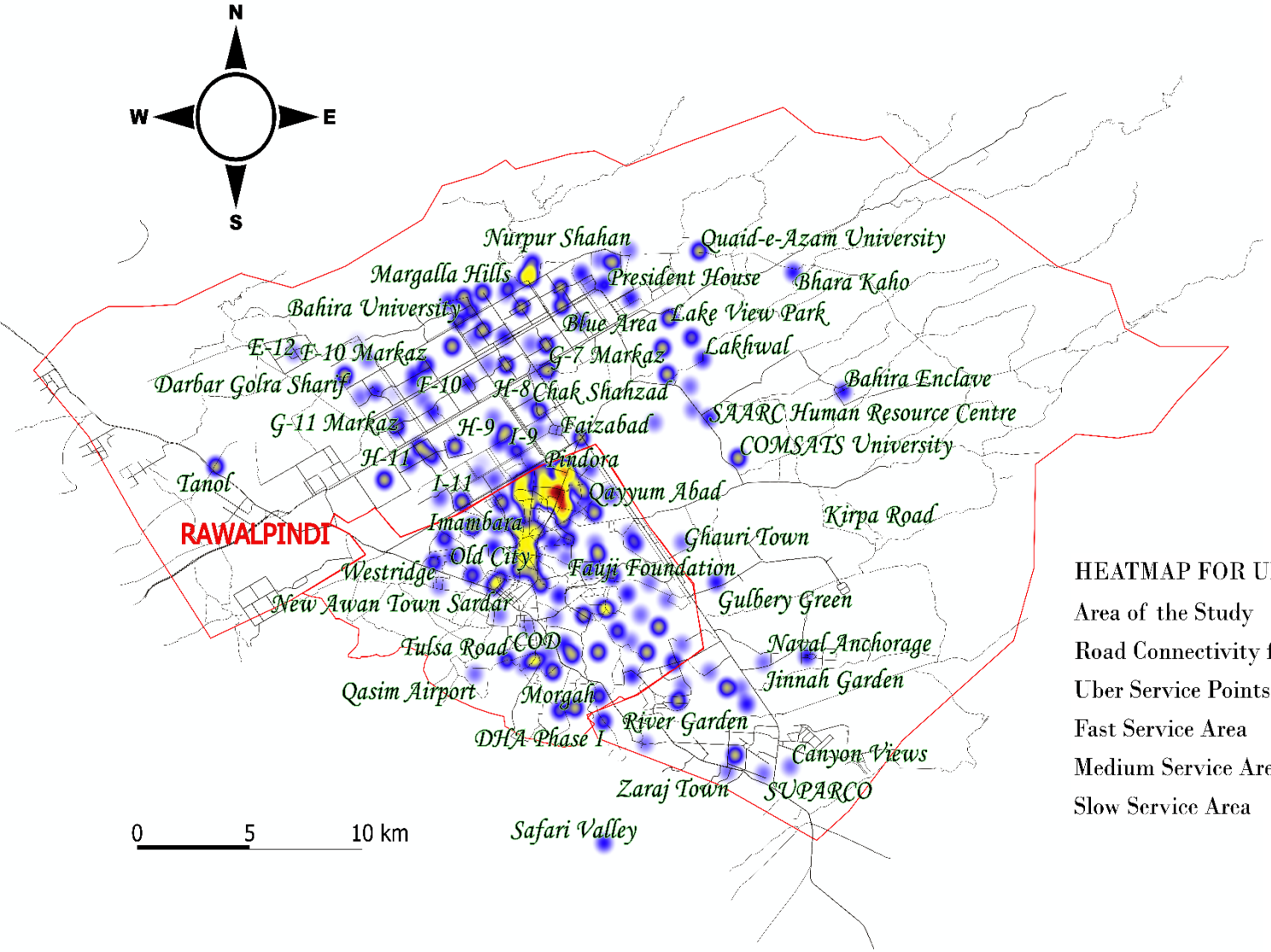
The second data for derived mobility is the data based on privately owned taxi system currently operational in Islamabad and Rawalpindi. The data was acquired from Pakistan GIS institute from Dr. Naeem Malik in Rawalpindi and was presented through google my maps. The data provide the current taxi stands locations as well as the number of vehicles in each area.

With the data on taxi, Pakistan GIS also provided data on rickshaws operational in only Rawalpindi and their routes that are regulated by the traffic police of Rawalpindi. The rickshaw operation in between the secondary and tertiary roads and are not allowed on primary highways. The taxi data is presented in a proportional label map with different values associated to different points. The maps below will help understand the density of taxi stand and taxi use in twin cities.

MAP 4-17: DESIRABLE TRAVEL DEMAND DENSITY IN ISLAMABAD-RAWALPINDI ACQUIRED FROM NON PROFIT ORGANIZATIONS BASED IN AMERICA AND AUSTRALIA (LEADDOG AND WSP)



