IMPACTS OF ROAD NETWORK CONNECTIVITY ON QUALITY OF IN ABUJA CITY

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DEDICATION

This thesis is dedicated to God Almighty. To whom be all the power, majesty, glory, honour and adoration.

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ABSTRACT

Development of well-connected road network to guarantee quality living in cities is a major concern in the current era. Efforts have been made to establish the underlying relation between road network and societal well-being. However, the causal relationship remains poorly understood due to inability to consider personal quality of life in the appraisal technique. This research introduces a novel model with multidimensional analytical approach for empirical exploration of road connectivity impact on quality of life (QOL) in Abuja City, Nigeria. Forty planning districts were used as spatial units for road network analysis. QOL survey data were generated from 367 respondents in the 15 sampled districts. Graph theory metrics comprising alpha, beta, cyclomatic number, eta, gamma and aggregate transportation score (ATS) indices were applied to determine the connectivity of road networks. Exploratory factor analysis (EFA) was used to examine the components of road connectivity and quality of life indicators for the model development. Structural equation modelling (SEM) was applied for confirmatory factor analysis (CFA) to determine the model fitness between the components of road connectivity and the latent indicators of quality of life. Weighted average score (WAS) and analysis of variance (ANOVA) were used to compare the quality of life among the districts with different levels of road connectivity. Finding revealed that most districts (60%) have low road connectivity (6.66 – 46.23 ATS). About 22.5% of the districts have moderate connectivity (51.04 – 91.00 ATS), while 17.5% districts have high road connectivity (100.98 – 146.13 ATS). Factor analysis affirmed that four connectivity components, six latent factors and 26 observable factors were fit for model development. The structural equation modelling showed high factor loading ($R^2 = 0.66$), implying that road connectivity components explained 66% of QOL. Path coefficient was 0.81, indicating that every one unit increase in connectivity, contributes 0.81 unit increase in QOL. Analysis of variance showed a statistical significant difference in quality of life at < .05 level between low and high connected districts. However, quality of life slightly varied between the moderate and low connected districts as well as between the moderate and high connected districts. Overall, the results of this research have contributed by revealing how road connectivity empirically affects QOL. Hence, the study suggests a multidimensional model that can be employed in future analyses. The model would be useful to researchers, planners and engineers for examining the impact of transportation network on societal quality of life.

ABSTRAK

Pembangunan rangkaian jalan yang bersambung dengan baik untuk memastikan kualiti hidup di bandar merupakan kebimbangan utama dalam era masakini. Usaha telah dibuat untuk mewujudkan hubungan asas antara rangkaian jalan dan kesejahteraan masyarakat. Walau bagaimanapun, hubungan kasual masih kurang difahami kerana ketidakupayaan untuk mengambilkira aspek kualiti hidup peribadi dalam teknik penilaian. Kajian ini memperkenalkan model baru dengan pendekatan analitik multidimensi untuk meneroka secara empirikal impak kesinambungan rangkaian jalan raya terhadap kualiti hidup (QOL) di Abuja City, Nigeria. Empat puluh daerah perancangan digunakan sebagai unit spatial untuk analisis rangkaian jalan raya. Data tinajuan QOL dihasilkan daripada 367 responden di 15 sampel daerah. Metrik Teori Graf yang terdiri daripada indeks alpha, beta, nombor cyclomatik, eta, gamma dan indeks skor agregat (ATS) digunakan untuk menentukan tahap kesinambungan rangkaian jalan. Analisis Faktor Eksplorasi (EFA) digunakan untuk mengkaji komponen kesinambungan jalan raya dan indikator kualiti hidup bagi pembangunan model. Model Persamaan Struktur (SEM) telah digunakan untuk Analisis Faktor Pengesahan (CFA) bagi menentukan kesesuaian model antara komponen kesinambungan jalan dan penunjuk kualiti hidup terpendam. Nilai purata berwajaran (WAS) dan analisis varians (ANOVA) digunakan untuk membandingkan kualiti hidup di antara daerah dengan tahap kesinambungan jalan yang berbeza. Dapatan menunjukkan bahawa kebanyakan daerah (60%) mempunyai tahap kesinambungan jalan yang rendah (6.66 – 46.23 ATS). Lebih kurang 22.5% daripada daerah mempunyai kesalinghubungan sederhana (51.04 - 91.00 ATS), sementara 17.5% mempunyai sambungan jalan raya yang tinggi (100.98 - 146.13 ATS). Analisis faktor mengesahkan empat komponen kesinambungan, enam faktor terpendam dan 26 faktor pemerhatian adalah sesuai untuk pembangunan model. Model persamaan struktur menunjukkan pemuatan faktor yang tinggi (R^2 = 0.66) yang mencadangkan bahawa komponen kesinambungan jalan raya menerangkan 66% QOL. Pekali laluan ialah 0.81 menunjukkan bahawa setiap satu unit peningkatan kesinambungan menghasilkan 0.81-unit perningkatan QOL. Analisis varians menunjukan perbezaan statistic yang signifikan dalam kualiti hidup pada tahap < .05 antara daerah berkesinambungan tinggi dan rendah. Walau bagaimanapun kualiti hidup berbeza sedikit antara kesinambungan sederhana dan rendah serta antara daerah kesinambungan sederhana dan tinggi. Secara keseluruhannya, kajian ini menyumbang kepada pendedahan bagaimana kesinambungan jalan secara empirikal mempengaruhi kualiti hidup. Oleh itu, kajian ini menunjukkan bahawa model multidimensi boleh digunakan untuk analisis prestasi pengangkutan. Model ini berguna untuk penyelidik, perancang dan jurutera untuk mengkaji kesan rangkaian pengangkutan terhadap kualiti hidup masyarakat.