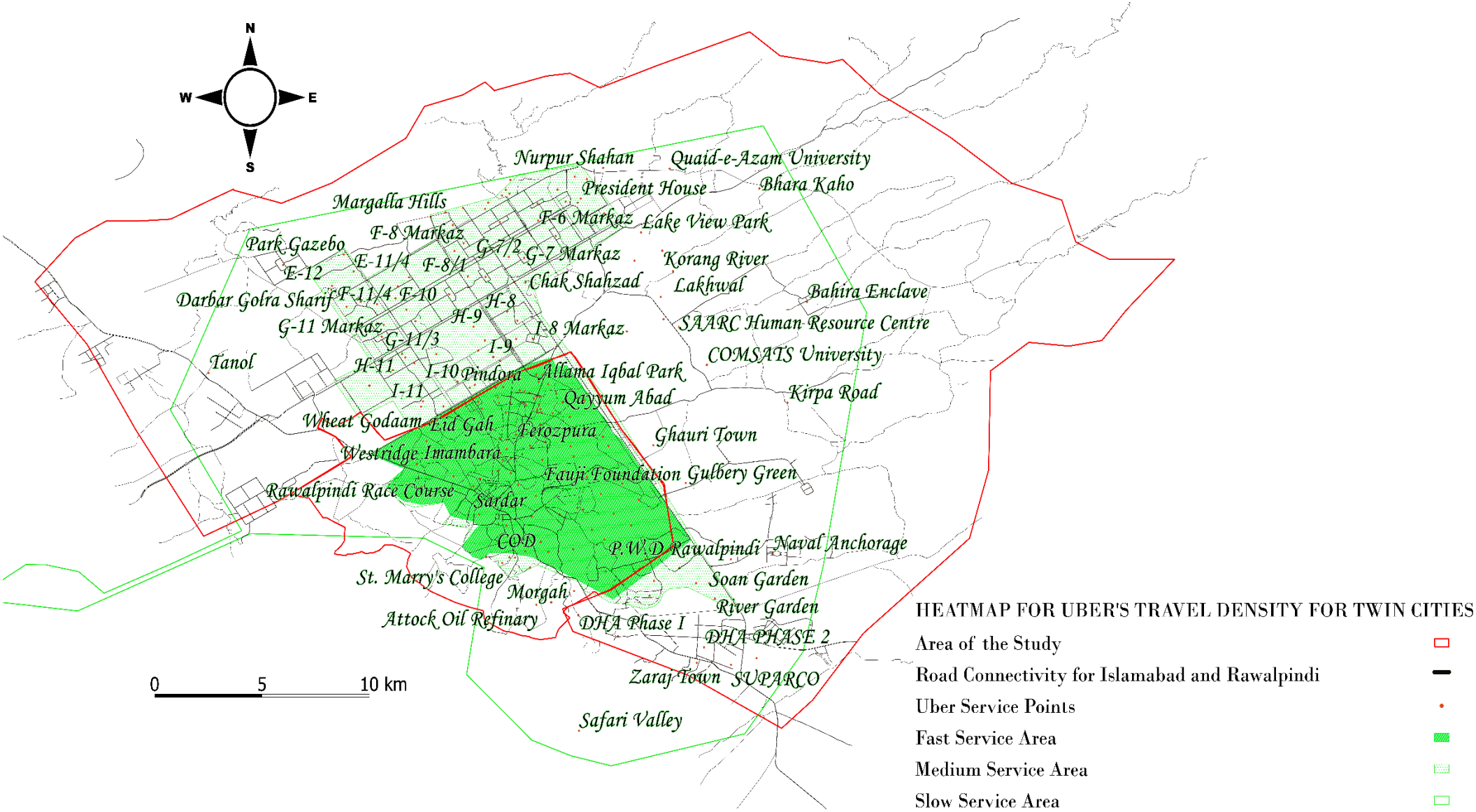
MAP 4-18: HEAT MAP FOR UBER TRAVEL PATTERNS OF ISLAMABAD-RAWALPINDI



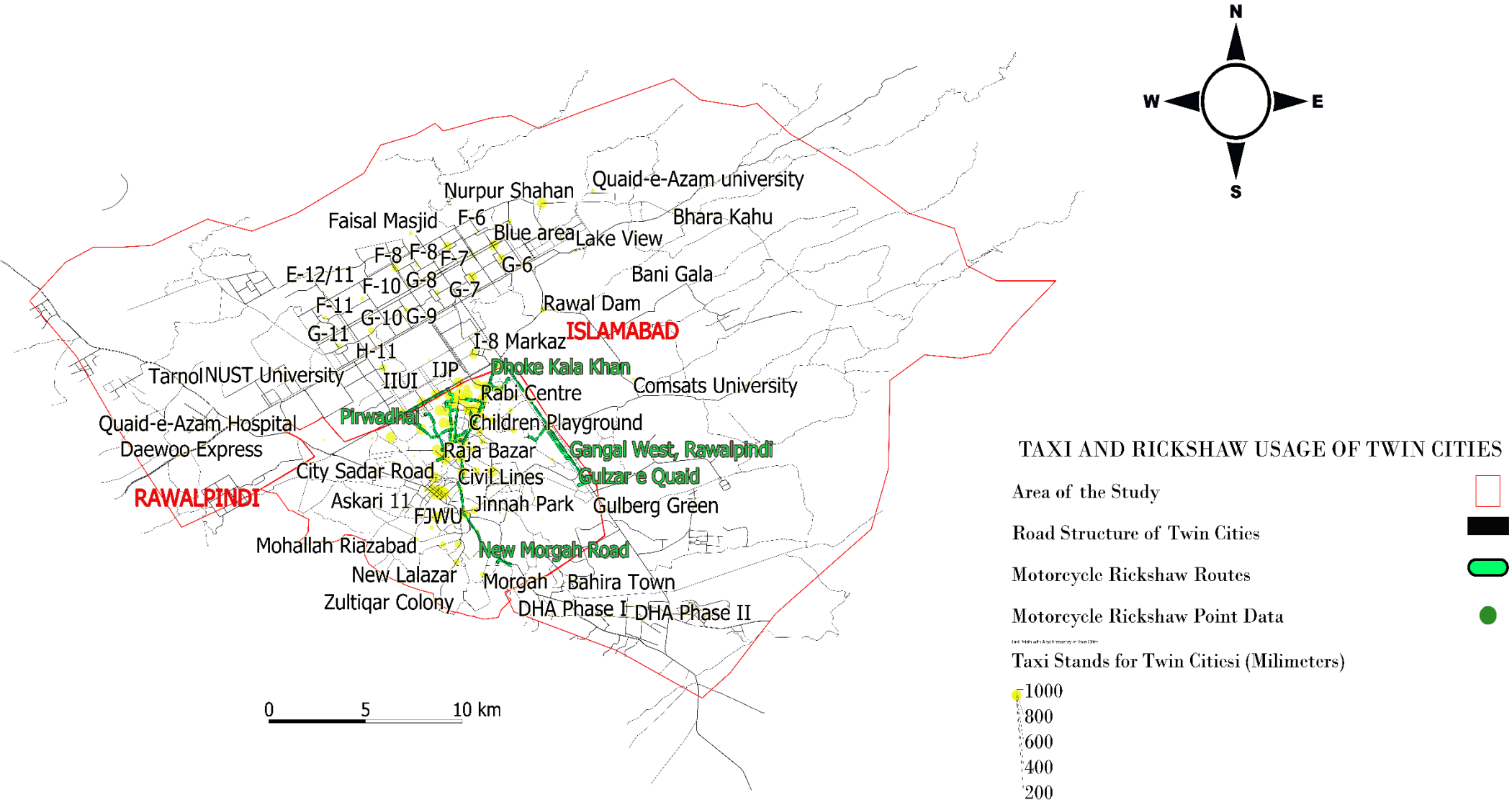
HEATMAP FOR UBER'S TRAVEL DENSITY FOR TWIN CITIES

- Area of the Study
- Road Connectivity for Islamabad and Rawalpindi
- Uber Service Points
- Fast Service Area
- Medium Service Area
- Slow Service Area

MAP 4-19: UBER TRAVEL DENSITY INDICATING HIGH DENSE AREAS TO LOW DENSE AREAS



MAP 4-20:


N
W
E
S
Nurpur Shahan
Quaid-e-Azam university
Faisal Masjid
F-6
Blue area
Lake View
Bhara Kahu
F-8
F-8
F-7
G-6
E-12/11
F-10
G-8
G-7
Bani Gala
F-11
G-10
G-9
Rawal Dam
G-11
ISLAMABAD
H-11
I-8 Markaz
Tarnol
NUST University
IIUI
IJP
Dhoke Kala Khan
Comsats University
Rabi Centre
Pirwadhai
Children Playground
Quaid-e-Azam Hospital
Daewoo Express
Raja Bazar
Gangal West, Rawalpindi
City Sadar Road
Civil Lines
Gulzar e Quaid
RAWALPINDI
Askari 11
Jinnah Park
Gulberg Green
FJWU
Mohallah Riazabad
New Morgah Road
New Lalazar
Morgah
Bahira Town
Zultiqar Colony
DHA Phase I
DHA Phase II
0
5
10 km
TAXI AND RICKSHAW USAGE OF TWIN CITIES
Area of the Study
Road Structure of Twin Cities
Motorcycle Rickshaw Routes
Motorcycle Rickshaw Point Data
Taxi Stands for Twin Citiesi (Milimeters)
1000
800
600
400
200

This below third map represents the routes and stops of government regulated semipublic transport operating in Islamabad-Rawalpindi. The data was acquired from the Regional Transport Authority in Rawalpindi and were created using google my maps for accuracy. The routes were feed in google my maps that generated the routes along with stops. The RTA also provided information on the number of semipublic transports currently operational in Islamabad-Rawalpindi like the number of minibuses as well as the number of Suzuki vans. Suzuki has the largest number of vehicles and coming second is cab rickshaw. The following table 4.3 provides detail numbers for each type of transport.

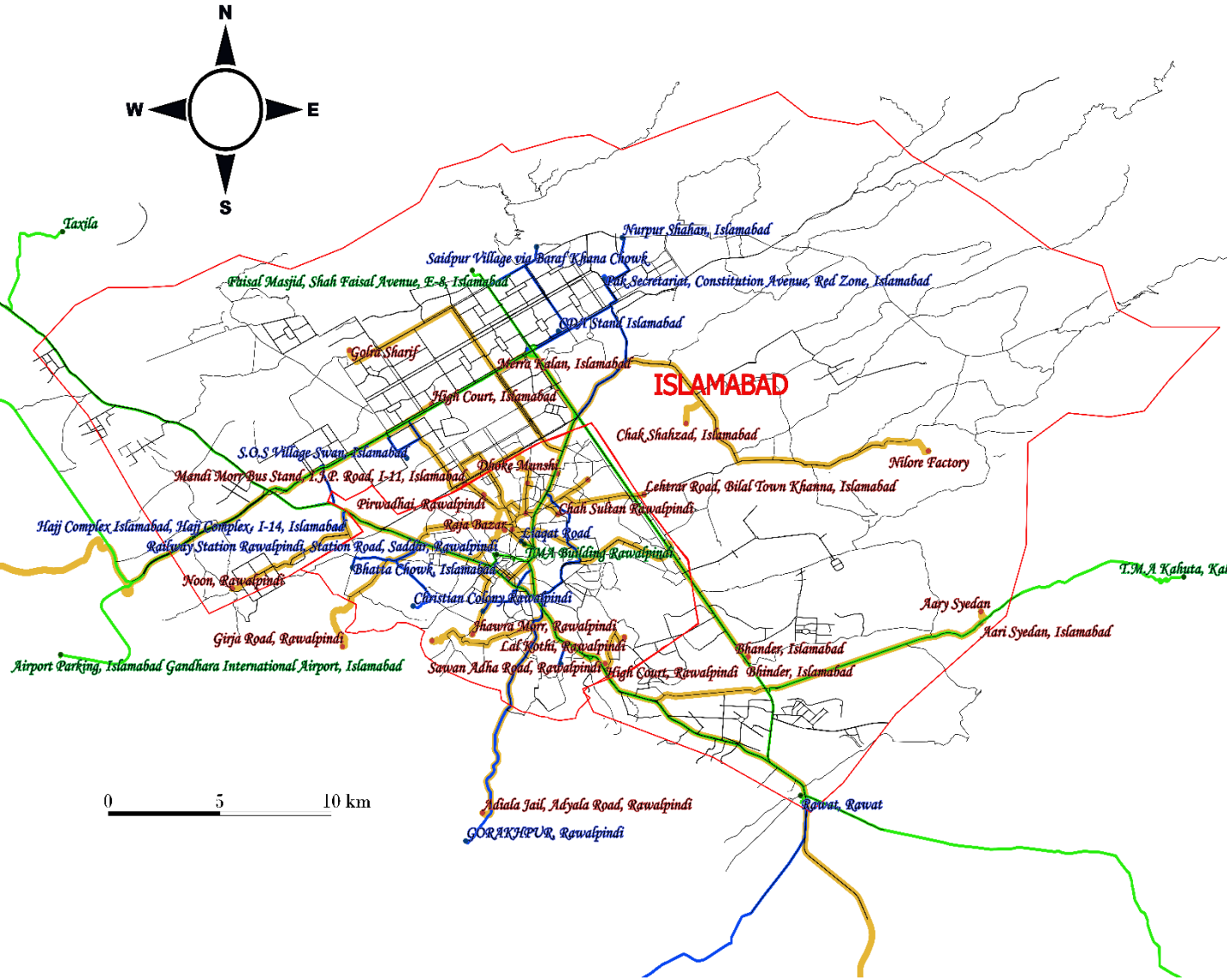
TABLE 4-21: THE NUMBER OF SEMI-PUBLIC VEHICLES REGISTERED BY REGIONAL TRANSPORT AUTHORITY IN ISLAMABAD-RAWALPINDI

Type of the vehicle	Number of the vehicle
Urban Wagons	1781
Urban Suzuki	3315
Motor Cab Rickshaws	26500
Motor Cab Taxi	8500
Motorcycle Rickshaws	212
Trucks	8036
Buses	265

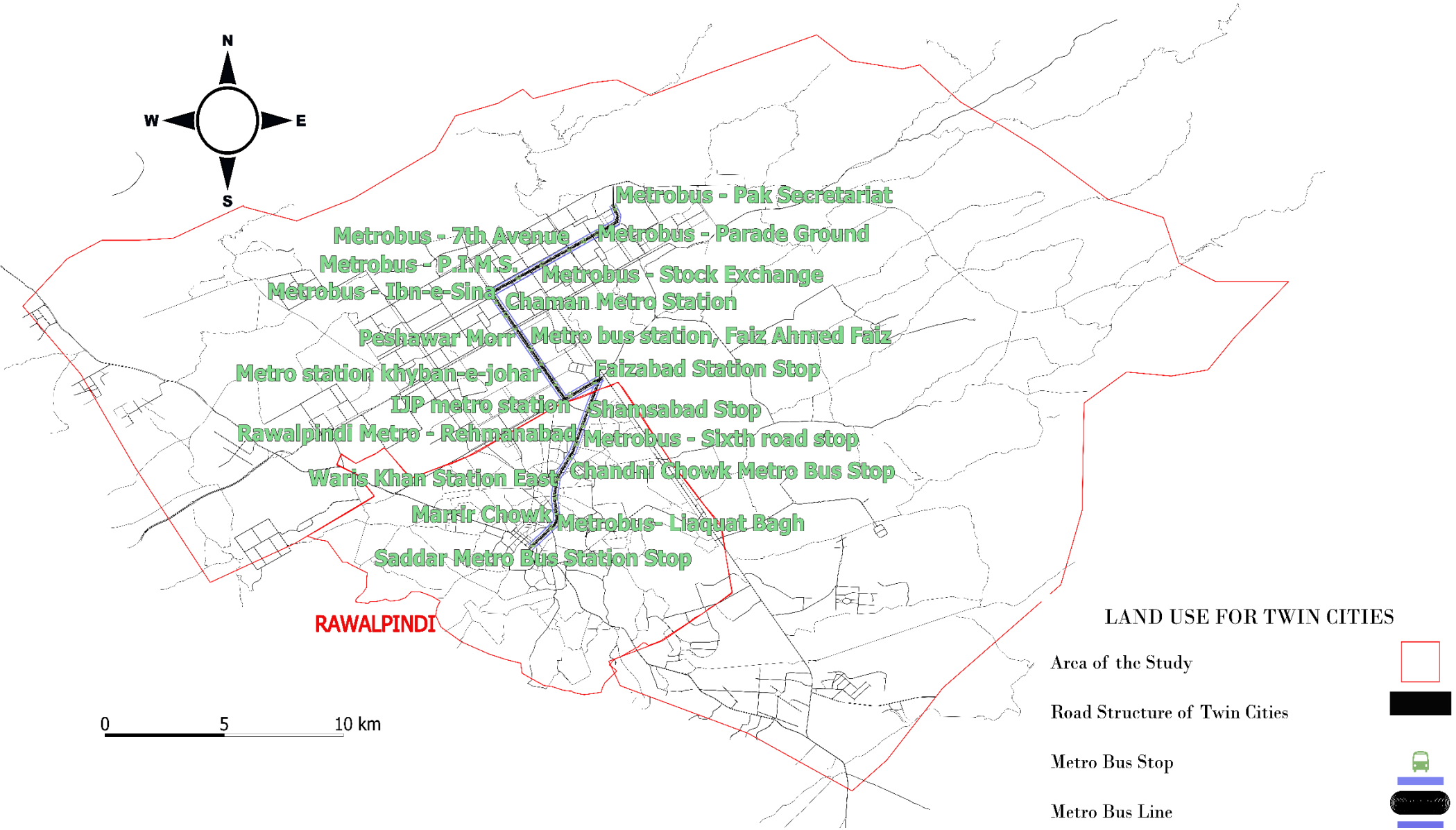
The fourth and fifth maps are extracted from online resources, maps of Metro Bus service and different universities were available online. Metro Bus being a public transport has information available online for the convenience of the customer, whereas universities like Allama Iqbal open university, Quaid_e_Azam University and Islamic International University have their transport schedules online for the students.