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LIST OF ABBREVIATIONS

ACEA	-	Association des Constructeurs Europeen
AEPB	-	Abuja Environmental Protection Board
AGIS	-	Abuja Geographic Information Studies
AMOS	-	Analysis of Moments Structure
ArcGIS	-	Aeronautical Reconnaissance Coverage Geographic Information System
BRT	-	Bus Rapid Transit
CBD	-	Central Business District
CFA	-	Confirmatory Factor Analysis
CFI	-	Comparative Fit Index
CMIN	-	Chi Square
EFA	-	Exploratory Factor Analysis
EU	-	European Union
EUR	-	Euro
FCDA	-	Federal Capital Development Authority
FCT	-	Federal Capital Territory
FHA	-	Federal Housing Authority
FRF	-	French Franc
GDP	-	Gross Domestic Product
GIS	-	Geographic Information System
GOT	-	Goodness of Fit
GT	-	Guarantee Trust Bank
KM	-	Kilo Meter
KMO	-	Kaiser Meyer Olkin
ND	-	Network Density
NGO	-	Non-Governmental Organization
NFI	-	Normed Fit Index
NO	-	Nitric Oxide
NOX	-	Nitrogen Oxide

PDR	-	People's Democratic Republic
QOL	-	Quality of Life
R^2	-	Squared Multiple Correlation
RMSEA	-	Root Mean Square of Approximation
SEM	-	Structural Equation Modelling
SINTEF	-	The Foundation for Industrial and Scientific Research
SPSS	-	Statistical Package for Social Science
TDM	-	Transportation Demand Management
TLI	-	Tusker-Lewis Index
TOD	-	Transit-oriented Development
UBA	-	United Bank of Africa
USA	-	United States of America
VEPI	-	Voter Education and Publicity Inec
VMT	-	Vehicle Miles Travelled
WHO	-	World Health Organization

LIST OF SYMBOLS

α	-	Alpha Index
β	-	Beta Index
η	-	Eta Index
∞	-	Infinity
μ	-	Cyclomatic Number
γ	-	Gamma Index

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Transportation is a process that satisfies human mobility demand by providing access to diverse activities in the society. The social and economic activities of human kind centre on transportation (Harriet et al., 2013 and Coffin, 2009). This is a means by which people physically access social capital, either in form of associations and community groups or simply to maintain linkages with extended family members. Activities such as social, cultural or economic interaction involve diverse functions comprising 'production, consumption and distribution' occur at locations served by various modes of transportation (Rodrigue et al., 2013).

Road as a mode of transportation serves as a conduit linking places, regions, and economy together; facilitating movement of people, goods and services (Venter et al., 2016, and Niazi, 2017). Road plays a central role in economic development and enhancement of social transaction. Thus contributes to productivity in other economic sectors, foster prosperity and support the foundation upon which economic strength of a place, region or nation rest (Patarasuk and Binford, 2012, and Papoutsis, 2013). This in turn has tremendous influence on societal well-being.

Network is a group of path nodes joined together by sets of linkages (Newman, 2010). It is also known as a framework of functional relations shaping the pattern of a territory (Borruso, 2003). Hence road network has a fundamental structure defined by layout, arrangement and connectivity of individual network elements and their intersections (Parthasarathi, 2011).

Road network connectivity can be considered as the systematic linkage of points, lines, and areas in relation to degree of properties such as size, distance, travel

time and optimal path' (Jayasinghe and Munasinghe, 2013). Connectivity in order words refers to linking many places so as to create interconnections which yields web-like network (Levinson, 2012). Bashir et al. (2012) aver that connectivity expresses the degree to which network permits direct movement between its various vertices or nodes. Thus road connectivity is critical for the success of other urban sectors. The advantages of road network connectivity are far ahead of accessibility and mobility in the city. But encompasses safer roads, reduced traffic congestion, and cost saving (Lehigh-Valley-Planning-Commission, 2011).

Road network connectivity influence pattern of urban growth and location of socio-economic activities, environmental aesthetics, employment and residential areas in the city. It as well affects commuters' choice of destination and accessibility (Huang and Levinson, 2012, Waddell, 2011, and Bogale, 2012). Also, Rodrigue et al. (2013) posits that connectivity does not only favour economic development but also determine the spatial organization in terms of locations, relations and accessibility. In a city setting where roads are the predominant means of mobility; land-use and roads are intertwined. Consequently, road networks are solely relied upon to access different activities such as businesses, educational institutions, employment opportunities, cultural and recreational centres. Shahi (2014) rightly observes that 'road network is the basic foundation of other development initiatives which ensures overall social, cultural and economic empowerment of communities'.

It could be inferred from the foregoing statements that a well-connected road network is an indispensable prerequisite for attainment of quality living condition. Deluka-Tibljaš et al. (2013) affirm that quality of life in cities greatly rely on the nature of transport services and as well on traffic infrastructure which, alongside with efficient transport system, make urban areas more accessible, and in turn raises their value. Road network therefore needs to be accessible and link up most places so as to create a promotional impact of land use activity and socio-economic well-being of people within the city-region. As Handy et al. (2010) proclaim that adequate road connectivity ensures social equity by providing travel options, accessibility and reduce travel cost to those who lack means of transportation in the city.

Road transport network is paramount to advancement of social and economic development in urban areas. In due course, investigations are directed towards understanding the link between transportation and economy, environment, social relationships and the people, and in turn their causal effect on societal well-being. Nevertheless, the social impact of transportation network has not been sufficiently explored particularly in developing country cities (Tiwari and Arora, 2012). It is equally acknowledged that the influence of transport network on urban lifestyle is scarcely investigated (Mohamed et al., 2013).

Existing investigations on road transport network impact on societal living quality mostly dwell on objective attributes while subjective quality of life is scarcely examined. For instance, preceding studies (Oluseyi, 2006, Özbil et al., 2008, Rifaat et al., 2012, Bornasal, 2012, Schneider, 2013, Parida, 2014) tried to describe the link between road network and societal well-being. However, their analysis and emphasis concentrate on selective individual indicators of objective (external attributes like air quality, noise, local economy, crime, traffic crash, social interactions) of well-being. Such individual objective variables neither indicate thorough and adequate measures nor provide sufficient information on societal quality of life.

The statistical framework employed is another major defect in analytical process. Most of the preceding studies presented only descriptive statistics or used simple bivariate tests of correlation, while some proposed theoretic models without empirical assessment. Thus results of such investigation cannot adequately relate the causal effect of road network on living quality. This makes judgements difficult, which result to indefinite and disputed conclusions about the causality between transport network and societal well-being (Reardon and Abdallah, 2013).

Thus far, no substantive predictive model has been developed for determining transport network connectivity impact on urban quality of life (Schneider, 2013). There is also no any previous study that has excursively investigated the impact of road connectivity on quality of life by examining multidimensional variables of well-being using self-reported (internal judgement) approach (Estlander, 2015; Lee and Sener, 2016).