MAP 4-22: ROUTES AND STOPS OF GOVERNMENT REGULATED SEMI-PUBLIC TRANSPORT IN ISLAMABAD-RAWALPINDI (SUZUKI, WAGON)

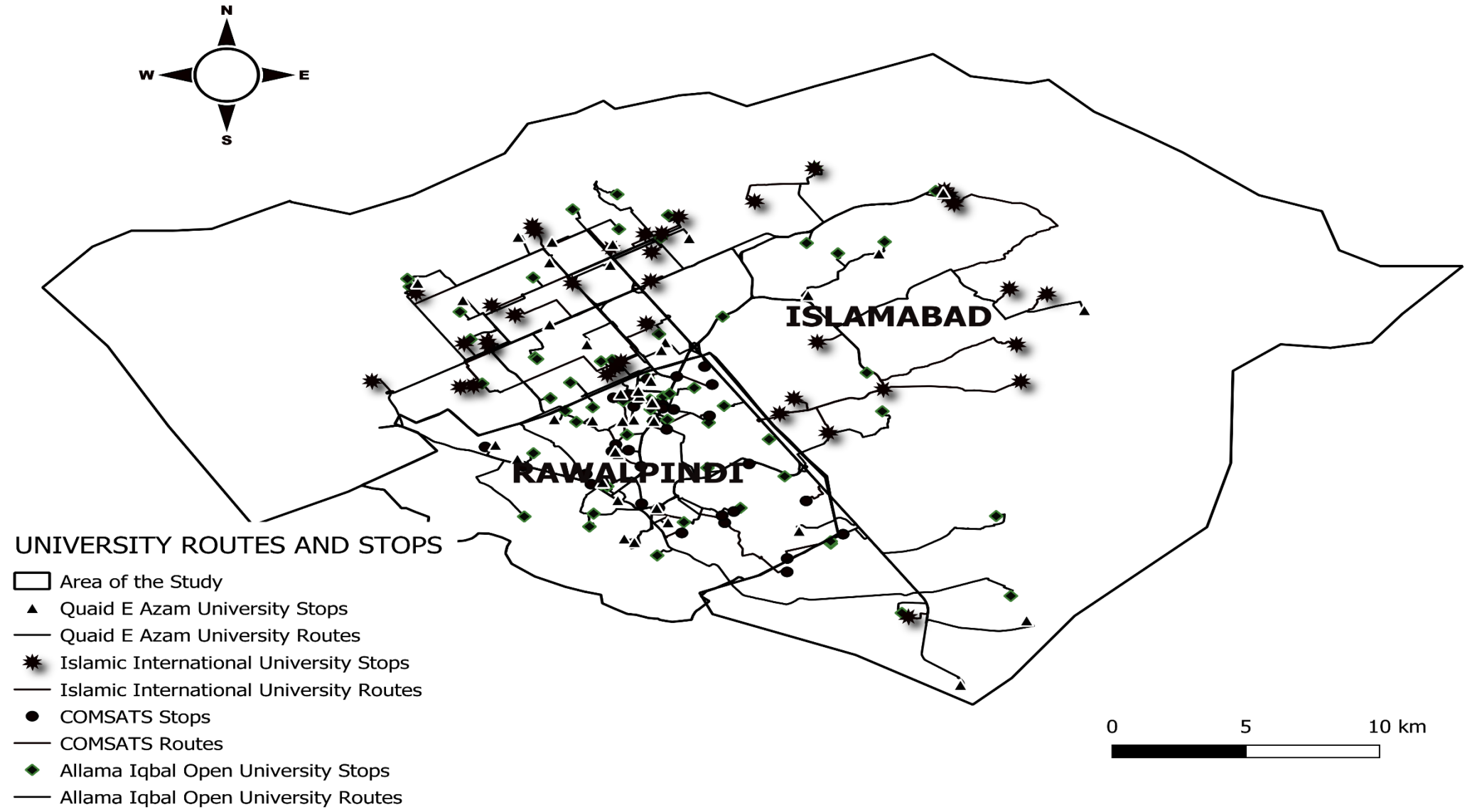
*For further Details on Careem Data visit Appendix A and B



MAP 4-23: BUS RAPID MASS TRANSIT (BRT) METRO BUS SERVICES ISLAMABAD-RAWALPINDI, ROUTES AND STOPS



MAP 4-24: UNIVERSITIES INDIVIDUAL ROUTES AND STOPS (QUAID-E-AZAM UNIVERSITY, ALLAMA IQBAL OPEN UNIVERSITY, AND ISLAMIC INTERNATIONAL UNIVERSITY ETC.)



Through this study, the author has collected different aspects of transportation in Islamabad and Rawalpindi and experienced the modes of transport through the lens of consumer who sees the government setting back and not providing options of transport to the public, a cheaper and easier option compared to that of private entities (Shabbir & Ahmad, 2010). The less then capable transportation network of Islamabad-Rawalpindi is based on the structural and resource problems, hence, all the policies in past have resulted in failure and forwarding the burden onto Private entities like Taxi, Rickshaws etc.

This study aims to fulfil the big quest of creating a public transportation plan by considering the mobility patterns and demands of Islamabad and Rawalpindi. What is the desirable state, length, distance, and condition of travel, most importantly, what are the common routes of connectivity people use in Islamabad and Rawalpindi? The mobility of women, children, rich, poor, and indifferent of people so that it will help establish a working plan for a sustainable bus system.

In the next chapter, the author will state and discuss the findings of the study based on mobility metrics and link connectivity.

CHAPTER NO: 5

FINDINGS AND DISCUSSION

5.1. DATA ANALYSIS AND FINDINGS:

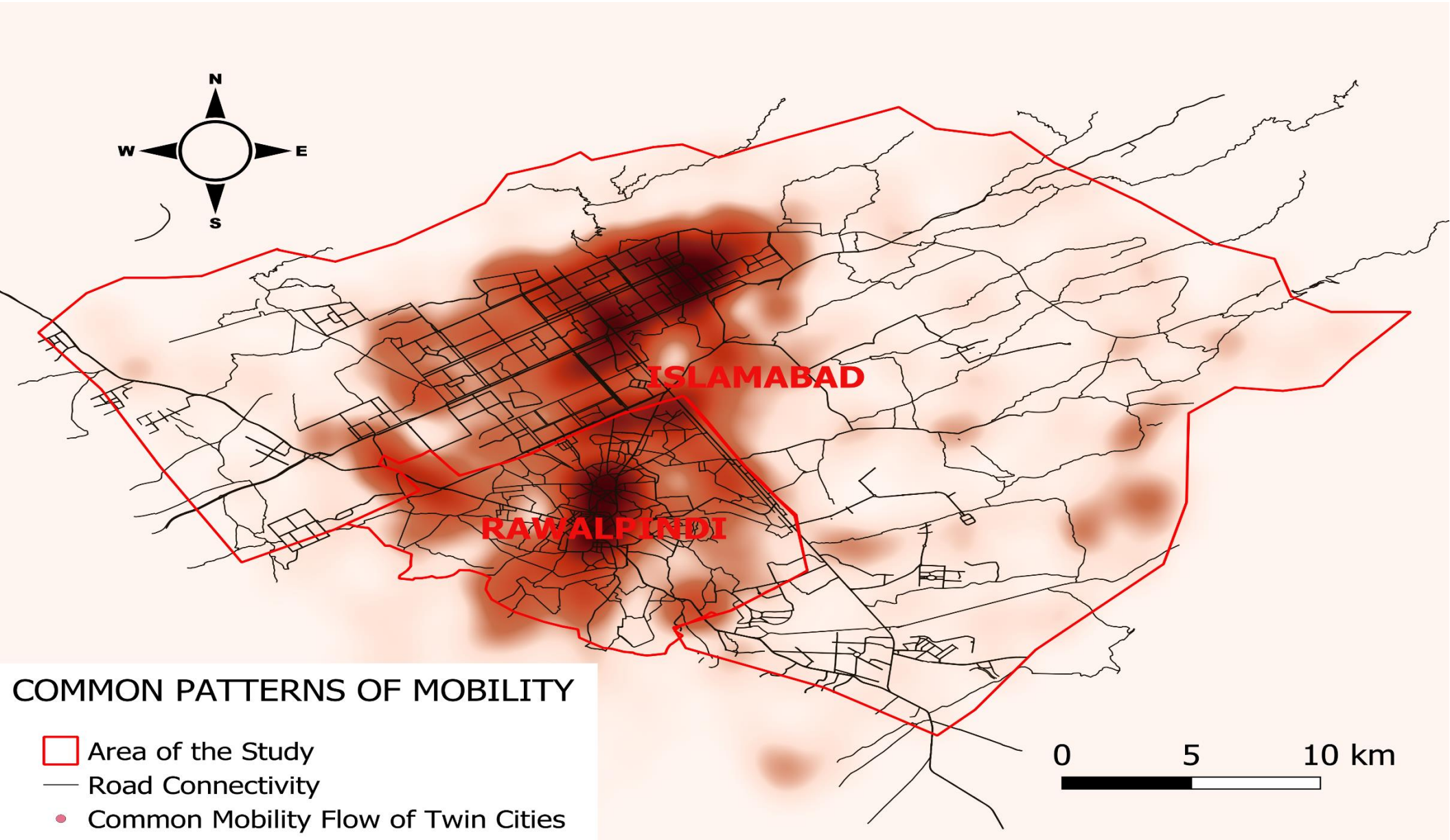
The aim of the study is to apply the 175 bus (chapter no 4 number of university buses) to create optimal accessibility for a public transport system. For the various data collected, it now time to analysis that in an organized and accurate method. Initially, the author divided the obtained data into direct mobility and derived mobility classification to later be converted into point data based on their movement nodes (start and end). For direct mobility, the starting of a trip and end of a trip provide the specific movement nodes but, for derived mobility, it is important to understand the geographical area and using temporal dependencies to draw some common nodes for the majority of transport.