Such limited capture of quality of life attributes in analysis, inadequate statistical approach, and undefined predictive model pose some difficulties to professionals and the society at large. Specifically, it constrains transport planners and engineers from gaining adequate insight to how their activities (policy and plan) influence the lifestyle of urban dwellers. It as well restricts policy-makers from comprehending the success of road investment in achieving the desired transport demand. It also makes the performance of urban road network in ensuring cultural, economic, social and overall urban development to remain unclearly defined.

The desire for more empirical approaches required in order to facilitate better insight to the rapport between societal well-being and transportation network stimulated interest in this present research. The motive is to introduce a firm and multi-dimensional (multiple interactive factor) model for empirical evaluation of road connectivity causal impact on quality of life. The model would help planners, engineers and decision-makers to better understand how road transportation system affect the well-being of urban dwellers. Thus the outcome of this research could facilitate future road planning, design, decision and implementation, without which sustainable transportation system and overall growth cannot be achieved in the city.

1.2 Research Problem Statement

The spatial growth of urban centres is an emerging phenomenon in developing countries. Cities are experiencing spectacular expansion which tremendously attracts the attention of urban planners (Tini and Peter, 2013). In this vein, Abuja city has experienced enormous attention and intensive resource infusion towards road infrastructure and transport facilities since its inception as federal capital of Nigeria in 1991. This resulted to significant changes in road network pattern. However, some disparities in connectivity across the city regions generate inequity in inhabitants' quality of life. Such phenomenon prompted the pertinence and desire for this investigation.

Generally, improvement of living quality has become a spectacular issue in cities. Thus, because it is one of the most essential dimensions for sustaining urban development (El-Din, et al., 2013). In realizing this objective, Jiménez-Espada and Gonzalez-Escobar (2016) have established that optimization of road transport network is one of the main ways to attain urban quality of life. Unfortunately, the causal impact of transportation system on societal well-being is not yet well established (Schneider, 2013 and Venables, 2014). Such predicament is prompted by limited capture of quality of life attributes in analysis, inadequate statistical analytical approach, and undefined predictive model for assessment (Carse, 2010, and Schneider, 2013).

These challenges and the rising need for better approach arouse interest in the present research to develop a more suitable and reliable technique for assessment of road network connectivity causal impact on societal quality of life in the context of Abuja city. The intention is to introduce a model with multidimensional analytical approach and diverse variables of transport related quality of life. Such involves modelling spatial connectivity of road network, ascertaining the components of road connectivity and quality of life indicators, and determining the implication of road connectivity on societal quality of life. Then lastly compare the quality of life between the districts with different road connectivity levels.

Four components, including route options, network reliability, transport efficiency and traffic flow have been identified from literature as the most relevant and essential social constituents of road network performance. Hence, they were adopted as connectivity social predictors of personal quality of life. Similarly, it is established form literature that personal accessibility, personal mobility, economic well-being, emotional travel safety, travel comfort and social interaction have scarcely been combined together as main constructs of transport related quality of life indicators and thus considered as endogenous factors in this analysis. Such constituents are vital for attainment of the intended goal in this empirical investigation as well as in developing a multidimensional model for assessing road connectivity causal impact on quality of life.

1.3 Research Aim

The main aim of this research is to extend the understanding of road network effect on societal quality living using multidimensional quantitative analytical approach. This will be achieved by investigating road network connectivity, and by determining the theoretical effect of connectivity components on quality of life via structural equation modelling. Such a dynamic approach can facilitate future planning and designing of roads, which in turn could offer sustainable transportation system, better quality of life and overall growth in the city.

1.4 Research Objectives

The specific objectives to be achieved in this study are to:

(a) Analyze the spatial pattern of road network connectivity in Abuja city.
(b) Examine the connectivity components and quality of life indicators suitable for assessing impact of road network,
(c) Determine the influence of road connectivity components on quality of life,
(d) Compare quality of life between the districts with different levels of road network connectivity.

1.5 Research Questions

The following are questions to enable the research achieve its objectives:

(a) What is the spatial pattern of road network connectivity in Abuja city?
(b) What are the connectivity components and quality of life indicators suitable for assessing impact of road network?
(c) To what extent do road connectivity components influence quality of life?

(d) Is there any similarity in quality of life between the districts with different levels of road connectivity?