As discussed in chapter no 3, the author will generate a graduation map for the union councils of Islamabad and Rawalpindi to highlight each UC's need for travel and, hence, develop the flow of routes of the final transport plan from them.

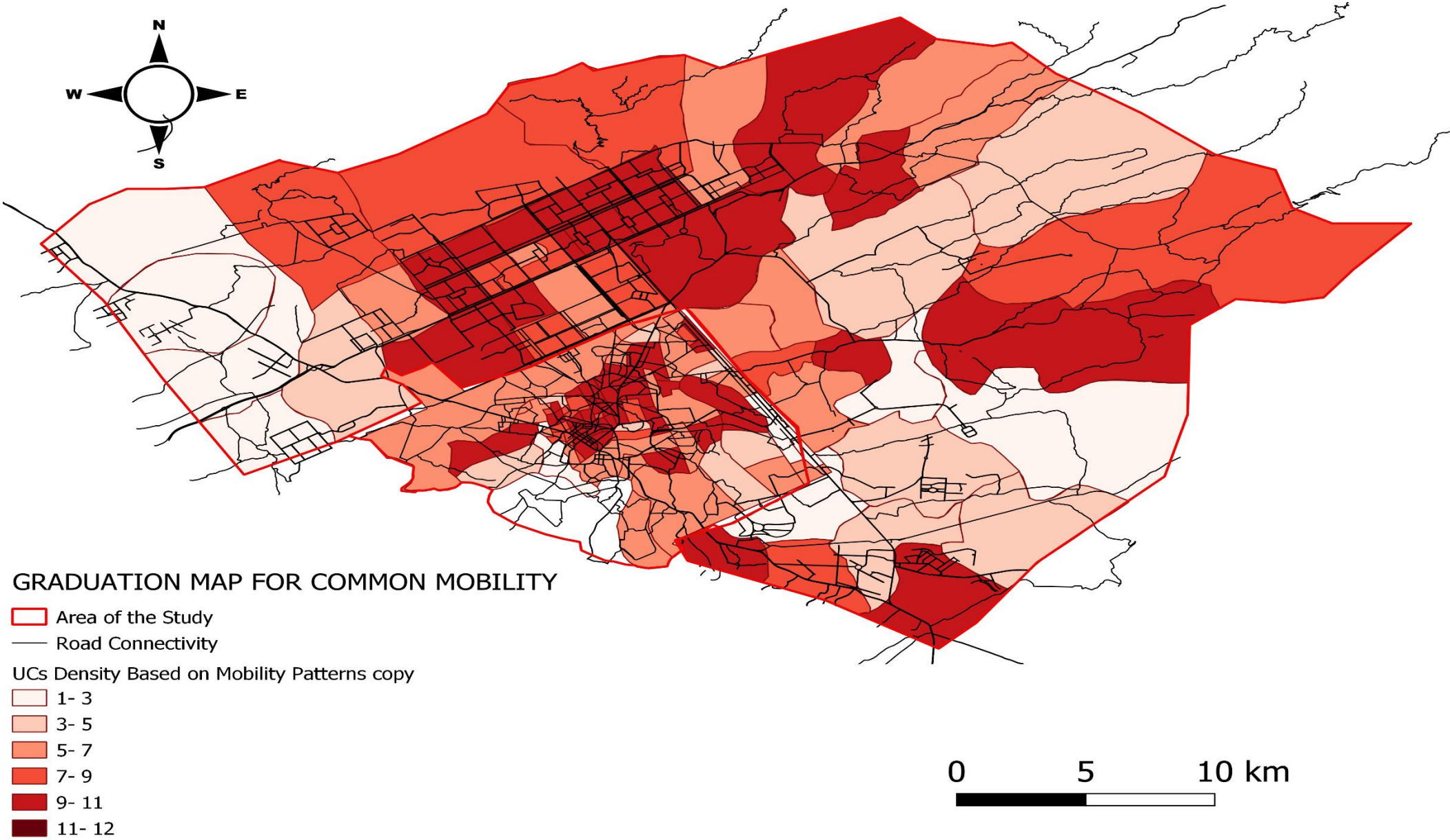
For the visual representation of the collected data, the author has created two maps as follows which provide a rough idea of the common mobility patterns or high traffic flow areas according to all the sources of data. The best visual map is a heat map for both Islamabad and Rawalpindi and for further understanding, a graduation map showing the difference of travel in between different union councils of Islamabad-Rawalpindi.

The following two maps are the initial stage for the analysis of determining the optimal routes of connectivity and accessibility.

MAP 5-25: HEAT MAP FOR THE COMMON PATTERNS OF MOBILITY IN ISLAMABAD-RAWALPINDI



MAP 5-26: MOBILITY DENSITY BASED ON UNION COUNCIL DIVISION FOR ISLAMABAD-RAWALPINDI



The following concept is used to rationalize the different spatial data (polygon, polyline, and point) obtained in chapter no 4.

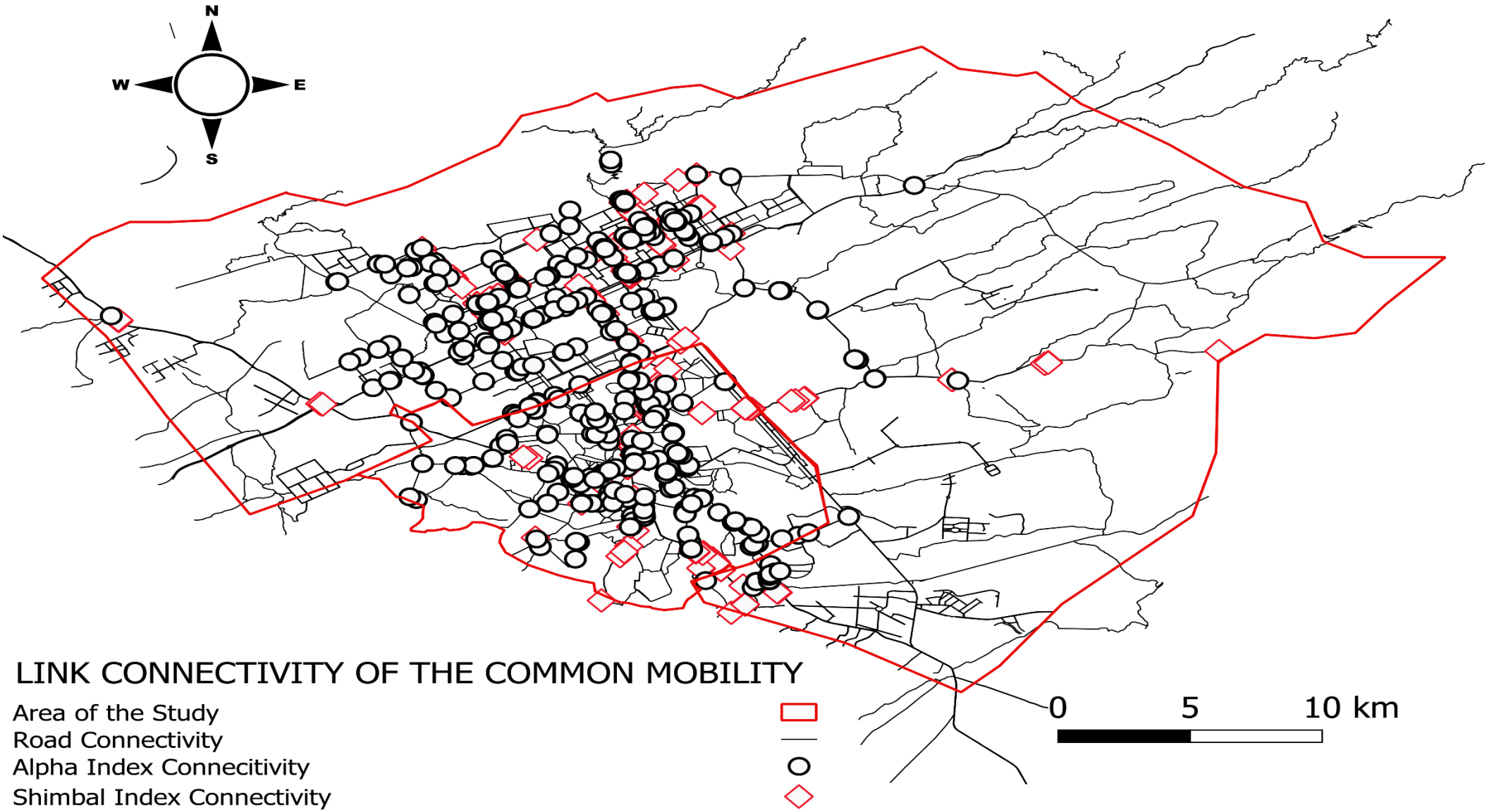
5.1.1. LINK CONNECTIVITY:

The concept of link connectivity is very commonly used in transportation planning, ranging from Mass Transit to Railway construction (Kevin S., 2019). The basic road connectivity consists of nodes (points of interaction between two or more roads) that are placed as indicators to highlight the connectivity of the roads. The nodes on the road connectivity represent the commonality of two different roads, hence, the word connect is used as these nodes are used to connect two or more lines. the link connectivity creates a circuit between multiple layers of data. If you observe a road structure closely, you will see lots of turns and points joining two or more lines, those points are known as link (node) connectivity (Xjini, 2018).

There are many types of link connectivity that are used in different types of areas from science to construction. There is alpha index (link connectivity) which represents all the common nodes in a connect. The alpha index simply includes all the common connectivity nodes and lines. For example, in a traffic stop intersection there are four alpha connectivity nodes as each share the same common point of interaction. There is beta index which represents a tree type connectivity where larger links are connected to smaller through beta index. For example, Murree Road is interconnected to 6^{th} road forming a tree like shape (Urban Lab, 2014).

There is also shimbel index of connectivity which represents the shortest distance between two nodes. This index determines the closeness of each node, it is also called closeness centrality or distance centrality. There is also gamma index (y) which is a ratio between the observed number of links and nodes of a given transportation network to get a clear picture of the scale of the transportation network.

MAP 5-27: LINK CONNECTIVITY FOR MOBILITY DENSE AREAS OF ISLAMABAD-RAWALPINDI



There are many other link connectives (detour, Pi index) which the author will use to determine the connectivity of the different types of data obtained. The aim is to create point shape file for the data obtained and create an output of common nodes based on that.

For this study, these nodes will be accumulated for each source of data obtained in chapter no 4 and combined to create a connectivity network for highlighting the opaquest nodded areas of Islamabad-Rawalpindi.

5.1.1. MAJOR AND MINOR TRIP GENERATOR:

To acquire the final routes of the public transport plan in this study, the author will employ trip generation techniques. The purpose of trip generation is to estimate the number of trips per route necessary to provide optimal accessibility to the citizens of Islamabad-Rawalpindi. The author will calculate the total travel time on each routes using ORS tools with real time API for traffic delay, hence, estimating the minimum number of buses used by each route.

The land use of any urban development is divided into two board categories, residential and non-residential areas, here most of the travel demand originates from and to depending on the usage. Hence, the trips are represented as residential trip production acquired from households and non-residential as trip attractions from different forms of land use. The trip generation is followed by destination choice, mode choice and route choice according to conventional transportation design process which determine the travel demands.

It predicts the number of trips originating in or destined for a particular traffic analysis zone. Every trip has two ends, and we need to know where both are. The first part is determining how many trips originate in a zone and the second part is how many trips are destined for a zone. Because land use can be divided into two broad categories (residential and non-residential) we

have models that are household based and non-household based (e.g., a function of number of jobs or retail activity).

For the residential side of things, trip generation is thought of as a function of the social and economic attributes of households (households and housing units are very similar measures, but sometimes housing units have no households, and sometimes they contain multiple households, clearly housing units are easier to measure, and those are often used instead for models, it is important to be clear which assumption you are using).

At the level of the traffic analysis zone, the language is that of land uses "producing" or attracting trips, whereby assumption trips are "produced" by households and "attracted" to non-households. Production and attractions differ from origins and destinations. Trips are produced by households even when they are returning home (that is, when the household is a destination). Again, it is important to be clear what assumptions you are using.

5.1.2. STOP DENSITY FOR EACH ROUTE:

The study will determine the trip generator of each route proposed based on high or low travel density of that area. The final routes will be divided into major trip generators and minor trip generators depending to the length of the route and their potential stops.

Also, the author will determine the ratio of stops or stop density for each route based on accessibility factor. Here, the ideal distance from and to a potential stop is taken as 1.2 kilometers or 15 minutes walking approx. as referred by Clarence Perry's 15 minutes' city in 1900s.

The formula to estimate the stop density of each route is as follows.

Equation

$$\text{Duration}_t \text{ from A to B} = \text{Duration}_c \sum N/\sum N + \alpha + \beta + \pi \qquad (5.1)$$

Whereas,

Duration $_t$ from A to B = Duration of travel between two consecutive bus stations.

Duration $_c$ $\sum N$ = Total duration of travel on one complete Bus Route.

N = Total number of stations 1.5 km apart on that Route

α = Traffic constant.

β = Traffic signal constant.

π = Occupancy of Passengers (loading and unloading).

Also, the formula to calculate the number of buses used per route is as follows.

Equation

$$N_b = \text{Duration c } \sum N \text{ / Duration t from A to B} \qquad (5.2)$$

So, the number of buses on one route is equal to total time used to travel on one route (in minutes) divided by the duration of travel between two consecutive bus stations.

TABLE 5-28: THE NUMBER OF BUSES USED AND THEIR USAGE ACCORDING TO THE TIME TRAVEL:

Name of the Routes	Number of Stops	Distance Between Two Stops in Minutes	Bus Interval between Two Stops Approx. (After a, b, π)	Total Distance of Route by QGIS	Total Travel Time of Route by ORS	Number of Buses on Each Route 10 minutes apart
Bhara Kahu to Morga	10	5.5 min	10 min	20 km	30 min	3
G-6 through RWP to I-8	15	7 min	10 min	37 km	2-hours 12 min	13
I-8 to PWD Housing Society	8	6 min	10 min	16.7 km	45 min	4
Islamabad Sectors	11	6 min	10 min	22 km	1-hour 10 min	7

PIEAS to Rawat to Afzal Town	12	5 min	10 min	26 km	79 min	8
PIEAS to Rawat	6	4 min	10 min	12 km	25 min	2
Pir Sohawa to F-7 Markaz	5	8 min	10 min	10 km	40 min	4
QAU to Saddar	15	6 min	10 min	30 km	2-hours	12
Raja Bazar to DHA House Scheme	9	5 min	10 min	15 km	60 min	6
Rawalpindi Medical Line	9	6 min	10 min	20 km	55 min	6
Satellite Town to Blue Area	16	6 min	10 min	24 km	2-hours 30 min	15
Tarnol to Westridge	7	4 min	10 min	18 km	20 min	2
Waris Khan to Murree	4	7 min	10 min	7 km	20 min	2
Total buses used to create Bus Transport System						**84**

TABLE 5-29: THE NAMES OF THE STOPS PER ROUTE IN THE PROPOSED BUS SYSTEM:

Name of the Routes	Number of Stops	Name of the Stops
Bhara Kahu to Morga	10	Kashmiri Mohalla Dohk Jillani, Lake View Park, Shakarparian National, Chaklala Scheme, Morga.
G-6 through RWP to I-8	15	F-8, F-9, F-10, I-9, I-8, G-8, G-6
I-8 to PWD Housing Society	8	I-8, Pirwandi, Holy Family Hospital, Chaklala Scheme
Islamabad Sectors	11	F-9, F-8, F-6, F-10, Blue Area, Faisal Avenbue
PIEAS to Rawat to Afzal Town	12	PIEAS, Chashzda, COMSATS, Rawat, Lake view
PIEAS to Rawat	6	Kashmiri Mohalla Dohk Jillani, Lake View Park, Shakarparian National, Chaklala Scheme, Morga.
Pir Sohawa to F-7 Markaz	5	F-8, F-9, F-10, I-9, I-8, G-8, G-6
QAU to Saddar	15	I-8, Pirwandi, Holy Family Hospital, Chaklala Scheme
Raja Bazar to DHA House Scheme	9	F-9, F-8, F-6, F-10, Blue Area, Faisal Avenbue
Rawalpindi Medical Line	9	PIEAS, Chashzda, COMSATS, Rawat, Lake view
Satellite Town to Blue Area	16	Kashmiri Mohalla Dohk Jillani, Lake View Park, Shakarparian National, Chaklala Scheme, Morga.
Tarnol to Westridge	7	Tarnol, Goral road, westridge no1, Westridge 2
Waris Khan to Murree	4	Murree, Waris Khan, Bahira enclaves

CHAPTER NO: 6

RESULTS AND FINAL PRODUCT

6.1. RESULTS OF THE STUDY:

Under 12th SDG goal 2030 responsible consumption is a way out of environmental and spatial degradation for the world as well as a nation's obligation towards a sustainable future, here responsible consumption is referring to the optimal utilization of resources at hand and refrain from overcrowding of a single resource. But sadly, the transportation planning for Islamabad-Rawalpindi is moving in opposite direction of overlaying or vertical infrastructure (over accumulation of land) and budgetary subsidies in vehicle purchase and manufacture.

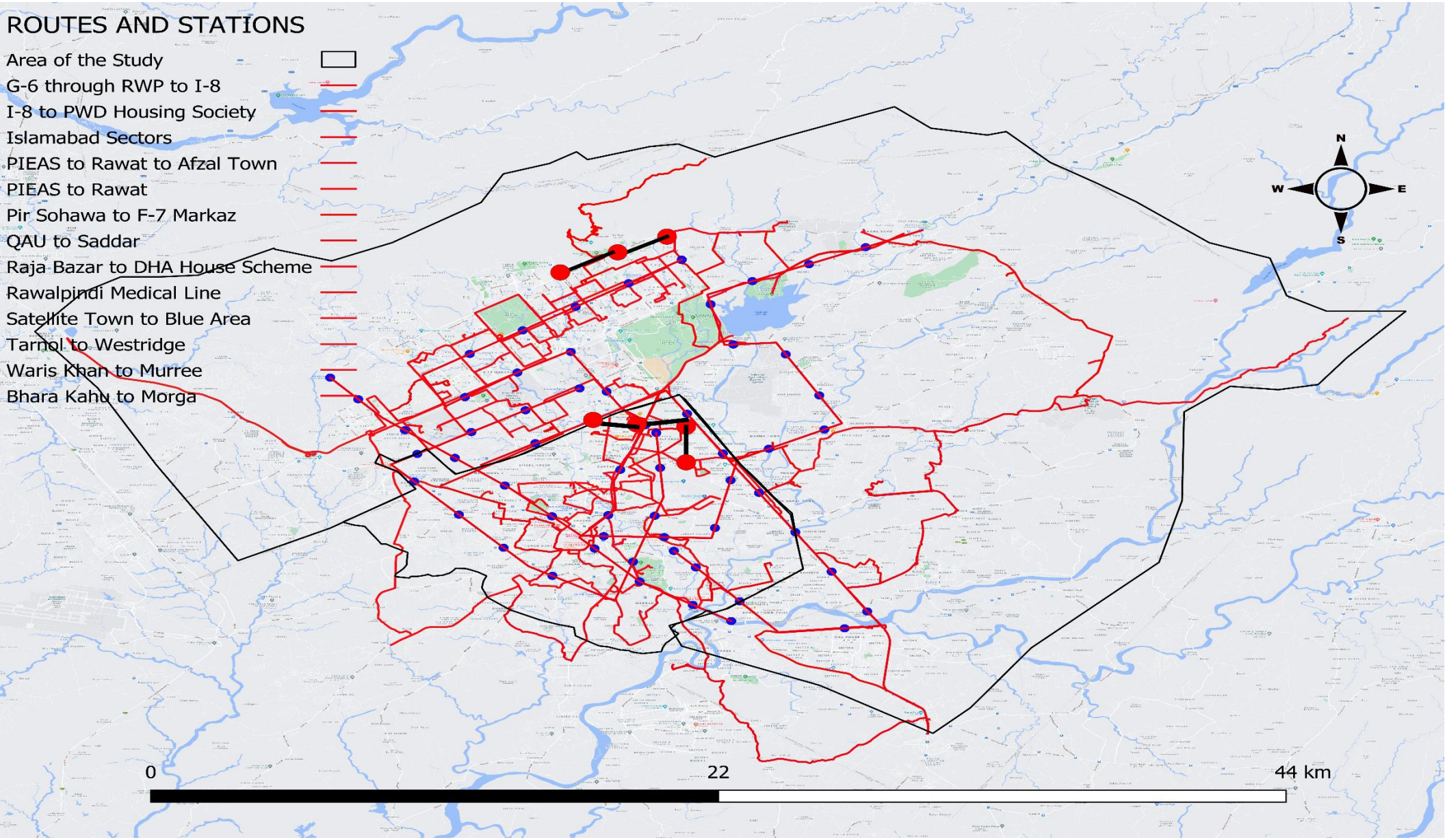
With growing spatial dispersion and an increase urbanized zoning, truly there is an increased demand of transportation, but answer does not lie in congestion of roads or parking lots, infrastructure with huge sank cost and partial mobility limiting its usage in a set geographical constraint. it lies with optimal utilization of resource.

Whereas several private ventures dove into the concept of shared mobility with, nevertheless, corrupted inhibitions of profit maximization.