1.6 Scope of the Study

This research is mainly a cross sectional analysis of road connectivity influence on quality of life in Abuja municipality. The aspects looked into were spatial structure of road connectivity, components of road connectivity and quality of life indicators. Forty planning districts were designated as unit of road network analysis. The structural analysis is confined to road network connection pattern in the study area. Alpha index, beta index, gamma index, cyclomatic number, eta index, and aggregate transportation score were used to determine the road connection pattern. The analysis did not involve complex network analysis such as betweenness, heterogeneity, and homogeneity. All categories of road comprising expressway, arterial, sub-arterial, secondary and local roads within the metropolitan area were unanimously represented as primal graph for analysis.

Social implication of road network in this research is restricted to the performance of road connectivity components and quality of life indicators. Four social components of road network connectivity were examined. These comprised route options, traffic flow, network reliability and transport efficiency. Six transport-related quality of life indicators were surveyed. These encompassed personal accessibility, personal mobility, economic well-being, travel comfort, travel safety, social interaction. The selection of few social components and quality of life indicators is for convenience, easy variable management, interpretation and result implementation.

Fifteen out of the forty districts were sampled as case study area to obtain survey data on quality of life and road connectivity performance. The data were collected from road users residing within Abuja metropolis, including males and females who were at the age of twenty years and above. The survey was conducted from the month of April to August 2016.

1.7 Research Limitations

This research will delineate connectivity of road network so as to know the pattern and properties of roads within Abuja municipality. Thereby provides adequate information to planners, engineers, administrators and the general public on the physical configuration and efficiency of road network in the city. This is vital for future decision on planning and development of roads. This investigation does not involve complex network analysis such as betweenness, heterogeneity, and homogeneity.

The study also ascertains the performance of road connectivity components and as well determines road users' life satisfaction with the road connectivity. This outcome will reveal to planners and engineers the impact of their activities on the lifestyle of city dwellers. The finding will also enable administrators to ascertain the ability of road investment in achieving the desired goal of improving standard of living of the urbanites.

Furthermore, the study shall verify and compare quality of life between the districts with different levels of road connectivity. Such understanding is essential for planning decision which could ensure cultural, economic, social equity and environmental sustainability at regional and the entire city levels.

1.8 Significance of the Research

The rational for this study was to develop a multidimensional analytical model which shall serve as a guide for transport planners and policy makers in assessing the impact of road connectivity on societal living quality. Thus the important and beneficial achievements of the research include the following:

This study will uncover the physical configuration of road network in Abuja city. Hence the outcome is beneficial since it will serve as a guide to planning authority in deciding for future need, plan and development of roads in the city. The research will analyse levels of road connectivity; therefore, the result will be helpful for the

inhabitants in choosing favourable location to reside either in the low, the moderate or the highly road connected districts.

Result of this research shall aid planning authority in detecting and finding solution to the problems associated with physical road network in Abuja city.

Findings of this study will also assist planning authority and administrators to know the performance of road connectivity in promoting societal liveability and quality of life.

In view of the rising requirement for approaches to assess transport impact on societal well-being. The active model introduced in this research will be useful for transport planners and researchers as a significant and flexible technique for evaluating the influence of road network on societal living quality. The study shall as well serve a future reference for researchers on urban transportation and human society.

Finally, the outcome of this work will provide planners and policy- makers with adequate information on the factors to be noted in designing an integral approach for planning quality and aesthetic urban environment with sustainable road network that would enhance cultural, social and economic well-being of the urbanites.

1.9 Structure of Thesis

This research is organized in six sections systematically outlined as follows: **Chapter 1** captures background of the study, research problem, research questions, aim and objectives, scope and limitation of the study, and research significance. Generally, it describes the concept and content of this research work.

Chapter 2 comprises detail literature review on transport network and societal well-being models, evolution of road network, trends of urban road network, concept of road network connectivity, its measures and societal impact. It also highlights

quality of life concept, its relationship with transportation network, quality of life indicators, and the related existing studies.

Chapter 3 describes the physical and social characteristics of the study area. Additionally, it gives hint about urban form and land use pattern of the city. The existing transportation policy and transport network of Abuja city are other issues captured in this section.

Chapter 4 presents the materials and methods used in achieving objectives of the study. It explains the types of data collected, data acquisition and processing methods. It further covers road network analysis, population sampling strategy, questionnaire administration, statistical test and structural equation modelling procedures.

Chapter 5 consists of the data analysis and results discussion. The collected data were analysed and interpreted based on the research objectives as follows: analysis of spatial pattern of road network connectivity, components of road connectivity and quality of life indicators, impact of road connectivity on quality of life, and comparison of quality of life between different road connectivity districts.

Chapter 6 concludes the entire research work. This constitutes the overall summary of the thesis, discussion of findings based on the research questions, conclusion and suggested future research areas in the field of study are highlighted. Graphical description of the thesis details is presented in research design (Figure 1.1).

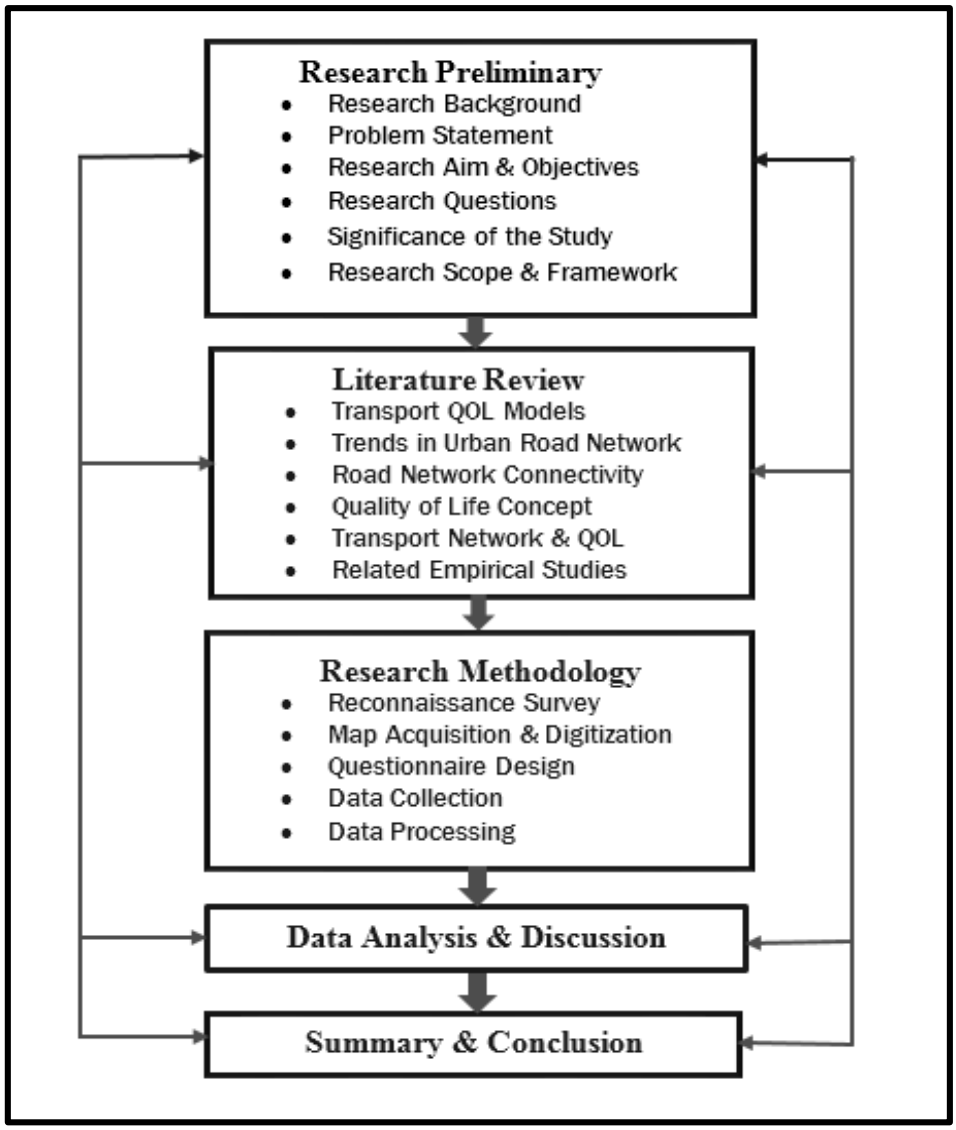

Figure 1.1: Research Design

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