6.2. FEASIBILITY ANALYSIS BETWEEM UNIVERSITY TRANSPORT AND CONVENTIONAL BUS SYSTEM:

So, the idea is to propose a sustainable alternative transportation plan which addresses increased demand and put forwards a solution for limited resources and Environmental degradation. The following map presents the proposed new routes for the conventional Bus Transport of Islamabad and Rawalpindi

MAP 6-30: THE PROPOSED NEW TRANSPORT SYSTEM WITH ROUTES AND STOPS FOR ISLAMABAD AND RAWALPINDI



A conventional Bus transportation system, now being adopted by developed countries like China, is age old example of shared mobility for a specific population (4.1 million). Islamabad and Rawalpindi are hosts of 23 public universities of which almost 20 universities are equipped with their own transportation system big or small containing 175 buses empowering only 3.7% of Islamabad-Rawalpindi's population. Now, removing these buses from university administration and using them to create a conventional bus transport system caters to a large portion of this population. Also, a sustainable solution to transportation demand in conscious of environment.

6.2.1. SOCIAL FEASIBILITY:

Islamabad and Rawalpindi are hosts of 23 public universities of which almost 20 universities are equipped with their own transportation system big or small containing 175 buses empowering only 3.7% (148,000) of Islamabad-Rawalpindi's population (6,500 students per university). The university Bus transport caters to 200 students per one bus, whereas the conventional bus system provides more flexibility and availability. The following graph represent the social feasibility of both among the people of Islamabad and Rawalpindi.

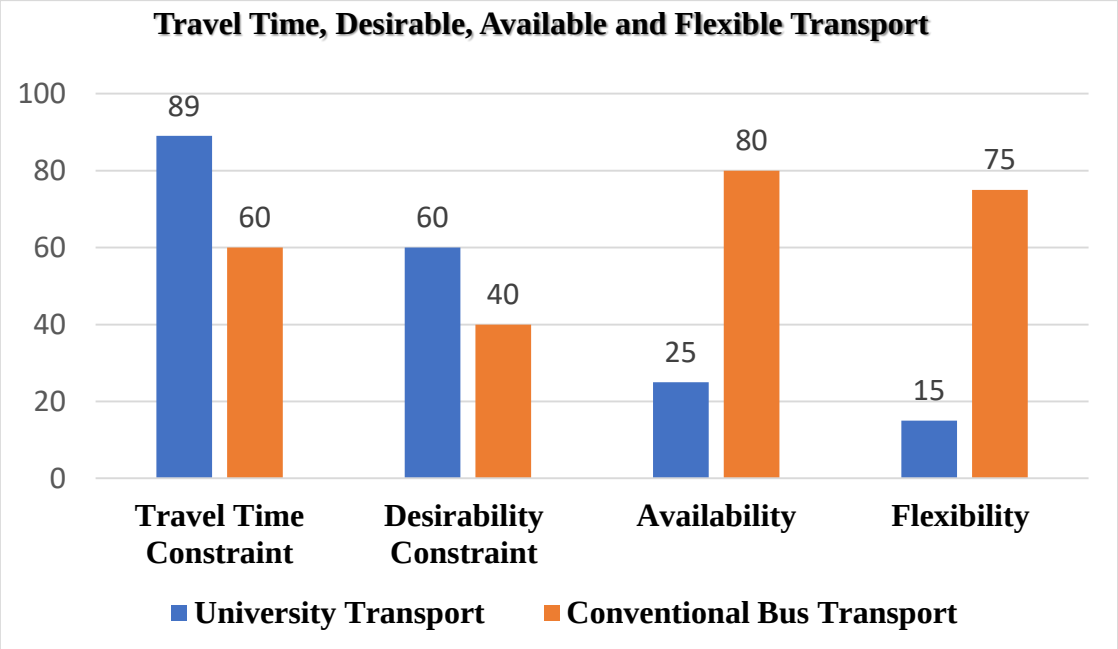


FIGURE 6-31: SOCIAL FEASIBILITY: TIME TRAVEL, AVAILABILITY AND FLEXIBILITY

6.2.2. ECONOMIC FEASIBILITY:

Building and implementing Sustainable system is yielding both monetary and sustainable results. Constructing investment side economic activities by providing affordable necessities is much beneficial as compared to consumption-based economy. Integrated and interconnection networking of resources is very important. The following figure presents the economic gains between the two system: university transport and conventional bus system. The chart above presents the daily expenditure and revenue of both university and conventional bus system with one yielding significant difference in revenue generation and if calculated on a time period of an year results in 3 million total collection on one bus.

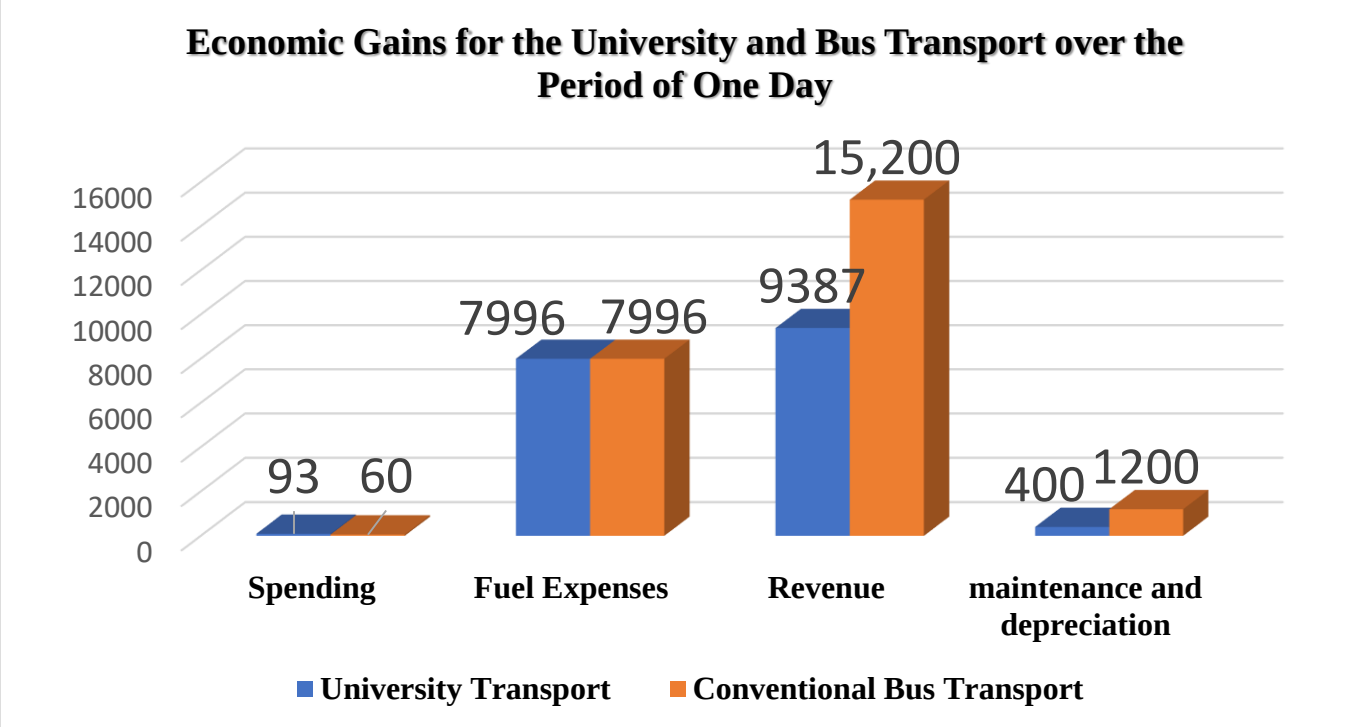


FIGURE 6-32: ECONOMIC GAINS FOR THE UNIVERSITY AND CONVENTIONAL BUS SYSTEM

6.2.3. ENVIRONMENTAL FEASIBILITY:

A university Transport only serves limited people and for limited time pushing for a passenger vehicle use instead.

A passenger car emission120 grams per km of CO2 with an occupancy of 1.6. Hence incurring 60 grams of emissions. Whereas an average emission from a bus is 820 grams per km with a occupancy of 36-55 people. Hence only 30 grams' emission is incurred by an single person reducing his or her carbon footprint. So, the university buses are utilized to serve only 3.7% (148,000) of population from 4.1 million, unfortunately, resulting in the use of private vehicles by the remaining population contributing to greater environmental degradation.

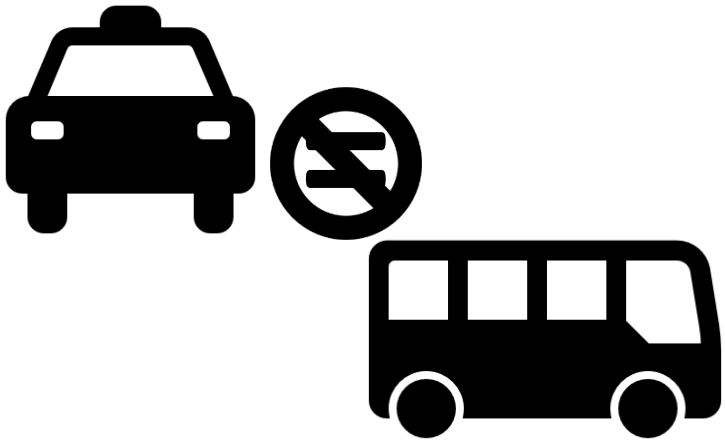


FIGURE 6-33: COMPARISON OF EMISSION BETWEEN CAR AND BUS

Enabling transport is one of the great motivators when it comes to economic growth of a country. Providing cheap and accessible transport can boast the current economic status of Pakistan, not to mention provide bases for future investments from foreign countries given the future increase in ease of business from a good transport sector.

CHAPTER NO: 7

CONCLUSION

Pakistan being a developing nation lacks the potential investments to establish a well-integrated and systematic transportation plan for its cities but sadly, Pakistan has also neglected creating a reasonable and sustainable solution for its transport problems. In the past, government of Pakistan based their policies on foreign aids project regarding infrastructure development but failed to properly accumulate its own population with an efficient public transportation system (Bajwa, 2017).

Pakistan's answer to complex mobility and accessibility issues includes building BRT projects with huge sunk cost on separate infrastructure and focus on private consumption of transport allowing exports from foreign countries, encourage local manufacturers of vehicle with subsidies on cost of production increasing road congestion with cars and bikes etc.

The concept of responsible consumption in transport is unconvinced and evident from the governmental policies mentioned in the last paragraph. Attitude in transport sector of Pakistan is of high consumption, if you can afford it, then it is okay. There is no regard for the consequence our frequent consumption brings on the future generations or the environment as long as the present needs are met (Smith, 2019).

Developing infrastructure is an important part of economic growth but it is also important to understand demand, supply, utilization and need of any resource. The wastage of any resource or service is unreasonable and unjust as this study highlights the wastage of available resource like university buses. Creating public bus system from university buses is based on optimal utility of

preexisting resource and responsible consumption. 10 people sharing one bus on a single route is economically, socially, and environmentally better than 10 people using 10 cars to travel on the same distance.

Understanding the mobility needs of different people helps generate common patterns of travel. This study has invested in the idea of responsible consumption and mobility trends to create a transportation system for the twin cities of Islamabad-Rawalpindi. The study proves that there is no shortage of resources to create public bus system and create bus sharing network for the twin cities to provide opportunities to all.

The 175 buses used in this study were in surplus usage as they were not fully used and were limited to a particular type of use. The routes of this study were determined based on common patterns and travel density of each union council of twin cities. The study included designs based on both inter and intracity transportation system where minor trip generator was mostly intercity and major trip generator were intracity.

The new use of these buses is sustainable, catering to larger masses, ensures complete utilization and generates revenue unlike its previous use as a university transport. The revenue earned from the implementation of this bus transport system can be used for enhancing and updating the transport sector in the future. One of the future benefits of this plan is decrease in the traffic congestions and improved road condition, not to mention, the decrease in parking issues.

The future benefit of this plan in the long-term aspect can be the adaptation of a healthier lifestyle by the general public involving walking and exercise. Also, the prospect of increased economic movement is one of the advantages of this plan where people might explore more distanced working opportunity regardless of the fear of cost of commuting. The factor of travel will not affect the decision making of people when considering employment at far-out places.

Enabling transport is one of the great motivators when it comes to economic growth of a country. Providing cheap and accessible transport can boast the current economic status of Pakistan, not to mention provide bases for future investments from foreign countries given the further increase in ease of business from a good transport sector.

Ensuring the proper implementation of this study and further research or evidence building can improve the quality of the output of each single route. Also, further additions like new routes can be added to this plan to achieve success. To address issues like over congestion in a bus passenger, new bus can be added to the same route.

Cost of operation of this plan can also be covered with the charge of travel instead of creating subsidies or budget allocations of huge amount of money. This plan can be self-sustaining if implemented correctly with proper analysis the affordability of the people. The affordability of this plan can be determined from further research and evaluation.

Hence, this study provides an outline to what and how a sustainable transportation plan can achieve if implemented correctly and with evidence-based policy.

7.1. RECOMMENDATIONS

Apart from the implementation of this study, the author has several recommendations on salvation and improvement of the transportation sector of Pakistan. So, the government and people can make more efficient decisions about the choice of consumption when it comes to the usage of private and public transport.

- Investment in understanding the need for and data collection on mobility patterns for any mass transit project should made mandatory by the government for increased efficacy.

- The presence of alternatives in transportation is beneficial in the long run growth of any country to adopt as it would help reduce over accumulation of any single mode. Policies regarding infrastructure development should encompass sustainable planning for all modes of transportation; Private, Public and Semi Public etc.
- Creation of a regulatory body at local level (for Islamabad-Rawalpindi) in transport sector for the integration and interconnection of public and private consumption is an idea worth investing in. For example, creating a sharing mobility bus by public/private collaboration.
- Integration of two or more public transportation plan should be considered for larger demand areas. For example, integrating Metrobus service with this proposed bus transportation policy or regulating private sector to support BRT project like creating taxi zones.
- Introduction of more sustainable policies like solar vehicles and electric or wind powered public transportation system are also advised.
- The research also proposes a thorough investigation on the current transport mechanism like analysis of road capacity against volume of traffic flow and developing separate lane concept for bus, track, bikes and cars.
- Teaching the value of public transport to the masses is also the responsibility of the government. Importance of public transport as necessity, not a hassle needs to be implemented to change all over consumption patterns.
- Unplanned spatial dispersion and urban expansion should be avoided, and proper planning on commuting should be in place for different developmental projects to ensure optimal accessibility.

7.2. LIMITATIONS

The following are some of the limitations of this study.

- Due to the financial and time constraint, the research was conducted only on the quantitative aspects of mobility (Number of trips from Rawalpindi to Islamabad) and, hence, has failed to acquire qualitative data of mobility (Type of occupation of people traveling from Rawalpindi to Islamabad). Survey on qualitative needs of transport can help increase inclusivity.
- The duration of this research was from June 2020 to February 2021, post pandemic world. Hence, the data collection on mobility might vary especially the data collected from google as it is based on the flow of traffic.
- The length of time for data collection from google was also short resulting in lack of variation and diversification in the data. The data was collected after lockdown.
- Another limitation results from the lack of primary data on the number of passenger accumulation on each route making it impossible to estimate the time taken to load and unload the bus on each stop, hence, the use of a constant value in the equation 3.1.

7.3. FUTURE DIRECTION

From the limitation of this study, the author proposes to conduct a primary sourced qualitative research to further understand the working and needs of direct and derived mobility for Islamabad-Rawalpindi. This will help develop reasoning behind certain travel patterns as well as creating a sustainable output of transport.

Secondly, the author would suggest an evaluation project for the transport sector of Islamabad-Rawalpindi to establish integration and interdependency of different modes of transportation. An

evaluation of this study after implementation will also be helpful in developing more lines or addition of more buses according to the accumulation of travel on a single route.

Thirdly, the involvement of technology to further increase efficiency and accuracy is ideal like introduction of apps to reduce waiting time and increase reliability of travel time. Also, technical intervention like addition of electric or solar buses to increase sustainability are some of the future directions of this study.

REFERENCES:

Aamir, M., Masroor, S., Ali, Z. A., & Ting, B. T. (2019). Sustainable Framework for Smart Transportation System: A Case Study of Karachi. *Wireless Personal Communications, 106*(1), 27-40. doi:10.1007/s11277-019-06259-4

Adeel, M., Yeh, A. G.-O., & Zhang, F. (2016). Transportation disadvantage and activity participation in the cities of Rawalpindi and Islamabad, Pakistan. *Transport Policy, 47*, 1-12.

Agency, T. R. B. F. H. A. U. S. E. P. (2005). Integrating Sustainability into the Transportation Planning Process. *Committee for the Conference on Introducing Sustainability into Surface Transportation Planning Baltimore, Maryland 37*.

Aggarwal, P., & Jain, S. (2016). Energy demand and CO2 emissions from urban on-road transport in Delhi: current and future projections under various policy measures. *Journal of Cleaner Production, 128*, 48-61. doi:10.1016/j.jclepro.2014.12.012

Aifadopoulou, G., Ziliaskopoulos, A., & Chrisohoou, E. (2007). Multiobjective Optimum Path Algorithm for Passenger Pretrip Planning in Multimodal Transportation Networks. *Transportation Research Record: Journal of the Transportation Research Board, 2032*(1), 26-34. doi:10.3141/2032-04

Amiri Khorheh, M., Moisiadis, F., & Davarzani, H. (2015). Socio-environmental performance of transportation systems. *Management of Environmental Quality: An International Journal, 26*(6), 826-851. doi:doi:10.1108/MEQ-09-2014-0140

Awan, J. H., Memon, S., Shah, A. A., & Pathan, K. T. (2020). Proposed framework of smart transportation in Pakistan: issues, challenges, vulnerabilities, and solutions. International Journal of Cyber Warfare and Terrorism (IJCWT), 10(4), 48-63.

Asif Bajwa, C. S. (2015). COMPENDIUM ON ENVIRONMENT STATISTICS OF PAKISTAN *Statistics House*(21).

Baloch, M. A. (2018). Dynamic linkages between road transport energy consumption, economic growth, and environmental quality: evidence from Pakistan. *Environmental Science and Pollution Research, 25*(8), 7541-7552.

Bast, H., Delling, D., Goldberg, A., Müller-Hannemann, M., Pajor, T., Sanders, P., . . . Werneck, R. F. (2016). Route planning in transportation networks. In *Algorithm engineering* (pp. 19-80): Springer.

Batool, I., & Goldmann, K. (2020). The role of public and private transport infrastructure capital in economic growth. Evidence from Pakistan. Research in Transportation Economics, 100886.

Batur, İ., & Koç, M. (2017). Travel Demand Management (TDM) case study for social behavioral change towards sustainable urban transportation in Istanbul. *Cities, 69*, 20-35.

Camargo Pérez, J., Carrillo, M. H., & Montoya-Torres, J. R. (2014). Multi-criteria approaches for urban passenger transport systems: a literature review. *Annals of Operations Research, 226*(1), 69-87. doi:10.1007/s10479-014-1681-8

Cao, R. (2016). Systems and methods for on-demand transportation. In: Google Patents.

Chen, T. D., Kockelman, K., & Zhao, Y. (2015). *What Matters Most in Transportation Demand Model Specifications: A Comparison of Outputs in a Mid-size Network.* Paper presented at the Journal of the Transportation Research Forum.

COHEN, S. L. (2016). Effect of Bus Turnouts on Traffic Congestion and Fuel Consumption *Transportation Research Record* 901

Cortés, C. E., Burgos, V., & Fernández, R. (2010). Modelling passengers, buses and stops in traffic microsimulation: review and extensions. *Journal of Advanced Transportation, 44*(2), 72-88. doi:10.1002/atr.110

Ditta, A., Figueroa, O., Galindo, G., & Yie-Pinedo, R. (2018). A review on research in transportation of hazardous materials. *Socio-Economic Planning Sciences*.

Donaldson, D. (2018). Railroads of the Raj: Estimating the impact of transportation infrastructure. *American Economic Review, 108*(4-5), 899-934.

Ghaffar, M. N.-u.-m. B. a. A. (2015). Use of Geospatial Techniques in Monitoring Urban Expansion and Land Use Change Analysis: A Case of Lahore, Pakistan *Journal of Basic & Applied Sciences, 11*, 265-273

Gomina Mama, F., Yang, Z. Z., & Xia, D. D. (2014). Strategies for Sustainable Urban Transport: A Case Study of Cotonou, Benin. *International Journal of Engineering Research in Africa, 13*, 9-20. doi:10.4028/www.scientific.net/JERA.13.9

Greene, D. L., & Wegener, M. (1997). Sustainable transport. *Journal of transport geography, 5*(3), 177-190.

Hanif, S., Mu, D., Baig, S., & Alam, K. M. (2020). A Correlative Analysis of Modern Logistics Industry to Developing Economy Using the VAR Model: A Case of Pakistan. Journal of Advanced Transportation, 2020.

Hassan, Z., Shabbir, R., Ahmad, S. S., Malik, A. H., Aziz, N., Butt, A., & Erum, S. (2016). Dynamics of land use and land cover change (LULCC) using geospatial techniques: a case study of Islamabad Pakistan. *Springerplus, 5*(1), 812. doi:10.1186/s40064-016-2414-z

Lee, J., & Miller, H. J. (2018). Measuring the impacts of new public transit services on space-time accessibility: An analysis of transit system redesign and new bus rapid transit in Columbus, Ohio, USA. *Applied Geography, 93*, 47-63. doi:10.1016/j.apgeog.2018.02.012

Lester, A. B., Winters, P. L., & Pham, M. (2019). Segment: Applicability of an Existing Segmentation Technique to Transportation Demand Management Campaigns in the United States. *Transportation Research Record*, 0361198119844248.

Li, D., Chi Man Hui, E., Xu, X., & Li, Q. (2012). Methodology for Assessing the Sustainability of Metro Systems Based on Emergy Analysis. *Journal of Management in Engineering, 28*(1), 59-69. doi:10.1061/(asce)me.1943-5479.0000092

Litman, T. (2007). Developing indicators for comprehensive and sustainable transport planning. *Transportation Research Record, 2017*(1), 10-15.

Litman, T. (2017). *Smart transportation emission reduction strategies*: Victoria Transport Policy Institute.

Lo, H. K., Watling, D. P., & Cantarellac, G. (2016). Day-to-day dynamics in transportation networks. *Transportation Research Part B: Methodological, 92*(Part A), 1-2.

Mahmoudi, M., Song, Y., Miller, H. J., & Zhou, X. (2019). Accessibility with time and resource constraints: Computing hyper-prisms for sustainable transportation planning. *Computers, Environment and Urban Systems, 73*, 171-183.

Majid, H., Alam, K., Madl, P., & Hofmann, W. (2013). Exposure assessment and associated lung deposition calculations for vehicular exhaust in four metropolitan cities of Pakistan. *Environ Monit Assess, 185*(6), 5265-5276. doi:10.1007/s10661-012-2942-0

Merlin, L. A., Levine, J., & Grengs, J. (2018). Accessibility analysis for transportation projects and plans. *Transport Policy, 69*(C), 35-48.

Mohmand, Y. T., Wang, A., & Saeed, A. (2017). The impact of transportation infrastructure on economic growth: empirical evidence from Pakistan. *Transportation Letters, 9*(2), 63-69.

Mohmand, Y. T., Mehmood, F., Mughal, K. S., & Aslam, F. (2020). Investigating the causal relationship between transport infrastructure, economic growth and transport emissions in Pakistan. Research in Transportation Economics, 100972.

Muhammad Adeel, A. G. O. Y. a. Z. F. (2014). TOWARDS AN INCLUSIVE PUBLIC TRANSPORT SYSTEM IN PAKISTAN. *oxford University 10*.

Nijkamp, P. (1994). Roads toward environmentally sustainable transport. *Transportation Research part A: Policy and Practice*, *28*(4), 261-271.

Ramli, M. A., & Monterola, C. P. (2015). The Resilience of the Encounter Network of Commuters for a Metropolitan Public Bus System. *Procedia Computer Science, 51*, 2117-2126. doi:10.1016/j.procs.2015.05.482

Ramudhin, A., & Lalwani, C. S. (2018). A COLLABORATIVE FRAMEWORK FOR MODELLING TRANSPORTATION INFRASTRUCTURE FOR MULTI-MODAL PLANNING. *on Logistics (ISL 2018) Big Data Enabled Supply Chain Innovations*.

Routray, R. K. M. a. J. K. (2001). Identification and accessibility analysis of rural service centers in Kendrapara District, Orissa, India: a GIS-based application. *Regional and Rural Development Planning, School of Environment, Resources and Development, Asian Institute of Technology (AIT) Bangkok, Volume 3* (Issue 1).

Sciara, G.-C. (2017). Metropolitan transportation planning: Lessons from the past, institutions for the future. *Journal of the American Planning Association, 83*(3), 262-276.

Shabbir, R., & Ahmad, S. S. (2010). Monitoring urban transport air pollution and energy demand in Rawalpindi and Islamabad using leap model. *Energy*, *35*(5), 2323-2332.Shahbaz, M., Chaudhary, A., & Ozturk, I. (2017a). Does urbanization cause increasing energy demand in Pakistan? Empirical evidence from STIRPAT model. *Energy*, *122*, 83-93.

Shahbaz, M., Chaudhary, A. R., & Ozturk, I. (2017b). Does urbanization cause increasing energy demand in Pakistan? Empirical evidence from STIRPAT model. *Energy, 122*, 83-93. doi:10.1016/j.energy.2017.01.080

Sobhani, M. G., Imtiyaz, M. N., Azam, M. S., & Hossain, M. (2019). A framework for analyzing the competitiveness of unconventional modes of transportation in developing cities. *Transportation Research Part A: Policy and Practice*. doi:10.1016/j.tra.2019.02.001

Tareen, W. U. K., Anjum, Z., Yasin, N., Siddiqui, L., Farhat, I., Malik, S. A., ... & Chek, L. W. (2018). The prospective non-conventional alternate and renewable energy sources in Pakistan—A focus on biomass energy for power generation, transportation, and industrial fuel. Energies, 11(9), 2431.

Taylor, G. R. (2015). *The transportation revolution, 1815-60*: Routledge.

Wang, Y., Zhang, D., Hu, L., Yang, Y., & Lee, L. H. (2017). A Data-Driven and Optimal Bus Scheduling Model With Time-Dependent Traffic and Demand. *IEEE Transactions on Intelligent Transportation Systems, 18*(9), 2443-2452. doi:10.1109/tits.2016.2644725

Weiner, E. (2016). *Urban transportation planning in the United States: history, policy, and practice*: Springer.

Yaqoob, H., Teoh, Y. H., Goraya, T. S., Sher, F., Jamil, M. A., Rashid, T., & Yar, K. A. (2021). Energy evaluation and environmental impact assessment of transportation fuels in Pakistan. Case Studies in Chemical and Environmental Engineering, 3, 100081.

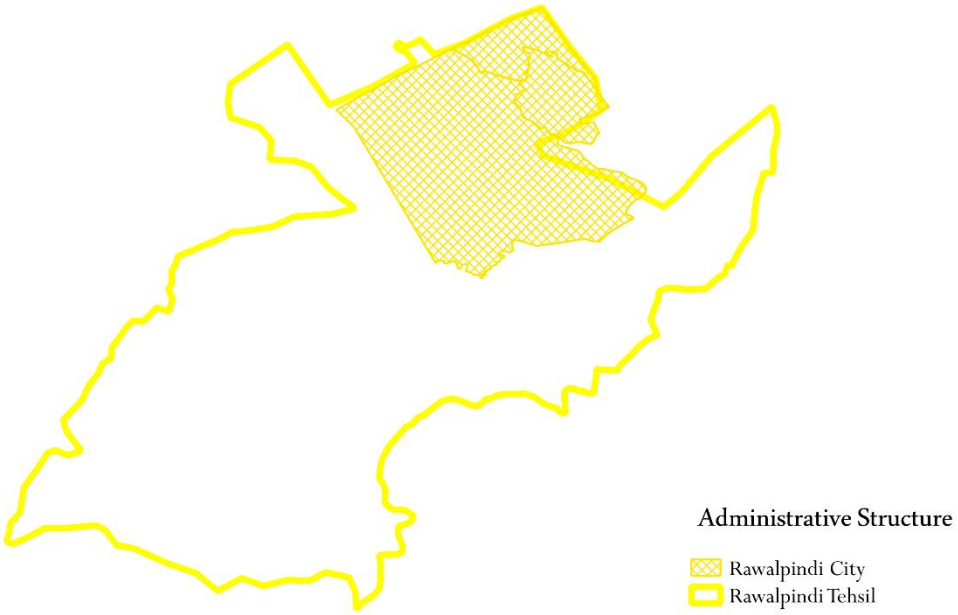
Zuberi, M. J. S., Torkmahalleh, M. A., & Ali, S. H. (2015). A comparative study of biomass resources utilization for power generation and transportation in Pakistan. *international journal of hydrogen energy*, *40*(34), 11154-11160.

APPENDIX A

Administrative Division Level 2, Rawalpindi District

Administrative Division Level 3 Tehsil

Administrative Division Level 3: Rawalpindi Tehsil and Capital City Rawalpindi



The Above shown figures are the maps clarifying the administrative boundaries of Rawalpindi city, Rawalpindi Tehsil and Rawalpindi District.

APPENDIX B

```
import requests
import time
import json


while True:

    url = "https://maps.googleapis.com/maps/api/distancematrix/json"

    querystring = {"units":"metric","departure_time":str(int(time.time())),"traffic_model"

    headers = {
        'cache-control': "no-cache",
        'postman-token': "something"
        }

    response = requests.request("GET", url, headers=headers, params=querystring)
    d = json.loads(response.text)
    print("On", time.strftime("%I:%M:%S"),"time duration is",d['rows'][0]['elements'][0]['
    time.sleep(1800)
    print(response.text)
```

In response:


```
{
    "destination_addresses": [
        "Tin Factory, Swamy Vivekananda Rd, Krishna Reddy Industrial Estate, Dooravani Naga
    ],
    "origin_addresses": [
        "Whitefield Main Rd, Pattandur Agrahara, Whitefield, Bengaluru, Karnataka 560066, I
    ],
    "rows": [
        {
            "elements": [
                {
                    "distance": {
                        "text": "10.5 km",
                        "value": 10505
                    },
                    "duration": {
                        "text": "35 mins",
                        "value": 2120
                    },
                    "duration_in_traffic": {
                        "text": "45 mins",
                        "value": 2713
                    },
                    "status": "OK"
                }
            ]
        }
    ],
    "status": "OK"
}
```

The JavaScript from latitude and longitude

```
function initMap() {
  const map = new google.maps.Map(document.getElementById("map"), {
    zoom: 13,
    center: { lat: 34.04924594193164, lng: -118.24104309082031 },
  });
  const trafficLayer = new google.maps.TrafficLayer();
  trafficLayer.setMap(map);
}
```

My own API key is inserted here

```
{
  "RWS": [
    {
      "RW": [
        {
          "FIS": [
            {
              "FI": [
                {
                  "TMC": {
                    "PC": 32483,
                    "DE": "SOHO",
                    "QD": "+",
                    "LE": 0.71682
                  },
                  "CF": [
                    {
                      "TY": "TR",
                      "SP": 9.1,
                      "SU": 9.1,
                      "FF": 17,
                      "JF": 3.2911,
                      "CN": 0.9
                    }
                  ]
                }
              ]
            }
          ],
....
```

Decodes for the python above:

"RWS" = A list of Roadway (RW) items

"RW" = This is the composite item for flow across an entire roadway. A roadway item will be present for each roadway with traffic flow information available

"FIS" = A list of Flow Item (FI) elements

"FI" = A single flow item

"TMC" = An ordered collection of TMC locations

"PC" = Point TMC Location Code

"DE" = Text description of the road

"QD" = Queuing direction. '+' or '-'. Note this is the opposite of the travel direction in the fully qualified ID, for example for location 107+03021 the QD would be '-'

"LE" = Length of the stretch of road. The units are defined in the file header

"CF" = Current Flow. This element contains details about speed and Jam Factor information for the given flow item.

"CN" = Confidence, an indication of how the speed was determined. -1.0 road closed. 1.0=100% 0.7-100% Historical Usually a value between .7 and 1.0 "FF" = The free flow speed on this

stretch of road.

"JF" = The number between 0.0 and 10.0 indicating the expected quality of travel. When there is a road closure, the Jam Factor will be 10. As the number approaches 10.0 the quality of travel is getting worse. -1.0 indicates that a Jam Factor could not be calculated

"SP" = Speed (based on UNITS) capped by speed limit

"SU" = Speed (based on UNITS) not capped by speed limit

"TY" = Type information for the given Location Referencing container. This may be freely defined string